Master of Public Health

Integrative Learning Experience Report

VETERINARIAN PERCEPTIONS OF CANINE GIARDIASIS AND COMMUNICATION ON ZOONOTIC POTENTIAL IN THE U.S.

by

Megan Elizabeth Eppler

MPH Candidate

submitted in partial fulfillment of the requirements for the degree

MASTER OF PUBLIC HEALTH

Graduate Committee:
Berlin Londono B.S., M.S., Ph.D.
Brian Herrin B.S., DVM, Ph.D.
Kathryn Reif MSPH, Ph.D.

Public Health Agency Site:
Kansas State University Parasite Outreach
January 2021- August 2021

Site Preceptor:
Jeba Jesudoss Chelladurai BVSc & AH, MS, Ph.D.

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2021

Copyright

Summary

Certain *Giardia* assemblages are capable of infecting both canines and humans, especially children. *Giardia*, specifically *G. duodenalis* (also known as *G. intestinalis* and *G. lamblia*), is studied unequally across species, likely because *Giardia* infections are treated differently in veterinary and human medical perspectives. A plethora of studies and data exist for human cases of giardiasis; however, it is impossible to know if a human or canine is carrying a zoonotic assemblage of *Giardia* because molecular characterization is not routinely carried out in the clinical setting. However, a study from 2011 found that asymptomatic urban dogs in the Western United States were more frequently infected with zoonotic assemblages of *Giardia* than with canine specific assemblages of *Giardia* (Covacin et al., 2011). Additionally, little data has been collected on how veterinarians treat pets and advise owners on how to best prevent re-infection or zoonotic infection. *Giardia* has no approved canine treatments in the U.S., but veterinarians may utilize three different drug treatments to help control the infection: metronidazole, fenbendazole, or febantel. It is important to understand veterinarian perceptions and practices for treating *Giardia* within the context of One Health. The goal of this cross-sectional study was to determine what types of treatments veterinarians are using, whether they are educating the pet owners on zoonotic potential from different assemblages of *Giardia*, and whether they are advising control measures to prevent environmental contamination by *Giardia* (e.g., washing bedding and bathing pets).

Subject Keywords: Giardia, Zoonotic, Veterinarians, Treatment, Survey, Dogs

Table of Contents

List of Figures

List of Tables

Chapter 1 - Literature Review

Giardia is a gastrointestinal protozoal parasite best known for causing diarrheal diseases in humans and animals, however, it can also cause asymptomatic infections in both species. Approximately 50% of human giardiasis infections are asymptomatic (Conners et al., 2021a). The feeding stage of *Giardia*, known as a trophozoite, is shaped like a tennis racket or a pear with a ventral sucking disk and flagella. The sucking disk aids in attachment to the host's intestinal wall. The haphazard beating of the four pairs of flagella makes the parasite's locomotion appear like that of a tumbling leaf. Each trophozoite has two nuclei on the rounded end. The trophozoite is quite small; measuring between 9.5-21 micrometers in length and between 5-15 micrometers in width (Wolfe, 1992). The infectious stage of *Giardia*, referred to as the cyst, is even smaller than the trophozoite; measuring between 8-15 micrometers in length and 7-10 micrometers in width (Wolfe, 1992; Patton, 2013).

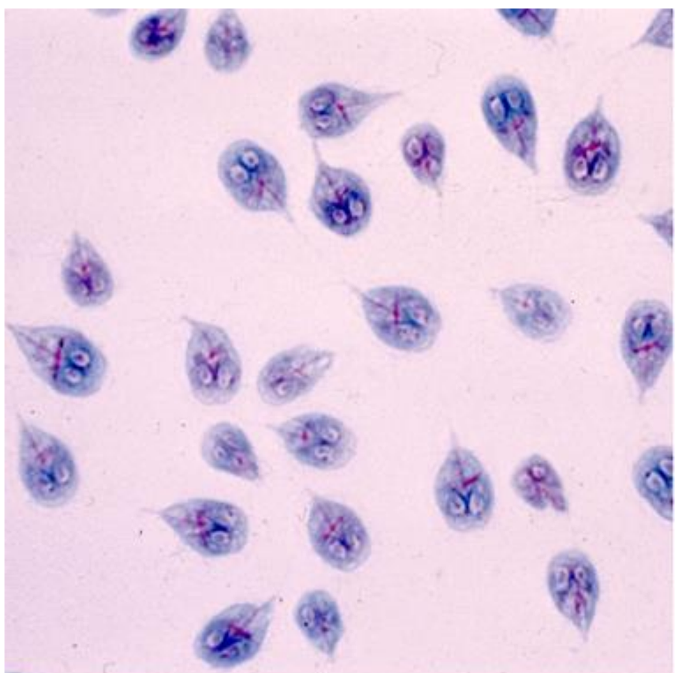


Figure 1.1: *Giardia* Trophozoites Stained with Trichrome (Division of Foodborne, Waterborne, and Environmental Disease [DFWED], 2015).

The methods of infection with *Giardia* vary slightly between dogs and humans, but both species are infected through the fecal-oral route. Canines are often infected when engaging in what the owner would believe is normal animal behavior like coming into contact/ingesting infected feces from another dog, playing in infected soil, self-grooming after physical contact with a contaminated surface, and drinking water from a contaminated natural water source (Center for Disease Control and Prevention [CDC], 2021a). Humans become infected with *Giardia* by consuming contaminated foods/water, having close contact with someone infected with *Giardia* (like a small child at a daycare who has yet to establish proper adherence to hygiene rules), individuals who travel to areas with poor sanitation, accidentally transferring *Giardia* from a contaminated surface to the mouth, and coming into contact with an animal or animal feces infected with the zoonotic assemblages of *Giardia* (CDC, 2021b). It has been suggested that *Giardia* infections can be transmitted via oral-anal and anal sexual intercourse in the male homosexual population (Meyers et al., 1977; Keystone et al., 1980; Phillips et al., 1981). In theory any type of oral-anal or anal intercourse with a *Giardia* infected individual, regardless of sexuality, could result in the transmission of *Giardia.* The CDC suggests practicing safe intercourse, avoidance of feces during intercourse, or waiting several weeks to have intercourse if one or both partners have recently recovered from giardiasis (CDC, 2021c).

Once the canine or human becomes infected, the lifecycle of *Giardia* behaves in the same way in each species. An infection with *Giardia* does not start with the trophozoite, but the cyst which is passed in the feces. After the parasite has been consumed, it evades destruction from the stomach and moves along with the digested material until it enters the small intestine where the cyst will go through excystation to release two trophozoites (CDC, 2021d). The trophozoites inhabit the mucosal membrane of the small intestine. They latch onto the brush border of the microvilli which are designed to absorb nutrients and begin pirating the nutrients for themselves. In addition, the trophozoites cause an increase in epithelial permeability and brush border shortening by releasing toxins and activating T lymphocytes. The shortening of the brush border significantly decreases the surface area available for absorption which impairs the action of digestive enzymes secreted from the brush border. This leads to decreased absorption of nutrients, electrolytes, and water causing the obvious clinical signs of continuous or intermittent diarrhea and weight loss. It is thought that the lack of effective enzymatic digestion leads to the soft, mucus filled, and almost fatty appearance of the feces. After a pre-patent period of three to ten days, the trophozoites begin to replicate through binary fission and encyst in the small and large intestine. These cysts are considered the infective stage of the parasite which are passed through the feces (Patton, 2013). The cysts are immediately infectious once passed into the environment and can survive for several weeks. The next host may pick the infectious cysts via the fecal-oral route by ingesting small amounts of the feces either in water, touching of the mouth after handling infectious feces, or in the case of animals, coprophagy and grooming.

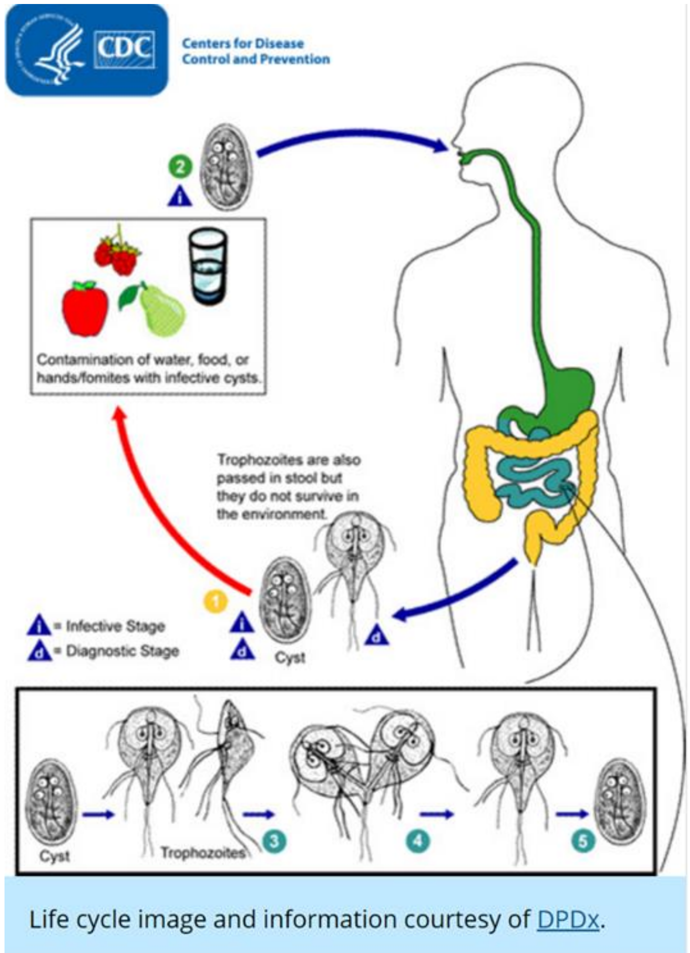
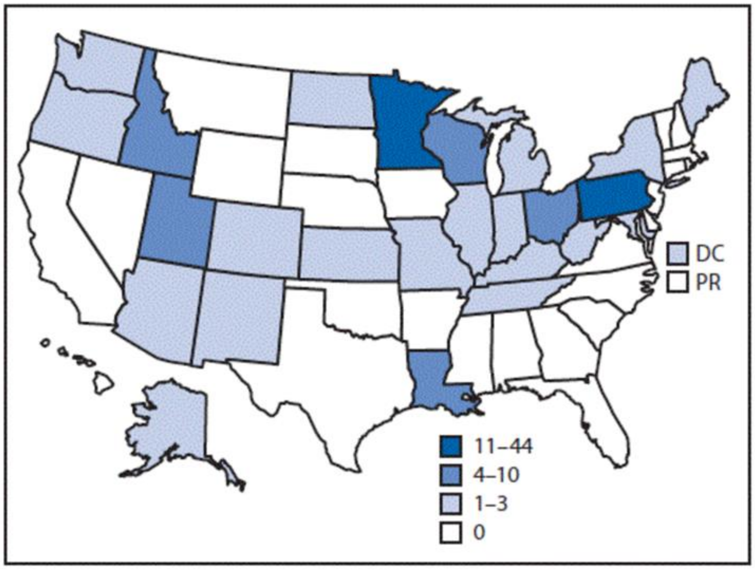


Figure 1.2: *Giardia* Lifecycle (DPDx, 2017).

The symptoms of *Giardia* infections are very similar between humans and animals. Symptomatic dogs may suffer from weight loss. The feces will be poorly formed, pale, and extremely pungent. Watery diarrhea rarely occurs in cases. Blood is usually not found in the feces as the parasite itself does not disrupt the mucosal barrier. On occasion, a symptomatic dog may present with vomiting (Patton, 2013). Dogs may also suffer from dehydration. Humans may experience violent, watery diarrhea or greasy stools which is accompanied by flatulence. The feces will be malodorous. Intestinal cramping, gurgling, or distension may occur as the gas passes through the intestines. Nausea and vomiting may also be experienced (Adams, 1991; Wolfe, 1992). Dehydration is a common symptom in humans and should be closely monitored in the case of small children who may not hydrate sufficiently. Additionally, humans may experience less common symptoms like fever, swelling of the eyes and joints, hives, and itchy skin (CDC, 2021c).

A tricky parasite, *G. duodenalis* can infect a wide range of mammalian hosts. *G. duodenalis* is organized into assemblages each responsible for infecting certain mammalian hosts. Assemblages can be host specific in some cases and non-host specific in others. To date, only *G. duodenalis* assemblages A and B can infect human hosts (Heyworth, 2016). Dogs can be infected with assemblages A, B, C, and D. Cats can be infected with assemblages A and F. There is potential for the zoonotic spread of assemblage A between dog/cat owners and their pets as well as assemblage B between dogs and their owners (Tangtrongsup & Scorza, 2010; Heyworth, 2016; Capewell et al., 2021). Other non-traditional pets such as ferrets, rabbits, chinchillas, and chickens also share assemblages A and B with people (Heyworth, 2016). However, the focus of this study was the zoonotic potential of *Giardia* in dogs. Though few cases of zoonotic transmission have been recorded, there is little to no data on the true rate of the zoonotic transmission of *Giardia;* however, the CDC does have a warning on their website that there is a small chance of owners acquiring *Giardia* from their cat or dog (CDC, 2021c).

The Morbidity and Mortality Weekly Report (MMWR) compilation document entitled *Giardiasis Outbreaks in the United States from 2012-2017* recorded 111 human outbreaks of *Giardia*, causing 760 cases of giardiasis across 26 states. The categories of infection methods included various means of waterborne, foodborne, person-to-person, and indeterminate or unknown. It is interesting that researchers found no known documented human giardiasis outbreaks attributable to environmental or animal-based infection. There were 29 waterborne outbreaks which contributed to 370 (49%) individual cases. Person-to-person methods of infection contributed to 28 outbreaks with a total of 129 (17%) individual cases. Foodborne outbreaks only had 6 outbreaks causing 97 (13%) individual cases. Indeterminate/unknown means of exposure had the highest number of outbreak cases at 48, but only accounted for 164 (22%) individual cases. The number of outbreaks of giardiasis varied by year and each year presented a unique combination of infection methods (Conners et al., 2021a).



Abbreviations: DC = District of Columbia; PR = Puerto Rico.

Figure 1.3: Reported Giardiasis Outbreaks (N=111), by Jurisdiction – National Outbreak Reporting System, United States, 2012-2017* (Conners et al., 2021b).

