8-1-2024

Canine Parasites in Southern Nevada Urban Dog Parks: Paravec Study

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CANINE PARASITES IN SOUTHERN NEVADA URBAN DOG PARKS: PARAVEC STUDY

By

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Bachelor of Arts - Anthropology
University of Nevada, Las Vegas
2020

A thesis submitted in partial fulfillment
of the requirements for the

Master of Public Health

Department of Environmental and Occupational Health
School of Public Health
The Graduate College

University of Nevada, Las Vegas
August 2024

UNLV | GRADUATE COLLEGE

Thesis Approval

The Graduate College
The University of Nevada, Las Vegas

July 9, 2024

This thesis prepared by

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entitled

Canine Parasites in Southern Nevada Urban Dog Parks: Paravec Study

is approved in partial fulfillment of the requirements for the degree of

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Abstract

While dogs are one of humans' greatest companions, they also serve as hosts for a multitude of parasites. Urban dog parks serve as environments where the transmission of diseases is likely to occur. Exposure to infective agents, contained within the soil, intermediate hosts (e.g., rodents, rabbits), and feces, can directly affect the health of dogs and their owners. Other factors that can further influence canine health include age, previous diagnoses of parasites/diseases, and migration. Many dog owners visit dog parks to encourage socialization and exercise. Such activities are meant to improve health, but unawareness of microbiological organisms can lead to detrimental health conditions if not prevented and treated at the early stages. Human populations, such as children, the elderly, pregnant women, and immunocompromised individuals, who are exposed to certain species of protozoa, helminths, and other parasites, may develop physical and neurological damage. In this study, n = 100 fecal samples from 16 Clark County, NV urban dog parks were collected from canine pets. After laboratory processing using fecal smear and fecal flotation procedures (i.e., sugar and salt), and microscopic observations, we found that canine parasites were present in n=50 (50%) of stool samples. Out of those that were observed, protozoan, nematode, and cestode species were identified, most of which have zoonotic potential. It is important that public health professionals encourage communities to monitor their pets' health. For instance, appropriate vaccination, routine veterinary checkups, and proper hygienic practices can reduce the risk of transmission.

Acknowledgements

I would like to acknowledge and give my gratitude to my advisors and co-chairs, Dr. Chad Cross and Dr. Louisa Messenger. This work would not have been possible without their guidance, support, and instruction throughout all stages of my research. I would also like to thank my committee members, Dr. Francisco Sy and Dr. Andrew Reyes, for providing me with their expertise and knowledge on my thesis study's topic. I would also like to thank my family; my mom for her encouragement, and my four younger sisters who make me feel at ease in times of stress. I would also like to thank my second family, the Schmids, for their continued support throughout this process and for pushing me to persevere. I would also like to thank my friends who have always given me academic advice and motivated me to succeed. To my PARAVEC laboratory friends who have spent countless hours with me both in the field and in the laboratory space, thank you for being present and cheering me on every step of the way. Finally, to the School of Public Health faculty and staff at the University of Nevada, Las Vegas (UNLV)—they have been an integral part of this journey of learning and meaningful experiences.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Problem Statement: Urban Dog Parks and Transmission of Zoonotic Diseases

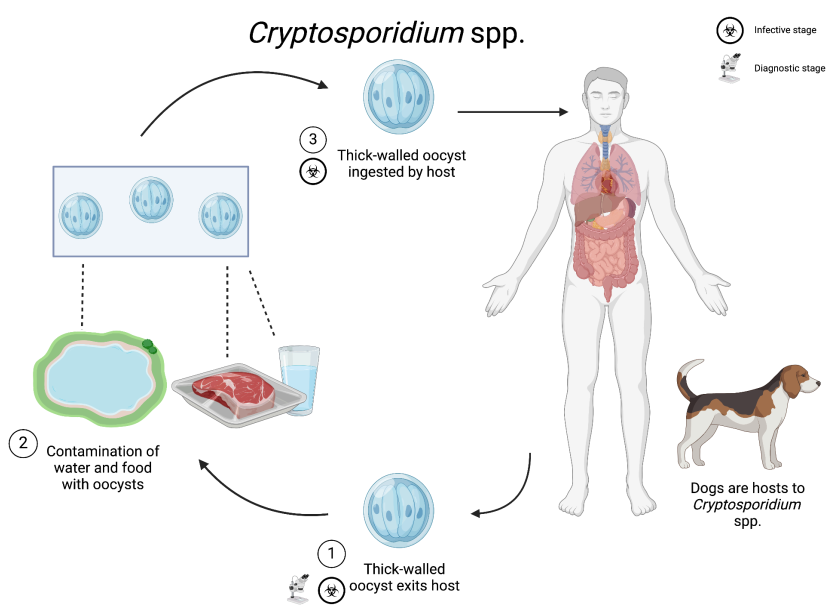
Urban dog parks represent some of the most commonly used spaces in which human owners and their pets participate in outdoor activities. These activities enhance the relationship between the owner and the pet, as well as increase physical and mental health. Such controlled areas can also increase quality of life by providing stress relief and other health benefits (Mori et al., 2023). However, urban dog parks have been investigated for zoonotic parasites across the United States and in several locations around the world (Torres-Chable et al., 2015; Villeneueve et al., 2015; Ayinmode et al., 2016; Ferreira et al., 2017; Suganya et al., 2019; Stafford et al., 2020; Kotwa et al., 2021; Massetti et al., 2022; Murnik et al., 2022; Souza et al., 2023). Stafford and colleagues (2020) found that common canine intestinal parasites exist in 20% of dogs and 85% of urban dog parks in the US. In Clark County, Nevada, several community dog parks exist yet prior studies have not included these in their sampling efforts. These spaces are known to accommodate an abundance of parasitic organisms that are easily transmitted among dogs and humans; pet feces or the soil can be infested by eggs, oocysts, or cysts from patent canine infections. The rates of pet abandonment in Clark County are high, and many owners do not take their pets for veterinarian check-ups or vaccinations often. The turnover in animal shelters is also high, which exacerbates parasite infections due to owners' negligence in comparison to other places. Infected humans are particularly affected from health and financial perspectives (Stafford et al., 2020). Additionally, human infections can have a plethora of risks unknown to many scientists and health professionals. Current literature suggests that parasitic diseases often impact minority communities, many of which actively visit dog parks with their pets (Hotez, 2014).

