

Master of Public Health Field Experience Report

***ZOONOTIC SOIL-TRANSMITTED HELMINTHS:
A TRIAD OF WORMS, ANIMALS, AND HUMANS
AND
THE VETERINARIAN'S ROLE IN COMMUNITY PUBLIC HEALTH***

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submitted in partial fulfillment of the requirements for the degree

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Abstract

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Although mankind has known about intestinal parasites for millennia, it has only been in the last century that scientists have recognized the diseases caused by zoonotic parasites. Soil-transmitted helminths (STHs), including *Toxocara canis* and *Ancylostoma caninum*, are an important subset of zoonotic parasites, and they have developed unique characteristics that allow them to infect humans and animals. Overt parasitism is no longer common in many developed nations; however, the subtle and varied symptoms associated with STH infection, along with the lack of experience and interest of the human healthcare industry, mean that many cases of zoonotic infection are missed. These diseases not only affect the health of humans, but they also have poverty-promoting effects. The lack of attention paid to these parasites in recent years has caused the World Health Organization to label them “neglected zoonotic diseases.” Human culture and individual behaviors are important risk factors for these diseases, as well as climate and geography. It will take a multidisciplinary approach to address zoonotic parasitic diseases, and veterinarians will have to engage as part of the community public health team, in order to make these efforts successful.

Keywords: neglected zoonotic diseases, soil-transmitted helminths, public health, veterinary medicine, multidisciplinary

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Introduction

Medieval history intersected with modern medicine when researchers excavated the body of England's King Richard III. "Scientists make a gross discovery..." headlined an article describing how biological anthropologists found the soil around the king's pelvis contaminated with roundworm eggs (*Ascaris lumbricoides*).^{1, 2} In today's world, parasites seldom make the news and rarely get splashy headlines. From historical evidence of intestinal parasitism found in the writings of Hippocrates, the Bible, and Egyptian medical papyri, to the present day confirmation of parasite eggs found in mummified human remains, we know that parasites have afflicted mankind throughout the ages.³ Parasites have played, and will continue to play, a role in human existence.

It appears from archeological records that humans did not keep dogs entirely for utilitarian purposes such as herding livestock, guarding property, or hunting; apparently humans also desired companionship from dogs.⁴ Ancient people understood there was a connection between animal diseases and human diseases; for thousands of years, food animals, draft animals, and sporting animals received medical attention, but dogs had very little medical

¹ Associated Press, "Scientists Make a Gross Discovery after Examining the Body of King Richard Iii Found under a Parking Lot," <http://www.theblaze.com/stories/2013/09/04/scientists-make-a-gross-discovery-after-examining-the-body-of-richard-iii-found-under-a-parking-lot/>.

² Piers D. Mitchell et al., "The Intestinal Parasites of King Richard Iii," *The Lancet* 382, no. 9895 (2013): 888.

³ P. J. Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," *J Clin Invest* 118, no. 4 (2008): 1311.

⁴ Elizabeth C. Hirschman, "Consumers and Their Animal Companions," *Journal of Consumer Research* 20, no. 4 (1994): 616.

care.⁵ Dog care came under “household-medicine,” and it was the responsibility of the wife, along with her other domestic duties, to provide care for these.⁶

With the advance of scientific research, human-medical laboratories began to use animals as models for disease and therapeutic response. As medical researchers learned about the physiology and diseases of animals, they began to have a greater understanding of zoonotic diseases. Although generally more often ignored than bacterial or viral zoonoses, parasitic diseases are just as important to human public health.^{7,8} This paper will address soil-transmitted helminths, one important class of zoonotic parasites.

The social and economic burden associated with zoonotic parasitism, specifically *Toxocara* spp. and *Ancylostoma* spp. (see Figure 1 and Figure 2), has long been ignored, thus these diseases are termed “neglected”; however, they are not confined to tropical, undeveloped countries, but are found globally.⁹ Surveys from all over the world show that soil-

⁵ A. L. Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," *The Veterinary Record* 169, no. 11 (2011): 281. “James Harlan Steele, a former USA assistant surgeon-general, noted that ‘The relation of animal disease to human disease was observed in the ancient civilisations of Babylon, the Nile Valley, and China. They were described by Leviticus in the Old testament, by Hippocrates in Greece, and by Virgil and Galen in Rome’ (Steele 1964).”

⁶ Chris Degeling, "Canines, Consanguinity, and One-Medicine: All the Qualities of a Dog except Loyalty," *Health and History* 10, no. 2 (2008): 26.

⁷ S. M. Gaafar and D. J. Ameel, "Incidence of Helminths in Some Kansas Dogs," *Transactions of the Kansas Academy of Science (1903-)* 53, no. 3 (1950): 328.

⁸ Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," 1311. Zoonotic parasites have even changed the course of history. This author notes that during the 20th century Cold War, the forces of Chinese communist leader Mao were sickened by schistosomiasis, and they were unable to conquer the island of Taiwan (formerly known as Formosa). The parasite is sometimes referred to as “the blood fluke that saved Formosa.”

⁹ P. R. Torgerson and C. N. Macpherson, "The Socioeconomic Burden of Parasitic Zoonoses: Global Trends," *Vet Parasitol* 182, no. 1 (2011): 86-8.

transmitted helminths (STHs) may affect as many as two-billion people.¹⁰ Global estimates report an annual loss of 39 million disability-adjusted life years (DALYs) due to STHs.¹¹

Toxocariasis, caused by *Toxocara canis*, is one of the most common zoonotic infections in the world. Due to the popularity of keeping dogs as household pets, *Toxocara canis* is perhaps the most common pet-related zoonotic disease in the United States.¹² The number of human zoonotic illnesses in the United States is low compared to global numbers, and the benefits of pet ownership far outweigh the risks of acquiring disease. However, any person with insufficient immune response needs to be aware of the potential for zoonotic disease transmission.¹³

In the United States, disease syndromes related to larva migrans caused by hookworms have not received adequate attention for many reasons, including: “the lack of symptoms associated with the disease, a low degree of physician and patient awareness, and a common belief that the wealth and standards of this nation protect its population from problems most often associated with developing countries.”¹⁴ Public and professional recognition of zoonotic

¹⁰ D. Traversa, "Pet Roundworms and Hookworms: A Continuing Need for Global Worming," *Parasites & Vectors* 5 (2012): 5.

¹¹ B. Speich et al., "Comparative Cost Assessment of the Kato-Katz and Flotac Techniques for Soil-Transmitted Helminth Diagnosis in Epidemiological Surveys," *Parasit Vectors* 3 (2010): 1.

¹² Peter Schantz, "Zoonotic Parasitic Infections Contracted from Dogs and Cats: How Frequent Are They?," *Veterinary Medicine* (2007), <http://veterinarymedicine.dvm360.com/zoonotic-parasitic-infections-contracted-dogs-and-cats-how-frequent-are-they>.

¹³ J. W. Stull et al., "Household Knowledge, Attitudes and Practices Related to Pet Contact and Associated Zoonoses in Ontario, Canada," *BMC Public Health* 12 (2012): 2. Stull includes in his list of at risk people: very young (<5 yrs), elderly (>65 yrs), pregnant women, anyone with certain diseases (like cancer, HIV, diabetes) where the disease or treatment (for example, splenectomy or radiation therapy) may cause decreased immune function.

¹⁴ M. L. Chorazy and D. J. Richardson, "A Survey of Environmental Contamination with Ascarid Ova, Wallingford, Connecticut," *Vector Borne Zoonotic Dis* 5, no. 1 (2005): 38.

soil-transmitted helminthic diseases—their causes, risks, and outcomes—is a prerequisite for forming an effective strategy against these pathogens. It is a great concern that these common diseases, with their profound health and socioeconomic effects, have slipped into a neglected status.

Zoonotic Soil-transmitted Helminths: A Triad of Worms, Animals, and Humans

There are many zoonotic diseases shared between humans and their pet dogs and cats. Helminths, or worms, are a small but significant subset of these diseases. This paper will focus mainly on information regarding soil-transmitted parasites, transmission, and risk factors associated with dogs and dog-ownership. Most people understand that parasitism leads to adverse health effects; however, there is also an educational and economic burden caused by parasitism.¹⁵ Helminth infections can have “poverty-promoting effects” in poor communities (e.g., decreased birth weights, impaired educational performance, and blindness) that may not be readily seen and may be a cause of reduced work productivity.¹⁶

Only a few parasites have developed mechanisms that allow for long-term survival by outwitting the immune system of their hosts.¹⁷ Parasites have also developed many delivery systems to get the infective egg or larva into the final host. In a non-definitive host, the larva will wander through various organs and tissues, causing inflammatory changes and diseases

¹⁵ Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," 1312.

¹⁶ Ibid., 1311.

¹⁷ D. Despommier, "Toxocariasis: Clinical Aspects, Epidemiology, Medical Ecology, and Molecular Aspects," *Clinical Microbiology Reviews* 16, no. 2 (2003): 265.

wherever they go. This migration can last for months or years; the “distribution in the host’s tissues may continue to shift,” leading to varying complaints and vague symptoms.^{18,19}

Zoonotic parasitic diseases are likely much more common than is currently recognized and documented.^{20,21} The CDC estimates there are greater than ten-thousand cases of larval toxocariasis occurring each year.²² Overcrowding and unintentional cohabitation occur as pets have greater access to the peridomestic environment, coupled with the increasing numbers of urban wildlife.²³ Public parks and playgrounds are no longer just places to have fun, but they are becoming areas with increased exposure to zoonotic diseases. To diagnose zoonotic parasitism in humans requires clinical experience and a willingness to look for these diseases, as well as effective laboratory support.²⁴ Fecal, or stool, exams are the tests that are widely used to look for parasite eggs and assess parasitism in dogs. However, this basic test is often overlooked and, when performed, many practices do not use the most sensitive test methods.

¹⁸ Ibid.

¹⁹ P. M. Schantz, "Toxocara Larva Migrans Now," *The American Journal of Tropical Medicine and Hygiene* 41, no. 3 Suppl (1989): 23.

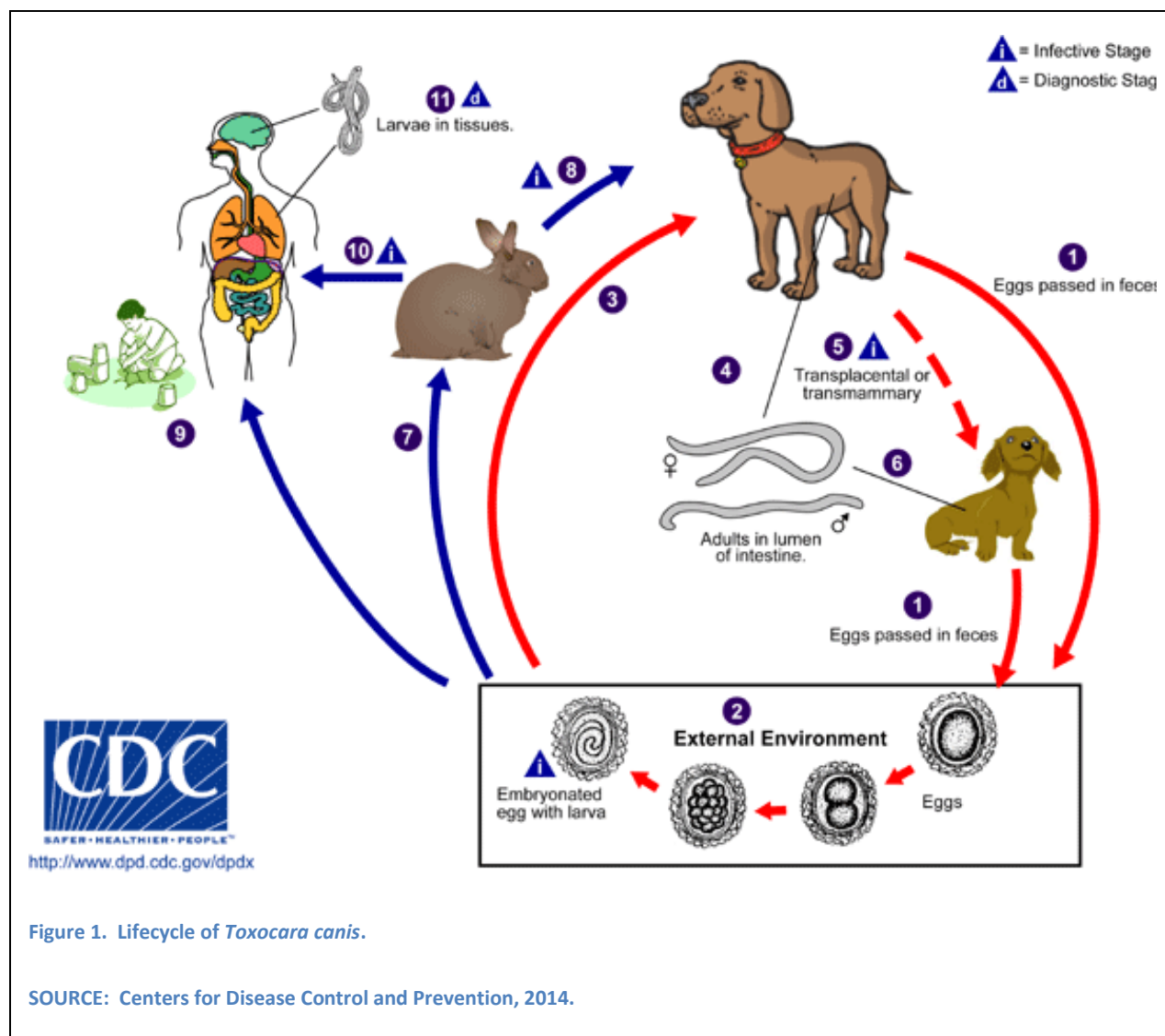
²⁰ Schantz, "Zoonotic Parasitic Infections Contracted from Dogs and Cats: How Frequent Are They?"

²¹ Traversa, "Pet Roundworms and Hookworms: A Continuing Need for Global Worming," 15.

²² Lora R. Ballweber, "Parasitic Zoonoses of Wildlife" (paper presented at the CVC San Diego, San Diego, CA, 2009).

²³ Despommier, "Toxocariasis: Clinical Aspects, Epidemiology, Medical Ecology, and Molecular Aspects." The “peridomestic” environment is that space that is outside the home, but is frequented in daily activity. This may be pet-driven, as in walks for exercise or elimination. It may also be owner-driven, because many owners now take their pets on social visits or errands.

²⁴ H. Smith et al., "How Common Is Human Toxocariasis? Towards Standardizing Our Knowledge," *Trends Parasitol* 25, no. 4 (2009): 183.



Assessing environmental contamination with soil-transmitted helminth eggs is another way to understand this issue. Infection rates in dogs provide an estimate of the number of eggs shed in the environment and to the potential for human and animal exposure. Researchers in Saskatoon, Saskatchewan developed a formula for estimating environmental contamination by estimating the number of dogs in Saskatoon, noting the prevalence of dog feces in certain city areas, and concluding with a survey of feces to determine parasitism rates. A study of stray dogs in Manhattan, Kansas in the 1950's showed that twenty-nine of the forty-two dogs

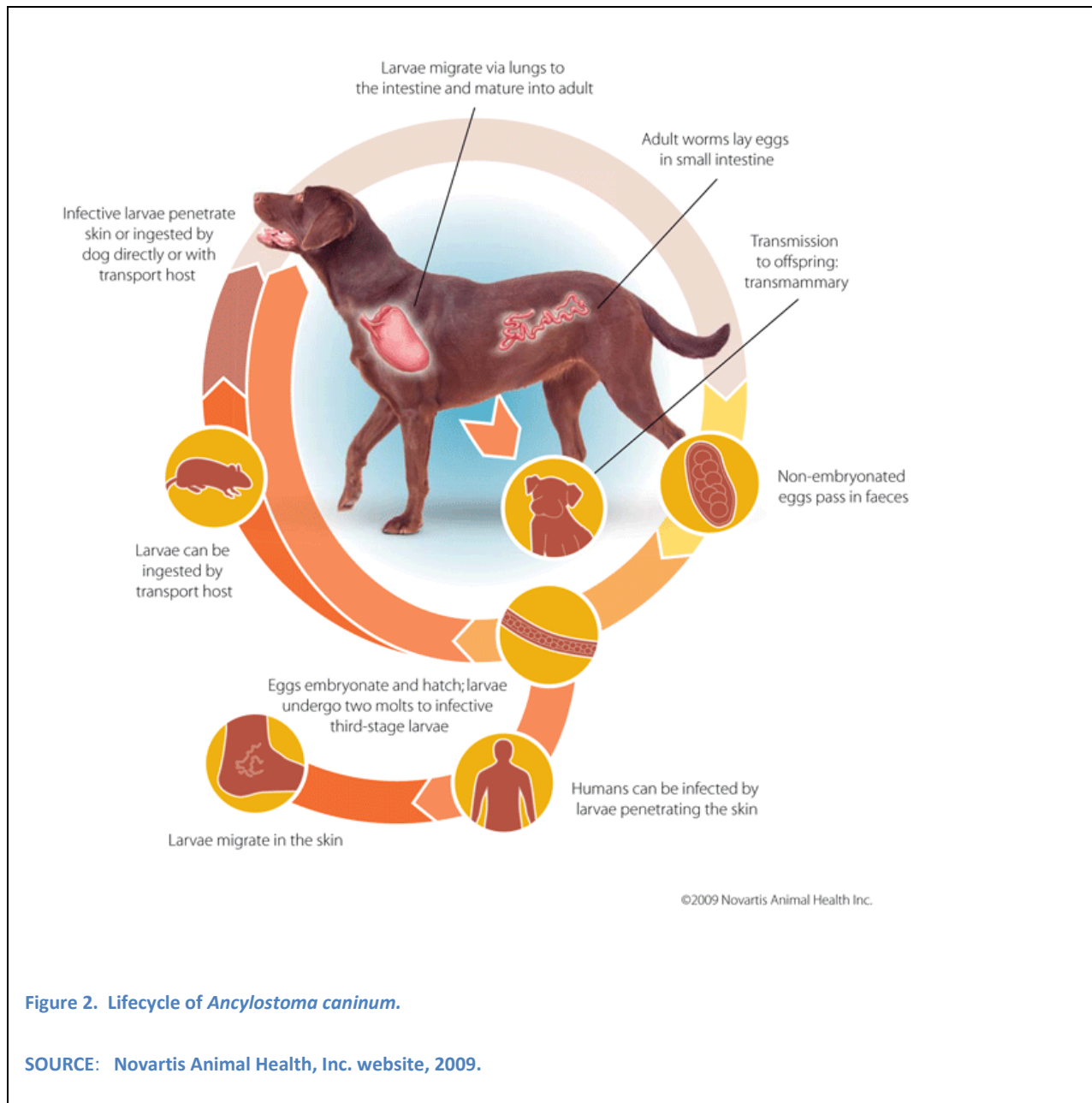
collected by the police department had 933 worms: 40% ascarids, 20% hookworms, and 50% tapeworms.²⁵ Another study of 1142 coyotes, captured in Kansas between 1948 and 1954, found hookworms in 19.8% and ascarids in 19.3%; this study also noted that the numbers of parasites were higher in coyotes living in flood plains than in upland range areas and were also higher during years that had wet springs.²⁶ Blagburn et al. reported in 2014, based on 6418 samples of canine feces from dog shelters across the United States, that the overall prevalence of *Toxocara canis* was 12.5% and *Ancylostoma caninum* was 29.8%.²⁷ In a 2014 study comparing the results of fecal flotation tests to parasites recovered at necropsy, Adolph et al. showed that approximately 50% of dogs with *T. canis* and 20% with *A. caninum* went undiagnosed.²⁸ Parasite infestations in dogs have not decreased over the last half century even with effective and available anthelmintics. In addition, the most-performed fecal tests, the passive floatation system, have poor sensitivity and veterinarians are not catching a large number of parasitized dogs.