***These numbers are dependent on reporting requirements and public health capacity, which vary across jurisdictions and do not necessarily indicate the actual occurrence of giardiasis outbreaks in a given jurisdiction.**

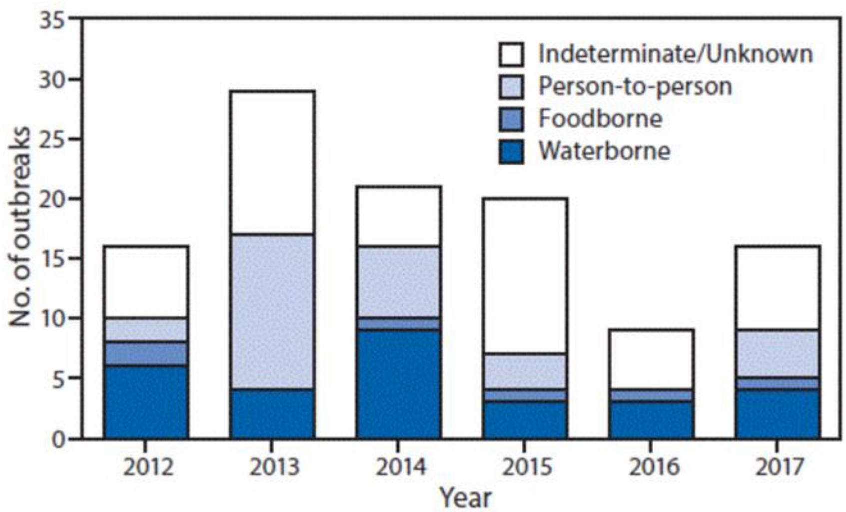


Figure 1.4: Reported Giardiasis Outbreaks (N=111), by Mode of Transmission* and Year of earliest Illness Onset Date – United States, 2012-2017 (Conners et al., 2021c).

***Transmission modes were categorized as follows: indeterminate/unknown if evidence to implicate one specific primary mode of transmission was insufficient; person-to-person if transmission occurred from direct contact with an infected person, their body fluids, or by contact with the local environment where the exposed person was present; foodborne if transmitted through consumption of contaminated food or non-water beverages; waterborne if transmission occurred via ingestion, inhalation, contact or another exposure to water (e.g., treated or untreated recreational water, drinking water [including bottled water], or an**

environmental or indeterminate water source). There were no outbreaks attributed to animal contact or environmental contamination other than food and water (https://www.cdc.gov/nors/forms.html).

According to the Giardiasis National Notifiable Disease Surveillance System (NNDSS) Summary Report for 2018 from the CDC, the confirmed and reported cases of human giardiasis has remained below 7 cases per 100,000 people since 2011. However, in 2018 alone 15,579 cases of giardiasis were reported with 96.8% of cases being confirmed and 3.2% non-confirmed. Of those confirmed cases, 61.4% were male, 38.3% were female, and 0.3% had missing data on gender. Confirmed cases which had data gathered on race showed that 70.1% of cases identified as white, 8.7% of cases identified as black, 3.3% of cases identified as Asian/Pacific Islander. However, the percentages of race identifications may be skewed as data on race was not recorded for 27.9% of total annual case reports and racial data was missing in 42.2% of case reports. The highest reported incidence was in individuals 1-4 years old (9.5 per 100,000). This was followed by individuals 25-29 years old (7.5 per 100,000) and individuals 55-59 years old (7.2 cases per 100,000) (CDC, 2020).

The Companion Animal Parasite Council (CAPC) maintains a parasite prevalence map for cats and dogs within the United States and Canada. In 2020, they recorded 749,048 positive *Giardia* cases in dogs out of the 10,983,745-total dogs tested. In 2021, they recorded 372,952 positive *Giardia* cases in dogs out of the 5,195,083 tested. Each of the 50 states reported cases of *Giardia,* though many counties within states had no data recorded for *Giardia* in dogs (Companion Animal Parasite Council [CAPC], 2021a; CAPC, 2021b). A study in 2011 by Covacin et al. aimed to provide the first large-scale urban survey of *Giardia* infections in domestic dogs in the Western United States which was where the highest recorded incidence of *Giardia* testing occurs in the nation according to ANTECH Diagnostics data. A total of 238 fecal samples were chosen at random from 35,172 positive *Giardia* microscopy tests conducted by ANTECH laboratories. Of those, 148 samples were identified as *Giardia* positive by polymerase chain reaction (PCR) and 128 of those sample yielded genetically identifiable material. From the 128 samples, a total of 296 different *Giardia* infections were identified. Approximately 28% of the assemblages identified were assemblage A, 41% were assemblage B, 15% were assemblage C, and 16% were assemblage D. This indicates that the zoonotic *Giardia* assemblages A and B occur more frequently in asymptomatic urban dogs in the Western United States than “dog specific” assemblages (Covacin et al., 2011).

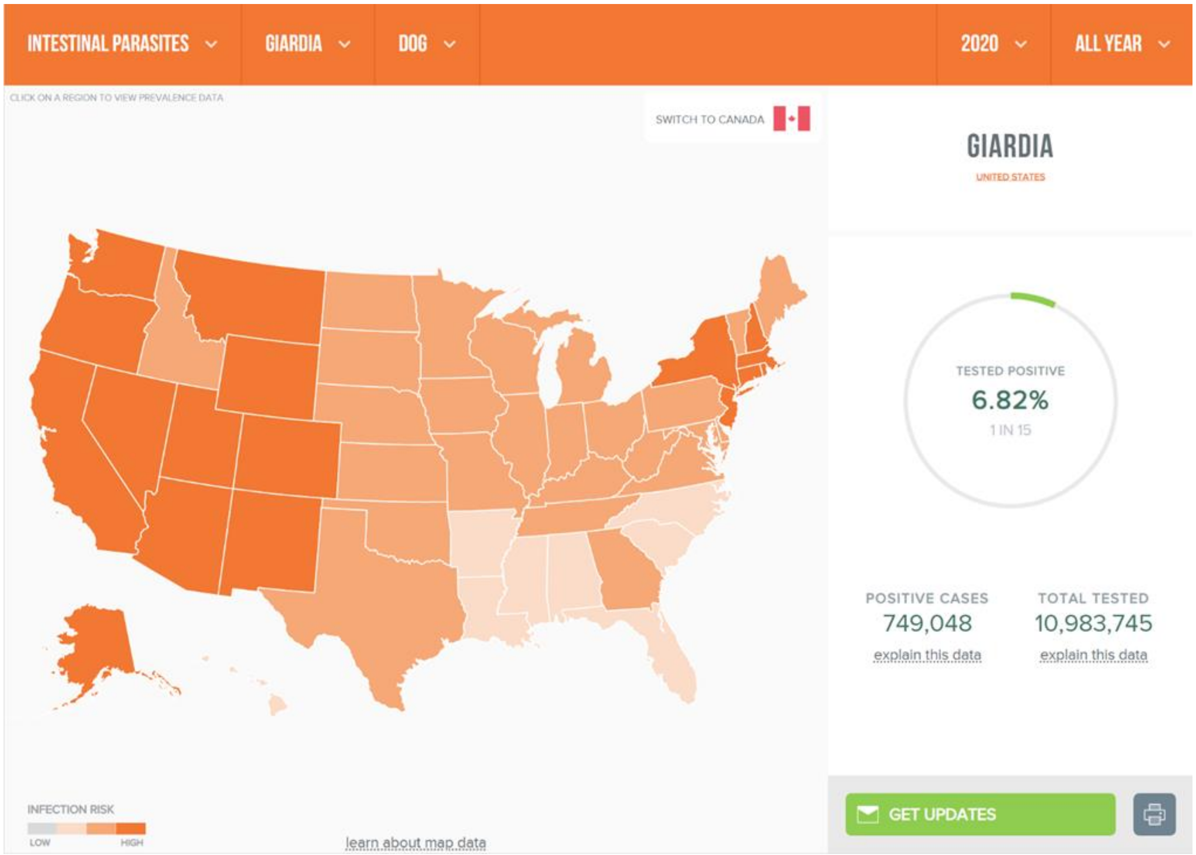


Figure 1.5: Map of *Giardia* Prevalence in the United States of America in 2020 (Companion Animal Parasite Council [CAPC], 2021a).

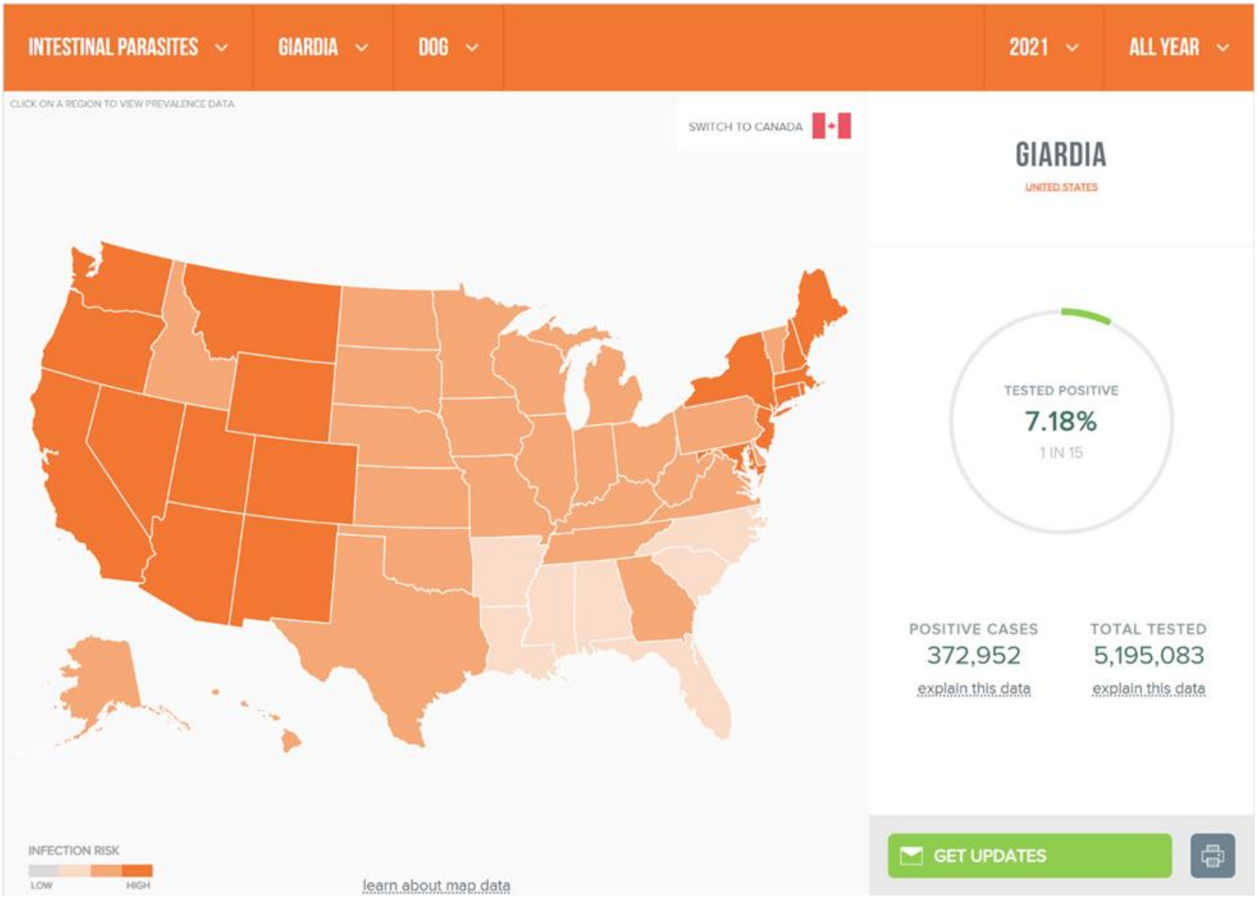


Figure 1.6: Map of *Giardia* Prevalence in the United States of America in 2021 (CAPC, 2021b).

Many methods are available to test for the presence of *Giardia*. The most common methods include direct smear of feces to look for trophozoites, passive fecal flotation to look for cysts, centrifugal fecal flotation with zinc sulfate, immunofluorescence assays (IFA) for antibodies, detection of antigens with ELISA, and identification of *Giardia* DNA by a polymerase chain reaction (PCR) assay. The tests can be used either alone or in combination, but in combination may be more common because of the difficulty of visualizing/recovering *Giardia* trophozoites and cysts. Centrifugal floatation with zinc sulfate is the best way to visualize *Giardia* cysts as the centrifugation leads to better rates of recovery on the coverslip for microscopic analysis. Additionally, Lugol's iodine can be added to the slide to help stain the distinct organelles present within the cyst, as the cysts can be easily mistaken for yeast. It can sometimes be difficult to identify *Giardia* cysts or trophozoites because cysts/trophozoites are intermittently shed within the dog's feces. Therefore, in-house ELISA antigen tests (SNAP *Giardia* test, IDEXX Laboratories) performed at the veterinarian's office can be unreliable because the levels of cysts (and antigen present) can vary drastically during the day. Additionally, the presence of a few trophozoites in non-symptomatic dogs can result in enough antigen to cause a positive result on the SNAP test. Thus, SNAP tests should be used in addition to the other detection methods listed, but not as a sole screening tool (Tangtrongsup & Scorza, 2010).

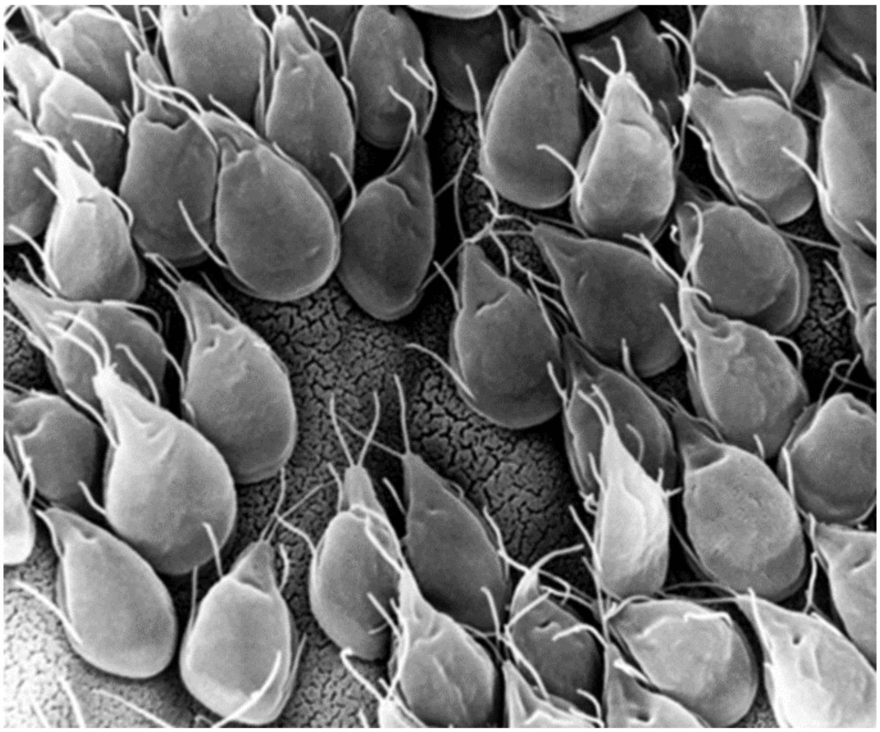


Figure 1.7: This scanning electron microscopic (SEM) image depicted the mucosal surface of the small intestine of a gerbil, infested with *Giardia* sp. protozoa. The intestinal epithelial surface is almost entirely obscured by the attached *Giardia* trophozoites (Erlandson, 1988).