Environmental contamination can act as a source of infection or reinfection to other dogs and their owners. Foreign-born dogs or dogs that have traveled across states may bring parasites and relocate diseases into a specific area. As the number of off-leash parks increases in the US, so do the health implications derived from human-animal relationships (Stafford et al., 2020). Although dogs can induce positive effects on humans (e.g., emotional support), they also have the potential to introduce allergens and pathogens to their owners. Parasitic infectious diseases are especially threatening to children, pregnant women, the elderly, and immunocompromised individuals; these are usually acquired from controlled spaces that promote socialization (Ferreira et al., 2017).

1.2 Common Canine Parasites

Figure 1

Cryptosporidium spp. transmission cycle.



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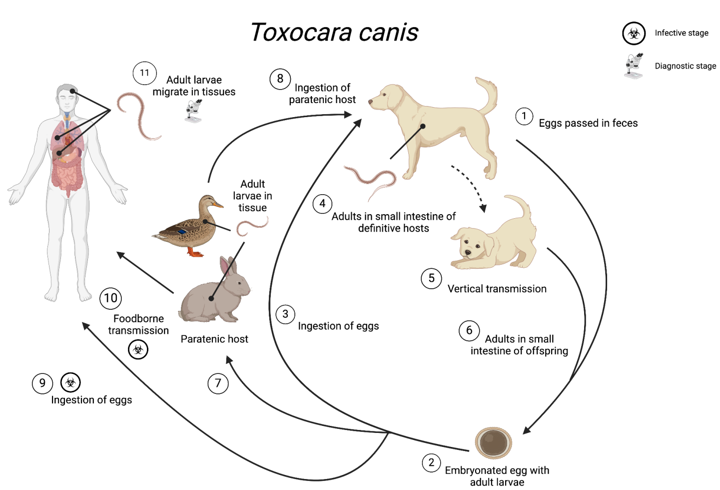
1.2.1 Protozoa. *Giardia*, *Cryptosporidium*, and *Blastocystis* are protozoa that contaminate water, soil, and vegetables, inducing diarrheal diseases in animals and humans (Morelli et al., 2021). Their direct life cycle thrives in dogs; infection can occur when parasitic cysts are ingested. Protozoan cysts are present in canine feces which are commonly found in urban dog parks. Protozoan can be indirect sources of infection to humans, though further research is needed to fully understand the severity and potency of disease (Morelli et al., 2021). Dogs infected with *Giardia* are often subclinical, making detection and identification of this parasite difficult as observable symptoms are not present **(Figure 1)** (Stafford et al., 2020). When symptoms are apparent, dogs, and especially puppies, may suffer from diarrhea, malabsorption, and stunted growth, leading to immunocompromisation and weakness (Murnik et al., 2022).

Figure 2

Toxocara canis transmission cycle.



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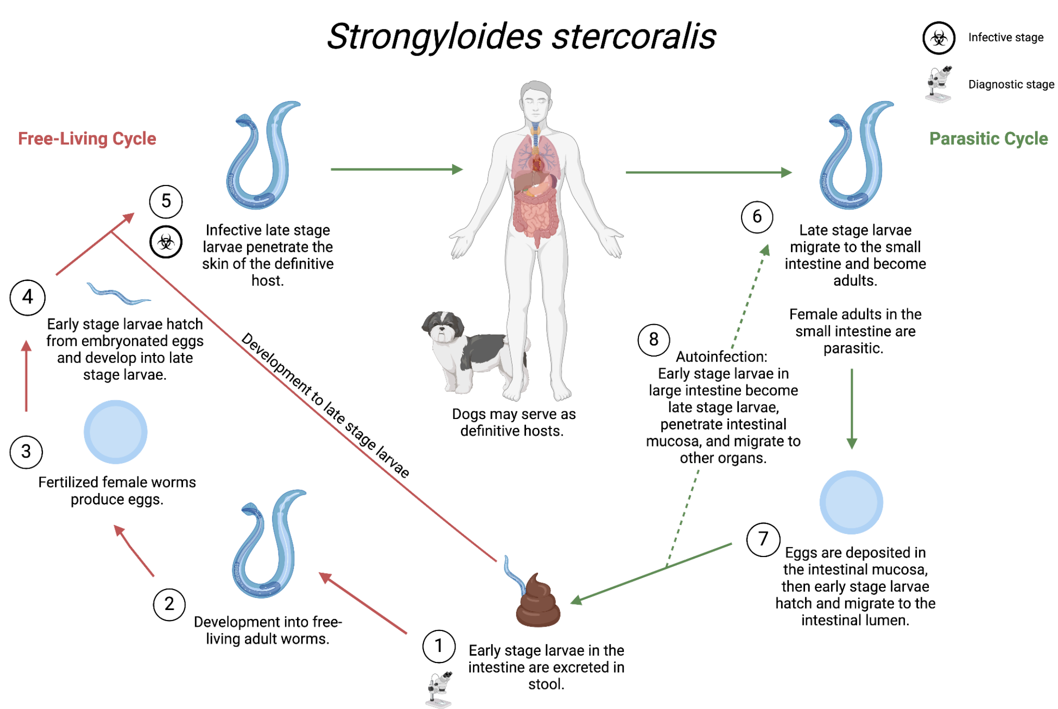
1.2.2 Roundworms and Hookworms. *Toxocara canis* is a type of ascarid that is categorized as one of the most widespread helminths in pets. Dogs are likely to be infected through the fecal-oral route and when eggs are ingested from the environment. Vertical transmission is possible via the placenta or breast milk, making *T. canis* a primary source of infection for young canines (Morelli et al., 2021; Murnik et al., 2022). Puppies who are patently infected in the first few weeks after birth have an increased risk of acquiring gastrointestinal issues that lead to disease **(Figure 2)** (Murnik et al., 2022).

Figure 3

Strongyloides stercoralis transmission cycle.



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Strongyloides stercoralis, a parasite with a free-living cycle and parasitic cycle, is an organism that can present symptoms in a multitude of ways; puppies can experience acute diarrhea, weakness, or in severe cases, sudden death. There may be no clinical signs, which makes it difficult to diagnose without visiting a veterinary clinic. Male and female free-living forms can reproduce in the environment (i.e., soil), while the parasitic female forms can infect dogs via fecal-oral route **(Figure 3)** (Dillard et al., 2007).