²⁵ James E. Ackert, "Review of Research in Parasitology in Kansas During the Last Century" (paper presented at the Transactions of the Kansas Academy of Science (1903-), Summer, 1956), 162.

²⁶ H.T. Gier, "Coyotes in Kansas," ed. Agriculture Experiment Station (Manhattan, Kansas: Kansas State University of Agriculture and Applied Science, 1957), 58.

²⁷ Byron L. Blagburn et al., "Prevalence of Internal Parasites in Shelter Dogs Based on Centrifugal Fecal Flotation.," in *American Association of Veterinary Parasitologists (AAVP)* (Denver, Colorado USA2014). Blagburn notes that the prevalence in shelter dogs is higher in 2014 than in a previous study conducted in 1996.

²⁸ Chris Adolph et al., "Evaluation of Fecal Samples from Dogs with Naturally Acquired Gastrointestinal Nematodes for Coproantigen of *Trichuris Vulpis*, *Toxocara Canis*, and *Ancylostoma Caninum*., "ibid. (Denver, Colorado, USA).



Environmental contamination can also be assessed by counting the numbers of eggs and larvae present in selected soil and water samples collected from sewage treatment plants.

Many studies in the past have found that the prevalence of *Toxocara* sp. ova is similar in play

areas in parks, as it is in grassy areas around sidewalks.²⁹ This is troubling, as one would expect to have more contamination in areas that have frequent dog traffic and defecation, where owners may not be diligent at removing stool. Studies of sandboxes from parks and daycares in Canada and France showed the presence of *Toxocara* spp. ova differed greatly, with regard to both seasons and proximity.³⁰ Carabin, et al. note that the variances are explained by many factors: environmental variations in temperature, humidity, and soil; differences in how children and animals move sand and soil; and defecation preferences and behaviors of domestic and wild animals.³¹ According to Glickman and Schantz, "...the most important factor favoring endemicity of soil-transmitted helminths is the character of the top soil," and soils that contain moisture-retaining clay are most conducive to survival of parasite eggs, as these soils protect the eggs from sunlight and desiccation.³² It is possible to monitor helminth eggs by checking effluents and sludges from municipal wastewater treatment plants, because they are not destroyed by common sewage treatment practices.³³ Although transmission rates can be

²⁹ Chorazy and Richardson, "A Survey of Environmental Contamination with Ascarid Ova, Wallingford, Connecticut," 38.

³⁰ H. Carabin et al., "Comparison of Methods of Sampling for *Toxocara* Species and Fecal Coliforms in an Outdoor Day Care Environment," *The Canadian Journal of Infectious Diseases* 9, no. 3 (1998): 154.

³¹ Ibid.

³² L. T. Glickman and P. M. Schantz, "Epidemiology and Pathogenesis of Zoonotic Toxocariasis," *Epidemiologic Reviews* 3 (1981): 233.

³³ Ibid. Per these authors, researchers from the US EPA conducted a study of municipal sewage treatment plants in the southern United States and found viable *Toxocara* eggs in samples from 27 plants.

affected by seasonal dynamics, weather fluctuations generally do not change a region's parasite load.³⁴

Transmission and Exposure Risks with Disease Outcomes

Understanding the relationship between culture and behavior is like reading the old riddle: which came first, the chicken or the egg? Both culture and behaviors have powerful effects on communities and upon the ability of a pathogen to spread. Part of this equation with zoonotic parasitic diseases is the manner in which humans interact with their pets and with wildlife. Children are very much at risk of exposure to zoonotic parasites because of their affection for animals and their playful behaviors when interacting with pets, as well as their curiosity about their surroundings and their limited hygiene skills. Food culture may also be a risk factor; this would include not only types of food eaten, but also the sanitation practices concerning food preparation and storage. Expanding urban zones, increasing contact with urban wildlife, changing water drainage systems, immigration, and travel with pets are causes of growing incidence of zoonotic diseases.

Increasing numbers of households with young children are adding dogs and cats to their families.³⁵ Although intestinal parasitism is thought of as a puppyhood condition, *Toxocara canis* can infect adult dogs that are dewormed regularly, unless dog owners are compliant with current recommended anthelmintic products and schedules. A recent study showed that of all

³⁴ Luciene Mascarini-Serra, "Prevention of Soil-Transmitted Helminth Infection," *Journal of Global Infectious Diseases* 3 (2011).

³⁵ Schantz, "Zoonotic Parasitic Infections Contracted from Dogs and Cats: How Frequent Are They?"

age dogs, puppies are most likely to have intestinal parasites; however, the next most parasitized group was dogs greater than ten years.³⁶ Older animals that have not been parasitized for many years may be just as susceptible as naïve puppies due to waning immune systems and the changing of parasitic surface antigens. Anyone, especially children, with exposure to a litter of puppies or elderly dogs should be considered at risk for visceral larval migrans. Basic sanitation, especially hand-washing, is the key to preventing soil-transmitted helminth parasites.

Households where certain pet behaviors are allowed, such as letting the pet lick hands, accepting “kisses,” or permitting the pet to sleep in bed with their owners, may have a higher risk of exposure. This threat can simply be reduced by implementing good hygiene practices and modifying the behaviors of pets and pet owners.

Studies conducted in the United States and around the world have demonstrated significant soil contamination of public places, especially parks and playgrounds.³⁷ There are a number of reasons behind the spread of STHs in wildlife in the United States; among these

³⁶ Traversa, "Pet Roundworms and Hookworms: A Continuing Need for Global Worming," 3. We usually think of roundworms and hookworms as puppy diseases, but according to these studies, intestinal parasitism is a problem that will increase as immunocompetence decreases. Considering that chronic diseases, such as periodontal infections, diabetes, hypothyroidism, and allergic diseases are becoming so common in our pets, we need to emphasize to pet owners the risk their older, sicker pets may be facing. Continuing anthelmintic use should be a vital part of the health program for older pets.

³⁷ Glickman and Schantz, "Epidemiology and Pathogenesis of Zoonotic Toxocariasis," 232-3.

forces are increasing populations of urban wildlife, increasing numbers of free-ranging domestic species, and warming urban microclimates.^{38,39}

Urbanization contributes greatly to the levels of parasites and infectious diseases in wild and feral canids and feral cats. Increased feeding opportunities (which may be intentional or simply increased access to human refuse) lead to larger litter sizes, increasing total numbers of wildlife and opportunities for co-mingling. Larger numbers of wildlife competing for food often progresses to starvation and immunosuppression, which leads to pathogens gaining a greater foothold in the population.⁴⁰ Estimates of parasite prevalence are 15-20% in wild canids and approximately 15% in domestic dogs.⁴¹ Although eliminating feeding stations will decrease wildlife congregation, at present there is no medical or economical way to control intestinal parasites in wild canids; however, it is possible to manage these parasites in pets. Controlling these parasites in domestic pets is presently the easiest way to control environmental contamination.⁴²

The United States National Health and Nutrition Examination Survey (NHANES III) showed that both “individual level risk factors and geographic contextual factors” affect

³⁸ Michael W. Dryden, "Potential Health Hazards of Urban Wildlife to Humans and Their Pets" (College of Veterinary Medicine, Kansas State University), 1.

³⁹ C. A. Bradley and S. Altizer, "Urbanization and the Ecology of Wildlife Diseases," *Trends in Ecology & Evolution* 22, no. 2 (2007): 95,99.

⁴⁰ Kathleen A. Alexander and J. Weldon McNutt, "Human Behavior Influences Infectious Disease Emergence at the Human—Animal Interface," *Frontiers in Ecology and the Environment* 8, no. 10 (2010): 526.

⁴¹ Ballweber, "Parasitic Zoonoses of Wildlife."

⁴² Ibid.

Toxocara sp. infection.⁴³ Using data from NHANES III, Congdon and Lloyd were able to apply a binary regression model to look at the relative risk of toxocariasis infection for the 20,396 survey subjects. This model looked at the relationships between geography (region of the country and metropolitan status), demographic attributes (gender, age, and ethnicity), and family poverty. They were then able to further break down the data and estimate the prevalence in each county. The following conclusions were drawn:

- Poverty and lower socioeconomic status are risk factors for toxocariasis.⁴⁴
- Poor housing conditions and sanitation, including access to water for personal and domestic hygiene, contribute to zoonotic helminths.⁴⁵
- A low level of education is a risk factor for toxocariasis.⁴⁶
- Higher levels of soil exposure (whether by work or play) are related to higher levels of *Toxocara* spp. exposure.⁴⁷
- *Toxocara* spp. infection is associated with local food habits, including consumption of raw or undercooked meat.⁴⁸

Thus, it becomes important not to classify these diseases as “a disease of the tropics” or “a disease of third-world countries,” because ethnicity, geography, and poverty in any country

⁴³ P. Congdon and P. Lloyd, "Toxocara Infection in the United States: The Relevance of Poverty, Geography and Demography as Risk Factors, and Implications for Estimating County Prevalence," *International Journal of Public Health* 56, no. 1 (2011): 15.

⁴⁴ Ibid.

⁴⁵ Mascarini-Serra, "Prevention of Soil-Transmitted Helminth Infection."

⁴⁶ A. C. Lee et al., "Epidemiologic and Zoonotic Aspects of Ascarid Infections in Dogs and Cats," *Trends in Parasitology* 26, no. 4 (2010): 157.

⁴⁷ Congdon and Lloyd, "Toxocara Infection in the United States: The Relevance of Poverty, Geography and Demography as Risk Factors, and Implications for Estimating County Prevalence," 16.

⁴⁸ Lee et al., "Epidemiologic and Zoonotic Aspects of Ascarid Infections in Dogs and Cats," 157. The authors note that the importance of *Toxocara cati*, the feline roundworm, has been underappreciated as a cause of zoonotic disease.

will have additive and cumulative effects; the prevalence of zoonotic parasitism will change depending upon how these characteristics are combined.

Pica behavior has been correlated with soil-transmitted helminthic zoonoses in humans; however, this is misleading. The definition of pica is “the craving to eat nonfood items, such as dirt, paint chips, and clay.”⁴⁹ STH diseases are more closely related to soil ingestion (or geophagia), which is “the consumption of soil resulting from various behaviors, including, but not limited to, mouthing objects or dirty hands, eating dropped food, and intentionally consuming soil.”⁵⁰ Soil ingestion results in approximately one-eighth of one teaspoon of dirt consumption daily versus soil-pica, where children intentionally eat dirt or soil-contaminated food, or exhibit mouthing behavior, leading to excessive soil ingestion of one teaspoon or more daily.⁵¹

Studies have shown that as many as twenty percent of preschool children may have soil-pica behaviors. Parents may not be aware of this behavior if it occurs during unsupervised outdoor playtime or in a preschool situation, especially if daycare providers are not forthcoming about the behavior.⁵² Toddlers who attend daycare centers are more at risk of developing infectious diseases. In addition to having limited hygiene skills, toddlers also are developing body awareness and interacting with their surroundings, leading to increased

⁴⁹ "Pica Behavior and Contaminated Soil: What's the Problem?," ed. US CDC, Gateway to Health Communication & Social Marketing Practice (Atlanta, GA: US CDC, 2011).

⁵⁰ Ibid.

⁵¹ Ibid.

⁵² Ibid.

mobility and oral exploration behaviors.⁵³ Research shows that every 2-3 minutes a toddler is putting his hand or another object in his mouth, leading to a high exposure to environmental contaminants.⁵⁴ One study of a U.S. daycare revealed that sixty-five children (1-4 years) consumed an average of forty milligrams of soil per day per child.⁵⁵

There are an estimated twenty percent of people in the United States considered immunocompromised, defined as having immune systems that are not functioning optimally.⁵⁶ These people are at higher risk of developing disease when exposed to zoonotic pathogens. This group includes

- children less than five years,
- elderly over sixty-five years,
- pregnant women,
- splenectomized people,
- patients with chronic diseases such as diabetes or HIV,
- cancer patients undergoing radiation or chemotherapy, and
- patients with autoimmune diseases undergoing immunomodulating therapy.⁵⁷

⁵³ Carabin et al., "Comparison of Methods of Sampling for Toxocara Species and Fecal Coliforms in an Outdoor Day Care Environment," 150.

⁵⁴ Ibid.

⁵⁵ Ibid., 155.

⁵⁶ R. T. Trevejo, M. C. Barr, and R. A. Robinson, "Important Emerging Bacterial Zoonotic Infections Affecting the Immunocompromised," *Veterinary Research* 36, no. 3 (2005): 494.

⁵⁷ Stull et al., "Household Knowledge, Attitudes and Practices Related to Pet Contact and Associated Zoonoses in Ontario, Canada," 2.

Internship at Lawrence-Douglas County Health Department

I interned with the Lawrence-Douglas County Health Department (LDCHD) from June through December 2013. I was under the supervision of Charlie Bryan MPA, Community Health Planner.⁵⁸ LDCHD facilitates the following programs:

- Clinical services—immunizations, disease testing and counseling, family planning;
- Family services—pregnancy and breastfeeding counseling;
- Community services—support for seniors, emergency preparedness, communicable disease investigation; and
- Regulatory services—childcare licensing, sanitary code enforcement, environmental health.

My intern class was introduced to all of these programs. I participated in the orientation program, which included several modules for FEMA (Federal Emergency Management Agency) and NIMS (National Incident Management System). Intern projects for the summer included assessments of: non-smoking housing availability, community emergency preparedness, and community food programs. I had the opportunity to observe the steps for planning and executing a health fair. I learned about implementing healthcare frameworks into actual practice. It was also very interesting to learn about the health department's role in senior wellness and childcare. I was most surprised that the LDCHD currently had no veterinarian on the health board. It was a good exposure to the many and varied aspects of public health, especially at a community level.

⁵⁸ Charlie Bryan, MPA. Community Health Planner with the Lawrence-Douglas County Health Department, 200 Maine, Suite B, Lawrence, Kansas 66044. CBryan@ldchealth.org.

In addition to the weekly intern sessions, I participated in a brainstorming session to discuss a ratings system for the Live Well/Eat Well program. I attended a presentation by Kansas University Public Administration students regarding preparedness for heat emergencies, including medical, electrical, and cultural issues. I also wrote a blog article for the LDCHD website encouraging dog owners to “scoop the poop.”⁵⁹

During this internship, I had the opportunity to assess the environmental contamination of specific public areas in Lawrence, Kansas with dog feces. Specifically, I was looking for presence of canine roundworm and hookworm that have zoonotic potential. I accumulated data by examining feces collected in these areas for parasites, interviewed representatives at veterinary practices and other pet-related industries in the area, and conducted a survey of dog owners who use these public places. My goals were to determine if there is indeed a problem with fecal contamination in public areas, which areas and people are most at risk, and what policies can be adopted to benefit the community.

Lawrence, in Douglas County, Kansas is in the central United States. It has characteristics of both humid continental and humid subtropical zones (Köppen Dfa and Cfa), as it lies in the transition area of this region.⁶⁰ Accordingly, Lawrence will be hot and humid during the summer, but have periods of cold and dry weather during the winter. Douglas County is 455.87 square miles in size, with 19 square miles of water surface area (mainly the Kansas River

⁵⁹ <http://ldchealth.org/the-scoop-on-dog-poop-is-it-matters-to-your-health/>

⁶⁰ M. C. Peel, B. L. Finlayson, and T. A. McMahon, "Updated World Map of the Köppen-Geiger Climate Classification," *Hydrology and Earth System Sciences* 11, no. 5 (2007): 452-4, 62, 69.

Lawrence, Kansas Data

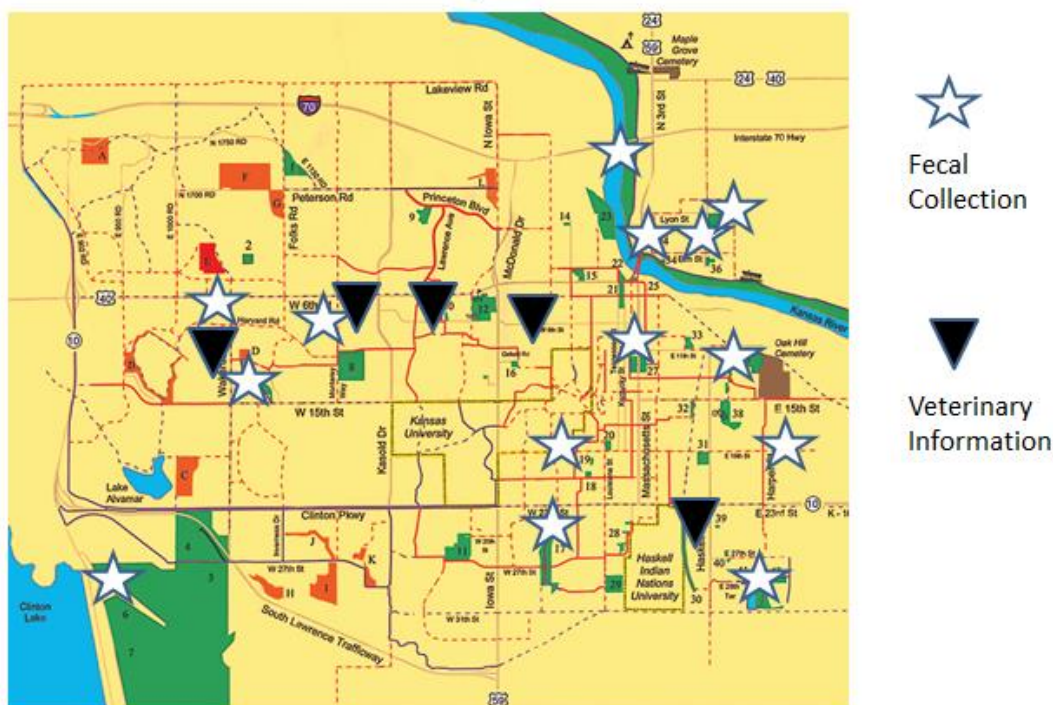


Figure 3. Data points in Lawrence, Kansas.