The Animal Medicinal Drug Use Clarification Act (AMDUCA) was passed in 1994 to allow veterinarians with a client/patient relationship to prescribe drugs on an extra-label basis. This means the drug is being used in any way differing from its labeled use including use in unlabeled species, in unlabeled indications, in differing dose or frequency of dose, and via a different route of administration (American Veterinary Medical Association [AVMA], 1994). Metronidazole is labelled as an antiprotozoal for treatment of canine infections with Trichomonads and Amebeas, and for the treatment of canine anaerobic bacterial infections (Boothe, 2015). Fenbendazole and febantel are used to treat helminthic infections in veterinary species. These medications fall into “extra-label use” because they are being used to treat a protozoal infection instead of a bacterial infection or helminthic infection, respectively. To date, metronidazole is the most common extra-label drug used to treat *Giardia* because of its anti-diarrheal properties. Metronidazole can be given to dogs over five to eight days in doses of 10-25 mg/kg. Fenbendazole can be given to dogs over 3-10 days at 50 mg/kg. Febantel when combined with pyrantel pamoate and praziquantel (known as DrontalPlus) can be given to dogs over a three-day period according to the dosing label on the box (Zimmer & Burrington, 1986; Barr et al., 1994; Zajac et al., 1998; Payne et al., 2002; Tangtrongsup & Scorza, 2010; Patton, 2013).

Often human cases of *Giardia* clear up in a few weeks, but in acute cases drug intervention may be needed. According to Gardner & Hill (2001), the drug of choice to treat human cases of giardiasis at the time was metronidazole because it was the only nitroimidazole class drug available in the U.S., despite lacking the Food and Drug Administration's (FDA) approval to be used in the treatment of *Giardia*. The recommended dose for adults is 250 mg three times a day for five to seven days and the recommended dose for children is 5 mg/kg three times a day for five to seven days. Human patients may experience adverse effects like headache, dizziness, nausea, hives, and a metallic taste in the mouth (Gardner & Hill, 2001). Additional drugs such as albendazole, paromycin, and bacitracin zinc may also be used to treat *Giardia* infections, though each may cause more severe side effects than metronidazole (Gardener & Hill, 2001). At the time of publication, none of the additional drugs reviewed by Gardener & Hill (2001) were available in the U.S. The Mayo Clinic states on their website that humans are usually treated with metronidazole, tinidazole, or nitazoxanide. Tinidazole has the same side effects as metronidazole but is given in a single dose. Nitazoxanide can cause yellowing of the eyes, bright yellow urine, nausea, and gas (Mayo Clinic, 2020). According to an FDA document on Flagyl® (metronidazole tablets) from 2010, metronidazole is only approved for treatment of human protozoal infections consisting of Trichomonads or Amebae and anaerobic bacterial infections (Food and Drug Administration [2007], 2010). This means metronidazole is still unapproved for the treatment of human cases of giardiasis. However, Tindamax® (tinidazole) is an antiprotozoal and antibacterial which received FDA approval in 2004 for the treatment of *Giardia* infections in humans (FDA, 2007). In 2005, the FDA approved Alinia® (nitazoxanide), which is an antiprotozoal, for the treatment of diarrhea caused by giardiasis in humans (FDA, 2005).

An important component of treating *Giardia* is regular cleaning of infected feces from the yard. Cysts are the source of infection for dogs as they are passed in the feces and can be spread and smeared in crowded environments like a small yard or breeding or boarding kennel. This means it is imperative that the feces be removed immediately to prevent environmental contamination and contamination of other dogs in the same household or kennel. Additionally, "scooping poop" prevents the dog from engaging in coprophagy and from reinfecting its fur with infectious cysts. Though impossible to truly clean a yard for the infectious cysts, the cysts are susceptible to desiccation (drying) by the sun and hot weather. If possible, the areas where the *Giardia*-infected dog defecated should be allowed to dry as much as possible and should be considered contaminated up to a month after its initial use (Patton, 2013). Dogs should be bathed on the first and last days of treatment to ensure thorough removal of cysts which could be ingested during self-grooming (Tangtrongsup & Scorza, 2010; Patton, 2013). The environment the animal lives in should be cleaned regularly with a quaternary ammonium compound, steam, or boiling water because they can inactivate the cysts (Patton, 2013). This means all dog toys, bedding, blankets, carpets, dog clothing, and flooring should be washed/steam cleaned to ensure removal of infectious cysts. The CDC and the Merck Veterinary Manual recommends steam cleaning carpets with a product containing a quaternary ammonium compound (alkyl dimethyl ammonium chloride) (Patton, 2013; CDC, 2015). The CDC recommends steam cleaning for five minutes at a temperature of 158°F. Another alternative is to steam clean the carpet for one minute a 212°F. In addition, the CDC recommends putting all dishwasher safe dog bowls and toys in for a wash with a final rinse or dry cycle that meets the following criteria: 113°F for 20 minutes, 122°F for five minutes, or 162°F for one minute. Boiling the toys or dog bowls in a large pot should also be effective if a dishwasher be unavailable (CDC, 2015). To clean hard flooring, in a home or a kennel facility, a quaternary ammonium compound should be used or ¾ cup of bleach to 1 gallon of water according to the cleaning instructions on the bottle (Patton, 2013; CDC, 2015; Paw Patch Place Animal Hospital, 2015).

I contacted Dr. Jeba Jesudoss Chelladurai, one of the members of the Diagnostic Medicine and Pathobiology faculty at Kansas State University, to see if she had any project involving parasites as I want to venture into parasitology. Luckily, she had a project available which matched the APE project perfectly. Dr. Jeba Jesudoss Chelladurai graduated with a Bachelor of Veterinary Science and Animal Husbandry (BVSc & AH) from Madras Veterinary College in Chennai, India. That was not enough for the brilliant native of India as she later pursued a Masters in Microbiology from North Dakota State University in Fargo, North Dakota. With two degrees to her name, Jeba Jesudoss Chelladurai pursued a third degree, this time a Ph.D. in parasitology from Iowa State University in Ames, Iowa. Not only did she complete three degrees, but Dr. Chelladurai was also awarded an American College of Veterinary Microbiologists (ACVM) diplomate. Currently, Dr. Chelladurai is a co-instructor for Veterinary Parasitology for year two veterinary students and Master of Public Health students. She also teaches the Parasitology portion to fourth year veterinary students completing the Diagnostic Medicine Rotation portion of their degree.

The project Dr. Chelladurai has graciously allowed me to work on with her involves one of her other research interests in novel or repurposed anti-parasitic drugs. The purpose of surveying veterinarians is to determine the methods of diagnosis, treatment, and control they are using when working with *Giardia* infected dogs. We are also interested in knowing whether the veterinarian is communicating the zoonotic potential of *Giardia* to clients and what means of environmental control the veterinarian is suggesting. My main role was to help develop the IRB protocol, design the survey to be sent to the veterinarians on Qualtrics, and analyze the data we received. I helped create and present a poster to the American Association of Veterinary Parasitologists at their 2021 Annual Meeting. In addition, Dr. Chelladurai and I will be writing a paper to publish our findings.

Chapter 2 - Learning Objectives and Project Description

The goal of this survey was to determine what types of extra-label treatments veterinarians are using, whether they are educating the pet owners on zoonotic potential from different assemblages of *Giardia*, and whether they are advising control measures against environmental contamination by *Giardia* (e.g., washing bedding and bathing pets). Dr. Chelladurai and I met approximately once a week over the spring and summer semesters (2020-2021 academic year). During our meetings we discussed the finer points of designing an appropriate survey which would be visually appealing, easy to use, and quick to complete. Originally, the target population for the study was veterinarians in Kansas who would be contacted through the Kansas State Veterinary Diagnostic Laboratory (KS-VDL) newsletter. I filled out the IRB form in a way which would narrow the focus of the study to Kansas practitioners. Later, Dr. Chelladurai recommended we expand the IRB to include respondents from outside of Kansas. We both edited the IRB document to allow for the additional veterinarians who would respond from out of state. I had previously completed the following required Collaborative Institutional Training Initiative's (CITI) training courses for MPH 720 Administration of Health Care Organizations and for a separate project with the Master of Public Health Program: Responsible Conduct of Research (RCR), Human Subjects Research (HSR) - IRB Researchers and personnel on IRB protocols, and Export Compliance. However, as I had never participated in an online study before, I additionally completed the Human Subjects Research (HSR) - Internet Research.

Our survey was designed on Qualtrics as it provides an easily customizable question set and interface for the surveyors. Qualtrics is an ideal format to use for survey participants because the created surveys were accessible through participant's phones or computers which increased the methods a participant could use to complete the survey. After the survey was created, Dr. Chelladurai contacted Dr. Hanzlicek who oversees the Client Care section of the KS-VDL. Dr. Chelladurai and Dr. Hanzlicek worked together to write a brief introduction to post with the survey link in the KS-VDL newsletter to introduce the premise of the survey to any small or mixed animal veterinarian who has previously used KS-VDL services.

A total of 14 questions (Q1-Q14, including the project summary and consent) were designed to help minimize the time constraints associated with longer surveys for ease of participant use. Q1 was the summary of the survey goals and the consent written in a "yes or no" format. Q2, Q3, and Q4 were created to help gather a little information on the veterinarians themselves. We wanted to know where the veterinarian was from so a map of respondents could be made. Thus, Q2 asked for the veterinarian's zip code. We were also interested in knowing whether the respondents were small animal or mixed animal veterinarians; this was asked in Q3 in order to determine the approximate distribution of participants between the two veterinary designations. In Q4, the veterinarian was asked how long they had been in practice.

Q5-Q10 were about the veterinarian's awareness of *Giardia* in their community, perceived *Giardia* frequency in their practices, *Giardia* testing methods, *Giardia* treatment methods, and whether the veterinarian encountered refractory or recurring infections in dogs under their care. In Q5, the veterinarian was asked if they were aware of the prevalence of *Giardia* in their areas of practice. This question was asked to determine if the veterinarians were aware of the information available on *Giardia* statistics within their area of practice. The phrase "area of practice" was utilized to ensure veterinarians who traveled between cities or counties were included because they could serve multiple communities and have knowledge on *Giardia* statistics in multiple communities. Q6 asked the veterinarian to identify how often they thought they saw *Giardia* in their practices on a zero to ten scale, zero representing very rarely and ten representing very often. This question was designed to gage the veterinarians' perception on how often they believed they saw *Giardia* in their clinics instead of asking for the exact number of cases which would be time consuming and detract from the ease of the survey. Q7 asked whether veterinarians tested symptomatic (or diarrheic) dogs for *Giardia* to determine if all symptomatic dogs were tested for *Giardia* infection, if some symptomatic dogs were tested for *Giardia* infection, or if dogs were treated symptomatically. Q8 asked what type(s) of confirmatory tests were used to diagnose *Giardia* in order to determine the most frequently used diagnostic tests among survey respondents. This question included a "select all which apply" option allowing us to determine what testing methods were used in differing combinations. Q9 asked the veterinarians extra-label treatments of choice for *Giardia* and also had a "select all which apply" option. Additionally, a fill-in-the-blank option was also available for this question in case the veterinarians selected all the listed extra-label treatments and utilized an additional treatment or in case the veterinarians used none of the listed treatments and instead utilized a treatment method not listed in the original answer choices. Q10 inquired about the veterinarians' encounters with refractory cases of *Giardia* as infections may reoccur due to treatment resistance or if the environment/dog was not properly cleaned after treatment.

Q11 inquired if the veterinarians mentioned environmental control to the owners as this is an important part of preventing reinfection of the dog and reducing potential zoonotic infections. Q12 asked the veterinarians what methods of environmental control were suggested to the owner and this question also had a "select all which apply" option. A fill-in-the-blank option was made available for this question in case a method of environmental control was suggested by the veterinarians but was not included in the answer options. Q13 asked whether the veterinarians suggested treatment and/or isolation of other pets in a *Giardia*-infected household. This question was important because *Giardia* is easily transmissible due to its utilization of the fecal-oral route, meaning another pet or a small child could easily pick it up from the infected dog or contaminated feces in the environment.

Q14, the final question, asked veterinarians if they communicated the zoonotic potential of *Giardia* to owners. This question was extremely important to help us determine the rates of veterinary communication of public health risks to owners living with *Giardia*-infected dogs as most individuals would likely forget to mention this to a human physician who could have warned them of the zoonotic threat. It is important to acknowledge the pivotal role that veterinarians play in preventing the spread of zoonotic disease to pet owners.