Another ascarid, *Baylisascaris procyonis*, can infect dogs once embryonated eggs are ingested from the environment, or when infective larvae are eaten from its paratenic hosts (i.e., rodents). This particular species is unique in that canines can serve as both paratenic and definitive hosts for the parasite, though raccoons (*Procyon lotor*) most often serve as the definitive host (Morelli et al., 2021). Similar to roundworms, hookworms (e.g. *Ancylostoma caninum*) are known to cause severe intestinal damage depending on the species. Young and adult worms can cause high death rates in immunocompromised puppies due to the hematophagic blood loss they undergo when hookworms feed on their gut mucosa (Souza et al., 2023). Some clinical symptoms include hemorrhagic diarrhea, reduced growth, lethargic tendencies, and iron deficiency anemia in adult dogs (Massetti et al., 2022; Morelli et al., 2021). *A. caninum* is one of the most commonly found nematodes infecting the gastrointestinal tract of canines (Ayinmode et al., 2016; Kotwa et al., 2021; Massetti et al., 2022; Ferreira et al., 2017; Souza et al., 2023; Suganya et al., 2019; Torres-Chable et al., 2015).

1.2.3 Whipworms. Whipworms, specifically *Trichuris vulpis*, have high survivability despite harsh conditions—its eggs are able to withstand cold climates in contaminated soil (Morelli et al., 2021). Dogs are susceptible to disease; from subclinical infections to acute or chronic enteritis, which include weight loss, dehydration, and anemia (Morelli et al., 2021). Dehydration and anemia can lead to fatal outcomes, especially when not mitigated early. Living conditions, such as small, overcrowded environments (e.g., farms, shelters) increase risk of infection as they favor the direct cycle of *T. vulpis* (Souza et al., 2023). This is important to note because *T. vulpis* symptoms can emerge early even before egg patency (Massetti et al., 2022). Additionally, adult lungworms (e.g., *Capillaria aerophila*) create lesions in the lungs, inducing respiratory complications. In some cases, neurological disorders may also occur (e.g., *Capillaria boehmi*) (Morelli et al,. 2021). A study by Murnik and colleagues (2022) suggested that dogs infected with *Capillaria* eggs may possibly be acquired through poultry rather than patent infection.

1.2.4 Heartworms and Lungworms. "Heartworm" and "lungworm" are traditional terms that usually entail various cardiopulmonary nematodes. *Dirofilaria immitis* is a vector-borne parasite commonly transmitted by mosquitoes. When an infected mosquito bites a dog, the nematode is able to localize and flourish in the pulmonary vessels, causing dirofilariasis. Other worms (e.g., *Angiostrongylus* spp.) can be transmitted through ingesting intermediate or paratenic hosts—these are most commonly known as lungworms and can infect both dogs and humans alike. Helminths can manipulate host immune systems and downregulate their responses, making them one of the primary causes for chronic illnesses in dogs (Morelli et al., 2021).

1.2.5 Other Canine Parasites. Dogs are at risk for acquiring *Neospora caninum*, a coccidian parasite that induces neosporosis. Infected canines experience partial paralysis of the hind legs and can be acquired congenitally (e.g., transplacental). Young dogs are more likely to shed *N. caninum* oocysts in the environment than their adult counterparts. There is no human infection for this parasite; therefore, it is not proven to have zoonotic potential (Morelli et al., 2021). Tapeworms (e.g., *Echinococcus* spp.) are able to infect their definitive hosts and cause detrimental health impacts; canines are a potential host. Infected adult dogs have increased risk since the parasite favors their bile composition, which also increases the shedding of *Echinococcus* eggs in the environment. Its effects can range from intense dilation of the abdomen to life-threatening situations such as organ dysfunction (Morelli et al., 2021). On the other hand, cystic echinococcosis (CE) is a fatal condition that is underreported in dogs and humans, yet exists worldwide. CE can be controlled; some prevention strategies that could help with eradication efforts include basic hygiene measures and drinking clean/sanitized water (Morelli et al., 2021).

1.3 Implications of Canine Parasites to Humans

1.3.1 Protozoa. Protozoan infections in humans are mostly caused by ingestion of cysts from fruits, vegetables, and/or water. Though infections can be asymptomatic, physical symptoms include diarrhea, epigastric pain, and nausea/vomiting. These can persist and cause chronic infections but most cases are often self-limiting. Humans have a higher risk of acquiring such diseases in low-middle income countries due to poor sanitation and lack of access to clean water, and the most common cause of bowel disturbances are caused by protozoa ingested from contaminated environments (Morelli et al., 2021).

1.3.2 Roundworms and Hookworms. When humans are exposed and ingest *Toxocara* eggs/infective larvae from paratenic hosts, larvae can wander in the body via the bloodstream and settle in tissues/organs. Pre-mature larvae can cause local reactions and lesions. Adult larvae can cause several major syndromes: visceral larva migrans (VLM) in the liver and the lungs, ocular larva migrans (OLM) in the eyes and optic nerve, as well as cerebral larva migrans (CeLM) in the brain. Cutaneous larva migrans (CuLM) can also occur, inducing bumps, blisters, or raised, reddish brown rashes that cause itchiness. Children and toddlers who are suffering from such conditions (e.g., VLM) experience severe symptoms from necrotic hepatitis to seizures. OLM induces impaired vision and eventual blindness; however, this condition is often misdiagnosed as others with similar symptoms like retinoblastoma. Behavioral signs or skin diseases may also arise when larvae migrate to some anatomical sites. *B. procyonis* is the most harmful ascarid, and it is particularly infectious when swallowed by humans and can cause neural larva migrans, a fatal condition inducing paralysis, subarachnoid hemorrhage, and eventual coma and death (Kazacos et al., 2013). Certain larvae present in contaminated soil can burrow under the skin and cause cutaneous lesions and localized irritation (e.g., dermatitis) (Kazacos et al., 2013; Morelli et al., 2021).