SOURCE: City of Lawrence, Kansas. 2013. http://www.lawrenceks.org/city_maps

and Clinton Reservoir). The city of Lawrence, as of 2010, is 33.56 square miles.⁶¹ The soil in Douglas County is comprised of silt and clay loams.⁶²

According to the 2010 United States census, there were 110,826 residents in Douglas County living in 43,422 households; 87,643 residents were recorded living in 34,459 households

⁶¹ <http://www.census.gov/prod/cen2010/briefs/c2010br-14.pdf>

⁶² "Soil Survey of Douglas County, Kansas," ed. Natural Resources Conservation Service (NRCS) (Washington, D.C.: National Cooperative Soil Survey, 1973), 7.

in Lawrence.⁶³ The 2012 American Veterinary Medical Association market research study found that 36.5 percent of households owned dogs, with an average of 1.6 dogs per household.⁶⁴ Extrapolating these data, the number of dogs residing in Lawrence and Douglas County could range from 20,000 to 25,000.

Interviews with veterinarians

I obtained a list of veterinarians in Douglas County from the Humane Society and attempted to contact, via email, phone, and on-site visits, seven of the thirteen practices listed.⁶⁵ My question to these practices included: the number of fecal exams done yearly; the numbers of tests positive for roundworms and hookworms; and how the results were stored (see Table 1 and Figure 3).

Unfortunately, despite computerized records, several practices were still keeping the results of fecal tests only on the patient record or in hand-written lab books. Of the two practices keeping laboratory results on computers, neither practice was readily able to retrieve results for individual parasites. This situation is unfortunate, as none of these practices is able to analyze their demographics or the efficacy of the parasite prevention programs.

⁶³ <http://www.census.gov/prod/cen2010/briefs/c2010br-14.pdf>

⁶⁴ American Veterinary Medical Association (AVMA), "U.S. Pet Ownership Statistics," in *2012 U.S. Pet Ownership & Demographics Sourcebook* (Schaumburg, IL: American Veterinary Medical Association (AVMA), 2012).
<https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx>

⁶⁵ <http://lawrencehumane.org/cms/wp-content/uploads/2013/05/Veterinarian-List.pdf>

Table 1. Veterinary practices in Lawrence, Kansas and information regarding their fecal testing program, including numbers of tests, numbers positive for roundworms and hookworms, and how the data is stored.

<u>Facility</u>	<u>Year</u>	<u># Tests</u>	<u># Positive for parasites</u>	<u>Format</u>
Animal Hospital of Lawrence	2012	616	39+ for rounds/hooks/or both	book
Bradley Animal Hospital			estimate 10-15%	book
Clinton Parkway Animal Hospital-NR				
Gentle Care Animal Hospital			estimate 10-15%	computer*
Lawrence Veterinary Hospital-NR				
Lewis Veterinary Clinic				on records
Wakarusa Veterinary Hospital	2008	1179	119	spreadsheet*
	2009	1172	125	
	2010	1167	121	
	2011	1192	116	
	2012	1194	120	
* Computerized records of results of individual tests not readily accessible.				
NR—no response				

Because certain populations of people (e.g., children and seniors) and animals are more at risk for STH infections, my goal was to examine some of these different populations in Lawrence. To assess the risk, I completed canine fecal exams according to recommended protocol (see Appendix 2 for results and Appendix 1 for the test protocol). Additionally, I had

dog owners complete a survey, then tabulated the responses, and correlated them with the test results. The following is an overview of the findings:

Lawrence-Douglas County KS Canine Fecal Study Survey—this survey was conducted on SurveyMonkey in conjunction with LDCHD (see Appendix 3 and 4). Dog owners that participated in the fecal analysis study were asked to respond to twenty questions. The questions included signalment (e.g., age and sex of dog), personal behaviors of owners (e.g., sharing personal space with dogs, frequency of hand washing, and frequency of picking up stool), knowledge about zoonotic dog parasites, and their current chemoprophylactic program. There were thirty-five respondents. Some of the most interesting findings are discussed below (n.b. results are rounded for clarity). The survey and the results are excellent examples of the barriers that exist to controlling STH parasitic diseases, which will be addressed more completely in the next section.

Question 5: Do you wash your hands after contact with your pets? Only 25% replied “Everytime” or “Frequently.” There are many people missing the opportunity to practice good hygiene methods.

Question 7: How often does your dog sleep in your bed (or a family member’s)? 32% responded “Daily” and 26% responded “Occasionally.” Close physical contact between pets and people creates the opportunity for parasite transmission.

Question 8: How often do you scoop your dog’s feces in your yard? 54% of owners reported scooping “Daily” or “A couple of times every week.” This habit is necessary to prevent the eggs present in the environment from developing into infective eggs.

Question 12: Are you aware that some parasites will infect humans as well as dogs? 20% of these dog owners replied “No.” This result shows that owners are lacking awareness of the potential for zoonotic diseases in their homes.

Question 13: How concerned are you that you or your family may be infected by parasites from your dog? Only 1 respondent replied affirmative; whether this was because of confidence in their chemoprophylactic program, or due to ignorance, would have to be discerned by further questioning.

Question 17: How often do you give heartworm prevention medication to your dog? 63% of these dog owners are using chemoprophylaxis as recommended for heartworm and intestinal parasite prevention. Including the 6% that replied “Never” or “Not sure,” this means that approximately one-third of dogs are not on a program that will provide public protection.

Childcare facilities—multiple facilities, contacted via email through the LDCHD childcare licensing division, were offered free fecal tests for their dogs with results reported anonymously. Initially, four providers were interested in the offer; however, only two finally participated. All three of the dogs tested were negative for parasites. The owners indicated on their survey that it was very important that their dog be protected from intestinal parasites (Question 14), that they cleaned feces in their yards weekly (Question 8), and that they gave their dogs monthly or seasonal heartworm anthelmintic medication (Question 17). It appears that these providers, their dogs, and the children they care for, are adequately protected against STHs. My concern with the low response is that providers do not want to open themselves to accusations of contaminated environments or additional oversight.

Senior housing—I contacted six senior housing facilities for this study. Three of the facilities allowed pets, per their online information. Only one facility was interested in

participating.⁶⁶ This facility is located in the northwest part of Lawrence, in an area that was rural until the last decade. It is presently experiencing commercial and residential growth. Coyotes, foxes, bobcats, and other wildlife are common to the area.⁶⁷

Of the six dogs tested at this facility, only one dog had positive results. This was a recently adopted small, mixed-breed intact female dog, 1-5 years old. The owner reported that she did not have a family veterinarian (Question 9). The dog tested positive for hookworms (3+ out of 4) and a rabbit coccidia (3+ out of 4). With further questioning, I learned that this dog had a habit of eating feces when it was taken out to exercise. The apartment manager related that the residents of the complex were fond of feeding the many rabbits in the area; so much so, that the rabbits would come right up to the units begging for food. Furthermore, the manager related that there were many coyotes sighted in a field nearby. This episode shows the role wildlife can play in the transmission of parasites. Additionally, although the seniors enjoy their interaction with the rabbits, encouraging prey species also increases the likelihood of predator animals feeding and defecating in the community.

Apartment complexes—there are a large number of apartment complexes in Lawrence, in part because of the presence of the University of Kansas. I contacted eleven complexes that were all reported to allow dogs, although some had restrictions on the size of dog. Eight

⁶⁶ Prairie Commons Apartments, 5121 Congressional Circle, Lawrence, Kansas 66049. Connie Daniels, Manager.

⁶⁷ Karrey Britt, "Pet Owners Fear Coyotes," *Lawrence Journal-World*, 09/23/2007 2007. During a conversation with Dr. Lewis of Lewis Veterinary Hospital, he shared that he regularly saw raccoons, coyotes and foxes in the city of Lawrence, as well as an occasional bobcat.

facilities responded; some noted that they already had stool pick-up policies and none volunteered to participate in the study.

Downtown Lawrence Inc.—this organization formed several decades ago to promote the businesses and lifestyle in the downtown business district.⁶⁸ Many people include their dogs when journeying to this vibrant area. I have heard reports about dog feces on sidewalks and have witnessed the same. I attempted to contact the director of DLI by phone and by email, but I had no luck. Unfortunately, the management of DLI changed during the period of my internship.

Doggy Daycare—Wagmore Inc. in Lawrence is an organization that offers onsite daycare for dogs.⁶⁹ Supervisors watch the dogs in an enclosed facility and feces are immediately cleaned up. The staff at Wagmore was very excited to participate in this study and collected the samples for analysis. They gave the dog owners written information on accessing the online survey (only two were completed, and neither pet had parasites). Of the seventeen samples collected, one dog had 1+ roundworm ova. However, Wagmore staff noted that the dog owners who spend the money to bring their pets to daycare are generally very invested in the health and well-being of their pets.

Lawrence Humane Society—this organization, founded in 1951, serves as a holding facility for the Lawrence Police Department's Animal Control Division, as well as sheltering

⁶⁸ Downtown Lawrence Inc. 833-1/2 Massachusetts Street, Lawrence, Kansas 66044. <http://www.downtownlawrence.com/>

⁶⁹ Wagmore Inc., 1411 W 23rd Street, Lawrence, Kansas 66046. <http://wagmoreinc.com/>

animals and adopting them to the public.⁷⁰ LHS cares for approximately 1,700 dogs annually. Dr. Jennifer Stone is the staff veterinarian. With her help, I collected fifty-three samples of feces, including six from cats. The samples were collected by volunteer staff from dogs upon intake, labeled, and refrigerated until I picked them up. This took place from July through October in 2013. The results of the study showed: forty-eight had no parasites observed, none had roundworms, three had hookworms, one had whipworms, and one had coccidia. The humane society treats dogs with a topical dose of Advantage Multi anthelmintic upon arrival to the facility, and this may have affected the shedding of ova.

Fecal samples from selected areas

Studies show that environmental contamination is common in certain public areas. It was my intent to look at some different areas in Lawrence to assess the accumulation of feces and possibly the presence of parasites. I visited these areas (see Figure 3), thoroughly searching for, and identifying probable canine feces; all deposits found were picked up and disposed of properly. Of the 34 samples collected, ten were desiccated or decomposing, thus unusable for the study. The information is broken down into the type of area with the results:

Dog Parks—there are two city-sponsored dog parks in Lawrence. Waste disposal rules are posted and disposal bags are provided in receptacles.

- Riverfront Dog Park—this is a prairie-type area near the Kansas River where a mowed path is available for owners to exercise their dogs. A large prominent

⁷⁰ Lawrence Humane Society, 1805 E 19th Street, Lawrence, Kansas 66046. Jennifer Stone DVM, staff veterinarian. <http://lawrencehumane.org/>

sign at the edge of the park lists the city's rules and regulations. A "doggy waste station" is present, providing disposal bags and a secured trash can. Of the four samples collected, one was positive for roundworms. There were no dogs or owners present at the time of collection.

- Mutt Run Dog Park—this is a nature area close to Clinton Reservoir. Owners are free to walk their dogs along a dirt road or grassy paths. As with the other dog park, the city placed a sign with the rules and provided multiple waste stations. This park is heavily used, and when I was there, I was able to collect not only samples but I also handed out written instructions for completing the online survey. I collected twenty-three samples of stool, and surveys were completed on seven dogs. Of these samples, one dog had 2+ hookworms and one dog had coccidia; neither of their owners filled out a survey.

Food-related areas—the citizens of Lawrence recognize the need for fresh, wholesome produce in their community.

- Lawrence Farmer's Market—this city market is located downtown in a parking lot and is operated on Saturday mornings. I saw one vendor with a pet dog. Unfortunately, there are no designated dog defecation areas in this parking lot, nor are there signs enforcing feces removal codes. This can be problematic as there are people who eat the produce on site without first washing it. Three feces samples were collected; however, none were usable for analysis.

- Garden Incubator at John Taylor Park—this garden is part of the Common Ground program, a community garden and urban agriculture program created by the city of Lawrence in 2012. This program’s goal is to transform vacant or under-utilized city properties into vibrant sites of healthy food production for citizens. Three samples were collected near the gardens, and none were positive for parasites.

Parks—Lawrence classifies its parks as community parks (CP), neighborhood parks (NP), greenways-preserve areas (GP), and other areas. Presumably, this classification is due to the size and purpose of the parks, as well as the facilities.

- Walnut Park (NP)—two samples collected with no parasites found.
- Brook Creek Park (NP)—five samples collected with no parasites found.
- Naismith Valley Park (GP)—five samples collected; one sample positive for unknown parasite; one sample positive with 4+ roundworms, 2+ hookworms, and 2+ whipworms.
- Prairie Park (CP)—fifteen samples collected. Two samples were positive for hookworms and one had live larvae.

I found dog feces present on concrete sidewalks and in tall and short grassy areas. The grass in the neighborhood parks I visited was mowed to a short length; however, the grass in the greenways-preserve park and the community park was mowed only along the sidewalk. I believe that dog owners are less likely to perceive the need to pick up their dog’s waste if it is in

this tall grass or if they are in a “natural” setting. Because there is no signage or disposal facilities prompting owners to pick up after their dogs, it is easier to leave the stool than to pick it up and carry it “somewhere,” be it a city trash receptacle or home. However, even when trashcans were present, garbage was found around the picnic tables and playgrounds.

In retrospect, the internship at LDCHD was very valuable, providing insights to human public health and allowing the opportunity to explore my interests in the role of companion animals in public health. I had heard anecdotes about dog stool fouling different locales in Lawrence, and I was able to document that many public places in the city did indeed have problems with fecal contamination. From the information I gained from veterinarians, it appears there is problem with gathering, storing, and recalling data about intestinal parasites in pets. Finally, the responses to the surveys provided an indication of the practices and behaviors of dog owners in Lawrence, and perhaps a glimpse at the issues faced around the country.

Barriers to Addressing Zoonotic Parasitism

In 1973, a pair of urban planners from the University of California in Berkeley coined the term “wicked problems” and laid out the parameters for these issues.⁷¹ Although “tame problems” could be complex, they argued, wicked problems are more difficult to address because they cannot be clearly defined. Their multi-causal and ever-changing natures prevent a logical and linear approach to solving them. Accordingly, because wicked problems involve many organizations, there will be jurisdiction issues and conflicting goals. One of the most

⁷¹ Commonwealth of Australia, “Tackling Wicked Problems: A Public Policy Perspective,” (2007), 3.

important outcomes of wicked problems is that societies, as well as individuals, must work to change their behavior. For these reasons, chronic policy failures and unforeseen consequences often plague wicked problems.⁷² Zoonotic parasitism, and specifically soil-transmitted helminths, is an example of a wicked problem, and there are many challenges to be addressed.

Is there accurate information about soil-transmitted helminths?

For zoonotic diseases, data collection systems, often gathered independently by various human and animal health agencies, produce fragmented data and often fail to identify outbreaks of disease at early stages.⁷³ Although only 3% of known zoonotic pathogens have humans as their primary hosts, the scientific community often is dependent upon spotting outbreaks of cases in humans before these diseases are identified in a region.⁷⁴ Misdiagnosis and under-reporting of zoonotic diseases in poor communities takes an economic toll, as they do not receive the resources for treatment and prevention attained by more advantaged populations.⁷⁵ To understand the true burden of zoonotic diseases, first it is important to determine the incidence of these diseases, not just in less-developed countries, but also in more developed nations, where migration and shifting demographics will cause past statistics and assumptions to be grossly incorrect. This is especially true for zoonotic parasites, including

⁷² Ibid., 3-4.

⁷³ Solomon Ngutor Karshima, "A Multidisciplinary Approach in the Control of Zoonoses in Nigeria," *J. Vet. Adv.* 2, no. 12 (2012): 558.

⁷⁴ D. Frank, "One World, One Health, One Medicine," *The Canadian Veterinary Journal* 49, no. 11 (2008): 1063.

⁷⁵ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 282.

hookworms and roundworms. A successful, proactive surveillance structure would require integration of human and animal programs not found in present systems.⁷⁶

Not only are zoonotic parasitic diseases being underdiagnosed, their impact on people's health is being underestimated. The disability-adjusted life year (DALY) is the metric most used to assess the burden of disease, and these calculations involve adults between twenty and forty years. The DALY framework may work adequately in affluent communities, but will not work as well in areas with lower socioeconomic status, because environmental and social characteristics are "closely tied" to infectious co-morbidities.⁷⁷ As Payne et al. reported,

*"...the DALY framework is blind to much more important non-linear processes apparent in the epidemiology of all infectious species, including threshold phenomena such as herd immunity, dynamic delays, peak shift, disruption of endemic stability, and bi-stability of equilibrium states."*⁷⁸

Additionally, the DALY will not adequately address the issue of STH infections in children; in this instance, it will be more useful to use another metric, such as the Quality of Life (QOL) assessment or a cost-benefit analysis.^{79 80 81}

⁷⁶ Frank, "One World, One Health, One Medicine," 1063.

⁷⁷ R. J. Payne, L. Turner, and E. R. Morgan, "Inappropriate Measures of Population Health for Parasitic Disease?," *Trends Parasitol* 25, no. 9 (2009): 394.

⁷⁸ Ibid.

⁷⁹ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 282.

⁸⁰ Payne, Turner, and Morgan, "Inappropriate Measures of Population Health for Parasitic Disease?," 393-4.

⁸¹ Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," 1314.

Are there misperceptions about soil-transmitted helminths?