Once enough answers were recorded, the data was exported out of Qualtrics into an Excel spreadsheet. A “master sheet” was created with individual sheets for each question asked and its corresponding data. As additional data was collected, it was added to the existing pages. This allowed sufficient space to analyze the data while leaving it easily accessible to new data transfer as needed. Once in Excel I was able to create graphical depiction for almost every question (eleven graphs and one map). Many of the initial graphs were made into bar charts which lacked the visual diversity needed to create a poster and paper for publishing. In addition, the map created on Excel contained a filter on the map created of the U.S. which muddied the image and distracted from the data points. To remedy this issue, Dr. Chelladurai taught me how to use software like Datawrapper and DisplayR, which are web-based visualization tools to create maps and charts that showcased our data more clearly than on Excel. The bar graphs were changed into more visually appealing forms of data presentation. Q3 and Q4 were modified into doughnut charts using PowerPoint because it allowed easier image modification and creation than Excel or Qualtrics. Q5, Q7, Q10, Q11, Q13, and Q14 all had answer options that were slight variations on the “yes, sometimes, or no” scheme. To conserve space on the planned poster and maintain the reader’s attention, the previously listed questions were combined into a series of stats bars which were assorted in descending order according to the question’s number. This provided a unique chart which was more visually engaging than a standard bar chart. Q6 had an answer system based on a 0-10 scale that led to the creative redesign of the chart into a pictograph. Q8 and Q9 had the answer format of “select all that apply,” allowing for unique combinations of answers. When shown in a bar graph the combination of treatment types was completely lost and instead only a count of individual answers could be seen. Dr. Chelladurai was able to use a software called DeepVenn to create Venn diagrams for each question; however, the diagrams created by the software were very messy. Dr. Chelladurai worked on reorganizing the image before sending it to me to be redesigned. I recreated the Venn diagrams in PowerPoint and changed them to match the color scheme of the poster. (For the poster, our combined work was used, but for this ILE report many of the graphs were originally created by me using computer skills that Dr. Chelladurai was kind enough to teach me.) Q12 also had the answer format of “select all that apply,” however, this data was presented in a bar graph to show which methods of environmental control were chosen most often.

For one of the products of the project, an abstract summarizing the project was submitted to the American Association of Veterinary Parasitologist (AAVP) in hopes of being selected to present at the 2021 Annual Meeting. Thankfully, our project was chosen. I then began to collaborate with Dr. Chelladurai and Dr. Londono on the layout of the poster. I redesigned many of the graphs for the poster. I created the color scheme and most of the text used in the poster. The poster went through many, many redesigns and layouts which I managed on my laptop. The AAVP Annual Meeting required a 2–3-minute pre-recorded presentation of the poster for viewing at the meeting in Lexington, Kentucky and online. After a brief meeting with Dr. Chelladurai and Dr. Londono, the majority of the script was created. I modified the script for time and ease of delivery, so it would meet the desired time requirements. I was responsible for recording and presenting the poster in the video as well as submitting the video and poster. This was followed a few days later by a live question and answer session with the poster judges, which I Zoomed in for. Additionally, a paper will be written later on the findings of this project, which will serve as a second product.

Chapter 3 - Results

The initial release of the survey occurred on February 25, 2021. The survey was sent to 8,670 email addresses, was opened by 1,462 people, and 126 clicks were recorded for the survey link embedded in the email. The survey was sent a second time on March 4, 2021, to 8,773 email addresses, was opened by 1,400 people, and 92 clicks were recorded for the survey link embedded in the email. A total of 293 and 282 emails bounced in the first and second rounds of distribution, respectively. Data was collected for this project between February and April 2021. Out of the total 134 respondents, 133 provided consent to take the survey in Q1, of which 123 completed the survey, while 10 respondents did not finish all questions on the survey.

A total of 123 U.S. small and mixed animal veterinarians responded to the survey from 31 U.S. states (Q2) with at least one veterinarian response from each of the six zip code sectors across the U.S (Figure 3.1).

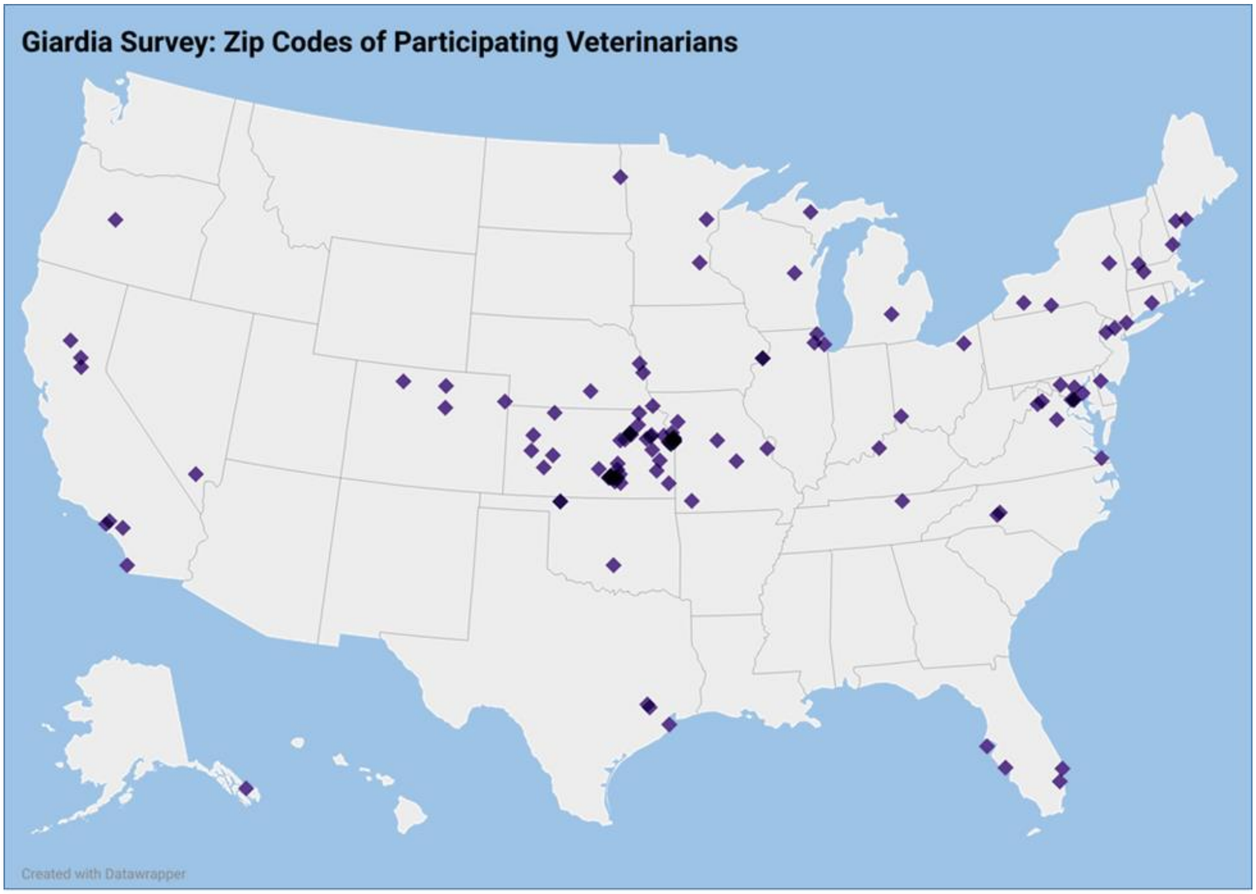


Figure 3.1: (Q2) Map of Participating Veterinarian Responses to the *Giardia* Survey from February 2021- April 2021. Created on Datawrapper.

Approximately 72% of participating veterinarians self-identified as small animal veterinarians, while 20% identified as mixed animal veterinarians (Q3, n=96, n=27) (Figure 3.2). There was an 8% no response rate (Q3, n=11) (Figure 3.2).

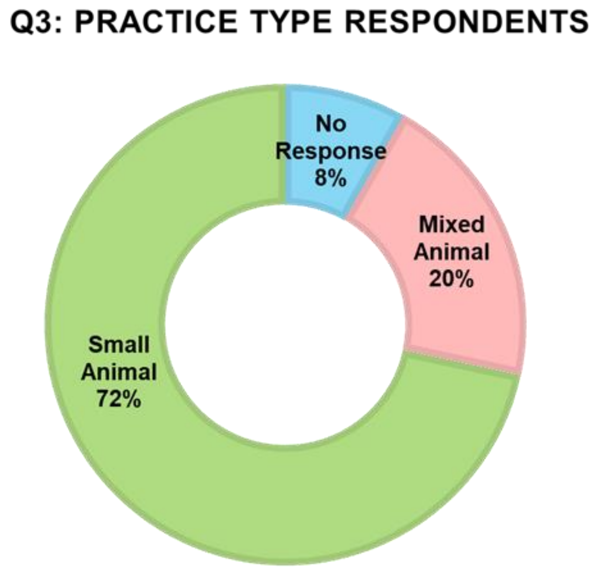


Figure 3.2: (Q3) Percentages of Small or Mixed Animal Veterinary Participants. Created on Excel and PowerPoint.

For Q4, regarding the number of years the veterinarian had worked in the field, the following percentages were recorded: 23% had practiced for 0-10 years (n=29), 18% had practiced 10-20 years (n=23), 15% had practiced between 20-30 years (n=18), 33% had practiced between 30-40 years (n=41), 8% had practiced between 40-50 years (n=10), and 3% had practiced 50-60 years (n=4) (Figure 3.3). These percentages do not include the 11 veterinarians who did not respond to the question.

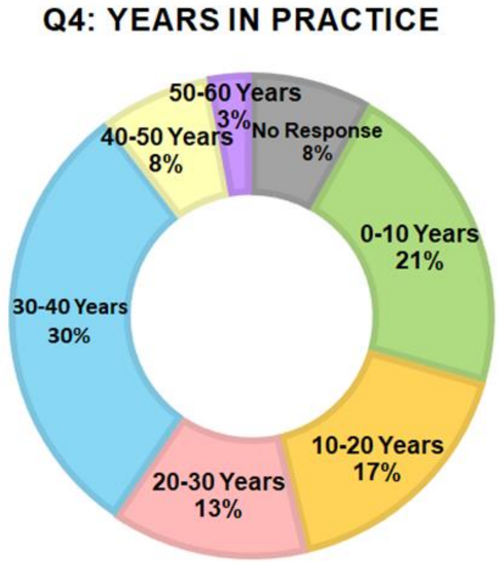


Figure 3.3: (Q4) Number of Years Participants have Worked in the Veterinary Field. Created on Excel and PowerPoint.

Q5 pertained to veterinarian awareness of *Giardia* in their area of practice. Approximately 70.1% (n=94) of responding veterinarians answered they were aware of the prevalence of *Giardia* in their area of practice, 11.2% (n=15) of veterinarians were unsure of the prevalence of *Giardia*, 10.5% (n=14) of veterinarians were unaware of the prevalence of *Giardia*, and 8.2% (n=11) of veterinarians did not respond to the question (Q5) (Figure 3.4).

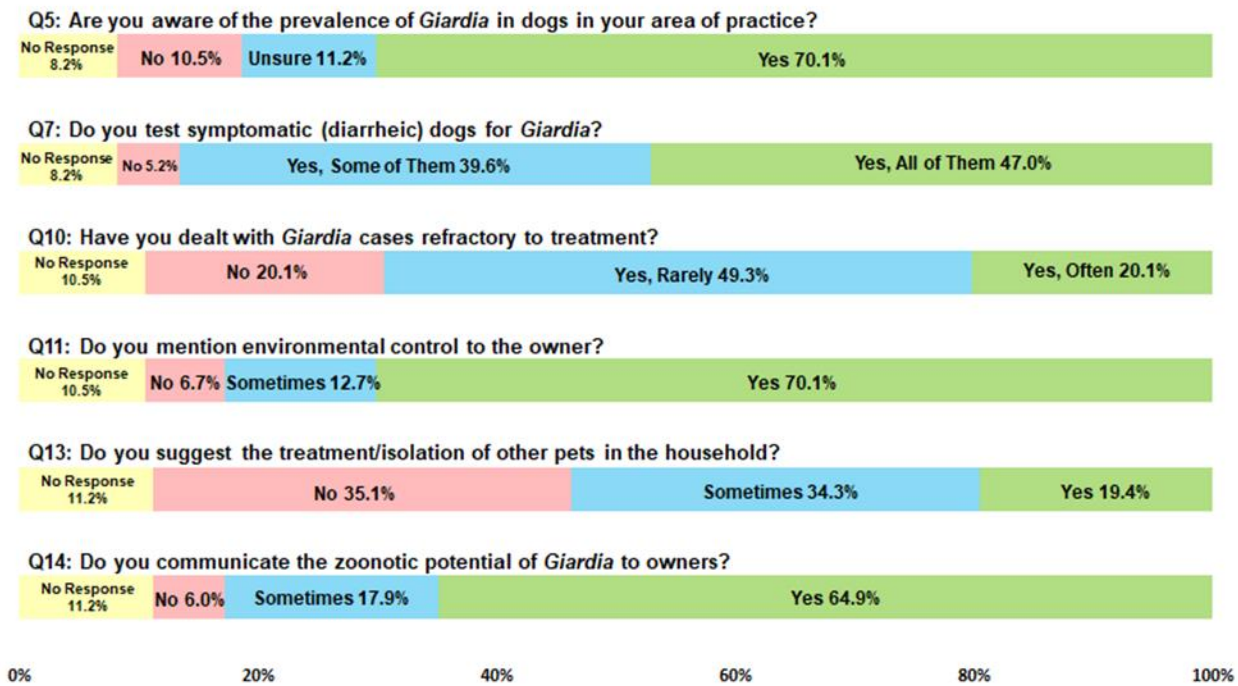


Figure 3.4: Bar Graphs Compiling Information on Veterinarian Perceptions and Communication Concerning *Giardia*. Created on PowerPoint.

Q6 asked veterinarians about the perceived frequency of *Giardia* occurrence in-clinic. The most commonly perceived prevalence frequency of *Giardia* in-clinic by veterinarians on a 0-10 scale was 3 (Q6) (Figure 3.5).