1.3.3 Whipworms. Human trichuriasis can be transmitted via ingestion of embryonated eggs from contaminated food/soil exposed to infected human feces. Low-middle income countries with tropical and subtropical areas where poor sanitation and warm/humid climates are prominent have the highest prevalence of human infection. The most common physical symptoms include gastrointestinal issues (e.g., diarrhea), but children may develop severe instances of malnutrition, chronic mucoid diarrhea, and rectal problems associated with massive infantile trichuriasis. In the most severe of cases, nutritional morbidity and cognitive impairment may develop (Morelli et al., 2021).

1.3.4 Heartworms and Lungworms. Dirofilaria caused by *D. immitis* can have health impacts on humans just as they do on canines. These nematodes can be found in the pulmonary arteries of humans when infected mosquitoes bite them (similar to how dogs acquire infection). Although humans do not directly acquire this parasite from dogs, domesticated canines who are infected can indicate higher risk of acquisition to their human owners. People who develop pulmonary nodules are likely to also develop granuloma also known as coin lesion. This condition can be asymptomatic, but respiratory conditions (e.g., chest pain, cough, hemoptysis) may ensue. Allergic conditions can also occur in highly enzootic areas. Subcutaneous or cavitary lesions and diseases can derive from sporadic non cardiopulmonary localizations. The inflammation-causing disease called Pediatric Multisystem Inflammatory Syndrome (PIMS) may also ensue in humans due to this parasite, but the disease's permanent presence or role in the pathogenesis of granuloma is currently unknown in the prevention of patent infections (Morelli et al., 2021).

1.3.5 Other Canine Parasites. There is currently no proven zoonotic prevalence for *N. caninum* in human populations though there is serological evidence that indicates fetal lesions in nonhuman primates; further studies are needed to ultimately determine its importance to human health (Morelli et al., 2021). For *Echinoccocus* spp., humans are dead-end hosts, the parasite cannot proficiently develop or thrive in their bloodstream. Regardless, human CE can still cause a multitude of health conditions whilst having a worldwide distribution. It has high infectivity but can be subclinical—severe fatal conditions only occur when it has reached organs. The prevalence of the parasite in humans increases with age, yet it is underreported in both humans and animals (Morelli et al., 2021). Metacestodosis, often related to alveolar echinococcosis (AE), are relatively rare in humans. *E. multilocularis* larvae infection can primarily occur in the liver but infiltrate proximal sites such as the lungs, brain, and other organs. AE develops slowly and may only show symptoms decades after infection; immunodeficient individuals have faster rates of experiencing fatal symptoms manifested by neoplastic characteristics (Morelli et al., 2021).

1.4 Objectives

This study aimed to assess and document the potential presence of canine (i.e., dog) parasites in Clark County, Nevada urban dog parks. The study objectives were to:

(1) Determine the prevalence of canine intestinal parasite infections in dogs visiting urban dog parks in Clark Countrу, Nevada;

(2) Identify potential spatial hotspots of canine intestinal parasite infections in urban dog parks in Clark Country, Nevada;

(3) Identify risk factors associated with owner and dog behavior which may contribute to canine infection; and,

(4) Determine what species of canine parasites are present in Clark County, NV that have zoonotic potential.

Chapter 2: Background and Significance

2.1 Populations at Risk

Canine parasites can infect humans and cause detrimental medical conditions if no preventative measures are in place. Populations at risk include children, the elderly, pregnant women, and immunocompromised individuals (Ferreira et al., 2017). Neglected parasitic infections particularly have strong correlations with poverty and minority communities. For instance, parasitic infections can induce problems related to cardiovascular, respiratory, and neuropsychiatric health conditions (Hotez, 2014). Although it is unknown why poverty is linked to increased parasitic infection in the USA, other factors such as poor housing, sanitation, and environmental contamination can perpetuate generational poverty among minority communities. The most common helminth derived from dogs, *Toxocara canis*, induces toxocariasis in humans. This disease widely affects both adults and children who live in low income and low education households, as well as those who identify as African American. Some symptoms include cognitive delays, epilepsy, and vision loss; pulmonary manifestations can lead to diminished lung function and asthma (Hotez, 2014).

While neglected parasitic infections are prominent in many communities, there is a need for public health surveillance programs to monitor dog-to-dog and dog-to-human parasitic transmission. Information on this demographical data can help identify populations at risk more accurately, eventually creating interventions that can prevent infectious diseases from spreading across communities.

2.2 Perceptions of Dog Owners on Canine Parasites

Dogs were domesticated 23,000 years ago and have been humans' friendly companions ever since (Perri et al., 2020). Though pets increase mental health prospects, they also constitute risks for zoonotic parasites and other infectious diseases. One of the most important interventions to combat parasite-induced illnesses is through human behavioral change and altering their perceptions on the human-dog relationship. A study conducted by Nguyen and colleagues (2021) used the Health Belief Model (HBM) to explain animal health to pet owners from a veterinary medicine perspective. Although the study setting targeted individuals from South East Queensland, Australia, its findings can be inferable to other high income countries such as the United States. Furthermore, Nguyen and colleagues (2021) demonstrated the importance of the One Health approach by evaluating preventative measures involving humans, animals, and the environment.

HBM uses perceived susceptibility, severity, and barriers to observe factors that influence decisions and their potential outcomes; in this case, pet owners' decisions towards canine parasite prevention. Their findings suggest women had higher perceived severity which increased health-related actions. The perceived benefits of such actions were positively correlated with worm treatment. The duration of ownership also seemed to increase perceived seriousness of the matter at hand—increased ownership showed the likelihood of being exposed to animal health information. Finally, increased awareness of canine parasites can influence the likelihood of using anthelmintic drugs. Though, the downside to this is that the use of anthelmintic drugs may decrease concerns of cooking meat, leading to gastrointestinal parasitic infection (Nguyen et al., 2021). Owner education varies by demographic, so it is important to ensure communities are aware of zoonotic diseases derived from their pets. Consistent veterinarian visits should be considered, as basic knowledge of canine parasites are usually discussed during medical sessions, influencing owners' decisions positively (Nguyen et al., 2021).