Yes, there are indeed. Perhaps the greatest misconception regarding zoonotic roundworms and hookworms is that people are only at risk of exposure during warm months or in tropical climates. Many people, even dog owners, consider themselves at little risk from these parasites, and the worms are viewed to be of little consequence in their lives. Multiple studies have shown that *Toxocara* eggs can easily survive in temperate environments, such as those in France, Canada, Germany, and Great Britain (see Figure 4).⁸² Eosinophilic enteritis in humans caused by *Ancylostoma caninum* is considered an “emergent disease” in Australia and the United States since the 1990’s; however, the true relationship between canine hookworms and humans is still under investigation.⁸³

⁸² Carabin et al., "Comparison of Methods of Sampling for *Toxocara* Species and Fecal Coliforms in an Outdoor Day Care Environment," 151.

⁸³ Traversa, "Pet Roundworms and Hookworms: A Continuing Need for Global Worming," 6.

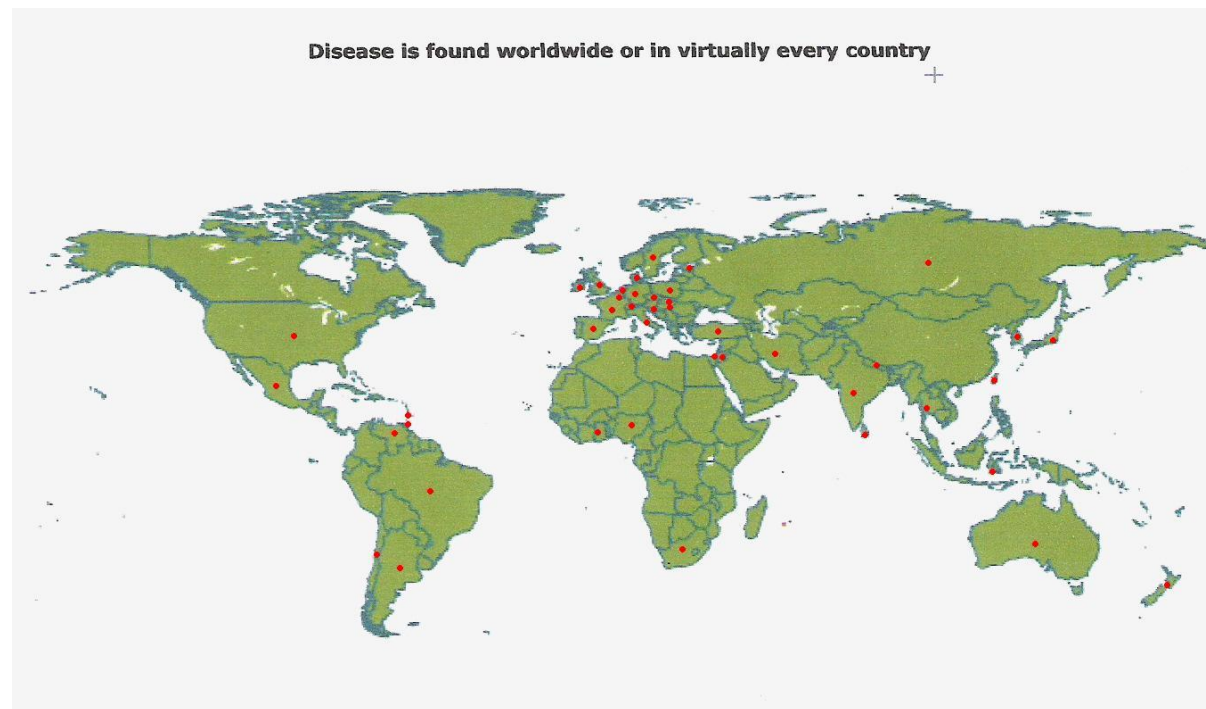


Figure 4. Map of countries with Toxocariasis.

SOURCE: Stanford University HUMBIO103

<http://web.stanford.edu/group/parasites/ParaSites2005/Toxocariasis/whole%20thing.htm>

Anthelmintics and sanitation measures (e.g., access to latrines and clean water) have controlled the presence of zoonotic parasites for decades in developed countries. This has decreased the dramatic role that intestinal parasites have in the lives of pets and pet owners. However, there is a misconception about the safety and effectiveness of anthelmintics. It is common knowledge, in veterinary circles, that many over-the-counter (OTC) products are sold with inappropriate dosages and incomplete instructions. Is it any wonder that these items, although considered safe because of their placement on the store shelf, are likely to have ill effects or be ineffective?⁸⁴ Some scientists fear that the indiscriminate use of OTC dewormers in concentrated groups of dogs may contribute to increased parasite resistance to current

⁸⁴ C. Gagnon, "Concerns About Recommending over-the-Counter Drugs to Treat Helminthiasis," *The Canadian Veterinary Journal* 40, no. 6 (1999): 379.

drugs, similar to what has occurred in livestock and horse parasites, creating a situation where new drugs must continually be developed to effectively treat and control parasites.^{85,86}

Decreased owner compliance with veterinary recommendations for deworming and parasite prevention is also a factor in the presence of parasites. The owner's reasons may not only include their misperception of the impact of parasites, but may involve other factors, including economic (e.g., disposable income) and inaccurate or incomplete messages presented to society as a whole (e.g., organic is more healthy). The public routinely hears about the danger of chemicals; this subliminally may contribute to a pet owner's decreased compliance in routine use of anthelmintics. Veterinarians too often stress vaccinations and other health considerations (such as weight and dental health) and do not strongly recommend routine fecal analysis and compliance with parasite prevention programs. Only with careful and thorough fecal analysis will veterinarians be able to detect a change in parasite prevalence or failure of an implemented program.

Parasitic diseases need to be studied more carefully, with attention given to not only cause and effect, but also recognizing the confounding roles played by polyparasitism, nutrition, and socioeconomic factors.⁸⁷ Once there is a better understanding of these diseases, then the entire healthcare community will be able to provide good education, at both the personal and public level.

⁸⁵ Traversa, "Pet Roundworms and Hookworms: A Continuing Need for Global Worming," 9.

⁸⁶ S. R. Kopp et al., "Application of in Vitro Anthelmintic Sensitivity Assays to Canine Parasitology: Detecting Resistance to Pyrantel in *Ancylostoma Caninum*," *Vet Parasitol* 152, no. 3-4 (2008).

⁸⁷ Payne, Turner, and Morgan, "Inappropriate Measures of Population Health for Parasitic Disease?," 395.

Is zoonotic soil-transmitted helminth disease a priority?

Considering the importance of parasites, and their profound effects upon human and animal health in many parts of the world, it is intriguing that these diseases receive less than 1% of research funds worldwide; is it any wonder then, that STHs are considered “neglected zoonotic diseases?”⁸⁸ Once a disease is understood and controlled, it falls out of the common awareness of a society, and from there it loses the attention of a once-rapt medical community. As Fisman and Laupland note:

“...a defining paradox of disease-control activities is the fact that once success is achieved (eg, in the control of such zoonotic threats as bovine tuberculosis or brucellosis), there is a tendency on the part of the public and some medical professionals to question the necessity of interventions that produced such health yields.”⁸⁹

Why is there such resistance to pursuing practices that were so successful in the past? Is it because there is no clear understanding of the effectiveness of those programs? Has there been a change in medical culture or a loss of education concerning “conquered” diseases? Are some practices (e.g., quarantine and compulsive treatment) now considered unethical or

⁸⁸ Hotez et al., “Helminth Infections: The Great Neglected Tropical Diseases,” 1312. The authors note that between 1975 and 2004 there were 1,556 new chemicals brought to market, but only four (albendazole, oxfeniquine, praziquantel, and ivermectin) were developed for treatment of helminthiasis.

⁸⁹ D. N. Fisman and K. B. Laupland, “The ‘One Health’ Paradigm: Time for Infectious Diseases Clinicians to Take Note?,” *The Canadian Journal of Infectious Diseases & Medical Microbiology* 21, no. 3 (2010): 113.

politically incorrect?⁹⁰ Studying the past is seldom a priority for developing future programs, but it should be.⁹¹

Long-term interventions must be easy to implement, widely available, and self-sustaining. It is doubtful that any project that requires external funding or support will be viable in the long-term. Research institutions and commercial entities must make investments in this area. These organizations should reside outside of the government domain; Hotez et al. note that unfortunately there are only a handful of these groups at this time.⁹² Until there is greater emphasis by large, multi-national human-drug companies to invest time and monies into anthelmintic research, the majority of advances in this drug class will continue to come from the veterinary community.⁹³

⁹⁰ Allen Tullos, "Book Review: The Germ of Laziness by John Ettling," *Southern Changes* 4, no. 6 (1982): 15-17. This author describes the officials with the Rockefeller Sanitary Commissions as "hookworm evangelists."

⁹¹ "Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference", (paper presented at the Veterinary public health and control of zoonoses in developing countries, Teramo, Italy, 2003 1999). A good example of this dilemma was presented in the FAO proceedings: "The merits of a 'vertical' over a 'horizontal' approach to the control of zoonotic diseases was the subject of considerable discussion, using cystic echinococcosis (CE) as an example. The vertical approach is defined as considering CE as a specific parasitic infestation with a causative agent (*Echinococcus granulosus*), final host (dog) and intermediate hosts (usually sheep but also other grazing animals). The horizontal approach as defined by Dr A. Mantovani (Contribution 32) considers CE as a complex in which there are many components besides the agent and hosts, including all of the suitable environmental and social conditions necessary for perpetuation of the life cycle. Thus a horizontal approach tends to be very long term, including health education, diagnosis, control, improved sanitation, meat inspection and long term primary health care. Dr P. Schantz (Contribution 41) stated that while horizontal approaches to the control of zoonotic diseases are always beneficial and do reduce transmission, they have not been effective in permanently reducing infection in animal and human hosts. He argues that vertical approaches directly targeted at the parasite, using dog population control and treatments supported by health education and community involvement, have been successful in some situations. For example CE has essentially been eliminated from New Zealand and Tasmania, and significantly reduced in Cyprus, Uruguay and parts of Chile and Argentina (Eckert et al., 2001)."

⁹² Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," 1312.

⁹³ Ibid., 1318.

If it is difficult for health professionals to determine the true impact of parasitism on a community, how are policymakers and legislators expected to “appreciate the more subtle aspects of dynamical interactions between individual behavior and group epidemiology”?⁹⁴ In this author’s opinion, for example, incoherent and lax U.S. immigration policies will decrease disease surveillance and increase marginalized communities, resulting in a loss of proactive healthcare and increasing zoonotic parasite prevalence. Studies have shown that children from countries in the western hemisphere have increased health problems related to STH infection.⁹⁵

Do the veterinary and human healthcare communities have dissimilar views on the importance of different zoonotic diseases?

Part of the resistance to change is that the goals of the healthcare community differ from those of the agricultural authorities and the veterinary profession (e.g., insecticide exposure and zoonotic potential). Biases of healthcare providers and the public health community have led to underreporting zoonotic parasitism. Rather than focusing only on those diseases which are perceived to have the highest incidence/prevalence in a community, all local health-related industries need to come together to get a clear picture of the true state of zoonotic disease in their community.

Are human healthcare providers educated about zoonotic diseases and are they aware of their patients’ exposures?

In today’s healthcare arena, physicians are not trained to adequately address zoonotic diseases. A survey in Toronto, Canada found that less than 10% of physicians routinely asked

⁹⁴ Payne, Turner, and Morgan, "Inappropriate Measures of Population Health for Parasitic Disease?," 394.

⁹⁵ C. Romero Nunez et al., "Prevalence and Risk Factors Associated with Toxocara Canis Infection in Children," *ScientificWorldJournal* 2013 (2013): 3.

patients about pet ownership.⁹⁶ Another survey in Ontario revealed that only 22% of respondents reported that doctors and staff asked about pets.⁹⁷ Yet another survey concluded that doctors do not understand zoonotic diseases and do not make their prevention a priority in practice.⁹⁸

Ignorance of healthcare providers can result from cultural misunderstanding (for instance, food consumption, sanitary practices, and health behaviors). In much of the United States, human healthcare providers and patients are not necessarily part of the same community; patients may travel many miles or visit a different part of their city to access healthcare. Physicians may not know the environment in which the patient resides, and may not have a holistic understanding unless they intentionally ask pointed questions. In the vastness of U.S. cultures and ethnic backgrounds, the doctor cannot assume that their cultural experience is similar to that of their patients'.

Is public education about zoonotic diseases the responsibility of the human healthcare community or the veterinary profession?

Both physicians and veterinarians are responsible for the healthcare of families, although from different aspects. Physicians need to look at pets as members of the family unit and consider zoonotic diseases as part of their rule-out lists. Veterinarians need to spend time

⁹⁶ Luisa Barton, "Barriers to One Health in Practice" (paper presented at the Central Veterinary Conference, Kansas City, Missouri, 2013).

⁹⁷ Stull et al., "Household Knowledge, Attitudes and Practices Related to Pet Contact and Associated Zoonoses in Ontario, Canada," 6.

⁹⁸ Barton, "Barriers to One Health in Practice."

with each client, sharing not just knowledge about animal health, but also teaching about zoonotic diseases and prevention.

However, having a one-size-fits-all plan does not work. Interventions that have worked well in one community or region may not work in another due to cultural, social, and economic incongruities.⁹⁹ In the present situation, there are many people not receiving ideal healthcare—the ten-minute office visit is hardly conducive to taking a thorough history. Likewise, veterinarians, often faced with time constraints, may not take the time to understand the family dynamics and risks, nor reinforce personal and domestic sanitary behaviors.

Local public health departments are probably better situated than many organizations to address the healthcare needs of marginalized populations. However, with shortening budgets and increasing staff responsibilities, it is no wonder that these organizations have very little resources dedicated to zoonotic disease prevention (save perhaps rabies). Particularly troubling is a survey that showed that high-risk populations did not have any better understanding about zoonotic diseases and pet-associated risks than the public.¹⁰⁰ The people who most need the information about their increased risk are not getting it; this is a failure of the veterinary profession, healthcare providers, and the public health community.

⁹⁹ K. Darwin Murrell, "Presidential Address: Dr. Stoll's Wormy World Revisited: The Neglected Animal Diseases," *The Journal of Parasitology* 80, no. 2 (1994): 184.

¹⁰⁰ Stull et al., "Household Knowledge, Attitudes and Practices Related to Pet Contact and Associated Zoonoses in Ontario, Canada," 12.

Are there established communication pathways between the human and animal healthcare providers?

The lack of communication between veterinarians, physicians, and public health officials has led to a fragmented healthcare system and an incomplete understanding of the true healthcare needs of communities.¹⁰¹ One obstacle is privacy—veterinarians are usually not aware of the immune status of the members of the pet's household. Laws intended to protect patients' privacy also prevent the dissemination of health-related information. A physician may not have a professional relationship with a veterinarian, unless the doctor is a pet owner or the veterinarian is a patient. Except for a few regional programs, there are no conduits routinely used to connect human and animal healthcare providers at the community level.¹⁰²

What can be learned?

Zoonotic diseases, even parasitic ones, are multi-faceted issues that pose many difficult challenges. Parasitic diseases are underdiagnosed, and their detrimental effects are underappreciated. Payne et al. states: "The dominant metric for setting public health priorities, the disability-adjusted life year (DALY), is unsuited for parasitic infections."¹⁰³ Parasitologists need to develop a method to better measure the true costs of parasitism by taking into account co-morbidities caused by polyparasitism. Epidemiologists must account for community levels of infection and recognize that pathology due to parasitism is non-linear.¹⁰⁴

¹⁰¹ Barton, "Barriers to One Health in Practice."

¹⁰² One program that has emerged in recent years is in central Missouri. The University of Missouri in Columbia, MO has colleges for medicine, veterinary medicine, and nursing. This situation has brought together professionals that have successfully collaborated on the ReCHAI program ([Research Center for Human-Animal Interaction](#)).

¹⁰³ Payne, Turner, and Morgan, "Inappropriate Measures of Population Health for Parasitic Disease?," 393.

¹⁰⁴ Ibid.

By providing misleading comparisons regarding the health impact of different diseases, the true burden of parasitism is being neglected, which leads to further neglect when setting priorities for funding of research and health interventions.¹⁰⁵

Increasing research and improving funding alone will not solve the problem of zoonotic parasitism. Parasitic diseases can cause subtle and low-grade disease and disabilities; it is often difficult to separate the symptomology of parasitic infection from clinical outcomes of disease. Effects of parasitism can be along a spectrum of clinical signs—how is the healthcare community to determine causality and significance when there is such variability between symptomatic and asymptomatic patients? Because outcomes of infection are also affected by other confounding factors such as nutrition and socioeconomic status, how is the true burden of zoonotic intestinal parasitism to be defined? Scientists and the entire health care community must address these and other questions to address zoonotic parasitism.

The Solution: A Multidisciplinary Approach

A multidisciplinary approach would be very beneficial in the study of neglected zoonotic parasitic diseases and in efforts to address the burdens on individuals, communities, and societies. It is important to understand not only the financial costs of lost life and productivity, but also the risk factors that contribute to the persistence of these diseases in animal and human hosts. Legislators and public health officials should create policies based on sound scientific evidence, exploiting the successful attributes of historic public health endeavors, but

¹⁰⁵ Ibid.

remaining open to new and creative approaches to zoonotic disease control. Once all stakeholders more fully understand these processes, only then can adequate resources be devoted to developing effective methodologies for outreach, education, and treatment. The FAO reports, “These strategies need to be technically sound, cost-effective, equitably available and take advantage of the economies of scale normally associated with the public good delivery of services.”¹⁰⁶

Clearly, with regard to combating zoonotic parasitism, one size does not fit all. Neglected zoonotic diseases have fallen into a gap between the human and animal healthcare industries. Classical approaches to health and disease, including biomedical and behavioral models, do not fully appreciate the complexity of this issue. A political economy approach—one that recognizes the political, economic, social, and cultural contexts of health and illness—would appear to be a perfect fit for addressing zoonotic parasitism.¹⁰⁷ However, this approach minimizes the very important biomedical and behavioral aspects of these diseases, while relying upon implementation of new programs and redistribution of assets. This topic requires a multidisciplinary approach, which “involves drawing appropriately from multiple disciplines to redefine problems outside of normal boundaries and reach solutions based on a new understanding of complex situations.”¹⁰⁸

¹⁰⁶ “Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference.” This quote is one of the conference objectives.

¹⁰⁷ Deborah J. Briggs, “Dmp844-Global Health Issues in a Dynamic World,” (Manhattan, Kansas: Kansas State University, 2012).