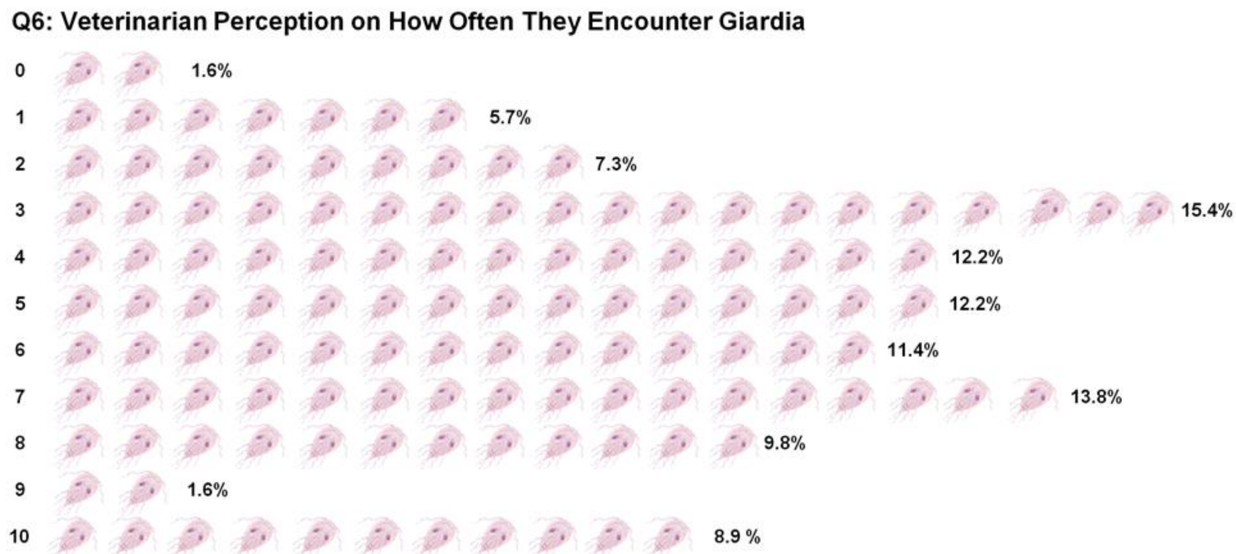
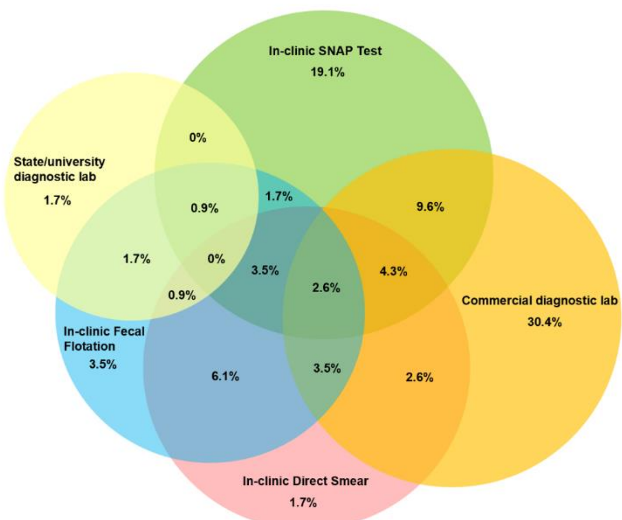


Figure 3.5: (Q6) Pictogram of Veterinarian Perceptions of *Giardia* Frequency In-Clinic. Created on PowerPoint.

Q7 asked veterinarians whether or not they tested symptomatic (diarrheic) dogs for *Giardia*. Approximately 47% of veterinarians (n= 63) reported that they test all symptomatic dogs, while 39.6% of veterinarians test symptomatic dogs only some of the time (n= 53). Only 5.2% (n=7) of veterinarians did not test symptomatic dogs and 8.2% (n=11) of veterinarians did not respond to the question (Q7) (Figure 3.4).

Q8 required veterinarians to select which test(s) they used to diagnose *Giardia* infections. The preferred confirmatory tests were ranked in the following order: commercial diagnostic lab > In-clinic SNAP Test > In-clinic Direct Smear > In-clinic Fecal Flotation > State/university diagnostic lab (Q8) (Figure 3.6). The most popular testing methods utilized were the commercial diagnostic lab at 30% and the in-clinic SNAP test at 20% (Q8) (Figure 3.6). The most popular combination of tests chosen by veterinarians when performing confirmatory tests for *Giardia* was an in-clinic SNAP test and a commercial diagnostic lab (9%) (Q8) (Figure 3.6).



Testing Methods Used*	Percentages
In-clinic Direct Smear, State/university diagnostic lab	1.7%
In-clinic Fecal Flotation, Commercial diagnostic lab	1.7%
In-clinic Direct Smear, In-clinic SNAP Test	0.9%
In-Clinic SNAP, State/university diagnostic lab, Commercial diagnostic lab	0.9%
In-clinic Direct Smear, In-clinic Fecal Flotation, State/university diagnostic lab, Commercial diagnostic lab	0.9%

Figure 3.6: (Q8) Venn Diagram of Testing Methods Used to Diagnose *Giardia*. Created on PowerPoint. *Missing 7% from Venn Diagram in table.

When veterinarians were asked which *Giardia* treatment methods they favored (Q9), 55% of respondents preferred using both fenbendazole and metronidazole simultaneously, 15% of respondents reported using fenbendazole only, and 20% of respondents reported using metronidazole only (Q9) (Figure 3.7). Like Q8, Q9 also featured a “select all that apply” answering system with the addition of a fourth answer option “other,” which featured a blank for veterinarians to fill in other treatment methods not listed in the question. In total 9 veterinarians utilized the "other" option, and their answers were the following: drontal, fenbendazole and metronidazole, probiotics, tinidazole, secnidazole, add bathing, drontal plus, rounidazole [sic] rarely, and metronidazole and panacur.

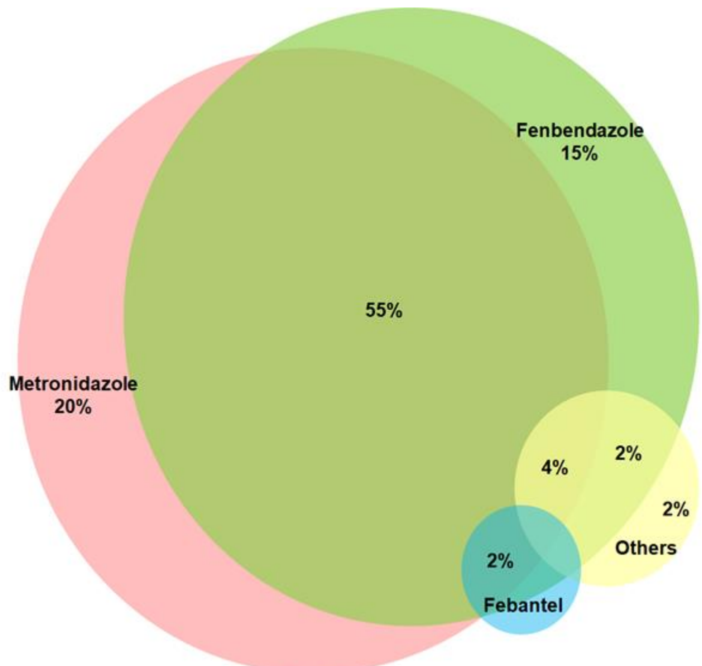


Figure 3.7: (Q9) Venn Diagram of Extra-label *Giardia* Treatments Used in the U.S. Created on PowerPoint.

Q10 asked the veterinarians their perceptions on if and how often they saw refractory cases of giardiasis. A combined total of 69.4% of respondents indicated they have dealt with treatment refractory cases either rarely or frequently (Yes, often= 20.1% (n=27); Yes, rarely= 49.3% (n=66)) (Q10) (Figure 3.4). Additionally, 20.1% (n=27) of respondents did not deal with refractory cases of *Giardia* and 10.5% (n=14) of respondents did not respond to the question (Q10) (Figure 3.4).

Q11 focused on whether veterinarians mentioned environmental control to owners of *Giardia*-infected dogs. Approximately 70.1% (n= 94) of veterinarians reported mentioning environmental control to pet owners (Q11) (Figure 3.4). Only 12.7% (n= 17) of veterinarians sometimes suggest environmental control while 6.7% (n= 9) of veterinarians do not suggest environmental control, and 10.5% (n=14) of veterinarians did not respond to the question (Q11) (Figure 3.4).

Q12 asked veterinarians to choose which methods of environmental controls they suggested, which included activities such as bathing the infected pet, cleaning toys/bowls/bedding, cleaning floors, and bathing other pets (Figure 3.8). The top three most popular method of environmental control selected was bathing the infected pet (28.2%, n=87) followed by cleaning toys/bowls/bedding (25.2%, n=78) and cleaning floors (22.3%, n=69) (Figure 3.8). Cleaning other pets and the other option both scored the lowest on the list of recommended methods of environmental control (12.3%, n=38 and 12.0%, n=37 respectively) (Figure 3.8). Q12 like Q9 featured a "select all that apply" answering system with a fifth "other" option, which allowed veterinarians to add additional environmental control methods that were not listed in the question. The "other" options recorded in Q12 are summarized as follows: cleaning fecal matter from the yard; avoiding standing water like by creeks, canals, lakes, and puddles; filter the dog's drinking water; bleach and seal indoor/outdoor and kennel areas to prevent contamination; washing the dog's paws, washing the dog's anal area, and clipping the dog's toenails to prevent accidental ingestion of *Giardia* cysts during grooming; and test other pets and wash/replace the infected dog's bedding. In total, 24 veterinarians did not respond to Q12, and it should be noted that the number of "no responses" is not included in Figure 3.8.

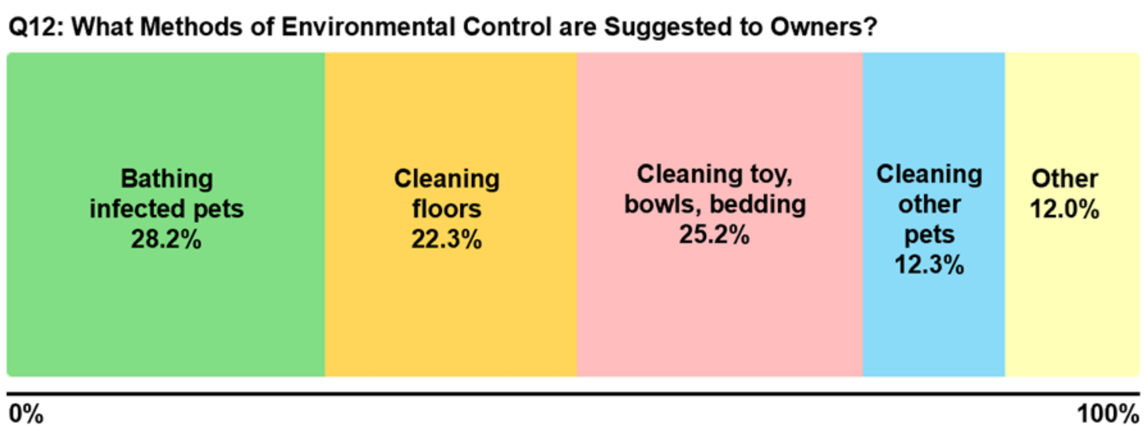


Figure 3.8: (Q12) Bar Graph of Methods of Environmental Control Suggested by Veterinarian to Client. Created on Qualtrics and PowerPoint.

Q13 inquired if veterinarians suggested treatment/isolation of other pets in a *Giardia* positive household. Interestingly, 35.1% (n= 47) of veterinarians answered they did not recommend the treatment or isolation of other pets in the household, while a close 34.3% (n=46) of veterinarians sometimes recommended treatment and isolation of other pets in the house (Q13) (Figure 3.4). Only 19.4% (n=26) of veterinarians suggested the treatment and isolation of other pets in the house and 11.2% (n=15) of veterinarians did not respond (Q13) (Figure 3.4).

Q14 pertained to whether veterinarians communicated the zoonotic potential of *Giardia* to owners. Approximately 64.9% (n=87) of veterinarians reported they regularly communicated the potential zoonotic nature of *Giardia* infections to the owners of *Giardia*-infected dogs (Q14) (Figure 3.4). This is followed by 17.9% (n= 24) of veterinarians sometimes mentioning the zoonotic potential of *Giardia*, 6.0% (n= 8) of veterinarians not mentioning the zoonotic potential of *Giardia*, and 11.2% (n= 15) of veterinarians did not respond (Q14) (Figure 3.4).

Chapter 4 - Discussion

Before starting on this project, it came to the attention of Dr. Chelladurai and I that a study like ours had not been conducted in the U.S. To my knowledge, a study like this has not been conducted on veterinary *Giardia* practice in any field. Unfortunately, there is nothing for me to compare our data to. This is the first survey to assess knowledge of the practices, perceptions, and communication of zoonotic potential from veterinarians in the United States when treating canine giardiasis. Nevertheless, I would like to point out some interesting things I noticed from our data and regarding American studies on *Giardia*.

In Q5, 70.1% of veterinarians were aware of the prevalence of *Giardia* in dogs in their areas of practice. Ideally, 100% of responding vets should be aware of the local prevalence of *Giardia* because it is an extremely transmissible parasite, especially if the infected dog presents as an asymptomatic case. This information is available to the public and practicing vets via the capcvet.com website, which is updated monthly at state and county levels.

For Q6, I was intrigued about the most common veterinarian perception of *Giardia* occurrence being a 3 on a 0-10 scale. I am curious if the perceived occurrence is low because the veterinarian does not often see *Giardia*, if the veterinarian unconsciously compared *Giardia* occurrence to another parasite, or if it is due to the geographical distribution of the practicing veterinarians. It is likely that bacterial and viral causes of canine diarrhea are encountered more often by practicing veterinarians.

Due to the complex differentials associated with canine diarrhea, veterinarians must use good clinical judgement to decide whether to perform a diagnostic test for *Giardia* or not. Surprisingly, 47% of veterinarians who responded to Q7 chose to test all symptomatic dogs for *Giardia*. While it was not asked whether a diarrhea panel was run on all symptomatic animals, it is presumed that the vets make the best choice for each clinical situation that they encounter within the financial ability of the owner.

The majority of respondents for Q8 (30%) chose using a commercial diagnostic lab as their means of diagnosing *Giardia*. This was followed by 20% of participants choosing to use an in-clinic SNAP test. Q8 was a "select all which apply" answering system, so I was anticipating a combination of testing methods to score the highest among respondents. The most popular combination of tests at 9% was the in-clinic SNAP test and the commercial diagnostic lab. I also thought the state/university diagnostic lab option would have been chosen more frequently than 2% (and in combination with other tests more frequently than 1% per test combination). The higher preference for a commercial lab over a VDL is likely due to legally binding contracts that large commercial labs enter with individual clinics with added offers of discounts on large volumes of submissions.

I anticipated a large percentage of practitioners would select a combination of metronidazole and one of the other drugs listed as the most popular answer based off my knowledge of the drugs and what I learned in Veterinary Parasitology at K-State. This proved to be true as the most popular treatment selected in Q9 at 55% was a combination of metronidazole and fenbendazole. However, I was surprised that treatment with only metronidazole was chosen by 20% of veterinarians. As mentioned in the literature review, metronidazole is an antibiotic and antiprotozoal only approved for the treatment of canine protozoal infections with Trichomonads and Amebeas (Boothe, 2015). Thus, prescribing metronidazole alone would only treat the symptoms experienced by a dog infected with *Giardia* instead of treating the *Giardia* infection itself. More research would be needed to investigate the veterinarians' reasoning behind prescribing metronidazole only.