While urban dog parks promote social interactions among dogs and other owners, they risk exposure to zoonotic pathogens and parasites. Ferreira and colleagues (2017) mention that controlled environments (e.g., parks) pose increased risk for the transmission of parasitic, zoonotic agents from fecal and soil exposure. They conducted a study which assesses dog owners' behaviors, their understanding of veterinary care, and the human-pet relationship. According to their findings, pet owners who give their pets antiparasitic drugs often do so in irregular intervals, ignoring veterinarian recommendations. Similar to Nguyen et al.'s study (2021), these findings are inferable to other high income countries.

2.3 Urban Parks and Canine Fecal Contamination

Fecal contamination is most common in urban areas, including parks, outdoor areas, and other recreational spaces, which are supposed to increase the quality of life of their inhabitants. Mori and colleagues (2023) explain that while clean and appealing areas are correlated to increased stress relief and various health benefits, factors such as fecal contamination deter park visitors due to unclean and unsafe environments, as well as risking their well-being from zoonotic infections. For instance, fecal matter can migrate to bodies of water such as rivers, contaminating many areas. This affects social aspects like the reduction of *wellness* for people in parks, negatively impacting positive characteristics gained from clean environments and infrastructures. Another important finding discussed was that when dogs were unleashed by their respective owners in enclosed spaces at the park, their owners' willingness to clean up after their dogs' feces decreased due to their sense—the lack of being observed diminishes the social pressures to clean up after their pets' litter.

Simple and effective approaches can positively impact individuals' behaviors to reduce urban park fecal contamination. Such practices include: (1) identifying and enforcing leash bylaws, (2) focusing on cleanliness efforts in parking lots and entrances, (3) educating dog owners of the potential effects of the non-disposal of canine feces, and (4) posting signs to remind people to clean up after their animal companions (Mori et al., 2023).

Chapter 3: Methodology

3.1 Study Design

3.1.1 Institutional Review Board (IRB). This research was exempted by the UNLV IRB Office as the study did not include human subjects. The notice of excluded activity states "No human subjects research" **(Appendix A)**.

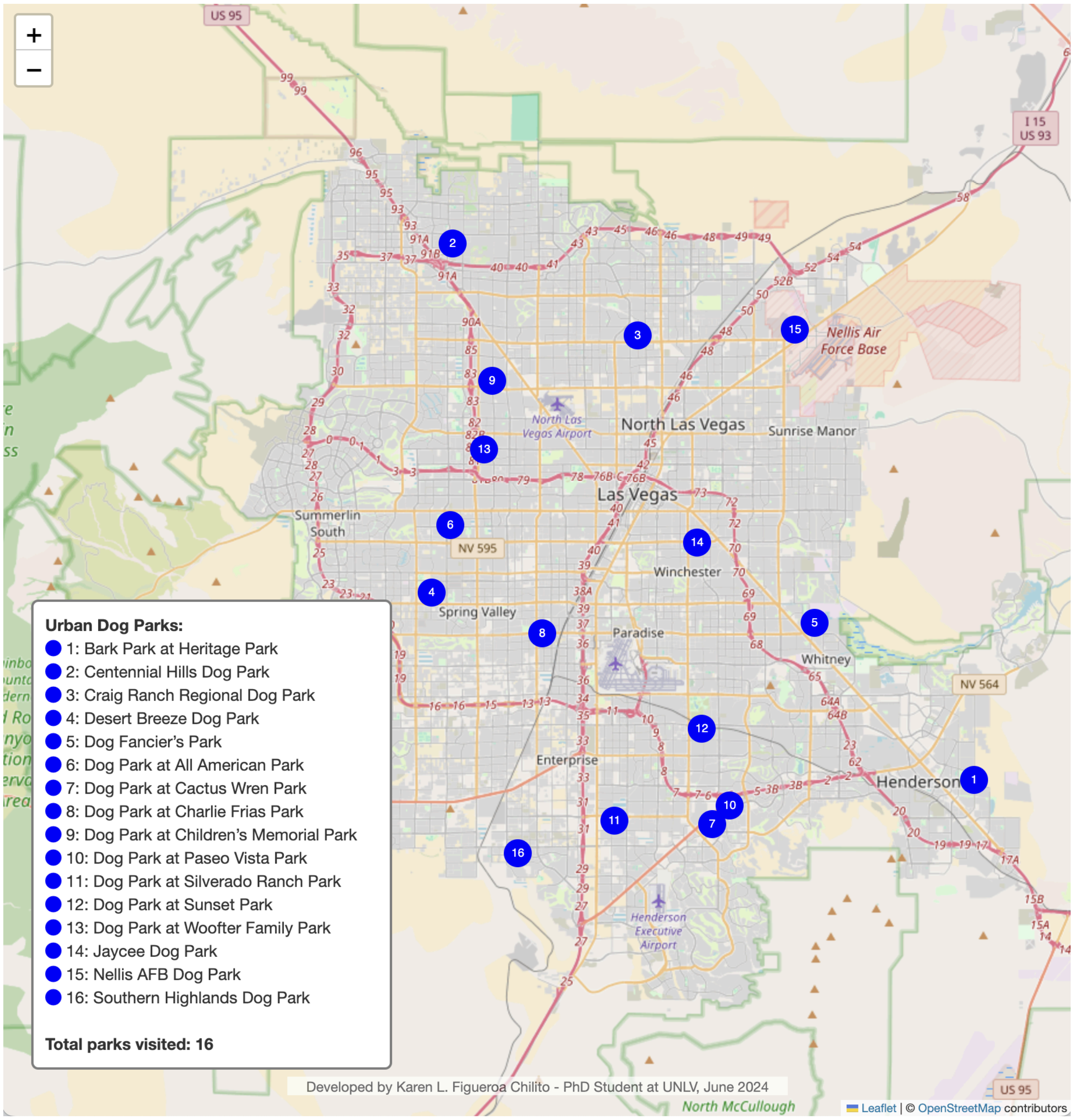
3.1.2 Collection in the Field. This study utilized quantitative data collection methods. Dog owners were approached before or after their pet had defecated in the park and were asked if its feces could be collected for the project. Upon conversing with the dog owner, we informed them of the study's purpose and goals. When the participant agreed to allow for collection, we collected the sample(s) **(Subsection *3.3.1*)** and asked the owner to complete a brief, anonymous survey about their pet **(Appendix B)**. After the owner had answered the survey questions, an informational handout **(Appendix C)** was provided if participants wanted to contact the PARAVEC Lab and learn more about the project. An overview and summary table was posted in the UNLV PARAVEC Lab website for public viewing. No information about the canine's owner was used for any purpose, and no individually identifiable information was taken. We were only interested in basic information about the canine subject.