¹⁰⁸ “Multidisciplinary Approach,” Wikipedia, http://en.wikipedia.org/wiki/Multidisciplinary_approach.

This paper will look at two tactics to addressing zoonotic parasitism. First, the One Health concept considers humans and animals as belonging to the same medical community, sharing not only pathogens, but also environmental and social risks. Secondly, the Risk Analysis Framework, a tool used in food safety and trade, brings together the scientific and social aspects of a risk, and then manages them with legislation, communication, and education, in order to be both responsive and proactive. Both approaches have a great deal to contribute to this issue.

The One Health Concept

The concept of One Health concerns interconnected relationships between the environment, wildlife, domestic animals, and humans (see Figure 5).^{109 110} This is not a new idea—when the first veterinary school was founded in 1761 in Lyon, France by Claude Bourgelat, he wrote, “We have realized the intimacy of the relation which exists between the human and the animal machines; this relation is such that either medicine will mutually enlighten and perfect the other when we discard a derisory, harmful prejudice.”¹¹¹ Doble and Fevre said: “Two tenets at the core of the One Health concept are the belief that human and animal health are irrevocably entwined and that the improvement of both requires close

¹⁰⁹ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 281.

¹¹⁰ M. J. Day, "One Health: The Small Animal Dimension," *ibid.* 167, no. 22 (2010): 847.

¹¹¹ *Ibid.*

collaboration between the medical and veterinary professions with support from allied disciplines.”¹¹²

The transdisciplinary spirit of medicine was lost in part due to the vastly increasing complexity of medicine and the growth of specializations. The general practitioner cannot stay ahead of every advancement. The growth of the specialist is leading to tunnel vision, which Victor Bressler, a medical humanist, referred to as “a medical tower of Babel.”¹¹³ Additionally, human medical practice and culture tend to focus on individual’s illness complaints, rather than taking a holistic approach and examining environment and community health.¹¹⁴ Although veterinarians are trained in “herd health,” they, too, tend to view health in terms of animal injuries and diseases; they may not see how those diseases relate to the bigger picture of public health.^{115 116}

¹¹² L. Doble and E. M. Fevre, "Focusing on Neglected Zoonoses," *ibid.* 166, no. 18.

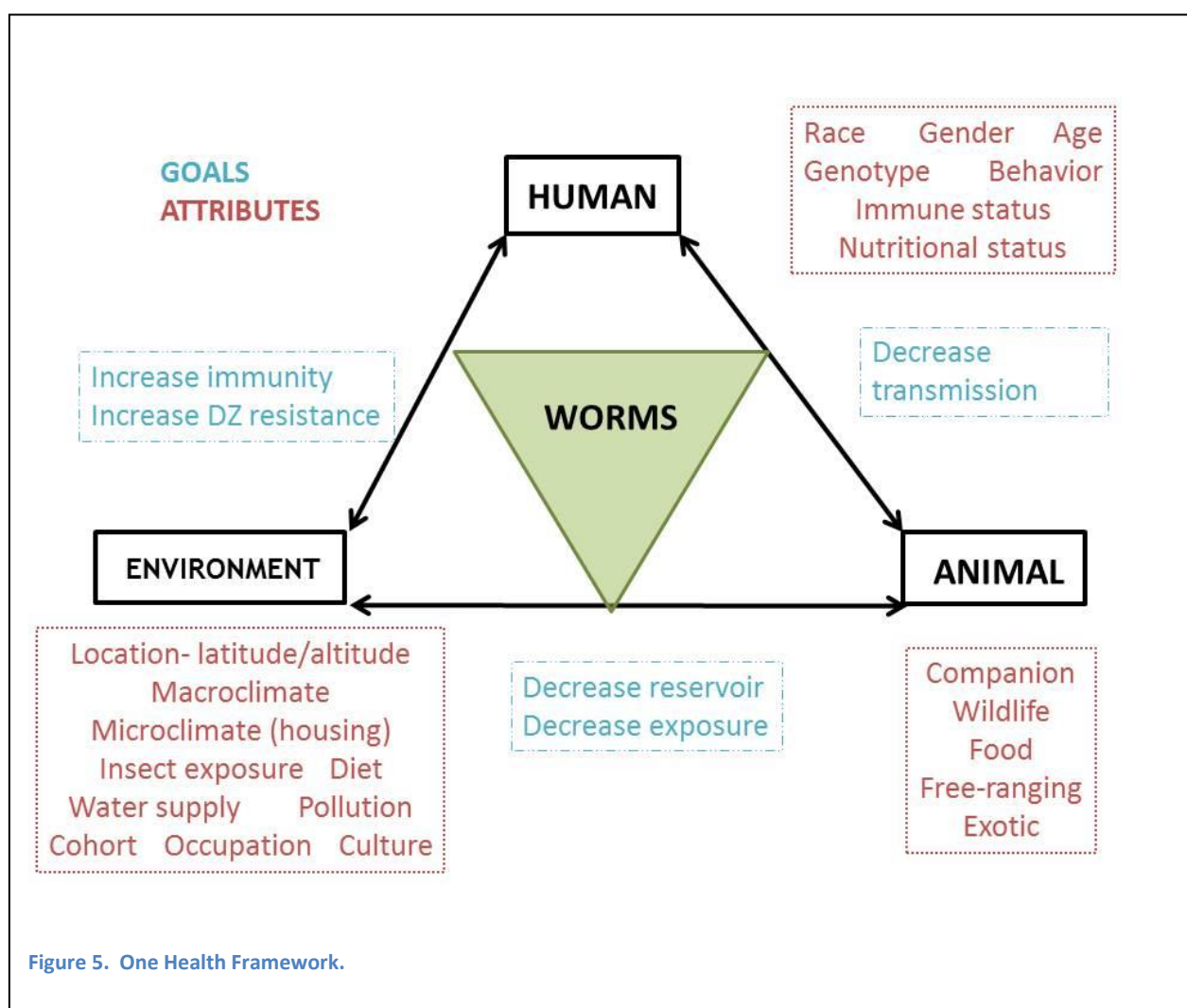
¹¹³ Fisman and Laupland, "The 'One Health' Paradigm: Time for Infectious Diseases Clinicians to Take Note?," 112.

¹¹⁴ "Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference."

¹¹⁵ *Ibid.*

¹¹⁶ "The 'One Health' Paradigm: Time for Infectious Diseases Clinicians to Take Note?," 112.

In the past, the healthcare community has focused on emergency responses to zoonotic diseases rather than looking at the dynamics of relationships—between pets and owners, and between hosts, pathogens, and environments. The focus needs to change from reacting to downstream effects and begin examining upstream causes. Intervention in zoonotic helminthic diseases has the opportunity to increase well-being and improve socioeconomic status by increasing health and productivity, especially in marginalized and rural populations. The key to



managing zoonotic diseases is to analyze the attributes in common between humans and animals, bringing together all stakeholders to address different facets and implement policies.

Concerning all zoonotic diseases, it is critical to adopt a One Health approach now. Researchers estimate that approximately 61% of human infectious diseases originated in animals.¹¹⁷ Frank notes that 60.3% of emerging infectious diseases (EID) are zoonotic in nature; the “emerging disease hotspots” where EIDs are most likely to develop strongly correlate with environmental, ecological, and socioeconomic factors.^{118 119} Human and animal healthcare workers must become stakeholders with other disciplines to identify the risks and prevent EIDs to the extent possible. Unfortunately, the lines of communication between animal and human health industries are indistinct and often non-existent, especially in respect to public health. Too often zoonotic diseases are considered on an individual basis; the shared animal-human interactions (such as pet-ownership and food production) are often overlooked as “background noise.”¹²⁰

“Veterinarians, physicians, and public health agencies have necessary roles to play in the prevention of zoonotic diseases and have contact with the public in different settings and for

¹¹⁷ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 281-2.

¹¹⁸ Frank, "One World, One Health, One Medicine," 1063.

¹¹⁹ Trevejo, Barr, and Robinson, "Important Emerging Bacterial Zoonotic Infections Affecting the Immunocompromised," 494. According to this paper, “The Institute of Medicine defines emerging infections as those whose incidence in humans has increased within the past two decades due to factors such as changes in human demographics and behavior; technology and industry; economic development and land use; international travel and commerce; microbial adaption and change; and breakdown of public health measures.”

¹²⁰ Fisman and Laupland, "The 'One Health' Paradigm: Time for Infectious Diseases Clinicians to Take Note?," 112.

different reasons.”¹²¹ One option to improve public health agencies’ knowledge of zoonotic diseases is to meet regularly with veterinarians and physicians, to facilitate discussions, and to develop programs and materials to educate healthcare workers and the public. Besides collaboration between organizations, data collection is one of the most important steps needed. The system for data collection and information dissemination should be readily available to all healthcare providers and public institutions. There needs to be a secure, online method for officials to monitor and report zoonotic diseases in their communities.¹²²

Working with their local schools, governments, healthcare communities, service organizations, and humane societies, veterinarians can spread the messages of disease risk and responsible pet ownership. Veterinarians should be leaders in their communities advocating spay/neuter programs. Studies have shown people believe that veterinarians, their family doctors, and the public health department, in that order, should publicly disseminate information about zoonotic diseases.¹²³ Addressing zoonotic parasitism is a good way to strengthen the integration of veterinarians into the public health community.

The goal of a successful One Health program is to increase public awareness regarding the risks of zoonoses while maintaining public confidence. Adopting a One Health approach should be ideal for addressing ZPD as this method gives public health a broader scope.

¹²¹ B. A. Lipton et al., "A Survey of Veterinarian Involvement in Zoonotic Disease Prevention Practices," *Journal of the American Veterinary Medical Association* 233, no. 8 (2008): 1247.

¹²² Ibid.

¹²³ Stull et al., "Household Knowledge, Attitudes and Practices Related to Pet Contact and Associated Zoonoses in Ontario, Canada," 7.

However, despite the enthusiasm with which many branches of healthcare had embraced One Health, integration into actual practice is not occurring.¹²⁴ It can be difficult to implement a One Health strategy into developed countries where culture and bureaucracies are entrenched. Legislation, along with emphasis on health, monetary, and societal benefits, may encourage the “public” to get into the practice of public health.¹²⁵ Policies must be coordinated between all levels of government by bringing all stakeholders—veterinarians, healthcare providers, legislators, and members of health, agricultural, and environmental organizations—into the process of decision-making.¹²⁶

The Risk Analysis Framework

A Risk Analysis is a “systematic way of gathering, evaluating, recording, and disseminating information leading to recommendations for a position or action in response to an identified hazard.”¹²⁷ A risk analysis consists of four steps (see Figure 6):

1. Hazard identification: The adverse event is described, to the best of current ability, by known characteristics.
2. Risk Assessment: The probability of the occurrence of the adverse event is considered, as well as the consequences and degree of uncertainty. This ongoing process will change as more information becomes available.
3. Risk Management: This is the strategies and action-steps implemented to address the hazard. Risk management can be proactive in an effort to prevent the adverse event, or responsive after the event has occurred.

¹²⁴ Karshima, "A Multidisciplinary Approach in the Control of Zoonoses in Nigeria," 561.

¹²⁵ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 285.

¹²⁶ Karshima, "A Multidisciplinary Approach in the Control of Zoonoses in Nigeria," 563.

¹²⁷ Justin Kastner, "Dmp816: Trade and Agricultural Health," (Manhattan, Kansas: Kansas State University, 2011).

4. Risk Communication: All stakeholders must have access to open and accurate exchange of information and ideas related to addressing the hazard. Not only does this ensure that all parties have the same evidence, but it also builds public confidence.¹²⁸

Successfully addressing zoonotic parasitism using a risk analysis framework will only be achieved if the framework encompasses both human and animal issues; this will require a great deal of commitment from all parties involved.

¹²⁸ Food and Agriculture Organization of the United Nations and World Health Organization, "FAO/WHO Guide for Application of Risk Analysis Principles and Procedures During Food Safety Emergencies," (2011).

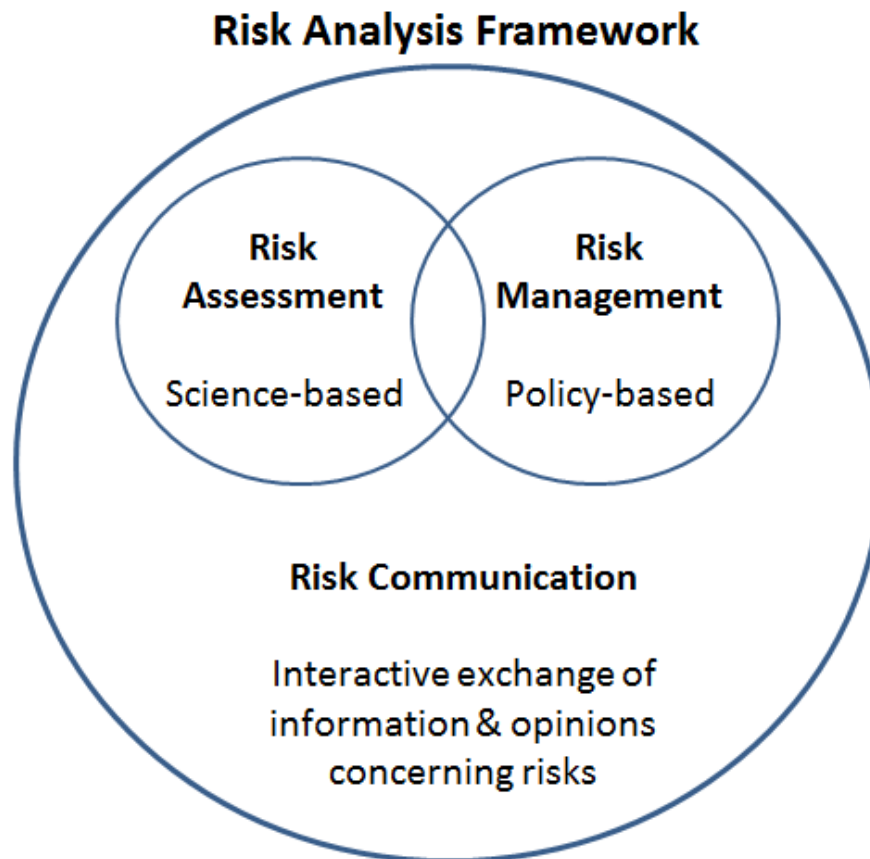


Figure 6. Risk Analysis Framework.

SOURCE: Kansas State University DMP816 Trade & Agricultural Health, 2011.

Risk Analysis—Science-based

As shown earlier in this paper, zoonotic parasitic diseases are a neglected problem in the world, including in developed countries like the United States, and there are many issues that need to be addressed:

- Despite decades of access to inexpensive and readily-available anthelmintic medication, research shows that intestinal parasitism in dogs in the United States is still very common.

- Owner attitudes towards their pets are liberalized—pets are often seen as children, having access to personal spaces in the home, and traveling with their owners outside of their residence.
- Studies show that human healthcare providers are largely unaware of the dangers of STHs.
- There is a lack of epidemiologic data in countries where helminthic diseases are endemic, so it is no wonder there is a shortage of reliable data in developed countries where STHs are not as prevalent. Smith, et al. state, “Toxocara, like many other zoonotic infections, produces a disease burden that is hard to evaluate and quantify.”¹²⁹
- There have not been enough studies of daycare centers to assess adequately the true potential for zoonotic disease spread in this setting.
- Additionally, many researchers in these settings had a particular bias—they predetermined where the children were most likely to play and where the animals were most likely to defecate.¹³⁰

As with any wicked problem, this issue will require the attention of stakeholders from many fields. It is important that students, who have an interest and talent in science, be encouraged to study parasites and their respective diseases. Epidemiologists can help provide continuity across the various health industries. They could accomplish this by providing standardized case definitions and ensuring that data are collected and analyzed using specific criteria and descriptive statistics. The FAO believes, “This harmonization is best achieved by adherence to standards developed by international organizations such as OIE and WHO.”¹³¹

Confounding co-morbidities and often-present polyparasitism means that STHs require more research to sift through risk determination. The information provided by the NHANES III

¹²⁹ Smith et al., "How Common Is Human Toxocariasis? Towards Standardizing Our Knowledge," 186.

¹³⁰ Carabin et al., "Comparison of Methods of Sampling for Toxocara Species and Fecal Coliforms in an Outdoor Day Care Environment," 150.

¹³¹ "Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference."

showed that poverty, geography, ethnicity, and sex were risk factors for *Toxocara* exposure; however, according to Congdon and Lloyd, these factors need to be examined at a local level to understand the true significance of individual and geographic risks.¹³² These authors note that the *Toxocara* seroprevalence in the U.S. is “relatively high” when compared to other similarly developed countries.¹³³ They note that regional poverty and socio-spatial inequality may account for the differences in seropositivity between regions of the United States. Social scientists may provide valuable insight on human culture and behaviors that promote emerging diseases; as part of a targeted-surveillance team, they would be able to predict where emergence is likely to occur.¹³⁴ Social scientists have proposed a conceptual model of the human/domestic animal/wildlife interface that includes four aspects:

1. host adaptation;
2. host range and spatial overlap;
3. host population and ecology; and
4. host physiology and invasion potential.¹³⁵

It is essential that targeted-need assessments and interventions be used, especially with marginalized populations in society. As the incidence of immune-related chronic diseases begin to rise, such as asthma and rheumatoid arthritis, it is important to look at co-morbidities to see

¹³² Congdon and Lloyd, "Toxocara Infection in the United States: The Relevance of Poverty, Geography and Demography as Risk Factors, and Implications for Estimating County Prevalence," 15.

¹³³ *Ibid.*, 22.

¹³⁴ Alexander and McNutt, "Human Behavior Influences Infectious Disease Emergence at the Human—Animal Interface," 526.

¹³⁵ *Ibid.*, 524.

if there is a connection between these diseases and parasitism.^{136 137} However, it must be recognized that there may not be a direct association between infestation and affliction (like Toxocarasis and asthma), but rather associations in risks that need to be discovered and examined.