In Q10, 49.3% of vets responded "yes, they rarely dealt with refractory cases of *Giardia*" and 20.1% of vets answered "yes, they often dealt with refractory cases of *Giardia*." It would be interesting to discover the biological cause for refractory cases of *Giardia* in practice. Refractory cases could be due to lack of treatment compliance, contact with an asymptomatic carrier, initial treatment failure, or a truly drug resistant case of *Giardia*. To date, I have been unable to find any literature supporting the existence of drug resistant cases of canine giardiasis.

It is interesting that in Q11, 70.1% of veterinarians suggested environmental control as a means of reducing the spread of *Giardia*, but the majority of veterinarians in Q13 (35.1%) did not suggest isolation of other pets from the environment shared with a *Giardia*-infected pet. This is interesting because *Giardia* is known to be a difficult environmental contaminate to remove and is highly transmissible between animals sharing the same environment (Patton, 2013; CDC, 2021a). Not separating another pet from the *Giardia*-infected dog would be counterintuitive to the prescribed environmental control methods for the infected dog because another dog living in the same household would be just as likely to become infected with *Giardia* as the infected dog to become re-infected with *Giardia*. Further investigation as to why the majority of respondents did not suggest isolation or treatment of other pets in the household would need to be investigated.

For Q12 it is wonderful that almost 30% of respondents suggested bathing of the infected pet, but that number is low considering that bathing a pet after treatment is a common addition to most treatment plans prescribed by veterinarian parasitologists because dogs can accidentally re-infect themselves during grooming if cysts are lodged in the fur (Patton, 2013; CDC, 2021a). It would be interesting to discover if the number of veterinarians recommending bathing is low due to a low client compliance rate or because of some alternative factor. It should be noted that in Q12, we thought we had created an option for “cleaning up feces in the environment”; however, upon inspection after the release of the survey it was discovered that the option had not been created. This is probably why many “other” responses were recorded by the respondents, the most popular “other” answer being the removal of feces from the environment. This slight snafu on the creation of the answer options for Q12 may have skewed which method of environmental control was most often selected, but we do know that 18 of the 36 vets who utilized the “other” option explicitly recommended the owners promptly remove contaminated feces. (If the 4 veterinarians’ responses of “cleaning the yard” and “cleaning environment” were meant to imply the removal of feces, the number of vets who suggested the removal of infected feces would rise to 22 of 36 vets who utilized the “other” option.)

I find it very promising that 64.9% of veterinarians confirmed they communicated the zoonotic potential of *Giardia* to their clients (Q14). Ideally, if One Health beliefs were upheld by all American health practitioners, all veterinarians would communicate the zoonotic potential of *Giardia* to all owners; one step at a time, I suppose.

If I had the time, funding, and resources to improve the study before it was conducted, I would have tried to find funding from a public health agency. After the original KS-VDL newsletter article on the survey was sent to 8,670 emails and 8,773 emails (respectively), we had a response from 134 veterinarians. This number was much larger than I anticipated because I was unsure if we would get a response of n=30. However, if an incentive could have been offered from the labs—like a free sample test per respondent—I believe the number of participating veterinarians would have increased significantly and we would have had a greater grasp of the veterinary diversity when treating *Giardia*. Additionally, Dr. Chelladurai reached out to some of her colleagues, and I contacted a few friends who work closely with vets, but we did not receive many additional respondents that way. If other veterinary college diagnostic labs across the country had agreed to distribute our survey, we would have had a much larger participant pool and a more accurate idea of the practices and perceptions of American veterinarians when working with *Giardia*.

When performing the literature review it came to my attention that little to no recent data (aside from the CDC's Morbidity and Mortality Weekly Report which are combined into a span of years) has been collected on giardiasis in American children since the 1980s to 1990s. In fact, little human data has been collected regarding *Giardia* in the U.S. since the 1990s to early 2000s. The studies I could find regarding giardiasis in American children focused on the occurrence of *Giardia* in Houston daycares, and on transmission of *Giardia* within a daycare and subsequently to the surrounding community (Pickering et al., 1984; Polis et al., 1986). In the abstract of the Houston study by Pickering et al. researchers first found that the number of enteric symptoms and nutritional status (based on height and weight) did not differ significantly between infected and non-infected children. Second, children under 36 months commonly presented as asymptomatic while excreting *Giardia,* while appearing to tolerate the infection. Third, children in the daycare system for periods of three months or longer were more likely than to excrete *Giardia* than their peers who had attended daycare for three months or less (Pickering et al., 1984). The latest data I could find on giardiasis in American children came from the MMWR *Giardiasis Outbreaks in the United States from 2012-2017* and the NNDSS Giardiasis Summary Report for 2018. Even then, the documents only recorded that the highest incidence of reported giardiasis cases occurred in children ages one to four, and that 12 of the

28 person-to-person outbreaks occurred in childcare centers and resulted in 49 cases (CDC, 2020; Conners et al., 2021a).

The most recent studies of *Giardia* infections in children seemingly occur everywhere but the United States. Several studies have found that many children with giardiasis were more likely to suffer from malnutrition (due to socioeconomic factors of the children tested and due to the malabsorption of nutrients caused by villi damage from *Giardia*) which led to stunting and wasting in Peruvian, Indigenous Brazilian, Malaysian, Egyptian, and Iranian children (Berkman et al., 2002; Carvalho-Costa et al., 2007; Nematian et al., 2008; Abou-Shady et al., 2011; Al-Mekhlafi et al., 2013). Berkman et al. found that Peruvian children with one or more *Giardia* episodes per year between birth and age two scored lower on intelligence tests conducted at age nine than Peruvian children with one or fewer *Giardia* episodes between birth and age two. This suggests *Giardia*-induced childhood diarrhea, and its ensuing contributions to malnutrition and growth stunting, potentially contributes to decreases in cognitive function in children (Berkman et al., 2002). Additional studies have found that Egyptian and Turkish children suffering from giardiasis had decreased zinc and iron concentrations in their blood, which is likely due to the malabsorption of nutrients in the small intestine due to villi damage caused by the *Giardia* trophozoites (Ertan et al., 2002; Demirci et al., 2003; Çulha & Sangün, 2007; Abou-Shady et al., 2011). It can be posited that children with decreased zinc levels will likely have weakened immune systems as necessity of zinc in establishing a healthy immune system has been documented in the scientific community (Prasad, 1998; Maares & Haase, 2016).

Giardia most likely infects children more frequently than adults because young children between the ages of one and four usually do not understand or perform traditional hygienic behaviors, which develop with age. It is important that families who are caring for a *Giardia*-infected dog recognize that small children, particularly those learning to crawl or beginning to walk, will be more likely to interact with *Giardia*-infected surfaces because they exist on the same plane as the dog due to their age. If this logic is followed, any children’s toys the dog interacts with should be cleaned in the same manner as the dog’s toys. Dogs can re-infect themselves when engaging in grooming behaviors and small children could possibly be infected with *Giardia* if the infected dog licks the child’s face, in the child’s mouth, or if the child touches the dog’s anal area. Contact between the infected dog and child should likely be reduced until the dog is no longer infected with *Giardia*. I believe it would be beneficial if methods of reducing the family’s risk (particularly the children’s risk) of contracting *Giardia* were explicitly added to the written control and treatment protocol the vet sends home for the dog. Hopefully, after the vet has communicated the risk of zoonotic transmission verbally to the owner, the written instructions on how to reduce canine (and potential human) infections would clarify that environmental control not only protects the dog but the family as well. It would be interesting to conduct another study between veterinarians, human physicians, and families with *Giardia*-infected dogs to study the limits of communication between veterinarians and human physicians, owner comprehension and compliance to *Giardia* treatment programs, owner communication to human physicians about a pet with *Giardia* in the home, and communication methods (if any) focused on educating children in households with *Giardia*-infected dogs. I would also advocate for a study to be conducted on American children suffering from *Giardia* infections to see if any significant negative impacts on their health was reported (because I could not find any studies of the kind for American children).

In summary, knowledge on the zoonotic aspect of *Giardia* is limited in the scientific community because few clinical cases of zoonotic transmission between canines and humans have been recorded. Given that children have a higher risk of developing *Giardia* infections, it is critical for veterinarians to preserve the health of canine companions to protect their human owners because an efficient means of communication does not exist between veterinarians and human physicians. Thus, the contributions of veterinarians in managing canine giardiasis within One Health initiatives should not be overlooked.

Chapter 5 - Competencies

Table 5.1 Summary of MPH Foundational Competencies

Number and Competency		**Description**
3	Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate.	I analyzed survey responses using Excel and Qualtrics data processing tools to develop graphs/tables which appropriately communicated the statistical relevance of the data.
4	Interpret results of data analysis for public health research, policy, or practice.	I used this competency when determining the statistical significance of the results from the graphs/tables I created.
18	Select communication strategies for different audiences and sectors.	I created a Qualtrics survey as well as graphs/tables of the data that were quick and easy to interpret for participants and individuals interested in interpreting the data.
19	Communicate audience-appropriate public health content, both in writing and through oral presentation.	Dr. Chelladurai, Dr. Londono, and I collaborated to create a poster for the AAVP summer conference. Additionally, Dr. Chelladurai and I will be publishing a paper on our findings.
21	Perform effectively on interprofessional teams.	I worked with Dr. Chelladurai from the Diagnostic Medicine and Pathobiology department when working on the *Giardia* project.

Competency 3 and 4: I analyzed the survey responses using Excel, Datawrapper, PowerPoint, and Qualtrics data processing tools to develop graphs/tables which appropriately communicated the statistical relevance of the data. Once the data was in an appropriate format, it was used to conclude what types of extra-label treatments veterinarians are using, whether they are educating the pet owners on zoonotic potential from different assemblages of *Giardia*, and whether they are advising control measures against environmental contamination by *Giardia* (e.g., washing bedding and bathing pets). The graphs and tables created during my analysis and interpretation of the survey results will be used in a paper Dr. Chelladurai and I will be writing on the project and were presented in a poster at the AAVP Summer 2021 Annual Meeting.

Competency 18: MPH 720 Administration of Health Care Organizations and DMP 815 Multidisciplinary Thought and Presentation helped me grasp the importance of understanding the audience or “stakeholders” that I am speaking to because my communication methods will need to change depending on audience education levels, audience values, and audience time constraints. For instance, I helped determine that Qualtrics would be the best survey method to reach veterinarians due to the ease of question customization for the survey purposes. It was also customized to be quick, easy, and efficient for busy veterinarians who lack the time to fill out a longer formal survey. Utilizing Qualtrics also increased participant accessibility because an email and smart phone accessible version of the survey were made available depending on the device the participant was using at the time. This made it even easier for veterinarians to respond because they could quickly fill out the questions between appointments on their phones (without losing progress), instead of being tethered behind their desks. Additionally, I created graphs/tables of the data that were quick and easy to interpret so everyone who read the article being published or who attended my defense could understand the significance of the statistics recorded. Neat, easy-to-read slides can be pivotal when trying to impart the significance of a data set to a community or committee in order to enact public health changes.

Competency 19: DMP 815 Multidisciplinary Thought and Presentation taught me the importance of being able to communicate information thoughtfully and accurately to different audiences. The creation of a poster for the American Association of Veterinary Parasitologists highlighted the need of utilizing more academic vocabulary and adhering to the common rules of creating a high-quality poster with which I could record and submit a 2–3-minute presentation video for the AAVP. This course also taught me how to comfortably switch from speaking in academic vocabulary to the common vocabulary of the public. I also gained the confidence to collaborate on a paper with Dr. Chelladurai which will hopefully publish the details of our survey to help better the veterinarian and human medical communities’ understanding of the importance of working together to treat *Giardia* in a cohesive One Health based method.

Competency 21: I worked on an interprofessional team composed of Dr. Chelladurai and myself. I had never worked with someone from the Diagnostic Medicine and Pathobiology program outside the classroom environment. Dr. Chelladurai and I quickly established a clear, open form of discussion during our meetings which enabled me to ask questions freely and learn where gaps in my knowledge existed. This open communication allowed us to collaborate on the survey question development, survey design phase, and IRB development, which enabled us to complete the project conception and creation in approximately one month. Additionally, the meeting times were very helpful in developing my skills in Excel to process the results from our Qualtrics survey. The weekly meetings also provided a safe environment for me to practice my professional conversation skills and practice how to properly communicate abstract ideas regarding data analysis. In addition, Dr. Londono joined Dr. Chelladurai and I in the creation of the AAVP poster by providing help in the design and organization phase. The *Giardia* survey truly was a partnership.

Product 3: During my time in the MPH program, I was privileged to co-author an article about fighting the transmission of disease with words (this later became the title of the article). The article referenced the importance of effective communication to help prevent the spread of disease during the bubonic plague, COVID-19, and other historical outbreaks. It was a joy collaborating with my co-authors because many new ideas and perspectives were added to the article. Upon completion the article was published in the One Health newsletter, which has a wide reader base ranging from academics to the general public. Competencies 18, 19, and 21 were used for this project: 21 was used when working with the various co-authors to write and edit a coherent piece, and 18 and 19 were used when determining that writing a brief article would be the most effective way to communicate the large topic of effective public health communication to the newsletter reader base.