3.2 Study Setting

The study was conducted in Clark County, Nevada. Urban, off-leash, and pet-friendly parks were investigated for canine parasites derived from stool samples. A total of 16 dog parks were visited **(Figure 4)**. The locations were selected due to its representation and potential spatial distribution of canine parasites in the Las Vegas valley.

Figure 4

Labeled locations of urban dog parks visited in Clark County, NV.



3.3 Data Collection

3.3.1 Sampling Procedures. In each dog park, 5-10 fecal samples were collected immediately after defecation with the exception of two locations; only two samples were collected at Dog Fancier's Park and only one sample was collected at Jaycee Dog Park. Each sample was collected in a plastic dog fecal bag, labeled with an ID number that matched the survey ID number, and placed in a non-food laboratory cooler with ice before transport to the UNLV PARAVEC Lab. A sample ID sheet was utilized to track the samples. There were no incentives for the participants in this project/study; participation was voluntary, and no personal or identifiable information was collected or used in this project.

3.3.2 Survey Development. The PARAVEC Urban Dog Park Parasite Study survey was specifically designed for Clark County, Nevada pet owners and their dogs. It was developed in reference to the original DOGPARCS study conducted nationally (Stafford et al., 2020). The one-page survey asked a total of 12 questions **(Appendix A)**.

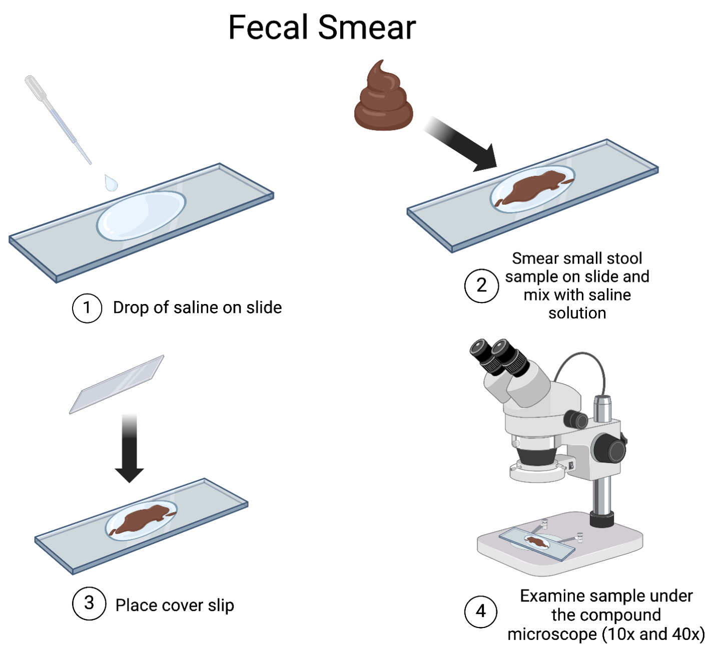
3.4 Laboratory Procedures

Stool tests can detect pathogens such as bacteria, viruses, and parasites that are detrimental for human and animal health. Specifically for dogs, parasite/worm eggs or protozoan cysts can be detected using this diagnostic procedure, allowing healthcare professionals (e.g., veterinarians) to implement interventions against disease transmission with appropriate prevention or treatment strategies. Three laboratory methods will be used to detect intestinal organisms derived from each canine stool sample collected in the field. These include a fecal smear, as well as sugar and salt flotation procedures.

3.4.1 Fecal Smear. Fecal smears are generally conducted to test for disease-inducing organisms that exist in the digestive tract, detecting parasite eggs or *Giardia* cysts from canine stool samples **(Figure 2) (Appendix D)**. A drop of saline solution is generally used to allow for microscopic examination.

Figure 5

Fecal smear procedure.



Note. Figure created with Biorender.com.

3.4.2 Flotation Solutions. Flotation solutions are necessary to observe certain parasite eggs and cysts when conducting fecal flotation methods. The following seven reagents/consumables are commonly used to float parasitic eggs and cysts for observation under a compound microscope: (1) Zinc Sulfate ($ZnSO_4$), (2) Magnesium Sulfate ($MgSO_4$), (3) Sodium Nitrate ($NaNO_3$), (4) Sodium Chloride (NaCL), (5) Sheather's Solution ($C_{12}H_{22}O_{11}$), (6) General Salt + Sugar (NaCL + $C_{12}H_{22}O_{11}$), and (7) Distilled Water. Generally, Sheather's Solution and magnesium sulfate will be used in this study. Procedures for creating these solutions are as follows:

Sheather's Solution ($C_{12}H_{22}O_{11}$) at 1.20-1.25 s.g.

1) 454 g of $C_{12}H_{22}O_{11}$
2) Add 355 mL water
3) Low heating of water may be useful prior to mixing
4) To preserve: After cooling, add 6 mL of formaldehyde or 30 mL of 10% formalin (reduce water to 330 mL in this case)