Therefore, there should be a requirement for tools that integrate human and animal health and promote professional collaboration. In considering zoonotic parasitism as a cause of human disease, doctors should make every attempt to obtain a correct diagnosis. The family genogram is a tool that identifies members of a family, their relationships, and associated health problems.^{138 139} Another tool recently developed is the Pet Query Framework (PQF), which allows healthcare providers to supplement a patient's health history by assessing contact with animals, as well as identifying the specific species of animals and the nature of contact.¹⁴⁰

To determine the extent of risk and the success of interventions, improved methods for surveilling zoonotic parasitism and environmental fecal contamination should be sought. This is important, not just for the helminths discussed in this paper, but also for viral and bacterial pathogens, some of which can remain viable in fecal matter for prolonged periods.¹⁴¹ The use

¹³⁶ Congdon and Lloyd, "Toxocara Infection in the United States: The Relevance of Poverty, Geography and Demography as Risk Factors, and Implications for Estimating County Prevalence," 23.

¹³⁷ E. Pinelli and C. Aranzamendi, "Toxocara Infection and Its Association with Allergic Manifestations," *Endocrine, Metabolic & Immune Disorders Drug Targets* 12, no. 1 (2012): 37.

¹³⁸ Luisa Barton, "Practice-Based Tools for One Health," (Toronto, ON: Ryerson University).

¹³⁹ Frank, "One World, One Health, One Medicine," 1604.

¹⁴⁰ Barton, "Practice-Based Tools for One Health."

¹⁴¹ Carabin et al., "Comparison of Methods of Sampling for Toxocara Species and Fecal Coliforms in an Outdoor Day Care Environment," 150. This publication notes a study in Montreal, Canada, where one-third of seagulls were

of GIS (geographic information system) or RS (remote sensing) to provide geographical distributions makes epidemiologic data more precise and provides valuable feedback on program effectiveness. This type of geographic surveillance has proven an effective and sustainable tool in Chad and Uganda.¹⁴² Having tools like these in place can save a great deal of time and money by leading to targeted and specific interventions.¹⁴³

Risk Management—Policy-based

*"Public health emergencies are failures of prevention."*¹⁴⁴

Stakeholders from all industries and levels of government must come together to determine which best practices will lead to successful interventions against ZPDs. Although public health is generally thought of as a public endeavor, there is a role for the private sector. Many people focus on human health when developing interventions for zoonotic diseases; however, focusing on the animal's role in the disease may provide the best control.¹⁴⁵

Past efforts at controlling zoonotic parasitic diseases have proven effective, showing that dedication and determination, along with proper understanding and implementation, can lead to tangible results. One of the first, and most successful, public health programs in the United States was the campaign against human hookworm disease. Addressing the seriousness

harboring *Campylobacter* species, *Salmonella* species, and *Listeria monocytogenes* in their cloacae. Although the transmission rates are unknown, the risk for environmental contamination via bird droppings is likely.

¹⁴² Mascarini-Serra, "Prevention of Soil-Transmitted Helminth Infection," 175.

¹⁴³ Two such tools are Epi Map and Epi Info. Epi Info is a program developed by the CDC for disease surveillance. (<http://wwwn.cdc.gov/epiinfo/>) Epi Map is a free software module based upon Esri MapObjects software that applies geographic boundaries for Epi Info information. (http://en.wikipedia.org/wiki/Epi_Map)

¹⁴⁴ "Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference."

¹⁴⁵ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 284.

of this disease in the southeastern United States, parasitologist Charles W. Stiles and journalist Walter Hines Page brought hookworms to national attention. Their efforts led John D. Rockefeller, Sr. to form the Rockefeller Sanitary Commission (RSC) for the Eradication of Hookworm Disease and fund the organization with a one-million dollar grant.^{146 147} The Rockefeller Foundation immediately embarked on another campaign by creating the International Health Commission to contend with malaria and yellow fever, along with hookworm disease.¹⁴⁸ In 1914, the United States government, influenced by the RSC, passed the Agricultural Extension Act; this act created county extension programs, employed home demonstration advisors, and sponsored county 4-H clubs.¹⁴⁹

Although “eradication” was part of the official name of the Rockefeller Sanitary Commission, the true goal of combating zoonotic parasitic diseases is not to eradicate, but simply to “blunt the curse.”¹⁵⁰ Controlling these diseases must focus more on limiting exposure to viable eggs and larvae in the environment than on treating individuals. Emphasis on education and changes to culture are probably more important to fighting these diseases than medical advancements. Prevention of zoonotic parasitic diseases is always cheaper than the cure.

¹⁴⁶ Helen J. Power, "History of Hookworm," in *ELs* (John Wiley & Sons, Ltd, 2001).

¹⁴⁷ "Charles Wardell Stiles," <http://rockefeller100.org/biography/show/charles-wardell-stiles>.

¹⁴⁸ "Rockefeller Sanitary Commission (RSC)," <http://rockefeller100.org/exhibits/show/health/rockefeller-sanitary-commissio>.

¹⁴⁹ Ackert, "Review of Research in Parasitology in Kansas During the Last Century," 167-8.

¹⁵⁰ Norman R. Stoll, "This Wormy World," *The Journal of Parasitology* 85, no. 3 (1999): 8.

Patients in the United States should be encouraged to seek medical advice and preventive therapies before traveling; in this manner, they would know in advance precautions to take when traveling to CLM endemic regions. Additionally, with the ease of travel in today's world, physicians should make it a point to ask about previous travel. Although it is well known that VLM seroprevalence is high in certain areas of the world, there is a dearth of data following immigration into developed countries.¹⁵¹ It is very difficult to diagnose zoonotic parasitism, but any physician who finds eosinophilia in patients from STH-prevalent regions should be acutely aware of the possibility of parasitism, especially if the patient presented with abdominal or respiratory signs.¹⁵²

Toxocara is the "most common human parasitic worm in the United States," and it is likely to become more important as this country experiences large-scale immigration and demographic shifts, as people move from endemic STH regions to non-endemic areas.¹⁵³ Any successful endeavor to combat soil-transmitted helminths will need to include programs that involve individuals, small groups, and communities. A control program for STHs could be incorporated into another more developed program that would, for minimal cost, provide additional benefits against these parasitic diseases. Any programs would necessarily include:

- Improvement in diagnostic testing with increased epidemiologic surveillance;
- Detection of cases followed by appropriate therapy and education;

¹⁵¹ M. C. Turrientes et al., "Visceral Larva Migrants in Immigrants from Latin America," *Emerging Infectious Diseases* 17, no. 7 (2011): 1263.

¹⁵² *Ibid.*, 1264.

¹⁵³ P. J. Hotez and P. P. Wilkins, "Toxocariasis: America's Most Common Neglected Infection of Poverty and a Helminthiasis of Global Importance?," *PLoS Negl Trop Dis* 3, no. 3 (2009): 1.

- Routine analysis of fecal samples from pet, shelter, and feral dogs (especially intact, breeding bitches and puppies) and chemoprophylaxis; and
- Improvement in sanitation, with an emphasis on hand-washing and access to clean water.^{154 155}

Mathers, et al. wrote, "Governments and international agencies are faced with setting priorities for health research and investment in health systems and health interventions in a context of increasing health care costs, increasing availability of effective interventions, and numerous and diverse priorities and interest groups."¹⁵⁶ Policymakers must consider the value of these programs, measured across not only time, but also space. It is not always easy to balance the science with the policies (see Figure 7).

It is possible to legislate the public towards health, but it is not always the most efficient way to get results. For instance, the governments of Iceland and the People's Republic of China have passed laws targeting dog owners. The laws include punitive taxes and prohibition of dogs in cities. These laws did work and dog ownership has decreased. However, both countries had to spend a great deal of time and money to educate the public in order to garner support for their programs and not ill will.¹⁵⁷

¹⁵⁴ Ibid., 3.

¹⁵⁵ Lee et al., "Epidemiologic and Zoonotic Aspects of Ascarid Infections in Dogs and Cats," 160.

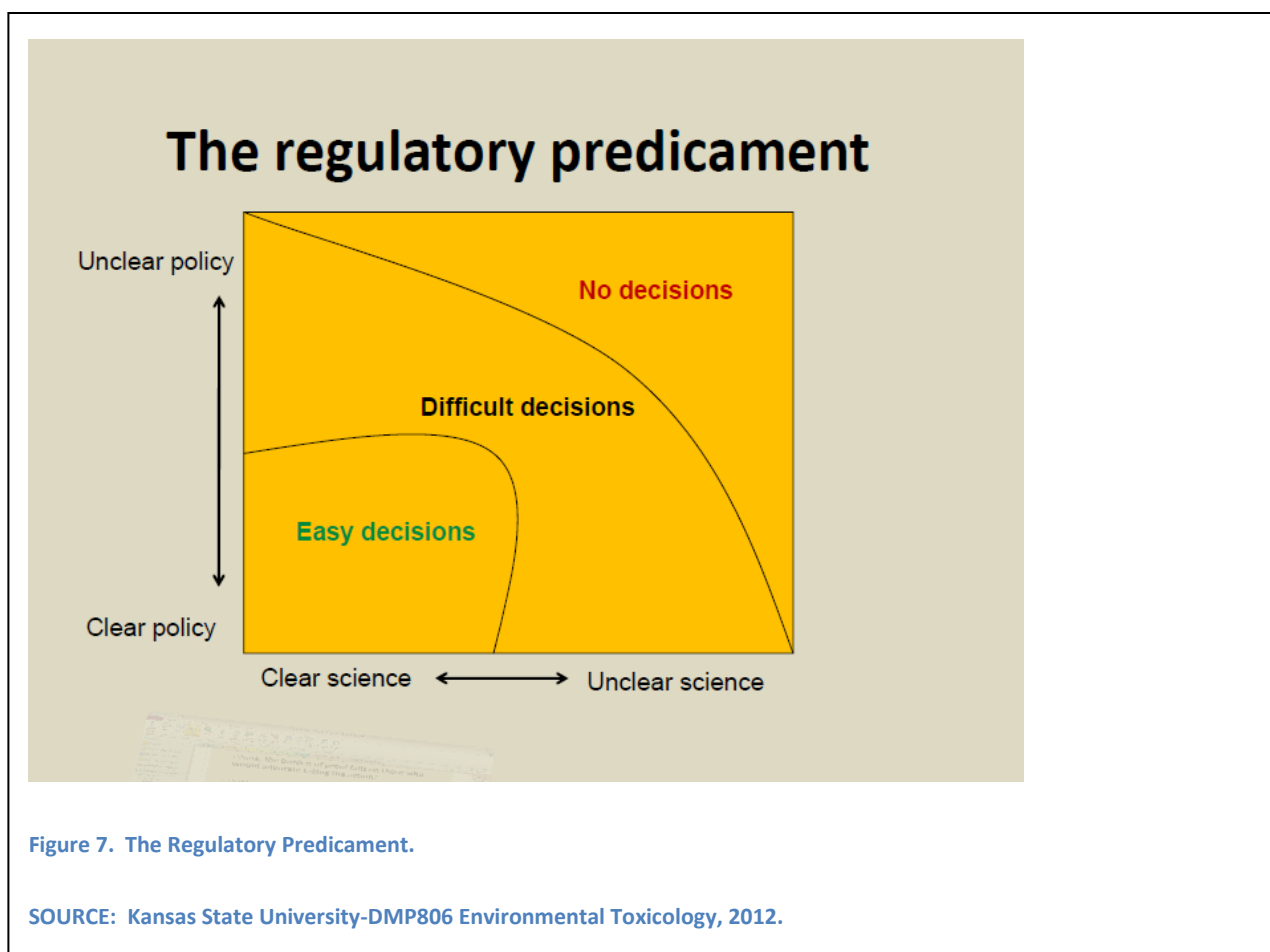
¹⁵⁶ C. D. Mathers, M. Ezzati, and A. D. Lopez, "Measuring the Burden of Neglected Tropical Diseases: The Global Burden of Disease Framework," *PLoS Negl Trop Dis* 1, no. 2 (2007): 1.

¹⁵⁷ Bruce Max Feldmann and Tony H. Carding, "Free-Roaming Urban Pets," *Health Services Reports* 88, no. 10 (1973): 959. This is not to say that these governments enacted this legislation arbitrarily. Dogs in China were contending with people for adequate food resources, while Iceland was experiencing a heavy burden of hydatid disease.

Just as China and Iceland had to educate their citizens to gain compliance, global organizations and governments need to start with the basics. The World Health Organization suggests classifying soil-transmitted helminths into three categories—high/category I, moderate/category II, and low/category III—according to the prevalence of the parasite and the intensity of infection.¹⁵⁸ Governments can implement national surveillance programs for STHs that monitor disease in both humans and animals. Gathering good information allows for implementing targeted strategies.¹⁵⁹

¹⁵⁸ Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," 1312.

¹⁵⁹ Lee et al., "Epidemiologic and Zoonotic Aspects of Ascarid Infections in Dogs and Cats," 155.



It can be difficult to address ZPD at the national level. Policies, targeting individual's health rather than public health, will be intrusive and have fragmentary application. Areas where national policies are important are health education, sanitation, food safety, and surveillance.¹⁶⁰ Instituting Public Private Partnerships (PPP) may prove to be one very workable solution for addressing zoonotic parasitic diseases.¹⁶¹ The Companion Animal Parasite Council, a collective of individuals with "broad expertise in parasitology, internal medicine, public health, veterinary law, private practice and association leadership," annually publishes recommendations, based on research and public data, regarding parasites that are clinically

¹⁶⁰ Mascarini-Serra, "Prevention of Soil-Transmitted Helminth Infection," 175.

¹⁶¹ Okello et al., "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 284.

important to animals and humans.¹⁶² Organizations already existing in the private sector can provide invaluable resources to the public health community.

At the regional and local levels of government, officials responsible for setting policies need to make zoonotic parasitism a priority. They must dedicate themselves to creating policies and legislation that will address the burden on their community, allocate resources, and communicate effectively with their constituents. Furthermore, it is the responsibility of the entire community to address the risks of zoonotic disease, because people encounter pets and feral animals in public settings.

When allocating resources for zoonotic interventions, it is difficult to determine who will pay for those resources, even though there is a great benefit to society in general. Oftentimes, the government is expected to pay for interventions, especially when there is a sense of urgency; but, if the disease burden is unknown or underestimated, it may be difficult to procure funding.¹⁶³ On the local level, zoonotic disease will not have a big impact on tourism, trade, or tax revenues. However, there will be an impact on the health and productivity of a community.

Interventions to address parasitism will reap more benefits than the same amount of resources spent on medical care.¹⁶⁴ Marginalized segments within a community may not be getting the resources they need to combat zoonotic diseases. Because of issues like geography,

¹⁶² "CAPC Recommendations," Companion Animal Parasite Council, <http://www.capcvet.org/capc-recommendations/>.

¹⁶³ "One Health and the Neglected Zoonoses: Turning Rhetoric into Reality," 284.

¹⁶⁴ Murrell, "Presidential Address: Dr. Stoll's Wormy World Revisited: The Neglected Animal Diseases," 174.

culture, and socioeconomic factors, these people may be sequestered from healthcare, education, and especially, political processes.¹⁶⁵ Although even marginalized and impoverished populations understand the importance of sanitation to prevent disease exposure, living in poverty may mean that they do not have access to routine sanitary measures. The prevalence of STHs in a community can show living conditions, levels of education and socioeconomic status, and the effectiveness of environmental sanitation.”¹⁶⁶

It is difficult to create environmental sanitation programs on a large-scale, and thus it is challenging to implement interventions aimed at controlling the transmission of STHs.¹⁶⁷ When considering STHs, it is important to understand which host species is responsible for environmental contamination in order to determine the true risks of zoonotic disease and to draft a responsible policy to raise awareness and decrease the risk.

“The veterinary orientation to ‘herd health’ is a metaphor for community health.”¹⁶⁸ Public officials, aware of the threat to human health by dog feces, may look to implement regulations before there is public understanding or political support. A good example of this is the Canine Waste Law enacted in New York City in 1978 that required dog waste to be picked-up and disposed of by dog walkers and owners. The success of this law raised New Yorker’s awareness of the health benefits, and this regulation became a model for other cities across the

¹⁶⁵ Karshima, "A Multidisciplinary Approach in the Control of Zoonoses in Nigeria," 558.

¹⁶⁶ Mascarini-Serra, "Prevention of Soil-Transmitted Helminth Infection," 175.

¹⁶⁷ Ibid.

¹⁶⁸ "Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference."

United States.¹⁶⁹ Chorazy and Richardson's paper, "A Survey of Environmental Contamination with Ascarid Ova, Wallingford, Connecticut," provides an excellent discussion of the zoonotic potential of dog feces in a community and regulation opportunities.¹⁷⁰

Children should receive special attention, because they are at most risk of contracting soil-transmitted parasites. Children with soil-eating behaviors are at most risk, and supervising adults should limit their exposure to public playgrounds that have the potential to be heavily contaminated with parasite eggs.¹⁷¹ Regulations in Quebec, Canada now require the presence of a minimum 1.2-meter fence around outdoor play areas, and animals are prohibited in these spaces. There are, however, no rules regarding the distance between these areas and those allowing animals; moreover, it is difficult to prevent the ingress of wildlife into restricted regions.¹⁷² Nevertheless, using fencing and landscaping to provide physical separation is practical and beneficial.

Although it is impossible to govern the activities of wild animals, policymakers can take steps to decrease their role in STHs. Controlling wildlife in public spaces often begins with controlling access to food. As enjoyable as it is to feed and watch wildlife, bird feeders are magnets for rodents and predators. Because birds, chipmunks, and squirrels feed on the

¹⁶⁹ Congdon and Lloyd, "Toxocara Infection in the United States: The Relevance of Poverty, Geography and Demography as Risk Factors, and Implications for Estimating County Prevalence," 22.

¹⁷⁰ Chorazy and Richardson, "A Survey of Environmental Contamination with Ascarid Ova, Wallingford, Connecticut."

¹⁷¹ Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.Ibid., 38.

¹⁷² Carabin et al., "Comparison of Methods of Sampling for Toxocara Species and Fecal Coliforms in an Outdoor Day Care Environment," 154.

ground and play a role in moving infected soil, separating feeding stations from playgrounds may help to segregate species and limit the spread of STH eggs.¹⁷³ Strategic deworming of feral canine and feline populations via bait stations is another step that will decrease the local parasite burden. The bait should be an effective, single dose anthelmintic; in the future, it may be possible to have oral molecular vaccines that work similar to those used for rabies control.¹⁷⁴

Medical ecology (an underappreciated tool in the fight against zoonotic parasitism), is the means by which habitat is manipulated to create a more healthful environment for humans.¹⁷⁵ Legislation, creating designated public areas for pet defecation, is easy to adopt and generally well accepted; this is the recommendation of the United States Environmental Protection Agency (EPA). These areas must not be conducive for egg continuity and they must be easy to clean and disinfect; the EPA recommends that sites have sandy soil that is easy to clean. They also promote the “long grass principle,” which provides the longer grass lengths that dogs seem to be attracted to, where decomposition can occur naturally and waste is filtered before it contributes to contaminated run-off.¹⁷⁶ Ten centimeters is ideal for the tall grass areas, which should be placed away from walkways, play areas, natural water run-off regions, and drinking wells. Another recommendation is to install “doggie loos,” which are disposal units that decompose waste. Landscaping must involve functionality, as well as beauty. One suggestion to address the costs of maintaining dog parks and disposal stations is

¹⁷³ Despommier, "Toxocariasis: Clinical Aspects, Epidemiology, Medical Ecology, and Molecular Aspects," 270.