Table 5.2 MPH Foundational Competencies and Course Taught In

22 Public Health Foundational Competencies Course Mapping	MPH 701	MPH 720	MPH 754	MPH 802	MPH 818
Evidence-based Approaches to Public Health					
1. Apply epidemiological methods to the breadth of settings and situations in public health practice	x		x		
2. Select quantitative and qualitative data collection methods appropriate for a given public health context	x	x	x		
3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate	x	x	x		
4. Interpret results of data analysis for public health research, policy or practice	x		x		
Public Health and Health Care Systems					
5. Compare the organization, structure and function of health care, public health and regulatory systems across national and international settings		x			
6. Discuss the means by which structural bias, social inequities and racism undermine health and create challenges to achieving health equity at organizational, community and societal levels					x

22 Public Health Foundational Competencies Course Mapping	MPH 701	MPH 720	MPH 754	MPH 802	MPH 818
Planning and Management to Promote Health					
7. Assess population needs, assets and capacities that affect communities' health		x		x	
8. Apply awareness of cultural values and practices to the design or implementation of public health policies or programs					x
9. Design a population-based policy, program, project or intervention			x		
10. Explain basic principles and tools of budget and resource management		x	x		
11. Select methods to evaluate public health programs	x	x	x		
Policy in Public Health					
12. Discuss multiple dimensions of the policy-making process, including the roles of ethics and evidence		x	x	x	
13. Propose strategies to identify stakeholders and build coalitions and partnerships for influencing public health outcomes		x		x	
14. Advocate for political, social or economic policies and programs that will improve health in diverse populations		x			x
15. Evaluate policies for their impact on public health and health equity		x		x	
Leadership					
16. Apply principles of leadership, governance and management, which include creating a vision, empowering others, fostering collaboration and guiding decision making		x			x
17. Apply negotiation and mediation skills to address organizational or community challenges		x			
Communication					
18. Select communication strategies for different audiences and sectors	DMP 815, FNDH 880 or KIN 796				
19. Communicate audience-appropriate public health content, both in writing and through oral presentation	DMP 815, FNDH 880 or KIN 796				
20. Describe the importance of cultural competence in communicating public health content		x			x
Interprofessional Practice					
21. Perform effectively on interprofessional teams		x			x
Systems Thinking					
22. Apply systems thinking tools to a public health issue			x	x	

Student Attainment of MPH Emphasis Area Competencies

Table 5.3 Summary of MPH Emphasis Area Competencies

MPH Emphasis Area: Infectious Diseases/ Zoonoses		
Number and Competency		**Description**
1	Pathogens/pathogenic mechanisms	Evaluate modes of disease causation of infectious agents.
2	Host response to pathogens/immunology	Investigate the host immune response to infection.
3	Environmental/ecological influences	Examine the influence of environmental and ecological forces on infectious diseases.
4	Disease surveillance	Analyze disease risk factors and select appropriate surveillance.
5	Disease vectors	Investigate the role of vectors, toxic plants, and other toxins in infectious diseases.

Competency 1: I learned how to evaluate modes of disease causation of infectious agents when I took DMP 814 Veterinary Bacteriology and Mycology, MPH 802 Environmental Health, and in DMP 718 Veterinary Parasitology. In each course I learned about the unique methods each disease can utilize to infect their host whether it be a bacteria, virus, parasite, or fungi. By giving me background information on disease causation, I feel confident that these courses provided the groundwork needed for me to enter the field of public health. I used knowledge from Veterinary Parasitology to help me understand how *Giardia* is spread between animals, humans, and zoonotically. Knowing that *Giardia* is a fecal-orally transmitted disease helped explain the etiology of symptoms and the dangers of zoonotic transmission between pets and owners alike.

Competency 2: I learned to investigate host immune response to infection when I took DMP 814 Veterinary Parasitology and DMP 705 Principles of Veterinary Immunology. In both courses I learned the unique ways the immune system was used to mount an attack on foreign pathogens in the body and how it led to unique symptoms in animals (and often the same symptoms occurred in humans). I learned that *Giardia* infected hosts are usually asymptomatic with a lesser number of cases presenting with classical diarrheal signs. This can make it difficult to determine if a dog has *Giardia* without running a SNAP test or doing a fecal examination. The SNAP test can be unreliable because sometimes enough antigen is secreted to register on the test and often within the same day the antigen levels may drop below detectable levels. Therefore, it is important for veterinarians to analyze fecal matter to determine whether there is a positive *Giardia* infection instead of relying on antigen tests only.

Competency 3: I learned about environmental and ecological effects on infectious diseases in MPH 802 Environmental health. In this informative class, I realized that disease is not the sole actor upon health. For instance, environmental disasters can act on the spread and severity of many diseases like Cholera. In addition, I learned about the dangers of nuclear cooling ponds and how some bacteria and parasites can thrive in the super-heated waters. My eyes were additionally opened to the disparities across the world in water treatment, air quality, and waste management which leads to greater spread of infectious agents among developing populations. I utilized the knowledge I gained about the method of fecal-oral transmission, the importance of maintaining clean indoor and outdoor environments, and fomite/biological contamination to guide the creation of the Qualtrics questions regarding control methods of *Giardia*.

Competency 4: I learned about disease surveillance in MPH 754 Introduction to Epidemiology and MPH 802 Environmental Health. Both courses covered the importance of differentiating the prevalence versus the incidence and the various types of studies available when conducting epidemiological data. Dr. Chelladurai and I decided that a cross-sectional study would be best to utilize. A cross-sectional study allows us to look at a specific population (veterinarians) and allowed us to specify the parameters of participants. In addition, a cross-sectional study allows us to gather observational data on the behaviors and preferences of veterinarians when treating *Giardia* infections and communicating zoonotic potential to clients.

Competency 5: I learned about the role of vectors, toxic plants, and other toxins in infectious diseases in DMP 814 Veterinary Bacteriology and Mycology, MPH 802 Environmental Health, and in DMP 718 Veterinary Parasitology. Each course covered the importance of mechanical vectors in disease whether it be bacterial, viral, or parasitic. MPH 802 emphasized the importance of toxic plants, toxins, and toxicants and how they could contribute to disease. DMP 814 and DMP 718 taught me the importance of biological vectors like ticks and mosquitos in the development of heartworms, rickettsial diseases, bacterial infections, and more. I utilized the knowledge that *Giardia* infected dogs can act as biological vectors to other animals or humans within its household. As a result, a question was developed for the survey regarding control methods aimed at minimizing the spread of *Giardia* from the infected animal to other pets and owners.

References

Covacin, C., Aucoin, D., Elliot, A., & Thompson, R. (2011). Genotypic characterisation of Giardia from domestic dogs in the USA. *Veterinary Parasitology, 177*(1-2), 28-32. doi:10.1016/j.vetpar.2010.11.029

Conners, E. E., PhD, Miller, A. D., MPH, Balachandran, N., MPH, Robinson, B. M., MPH, & Benedict, K. M., DVM, PhD. (2021a, March 04). Giardiasis Outbreaks - United States, 2012–2017. Retrieved June 24, 2021, from https://www.cdc.gov/mmwr/volumes/70/wr/mm7009a2.htm

Wolfe, M. S. (1992). Giardiasis. *Clinical microbiology reviews*, *5*(1), 93-100.

Patton S., MS, PhD. (2013, September). Overview of Giardiasis - digestive system. Retrieved January 21, 2021, from https://www.merckvetmanual.com/digestive-system/giardiasis-giardia/overview-of-giardiasis

Division of Foodborne, Waterborne, and Environmental Disease [DFWED]. (2015, July 21). Giardia trophozoites stained with trichrome. [Digital image]. Retrieved February 6, 2021, from https://www.cdc.gov/parasites/giardia/illness.html

Centers for Disease Control and Prevention [CDC]. (2021a, February 26). Giardia and pets. Retrieved May 21, 2021, from https://www.cdc.gov/parasites/giardia/prevention-control-pets.html

CDC. (2021b, February 26). Transmission. Retrieved May 21, 2021, from https://www.cdc.gov/parasites/giardia/infection-sources.html

Phillips, S. C., Mildvan, D., William, D. C., Gelb, A. M., & White, M. C. (1981). Sexual transmission of enteric protozoa and helminths in a venereal-disease-clinic population. *New England Journal of Medicine*, *305*(11), 603-606.

Keystone, J. S., Keystone, D. L., & Proctor, E. M. (1980). Intestinal parasitic infections in homosexual men: prevalence, symptoms and factors in transmission. *Canadian Medical Association Journal*, *123*(6), 512.

Meyers, J. D., Kuharic, H. A., & Holmes, K. K. (1977). Giardia lamblia infection in homosexual men. *Sexually Transmitted Infections*, *53*(1), 54-55.

CDC. (2021c, February 26). General information. Retrieved June 24, 2021, from https://www.cdc.gov/parasites/giardia/general-info.html#anchor_1614258835081

CDC. (2021d, February 26). Pathogen and environment. Retrieved May 21, 2021, from https://www.cdc.gov/parasites/giardia/pathogen.html

DPDx. (2017). [Giardia Lifecycle]. Retrieved May 21, 2021, from https://www.cdc.gov/parasites/giardia/pathogen.html

Adam, R. D. (1991). The biology of Giardia spp. *Microbiological reviews*, *55*(4), 706-732.

Conners, E. E., PhD, Miller, A. D., MPH, Balachandran, N., MPH, Robinson, B. M., MPH, & Benedict, K. M., DVM, PhD. (2021b, March 04). *Reported giardiasis outbreaks (N=111), by jurisdiction – National outbreak reporting system, United States, 2012–2017* [Map]. Retrieved June 24, 2021, from https://www.cdc.gov/mmwr/volumes/70/wr/mm7009a2.htm

Conners, E. E., PhD, Miller, A. D., MPH, Balachandran, N., MPH, Robinson, B. M., MPH, & Benedict, K. M., DVM, PhD. (2021c, March 04). *Reported giardiasis outbreaks (N=111), by mode of transmission and year of earliest illness onset date - United States, 2012–2017* [Chart]. Retrieved June 24, 2021, from https://www.cdc.gov/mmwr/volumes/70/wr/mm7009a2.htm

Heyworth M. F. (2016). Giardia duodenalis genetic assemblages and hosts. *Parasite (Paris, France)*, *23*, 13. https://doi.org/10.1051/parasite/2016013

Thompson, R. A. (2004). The zoonotic significance and molecular epidemiology of Giardia and giardiasis. *Veterinary Parasitology, 126*(1-2), 15-35. doi:10.1016/j.vetpar.2004.09.008

Tangtrongsup, S., & Scorza, V. (2010). Update on the diagnosis and management of Giardia spp infections in dogs and cats. *Topics in companion animal medicine*, *25*(3), 155-162.

Capewell, P., Krumrie, S., Katzer, F., Alexander, C. L., & Weir, W. (2021). Molecular epidemiology of Giardia infections in the genomic era. *Trends in Parasitology, 37*(2), 142-153. doi:10.1016/j.pt.2020.09.013

CDC- National Notifiable Diseases Surveillance System. (2020, February 18). Giardiasis NNDSS summary report for 2018. Retrieved February 23, 2021, from https://www.cdc.gov/healthywater/surveillance/giardiasis/giardiasis-2018.html#:~:text=Since 2011, the incidence of,confirmed and 3.2% nonconfirmed).

Companion Animal Parasite Council [CAPC]. (2021a). *Parasite prevalence maps* [Map]. Retrieved June 30, 2021, from https://capcvet.org/maps/#/2020/all-year/giardia/dog/united-states

CAPC. (2021b). *Parasite prevalence maps* [Map]. Retrieved June 30, 2021, from https://capcvet.org/maps/#/2021/all-year/giardia/dog/united-states

Erlandson, S., PhD. (1988). [This scanning electron microscopic (SEM) image depicted the mucosal surface of the small intestine of a gerbil, infested with Giardia sp. protozoa. The intestinal epithelial surface is almost entirely obscured by the attached Giardia trophozoites.]. Retrieved February 6, 2021, from https://phil.cdc.gov/Details.aspx?pid=11632

American Veterinary Medical Association [AVMA]. (1994). Animal medicinal drug use clarification act (AMDUCA). Retrieved January 25, 2021, from https://www.avma.org/resources-tools/animal-health-and-welfare/amduca

Boothe, D. M., DVM, PhD. (2015, November). Nitroimidazoles - pharmacology. Retrieved July 16, 2021, from https://www.merckvetmanual.com/pharmacology/antibacterial-agents/nitroimidazoles

Zimmer, J. F., & Burrington, D. B. (1986). Comparison of four protocols for the treatment of canine giardiasis. *Journal of the American Animal Hospital Association*, 22:168.

Barr, S. C., Bowman, D. D., & Heller, R. L. (1994). Efficacy of fenbendazole against giardiasis in dogs. *American journal of veterinary research*, *55*(7), 988-990.

Zajac, A. M., LaBranche, T. P., Donoghue, A. R., & Chu, T. C. (1998). Efficacy of fenbendazole in the treatment of experimental Giardia infection in dogs. *American journal of veterinary research*, *59*(1), 61-63.

Payne, P. A., Ridley, R. K., Dryden, M. W., Bathgate, C., Milliken, G. A., & Stewart, P. W. (2002). Efficacy of a combination febantel-praziquantelpyrantel product, with or without vaccination with a commercial Giardia vaccine, for treatment of dogs with naturally occurring giardiasis. *Journal of the American Veterinary Medical Association*, *220*(3), 330-333.

Gardner, T. B., & Hill, D. R. (2001). Treatment of giardiasis. *Clinical microbiology reviews*, *14*(1), 114-128.

Mayo Clinic. (2020, November 17). Giardia infection (giardiasis). Retrieved July 13, 2021, from https://www.mayoclinic.org/diseases-conditions/giardia-infection/diagnosis-treatment/drc-20372790

Food and Drug Administration (FDA). (2010). Flagyl® (metronidazole tablets) PDF. Retrieved July 16, 2021, from https://www.accessdata.fda.gov/drugsatfda_docs/label/2010/012623s061lbl.pdf

FDA. (2007). Highlights of prescribing information for Tindamax® (tinidazole) tablets for oral use PDF. Retrieved July 16, 2021, from https://www.accessdata.fda.gov/drugsatfda_docs/label/2007/021618s003lbl.pdf

FDA. (2005). Prescription information Alinia® (nitazoxanide) tablets (nitazoxanide) for oral suspension PDF. Retrieved July 16, 2021, from https://www.accessdata.fda.gov/drugsatfda_docs/label/2005/021818lbl.pdf

CDC. (2015, July 21). Giardia & pets. Retrieved February 1, 2021, from https://www.cdc.gov/parasites/giardia/prevention-control-pets.html#:~:text=If feces are on a,upholstered furniture to fully dry.

Paw Patch Place Animal Hospital. (2015). My pet has Giardia... now what do I do!?! [Client Education Handout]. Retrieved February 1, 2021, from https://pawpatchplace.com/files/2015/12/Amy-Giardia.pdf

Pickering, L. K., Woodward, W. E., DuPont, H. L., & Sullivan, P. (1984). Occurrence of Giardia lamblia in children in day care centers. *The Journal of pediatrics*, *104*(4), 522-526.

Polis, M. A., Tuazon, C. U., Alling, D. W., & Talmanis, E. (1986). Transmission of Giardia lamblia from a day care center to the community. *American Journal of Public Health*, *76*(9), 1142-1144.