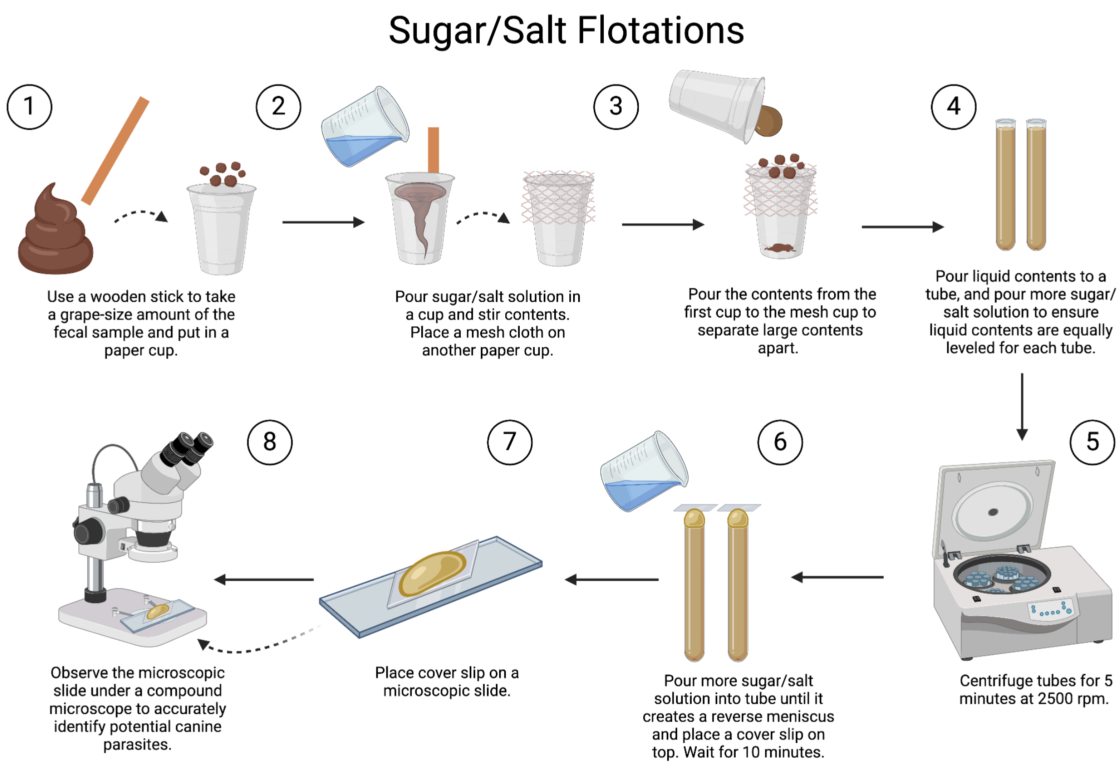
Magnesium sulfate ($MgSO_4$) at 1.2 s.g.

1) 450 g of $MgSO_4$
2) 1000 mL water

3.4.3 Fecal Flotations. Similar to fecal smears, fecal flotations can detect parasitic organisms that are currently existing within dogs' intestinal tract. Sheather's solution (i.e., sugar flotation) or magnesium sulfate (i.e., salt flotation) will be used to accompany specific laboratory procedures that include centrifugation, extraction, and examination of stool samples **(Figure 3) (Appendix E)**. Fecal flotations are more sensitive to detecting specific parasitic indicators that otherwise cannot be observed with a fecal smear. Furthermore, this method provides a clearer visualization of the samples under the microscope, making identification easier, and in turn, more accurately representative of the data being collected.

Figure 6

Sugar/salt fecal flotation procedures.



Note. Figure created with Biorender.com.

3.5 Sample Processing

The collected canine fecal samples were processed in a single laboratory (PARAVEC Lab at the University of Nevada, Las Vegas, NV USA 89154). After conducting a fecal smear, sugar flotation, and salt flotation methods, the samples were placed on a slide with a cover slip for microscopic observation. A Canine Parasitology Visual Reference Guide was used to accurately identify parasitic eggs, cysts, larvae, and other indicators found under the microscope. A parasite collection sheet was used to track observed parasites for each sample procedure (e.g., smear, Sheather's, $MgSO_4$) **(Appendix F)**.

3.6 Data Analysis

The survey data were collected via in-person interactions and the fecal smear, and sugar and salt flotation data were collected after laboratory processing. They were exported to IBM IBM SPSS Statistics (v. 29; Armonk, New Jersey) for analysis. Analyses for each question and hypotheses are provided in **Table 1**. In addition to the descriptive statistics and contingency table analyses in the table, a binary logistic regression model was estimated using presence/absence of parasites as the dependent variable and each of the survey questions as potential predictor variables to ascertain which set of variables may lead to an increased odds of the presence of canine parasites. Analyses were all tested at alpha = 0.05.

Table 1

Research methodological plan.

Research Question	**Hypotheses**	**Statistical Analysis**
1. What is the frequency (i.e., presence or absence) of canine parasites in dogs who visit urban dog parks in Clark County, NV?	a. Canine parasites will be present in dogs which frequent urban dog parks in Clark County, NV.	Descriptive statistics: Frequency and percent of each canine parasite found.
	b. Canine parasites found in Clark County, NV urban dog parks will be potentially zoonotic.	Descriptive statistics: Frequency and percentage of canine parasites categorized by known zoonotic status.

2. If parasites are found, are there associations in dog park location and/or among different canine characteristics (dog breed, age, medication status, etc.)?	a. Frequent dog park visits increase the likelihood of canine parasite acquisition.	Chi-square analysis of visit frequency against presence/absence of parasites with Bonferroni-corrected categorical post hoc analysis if significant.
	b. Canines imported from a different state will have an effect on canine parasite acquisition.	Fisher's exact test of local/imported dogs against presence/absence of parasites.
	c. Kenneled dogs will likely have existing canine parasites.	Chi-square analysis of kenneling frequency against presence/absence of parasites with Bonferroni-corrected categorical post hoc analysis if significant.
	d. Rescue animals will likely have existing canine parasites.	Fisher's exact test of local/imported dogs against presence/absence of parasites.
3. Are there associations among different canine characteristics themselves?	a. There is a relationship between dog age and parasitic burden.	Chi-square analysis of dog age category frequency against presence/absence of parasites with Bonferroni-corrected categorical post hoc analysis if significant.
	b. Heartworm medication affects the risk of transmitting canine parasites.	Chi-square analysis of heartworm medication use against presence/absence of parasites with Bonferroni-corrected categorical post hoc analysis if significant. Additionally, Fisher's exact test of binary medication use response against presence/absence of parasites.

	c. The frequency of veterinary visits affect dogs' risk of canine parasites.	Chi-square analysis of veterinary visits category frequency against presence/absence of parasites with Bonferroni-corrected categorical post hoc analysis if significant.
	d. Other pets living alongside the dog increase the risk of canine parasite acquisition.	Descriptive statistics: Frequency and percentage of other pets in the household followed by Fisher's exact test of other pets against presence/absence of parasites.
4. Are any parasites found potentially zoonotic canine parasites? If so, what health concerns are there for the public and pet owners?	a. Some species of parasites found will be potentially zoonotic.	See question 1(b)
	b. There are associated health concerns for zoonotic canine parasites.	Descriptive analysis of potential health concerns of zoonotic canine parasites and their exposure.