¹⁷⁴ *Ibid.*, 271.

¹⁷⁵ *Ibid.*, 170.

¹⁷⁶ "Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water," ed. USEPA Office of Water, Source Water Protection Practices Bulletin (USEPA, 2001).

to levy a graduated tax on dog owners based upon the size of their dog, since larger dogs produce larger amounts of waste.¹⁷⁷ Sites for off-leash dog parks must be chosen wisely, because there is a risk on infecting wildlife with parasites, leading to a population over which there is little control.¹⁷⁸ “Climate and topography are crucial determinants of the distribution of helminth infections,” according to Hotez et al.; therefore it is important that policymakers consult experts in climatology, landscaping and environmental engineering.¹⁷⁹

Because fecal environmental contamination may also be a food safety issue, policymakers should address this topic proactively. Outdoor food markets and restaurants should have regulations for sanitation and garbage disposal to decrease the enticement to wildlife. Some eggs are also spread via water, as shown in a report from a public beach in Moscow, Russia, where bathers inadvertently drank water and consumed *Toxocara* eggs.¹⁸⁰ Pet dogs should not be present on public beaches where people swim or in public venues with food consumption.

Risk Communication—Message-based

Neglected zoonotic diseases are a great encumbrance on communities, and this is especially true of STHs.¹⁸¹ Without the microphone of a celebrity or the support of a well-marketed organization, many diseases “have no voice” and get little media coverage. In this

¹⁷⁷ Feldmann and Carding, "Free-Roaming Urban Pets," 958.

¹⁷⁸ Mascarini-Serra, "Prevention of Soil-Transmitted Helminth Infection," 175.

¹⁷⁹ Hotez et al., "Helminth Infections: The Great Neglected Tropical Diseases," 1313.

¹⁸⁰ Despommier, "Toxocariasis: Clinical Aspects, Epidemiology, Medical Ecology, and Molecular Aspects," 170.

¹⁸¹ Doble and Fevre, "Focusing on Neglected Zoonoses," 546.

age of instant media, it is the adrenaline-pumping, provocative news that gets headlines.

Intentional public health education, good communication methods, and proper use of media are important to address STHs.

Public Health Education

In order to facilitate a common understanding of important zoonotic topics, veterinarians, human healthcare providers, social workers, and public health officials should meet in the classroom to learn content. University degree programs and continuing education seminars are ideal venues to bring together all groups to learn about STHs. Once these officials converge and have common knowledge about zoonotic diseases, they will be able to present a valid assessment of the risk of STHs to the public and industries that will have a hand in addressing this issue.

There also must be an intentional effort by the public to address their critical role in public health. Citizens must recognize their risks and responsibilities, and they should learn about the policies presented to them by officials. People should form close relationships with their healthcare partners, realizing that patients are partly responsible for their own health. Parents should teach, and model, sanitary habits in the home to their children. Pet owners must understand the role that dogs have in perpetuating STHs. Education, obviously, is a critical endeavor.

Messages aimed at individuals

Surveys of veterinary clients have indicated that pet owners are concerned about zoonotic diseases when media coverage piques their curiosity or paranoia; this interest is not

related to a correct understanding of the diseases or the owners' risks.^{182,183} A study in Great Britain revealed that pet owners, who should have an understanding of zoonotic parasites, were no more aware of these diseases than non-pet owners. The author concluded that targeted messages aimed at dog owners would be more effective overall in controlling zoonotic risks than providing general information to the public.¹⁸⁴ Even if pet owners do have some knowledge about zoonotic diseases, they must be encouraged to be vigilant and responsible; veterinarians, animal- and human-healthcare industries, and public health communities must stress this.

Messages targeted to communities

Media is very important to informing the public on diseases, risk behaviors, prevention methods, and control programs instituted by their communities. Successful media campaigns may raise awareness in the community and increase local education surrounding a specific topic, but it may not be enough to overcome culture or change behaviors. In this instance, the average public citizen who is not a pet owner is likely unaware of the potential for zoonotic parasite exposure in public areas where dogs are present. Any measures to address the issues of zoonotic parasitic diseases will require an interested and informed public, which is willing to expend the time and resources to battle these diseases. Educational materials and media communications have to be in language that is understandable and relatable. Storytelling is more effective than merely reciting statistics.

¹⁸² Lipton et al., "A Survey of Veterinarian Involvement in Zoonotic Disease Prevention Practices," 1247.

¹⁸³ Lloyd A. Selby et al., "A Survey of Attitudes toward Responsible Pet Ownership," *Public Health Reports* (1974-) 94, no. 4 (1979): 385.

¹⁸⁴ Lee et al., "Epidemiologic and Zoonotic Aspects of Ascarid Infections in Dogs and Cats," 160.

Any successful campaign to educate the public about zoonotic diseases must include children, because they are very interested in pets and are most likely to approach strange animals without reservations. By reaching out to schoolchildren, the messages—responsible pet ownership, the hazards of zoonotic diseases, and the importance of sanitation—will be transferred from the classrooms into the homes.¹⁸⁵ Changing culture and habits often start with programs aimed at youth.

Messages directed globally

Many factors contribute to the continuation of zoonotic diseases in less-developed countries. Healthcare services may be prohibitively expensive and healthcare-seeking behaviors may not be ingrained into the culture. Common diseases are misunderstood or misdiagnosed. Diagnostic services and tests are not available to the public. The availability of veterinary services and therapeutics is likewise limited. In less-developed countries, the natural environment provides the ideal transmission route for many zoonotic diseases:

- “regular close contact between people and their animals;”
- “access of those animals to human waste;”
- “poor quality food and forage for both humans and animals;”
- “inconsistent meat inspection;”
- “little preventive health provision for domestic stock;” and,
- the presence of endemic infectious diseases such as malaria and HIV/AIDS, increasing the likelihood of comorbidities.¹⁸⁶

¹⁸⁵ Feldmann and Carding, "Free-Roaming Urban Pets," 961.

¹⁸⁶ Doble and Fevre, "Focusing on Neglected Zoonoses," 546.

It important not to allow medical biases to lead to predetermined diagnoses. One prevalent disease in a community may overshadow other equally serious issues. Doble and Fevre state:

“...people in marginalized communities can easily fall off the policy radar—many may be born, live and die without official record being made of them and, as such, they have a weak, or nonexistent, political voice. Thus, while the diseases are grouped as ‘neglected zoonotic diseases,’ it would be equally correct to identify them as ‘diseases of neglected populations.’”¹⁸⁷

However, many of these same risk factors can occur in developed countries as well, found in marginalized populations or manifested in different ways. For instance, there is regular and close contact between people and pets where some animals are allowed to recline and sleep with their owners. Many people do not practice sanitary methods when cleaning pet waste from the yard or litter box. A struggling economy, with increasing food prices means that many people will choose food that is filling but less nutritious, leading to malnutrition (this may be due to inadequate or in-excess calories or nutrients). Again, in a weak economy, many people forgo preventive healthcare programs for themselves and their pets. Finally, developed societies are likely to have immunocompromised citizens.

Access to accurate and current information is imperative. National surveys, such as the NHANES III, contribute to identifying target populations and to delivering messages that are effective. Another suggestion that came out of the 1999 FAO conference was to develop a system of the scientific peer-review process that categorizes internet sites and information, much in the same way as scientific journals. This would allow for freer access to current

¹⁸⁷ Ibid., 547.

information and publications, while maintaining high standards for accuracy, competency, and credibility of public works.¹⁸⁸

Conclusions

In 1999, the role of veterinary public health was defined by the World Health Organization as: “The contributions to the physical, mental and social well-being of humans through an understanding and application of veterinary science.”¹⁸⁹ As the most trusted source for information on zoonotic diseases, surveys show that the veterinary community, as a whole, is missing many opportunities to educate clients.¹⁹⁰ It is vital that veterinarians recognize their important role in protecting the health, not only of the four-legged patients, but of the two-legged family members, as well. Their vigilance, along with a strong drive to educate the public, is vital to controlling zoonotic parasitism, preventing devastating health effects, and maintaining quality of life for all concerned.

¹⁸⁸ "Veterinary Public Health and Control of Zoonoses in Developing Countries - Summary of Comments and Discussions from the FAO/WHO/OIE Electronic Conference."

¹⁸⁹ Ibid.

¹⁹⁰ Stull et al., "Household Knowledge, Attitudes and Practices Related to Pet Contact and Associated Zoonoses in Ontario, Canada," 11.

Appendix 1—Fecal Analysis Protocol

The test method used was the “Fixed Head Centrifuge Standard Qualitative Fecal.”¹⁹¹

1. Sample collection was of fresh feces (at least 4 grams,) stored in plastic bags and labeled, and kept in a cooler separated from an ice pack. Except for the humane society samples, I processed samples the same day they were collected.
2. I labeled test tubes and prepared a worksheet prior to the tests.
3. I mixed approximately 2 grams of feces with water and made it into a slurry. I poured the samples through a filter of 2x2 layered gauze sponges to remove excess debris; I collected the supernatant into 15ml centrifuge tubes. After balancing the tubes with additional water, I spun the tubes for 10 minutes in The Drucker Company Model 614B fixed head centrifuge at approximately 3200rpm.
4. I poured off the supernatant from each sample, preserving the pellet at the bottom of the tube. I filled the tubes part way with Sheather’s Sugar Solution (Sp. Gr. 1.27) and mixed thoroughly. Then, I filled the tubes to the 12ml mark with the sugar solution.
5. I spun the samples for 5 minutes.
6. I removed the tubes from the centrifuge. I added additional sugar solution to the tubes until full and placed a coverslip on the tube. The samples sat for an additional 10 minutes.
7. I removed the coverslip from the tube and placed it on a microscope slide. The samples were examined at 4x, 10x, and 40x.
8. I recorded the results of the tests. In some cases, I photographed the eggs and debris.
9. I disposed of fecal samples and supplies in a safe manner and cleaned the lab equipment.

¹⁹¹ Michael W. Dryden, "Fecal Flotation Procedures," (2010).

Appendix 2—Findings of Fecal Exams

<u>Setting</u>	<u>Sample</u>	<u>Parasites</u>	<u>Type</u>
Farmer's Market	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
Walnut	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
John Taylor	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
Brook Creek	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
	Dessicated/decomposing	n/a	
Naismith Valley Park	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	Y	
	Fresh	Y	4+ Toxocara, 2+ Trichuris, 2+ Ancylostoma
Prairie Park	Fresh	N	
	Fresh	N	
	Fresh	Y	1+ Ancylostoma

	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	N	
	Fresh	Y	1+ Ancylostoma
	Fresh	Y	1+ Isospora
Riverfront	Dessicated/decomposing	N	
	Fresh	N	
	Fresh	N	
	Fresh	Y	1+ Toxocara

<u>Setting</u>	<u>Dog</u>	<u>Sex</u>	<u>Age (Yrs)</u>	<u>Parasites</u>	<u>Type</u>
Senior	Cookie	F	1-5	Y	3+ Ancylostoma, 3+ Eimeria
	Hera	FS	>10	N	
	Jill	FS	6-10	N	
	Millie	FS	6-10	N	
	Bailey	FS	1-5	N	
	Bella	FS	1-5	N	

Childcare	Sheridan	FS	1-5	N	
	Hagan	FS	1-5	N	
	Bella	FS	1-5	N	
LDCHD	Lucy	FS	6-10	N	
	Zoey	FS	1-5	N	
	Zoey	FS	6-10	N	
	Frieda	FS	6-10	Y	1+ Paragonimus
Doggy Daycare	Pablo			N	
	Molly			N	
	Zoey			Y	1+ Toxocara
	Kirby	MN	1-5	N	
	Luna			N	
	Reba			N	
	Annabelle			N	
	Poppy			N	
	Gracie			N	
	Salvador			N	
	Phin			N	
	Gus			N	
	Bonnie			N	
	Minnie	FS	1-5	N	
	Rico			N	
	Mookie			N	
	Digby			N	

MuttRun	Buster	MN	>10	N	
	Alfie			N	
	Marco Polo			N	
	Lana			N	
	Tucker			N	
	Donner	MN	>10	N	
	Echo			Y	2+ Ancylostoma
	Stella	FS	1-5	N	
	Buddha			N	
	Charlie			N	
	Rook			N	
	Lola	FS	<1	N	
	Sophie			N	
	Katie			N	
	Socrates	MN	1-5	N	
	Abby			Y	1+ Isospora
	Tashama			N	
	Marley	FS	1-5	N	
	Baxter	MN	1-5	N	
	Captain			N	
	Gracie			N	
	Sam			N	
	Bella			N	
	Beatrice			N	

Appendix 3—Lawrence-Douglas County, Kansas Fecal Study

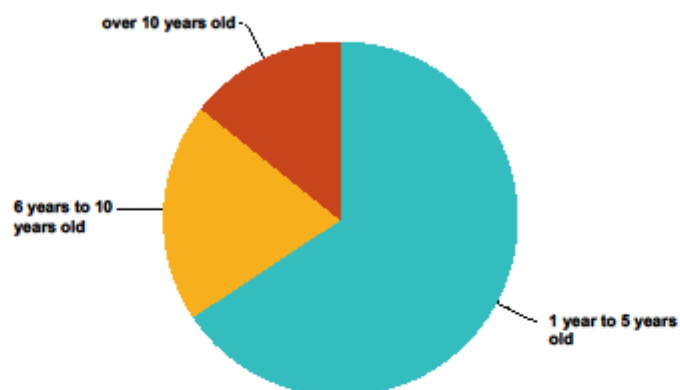
Lawrence-Douglas County KS Canine Fecal Study
About your dog
1. What is your dog's name?
<input type="text"/>
2. What breed is your dog?
<input type="text"/>
3. How old is your dog?
<input type="radio"/> Less than 1 year old
<input type="radio"/> 1 year to 5 years old
<input type="radio"/> 6 years to 10 years old
<input type="radio"/> over 10 years old
4. What sex is your dog?
<input type="radio"/> Female - spayed
<input type="radio"/> Female - not spayed
<input type="radio"/> Male - neutered
<input type="radio"/> Male - not neutered
Healthy Habits
5. Do you wash your hands after contact with your pet?
<input type="radio"/> Everytime
<input type="radio"/> Frequently
<input type="radio"/> Sometimes
<input type="radio"/> Rarely
<input type="radio"/> Not important to me

Appendix 4—Survey Results from Survey Monkey

Lawrence-Douglas County KS Canine Fecal Study

Q3 How old is your dog?

Answered: 35 Skipped: 0

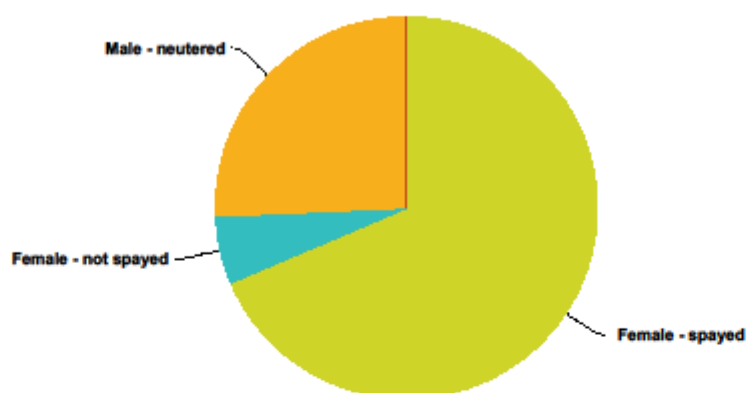


Answer Choices	Responses	
Less than 1 year old	0.00%	0
1 year to 5 years old	65.71%	23
6 years to 10 years old	20.00%	7
over 10 years old	14.29%	5
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q4 What sex is your dog?

Answered: 35 Skipped: 0

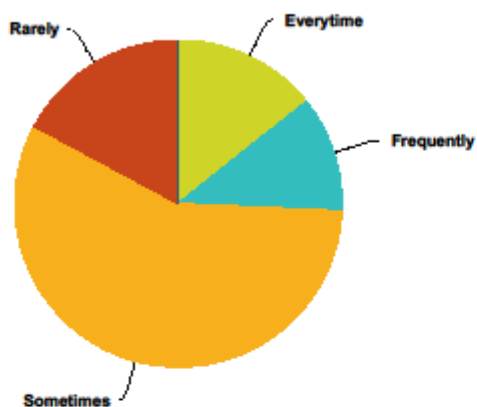


Answer Choices	Responses	
Female - spayed	68.57%	24
Female - not spayed	5.71%	2
Male - neutered	25.71%	9
Male - not neutered	0.00%	0
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q5 Do you wash your hands after contact with your pet?

Answered: 35 Skipped: 0

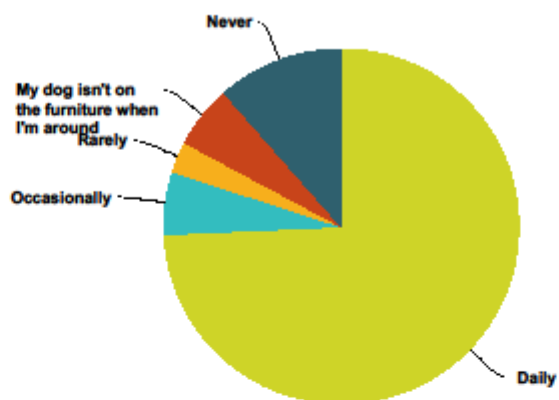


Answer Choices	Responses	
Everytime	14.29%	5
Frequently	11.43%	4
Sometime	57.14%	20
Rarely	17.14%	6
Not important to me	0.00%	0
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q6 How often is your dog on the furniture?