Berkman, D. S., Lescano, A. G., Gilman, R. H., Lopez, S. L., & Black, M. M. (2002). Effects of stunting, diarrhoeal disease, and parasitic infection during infancy on cognition in late childhood: a follow-up study. *The Lancet*, *359*(9306), 564-571.

Carvalho-Costa, F. A., Gonçalves, A. Q., Lassance, S. L., Silva Neto, L. M. D., Salmazo, C. A. A., & Bóia, M. N. (2007). Giardia lamblia and other intestinal parasitic infections and their relationships with nutritional status in children in Brazilian Amazon. *Revista do Instituto de Medicina Tropical de São Paulo*, *49*(3), 147-153.

Nematian, J., Gholamrezanezhad, A., & Nematian, E. (2008). Giardiasis and other intestinal parasitic infections in relation to anthropometric indicators of malnutrition: a large, population-based survey of schoolchildren in Tehran. *Annals of Tropical Medicine & Parasitology*, *102*(3), 209-214.

Abou-Shady, O., El Raziky, M. S., Zaki, M. M., & Mohamed, R. K. (2011). Impact of Giardia lamblia on growth, serum levels of zinc, copper, and iron in Egyptian children. *Biological trace element research*, *140*(1), 1-6.

Al-Mekhlafi, H. M., Al-Maktari, M. T., Jani, R., Ahmed, A., Anuar, T. S., Moktar, N., ... & Surin, J. (2013). Burden of Giardia duodenalis infection and its adverse effects on growth of schoolchildren in rural Malaysia. *PLoS Negl Trop Dis*, *7*(10), e2516.

Ertan, P., Yereli, K., Kurt, Ö., BalcioĞlu, I. C., & OnaĞ, A. (2002). Serological levels of zinc, copper and iron elements among Giardia lamblia infected children in Turkey. *Pediatrics international*, *44*(3), 286-288.

Demirci, M., Delibas, N., Altuntas, I., Oktem, F., & Yönden, Z. (2003). Serum iron, zinc and copper levels and lipid peroxidation in children with chronic giardiasis. *Journal of Health, Population and Nutrition*, 72-75.

Çulha, G., & Sangün, M. K. (2007). Serum levels of zinc, copper, iron, cobalt, magnesium, and selenium elements in children diagnosed with Giardia intestinalis and Enterobiosis vermicularis in Hatay, Turkey. *Biological trace element research*, *118*(1), 21-26.

Prasad, A. S. (1998). Zinc and immunity. *Molecular and Cellular Effects of Nutrition on Disease Processes*, 63-69.

Maares, M., & Haase, H. (2016). Zinc and immunity: An essential interrelation. *Archives of biochemistry and biophysics*, *611*, 58-65.

Appendix 1: Qualtrics Survey

KANSAS STATE
UNIVERSITY

Giardia is a common GI protozoa in dogs. We are interested in gathering baseline information from small animal and mixed animal veterinarians on practices and perceptions of *Giardia* diagnosis, treatment, and zoonotic potential. The valuable information gathered from this survey will help identify the needs of veterinarians in the United States to offer better diagnostic services and case-consultation support, be used in a Master's research project and be published to increase practical knowledge regarding canine giardiasis.

The survey is optional and anonymous. It should take less than 10 minutes to complete the survey. There are minimal risks involved in taking this survey. No identifiable information will be collected except zip code. Zip code of the veterinary practice will only be used to create of a map of respondents.

If during the survey you withdraw your consent, you are free to exit the survey at any time with no penalty. Selecting "yes" indicates that you provide consent and would like to participate in the survey. Selecting "no" indicates you do not consent and would not like to complete the survey. Choosing "no" will end the survey at this time and will ensure that your responses are not included in the collected survey data.

will end the survey at this time and will ensure that your responses are not included in the collected survey data.

For any questions or concerns please contact the graduate student Megan Eppler at megeppler96@ksu.edu or the principal investigator Dr. Jeba Jesudoss Chelladurai, DVM, PhD, DACVM (Parasitology) at jebaj@vet.k-state.edu.

IRB Chair Contact Information: Rick Scheidt, Chair, Committee on Research Involving Human Subjects, 203 Fairchild Hall, Kansas State University, Manhattan, KS 66506, (785) 532-3224; Cheryl Doerr, Associate Vice President for Research Compliance, 203 Fairchild Hall, Kansas State University, Manhattan, KS 66506, (785) 532-3224.

Yes

No

→

KANSAS STATE
UNIVERSITY

What is the zip code of practice location?

Are you a small animal or mixed animal veterinarian?

Small animal

Mixed animal

How long have you been in practice?

KANSAS STATE
UNIVERSITY

Are you aware of the prevalence of *Giardia* in dogs in your area of practice?

Yes

No

Unsure

How often do you think you see *Giardia* in dogs in your practice?

Very rarely — Very often

0 1 2 3 4 5 6 7 8 9 10

How often do you think you see *Giardia* in dogs in your practice?

Very rarely — Very often

0	1	2	3	4	5	6	7	8	9	10

Do you test symptomatic (diarrheic) dogs for *Giardia*?

- Yes, all of them
- Yes, some of them
- No, I/we treat symptomatically

← →

KANSAS STATE
UNIVERSITY

What confirmatory test do you perform? (Please select all that apply.)

- In-clinic Direct Smear
- In-clinic Fecal Flotation
- In-clinic SNAP Test
- State/university diagnostic lab (KS-VDL or other)
- Commercial diagnostic lab (IDEXX, Antech or other)

What is your chosen treatment for *Giardia*? (Select all which apply.)

What is your chosen treatment for *Giardia*? (Select all which apply.)

- Metronidazole
- Fenbendazole
- Febantel
- Other (Please specify)

Have you dealt with *Giardia* cases refractory to treatment?

- Yes, often
- Yes, rarely
- No

KANSAS STATE UNIVERSITY

Do you mention environmental control to the owner?

- Yes
- No
- Sometimes

← →

KANSAS STATE UNIVERSITY

What methods of environmental control are suggested to the owner? (Select all which apply.)

- Bathing infected pet
- Cleaning floors
- Cleaning toys/bowls/bedding
- Cleaning other pets
- Other (Please specify)

- Cleaning other pets
- Other (Please specify)

Do you suggest the treatment/isolation of other pets in the household?

- Yes
- No
- Sometimes

← →

KANSAS STATE UNIVERSITY

Do you communicate the zoonotic potential of *Giardia* to owners?

- Yes
- No
- Sometimes

← →

Powered by Qualtrics

KANSAS STATE UNIVERSITY

We thank you for your time spent taking this survey.
Your response has been recorded.

Powered by Qualtrics

Appendix 2: Poster for the AAVP

KANSAS STATE UNIVERSITY | Master of Public Health Interdisciplinary Program

Veterinarian Perceptions of Canine Giardiasis and Communication on Zoonotic Potential in the U.S.

Megan Eppler 1, Gregg Hanzlicek 2,3 , Berlin Londono 4, Jeba Jesudoss Chelladurai 2,3,5

1 MPH program, College of Veterinary Medicine, Kansas State University
2 Kansas State Veterinary Diagnostic Laboratory, College of Veterinary Medicine, Kansas State University
3 Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University
4 Vector Biology Laboratory, Department of Entomology, Kansas State University
5 jebaj@vet.k-state.edu

Introduction

- Certain *Giardia* assemblages are capable of infecting both canines and humans, especially children. *Giardia* infections are treated differently in veterinary and human medical perspectives:
  - Humans receive metronidazole, tinidazole, and nitazoxanide.
  - Canines receive extra-label treatments of metronidazole, fenbendazole, and febantel.
- It is impossible to know if a canine or human is carrying a zoonotic assemblage because molecular characterization is not routinely carried out.
- Thus, it is important to understand the veterinarian perception and practices of treating *Giardia* within the context of One Health.

Methods

- As part of a public health study, a questionnaire-based Qualtrics survey was distributed among U.S. small and mixed animal veterinarians to assess:
  - perceived prevalence, preferred testing and treatment methods, recommended control measures, and relevant information communicated about the zoonotic potential of canine Giardiasis.
- Approved by the Ethical Review Board (URCO) at Kansas State University.
- Distributed by KS-VDL online newsletter.

Discussion

- Knowledge on the zoonotic aspect of *Giardia* is limited in the scientific community because few clinical cases of zoonotic transmission between canines and humans have been recorded.
- Given that children have a higher risk of developing *Giardia* infections, it is important for veterinarians to preserve the health of canine companions to protect their human owners.
- Thus, the contributions of veterinarians in managing canine Giardiasis within One Health initiatives should not be overlooked.

Acknowledgements

The authors thank KS-VDL Client Services for distributing the survey, Dr. Mulcahy of the Master of Public Health Program, and the Master of Public Health Program for funding the registration for the AAVP 2021 Annual Meeting.

Results

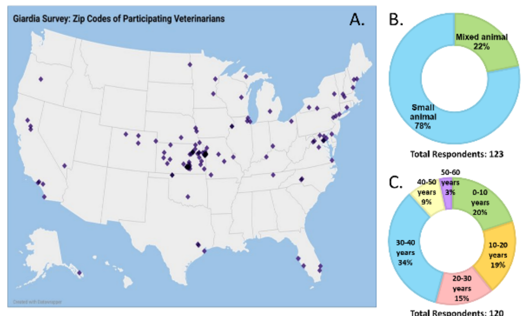


Figure 1: A. Map of Participating Veterinarian Responses. B. Practice Type of Respondents. C. Years in Practice by Respondents.

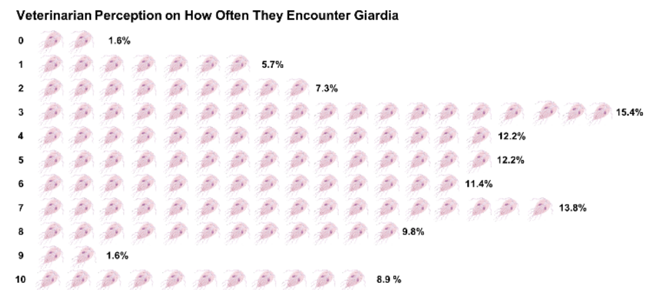


Figure 2: Pictogram on Veterinarian Perception of Giardia Frequency in clinic.

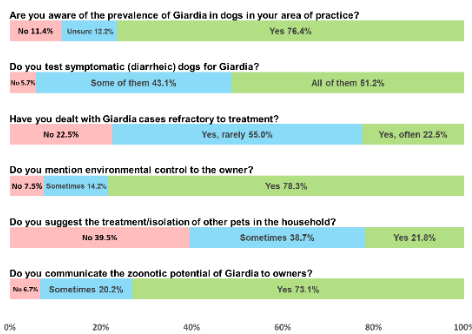


Figure 3: Bar Chart Compiling Information on Veterinarian Perceptions and Communication Concerning Giardia .

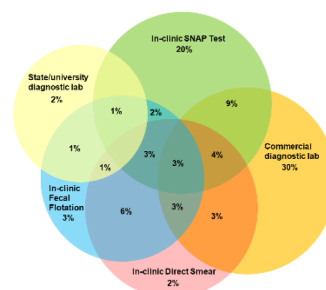


Figure 4: Venn Diagram of Testing Methods Used to Diagnose Giardia.

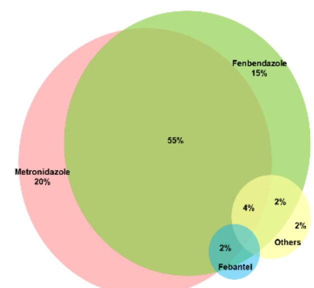


Figure 5: Venn Diagram of Extra-label Giardia Treatments Used in the U.S.

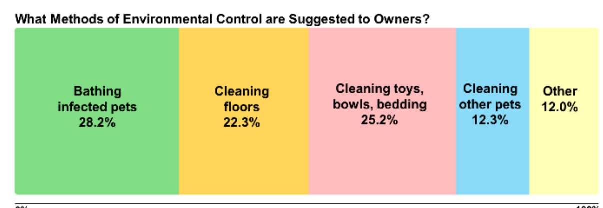


Figure 6: Bar Graph of Veterinarian Recommended Methods of Environmental Control.

Interested in participating? Follow the QR code to the survey.

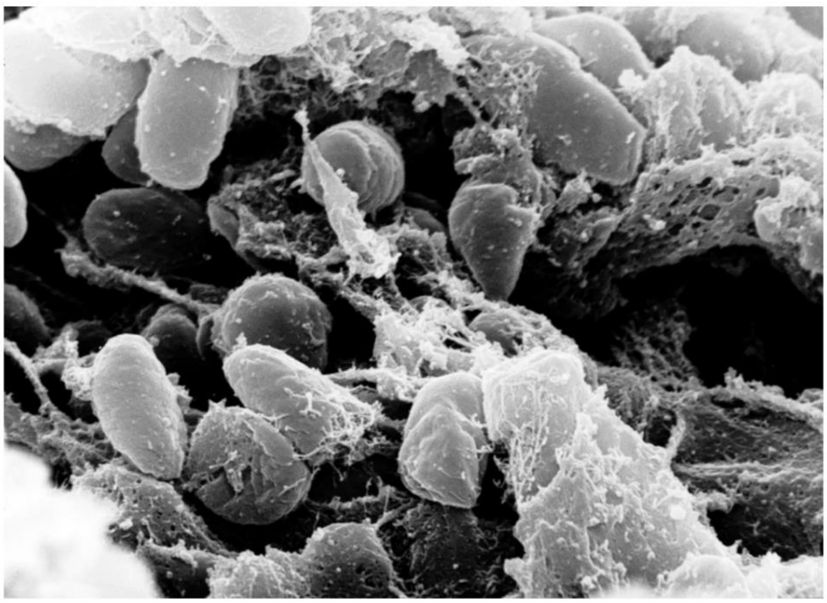
KANSAS STATE UNIVERSITY

Appendix 3: *Fighting the Spread of Disease with…Words?*

Fighting the Spread of Disease With…Words?

by Justin Kastner, Megan Eppler, Valerie Jojola-Mount, Ellyn Mulcahy, Phutsadee Sanwisate and Kate Schoenberg

While we need to be wary of the transmission of the novel coronavirus in our communities, perhaps we ought to be equally concerned about the transmission of information *about it*.



https://www.vet.k-state.edu/about/news-events-publications/OneHealth/Previous_Issues/Vol12-Iss2/