Answered: 35 Skipped: 0

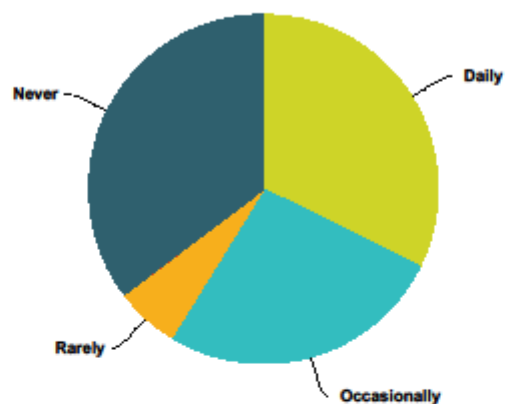


Answer Choices	Responses
Daily	74.29% 26
Occasionally	5.71% 2
Rarely	2.86% 1
My dog isn't on the furniture when I'm around	5.71% 2
Never	11.43% 4
Total	35

Lawrence-Douglas County KS Canine Fecal Study

Q7 How often does your dog sleep in your bed (or a family member's)?

Answered: 34 Skipped: 1

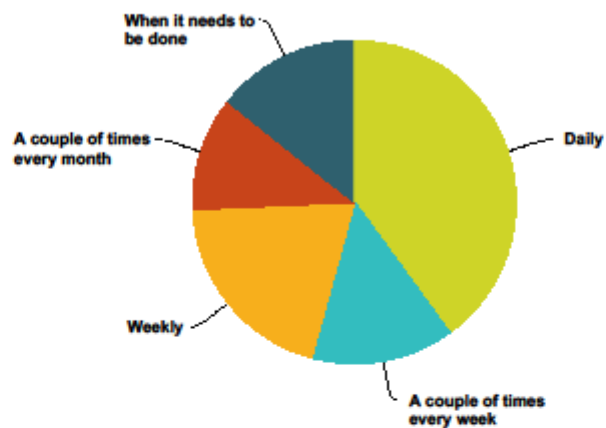


Answer Choices	Responses
Daily	32.35% 11
Occasionally	26.47% 9
Rarely	5.88% 2
My dog isn't on the bed when I'm around	0.00% 0
Never	35.29% 12
Total	34

Lawrence-Douglas County KS Canine Fecal Study

Q8 How often do you scoop your dog's feces in your yard?

Answered: 35 Skipped: 0

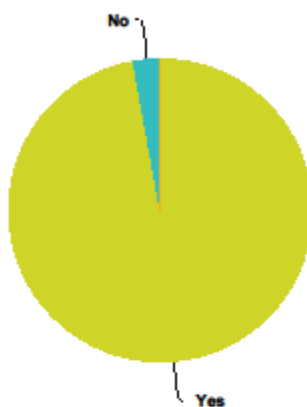


Answer Choices	Responses	
Daily	40.00%	14
A couple of times every week	14.29%	5
Weekly	20.00%	7
A couple of times every month	11.43%	4
When it needs to be done	14.29%	5
Not sure	0.00%	0
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q9 Do you have a family veterinarian for your dog?

Answered: 35 Skipped: 0

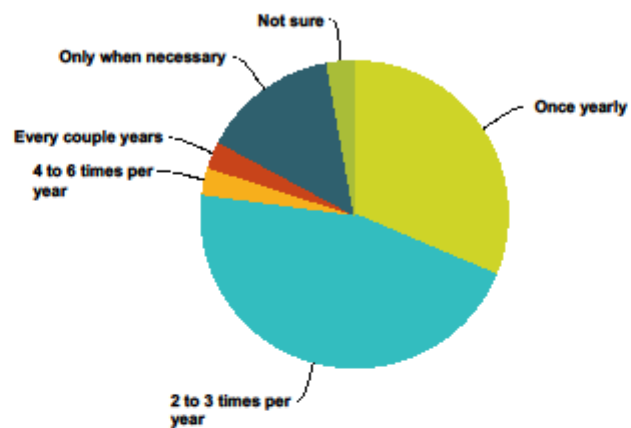


Answer Choices	Responses
Yes	97.14% 34
No	2.86% 1
Not sure	0.00% 0
Total	35

Lawrence-Douglas County KS Canine Fecal Study

Q10 How often does your dog see your veterinarian?

Answered: 35 Skipped: 0

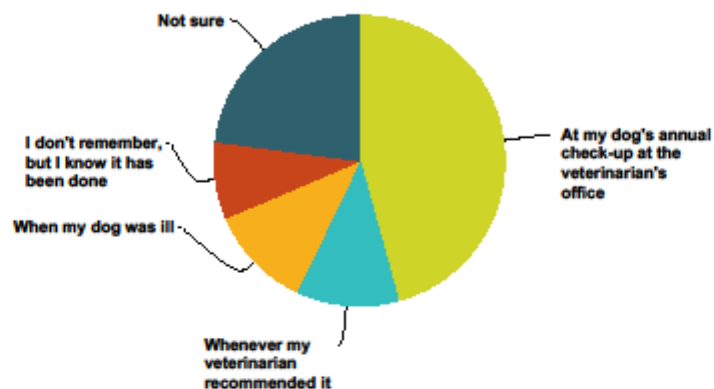


Answer Choices	Responses	
Once yearly	31.43%	11
2 to 3 times per year	45.71%	16
4 to 6 times per year	2.86%	1
Every couple years	2.86%	1
Only when necessary	14.29%	5
Not sure	2.86%	1
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q11 When was the last time your dog had a fecal or stool exam?

Answered: 35 Skipped: 0



Answer Choices	Responses
At my dog's annual check-up at the veterinarian's office	45.71% 16
Whenever my veterinarian recommended it	11.43% 4
When my dog was ill	11.43% 4
I don't remember, but I know it has been done	8.57% 3
Not sure	22.86% 8
Total	35

Lawrence-Douglas County KS Canine Fecal Study

Q12 Are you aware that some parasites will infect humans as well as dogs?

Answered: 35 Skipped: 0

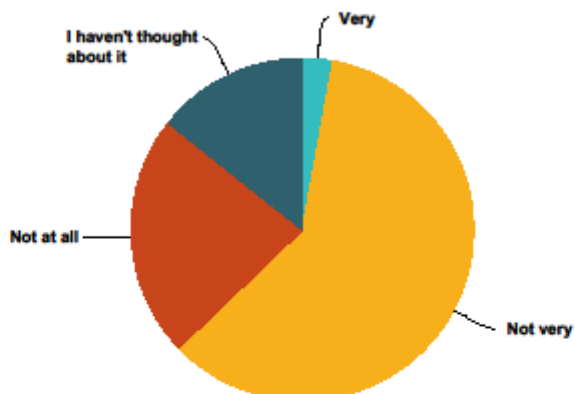


Answer Choices	Responses	
Yes	80.00%	28
No	20.00%	7
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q13 How concerned are you that you or your family may be infected by parasites from your dog?

Answered: 35 Skipped: 0

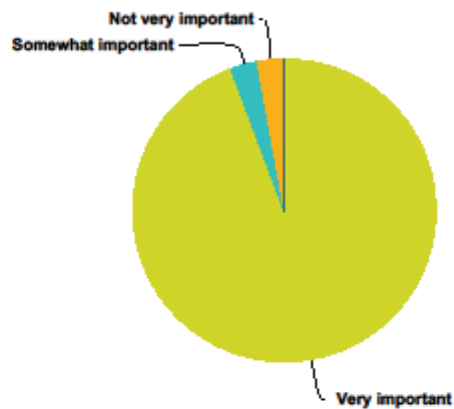


Answer Choices	Responses
Extremely	0.00% 0
Very	2.86% 1
Not very	60.00% 21
Not at all	22.86% 8
I haven't thought about it	14.29% 5
Total	35

Lawrence-Douglas County KS Canine Fecal Study

Q14 How important is it to you that your dog is protected from intestinal parasites (worms)?

Answered: 35 Skipped: 0



Answer Choices	Responses	
Very important	94.29%	33
Somewhat important	2.86%	1
Not very important	2.86%	1
Not a concern at all	0.00%	0
I haven't thought about it	0.00%	0
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q15 Do you give your dog heartworm preventive medication?

Answered: 35 Skipped: 0

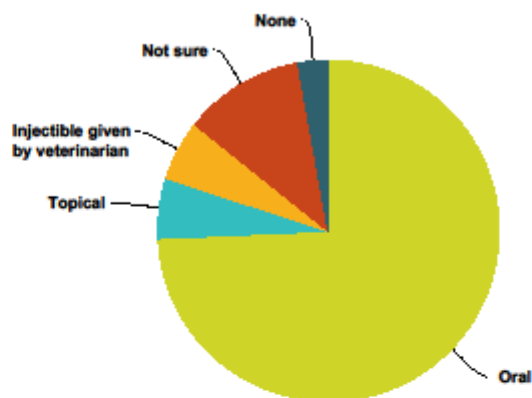


Answer Choices	Responses	
Yes	85.71%	30
No	8.57%	3
Not sure	5.71%	2
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q16 What type of heartworm preventive medication do you use?

Answered: 35 Skipped: 0

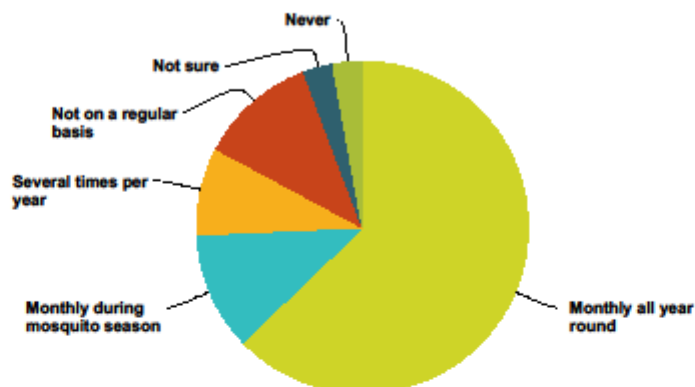


Answer Choices	Responses	
Oral	74.29%	26
Topical	5.71%	2
Injectable given by veterinarian	5.71%	2
Not sure	11.43%	4
None	2.86%	1
Total		35

Lawrence-Douglas County KS Canine Fecal Study

Q17 How often do you give heartworm preventive medication to your dog?

Answered: 35 Skipped: 0

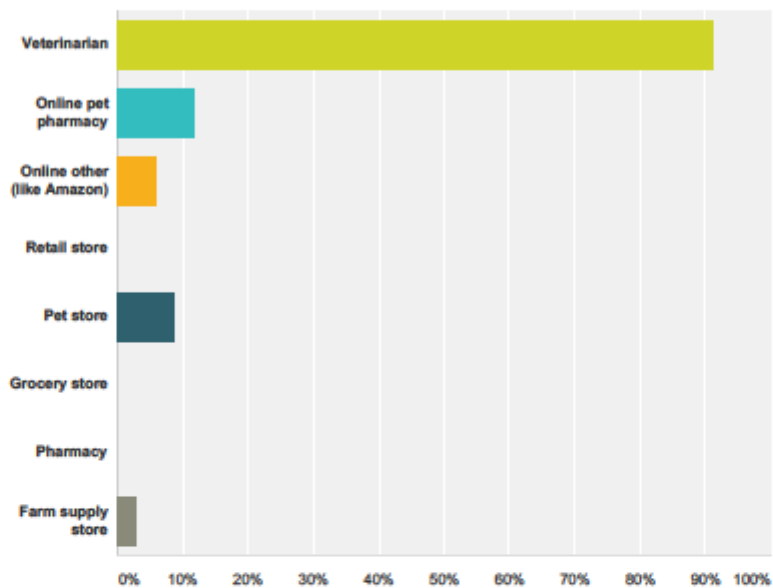


Answer Choices	Responses
Monthly all year round	62.86% 22
Monthly during mosquito season	11.43% 4
Several times per year	8.57% 3
Not on a regular basis	11.43% 4
Not sure	2.86% 1
Never	2.86% 1
Total	35

Lawrence-Douglas County KS Canine Fecal Study

**Q18 Where do you purchase your heartworm preventive medication from?
(check all that apply)**

Answered: 34 Skipped: 1

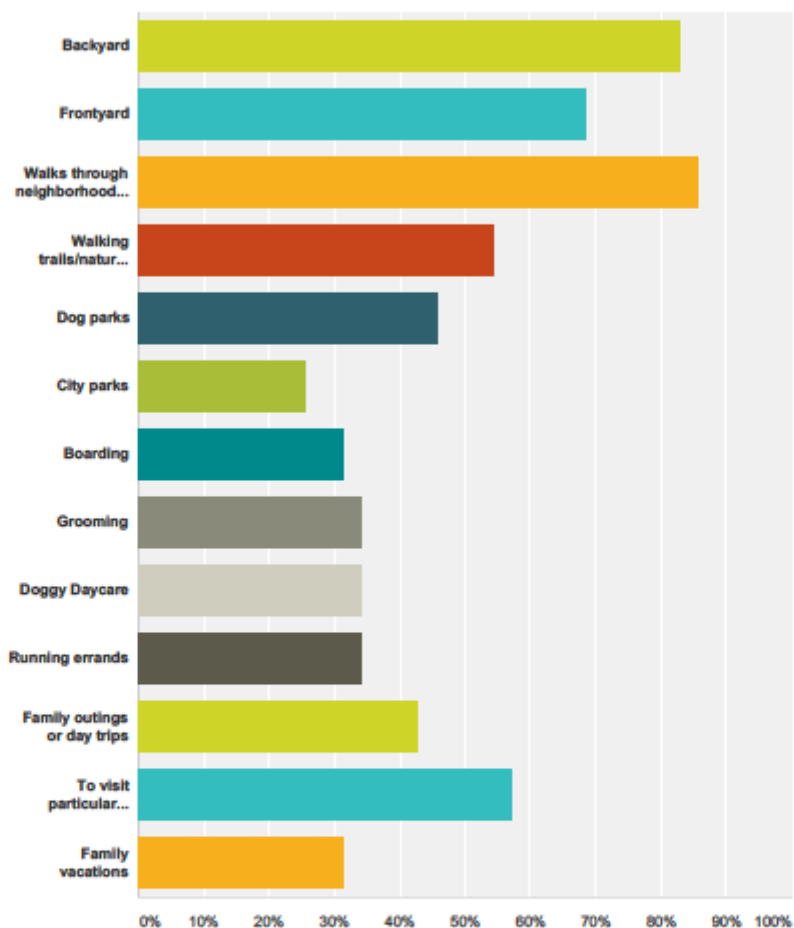


Answer Choices	Responses
Veterinarian	91.18% 31
Online pet pharmacy	11.76% 4
Online other (like Amazon)	5.88% 2
Retail store	0.00% 0
Pet store	8.82% 3
Grocery store	0.00% 0
Pharmacy	0.00% 0
Farm supply store	2.94% 1
Total Respondents: 34	

Lawrence-Douglas County KS Canine Fecal Study

Q19 Does your pet go any of these places?
(check all that apply)

Answered: 35 Skipped: 0



Answer Choices	Responses
Backyard	82.86% 29
Frontyard	68.57% 24
Walks through neighborhood on streets or sidewalks	85.71% 30
Walking trails/nature trails	54.29% 19
Dog parks	45.71% 16

Lawrence-Douglas County KS Canine Fecal Study

**Q20 Is there any information about
intestinal parasites of dogs that you feel
would be useful to know?**

Answered: 11 Skipped: 24

#	Responses	Date
1	issues related to dog owners who contract parasites through their dogs-such as frequency of this occurrence and symptoms of humans (especially children) contracting parasites from dogs.	8/18/2013 12:15 PM
2	How they can be prevented. How they are transmitted to humans and how transmission be prevented.	8/17/2013 9:38 PM
3	Which ones affect humans, and also if there are any symptoms from infection for the dog (or human).	8/17/2013 5:15 PM
4	No.	8/17/2013 4:25 PM
5	I feel well informed	8/17/2013 3:54 PM
6	What is the cheapest, easiest, and most effective way to protect a dog against intestinal parasites? What dog behaviors promote acquisition of intestinal parasites?	8/17/2013 1:12 PM
7	No.	8/17/2013 6:54 AM
8	-most common place(s) they can pick up these parasites -signs & symptoms of an infection (early, latent, asx?)	8/16/2013 6:41 PM
9	Any	8/8/2013 2:29 PM
10	Anything to help.	8/8/2013 2:19 PM
11	Anything to help	8/8/2013 2:15 PM

Appendix 5—Competencies and Core Requirements

Introduction to Epidemiology (DMP754, Fall 2010, Dr. Bob Larson): Although I had learned some of the information during a course in veterinary school, Dr. Larson presented much more depth and provided clear reasons for epidemiologic formulas and concepts. The concept I have found the most useful has been the host/agent/environment triad.

Trade & Agricultural Health (DMP816, Spring 2011, Dr. Justin Kastner): The concepts that has really stuck with me, though, are the importance of understanding the history of diseases, globalization, and the risk analysis framework

Administration of Healthcare Organizations (HMD720, Summer 2011, Dr. Deb Canter): This class provided an excellent overview of the healthcare industry, including novel programs (like concierge medicine) that may become more available in the future

Principles of Animal Disease Control (ASI540, Fall 2011, Dr. Larry Hollis): This class provided a very good review of animal diseases about which I learned in veterinary school

Environmental Toxicology (DMP806, Spring 2012, Dr. Deon van der Merwe): Although I had a toxicology class in my veterinary education, I came away from this class with a much better understanding of about the parts of a risk assessments and how to conduct research for a paper.

Social & Behavioral Basis of Public Health (KIN818, Summer 2012, Dr. Mary McElroy): This was an interesting class with the exposure to other students in the MPH program and their opinions and experiences in public health. The concept that has been more useful to me is different frameworks used to address health and behavior.

Global Health Issues (DMP844, Fall 2012, Dr. Deborah Briggs): This class was very interesting because it enjoined global politics and economics with public health; this was a new way for me to view public health. This reinforced my interest in policymaking and my understanding of how public health is influenced by so many different political strategies.

Biostatistics (STAT701, Spring 2013, Dr. Clifford Blair): I was impressed by Dr. Blair and his patience in explaining the math. I came away from this course with a much better understanding of probability, sampling methods, and statistical relationships.

Food Safety & Security (FDSCI730, Fall 2013, Dr. Abbey Nutsch): Although I had a little exposure to food inspection in veterinary school, I learned a great deal about how food safety relates to public health.

Field Experience (MPH840, Spring 2014): See the section on my internship.

Multidisciplinary Thought & Presentation (DMP815, Fall 2014, Dr. Kastner): This class re-tuned my writing skills.

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