Chapter 4: Results

A total of n = 100 fecal samples from 16 urban dog parks were collected. At least five fecal samples were collected in 14 urban dog parks; two fecal samples were collected at Dog Fancier's park, and only one stool sample was collected at Jaycee Dog Park. One hundred and four dog owners were asked to participate in the study, and only four declined (Response Rate = 96.2%).

4.1 Descriptive Analysis: Demographics and Survey

Figure 7

Prevalence of parasite presence in urban dog parks visited in Clark County, NV. The size of the circles indicates the relative number of parasites at each location.

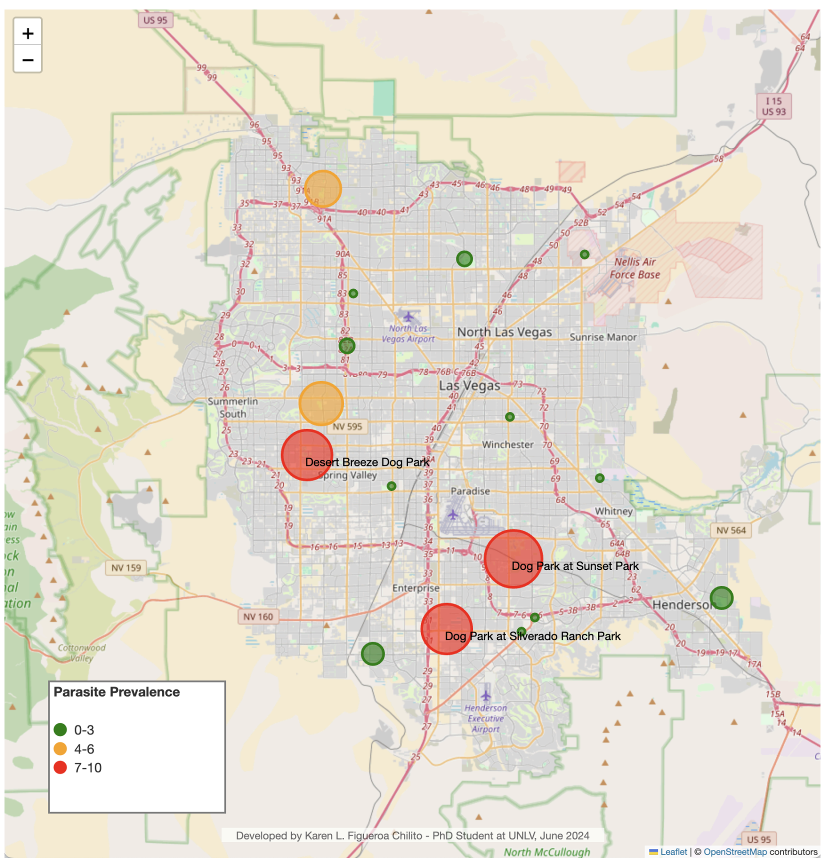


Table 2

Summary of collection sites shown as N (%). Totals for each park along with categories of those parasitized or not parasitized and total positives out of n = 50 for each park (%) are shown.

Collection Site	Total Samples	Parasites Present in Park	Parasites Absent in Park	Total Positivity Rate across All Parks (%)
Bark Park at Heritage Park	10 (10.0)	3 (3.0)	7 (7.0)	6.0
Centennial Hills Dog Park	5 (5.0)	5 (5.0)	0 (0.0)	10.0
Craig Ranch Regional Dog Park	5 (5.0)	2 (2.0)	3 (3.0)	4.0
Desert Breeze Dog Park	10 (10.0)	7 (7.0)	3 (3.0)	14.0
Dog Fancier's Park	2 (2.0)	1 (1.0)	1 (1.0)	2.0
Dog Park at All American Park	10 (10.0)	6 (6.0)	4 (4.0)	12.0
Dog Park at Cactus Wren Park	5 (5.0)	1 (1.0)	4 (4.0)	2.0
Dog Park at Charlie Frias Park	5 (5.0)	1 (1.0)	4 (4.0)	2.0
Dog Park at Children's Memorial Park	5 (5.0)	1 (1.0)	4 (4.0)	2.0
Dog Park at Paseo Vista Park	5 (5.0)	1 (1.0)	4 (4.0)	2.0
Dog Park at Silverado Ranch Park	9 (9.0)	7 (7.0)	2 (2.0)	14.0
Dog Park at Sunset Park	9 (9.0)	8 (8.0)	1 (1.0)	16.0
Dog Park at Woofter Family Park	5 (5.0)	2 (2.0)	3 (3.0)	4.0
Jaycee Dog Park	1 (1.0)	1 (1.0)	0 (0.0)	2.0
Nellis AFB Dog Park	9 (9.0)	1 (1.0)	8 (8.0)	2.0
Southern Highlands Dog Park	5 (5.0)	3 (3.0)	2 (2.0)	6.0

Table 3

Summary of survey responses shown as N (%). Totals for each question along with categories of those parasitized (X.X) over total (X.X) and not parasitized over total (X.X) are shown. Statistical tests for each comparison are to compare parasitized and non-parasitized canines.

Category	Total	Parasites Present	Parasites Absent	Test Statistics and p-value
What breed is your dog?				
Mixed	58 (58.0)	30 (51.7)	28 (48.3)	$\chi 2$ = 8.823 p = 0.357
Toy	14 (14.0)	5 (35.7)	9 (64.3)	
Working	9 (9.0)	2 (22.2)	7 (77.8)	
Herding	8 (8.0)	5 (62.5)	3 (37.5)	
Non-Sporting	3 (3.0)	2 (66.7)	1 (33.3)	
Sporting	3 (3.0)	3 (100.0)	0 (0.0)	
Foundation Stock Service (FSS)	2 (2.0)	1 (50.0)	1 (50.0)	
Terrier	2 (2.0)	1 (50.0)	1 (50.0)	
Hound	1 (1.0)	1 (100.0)	0 (0.0)	
What is the sex of your dog?				
Female	42 (42.0)	22 (52.4)	20 (47.6)	Fisher's Exact Test p = 0.840
Male	58 (58.0)	28 (48.3)	30 (51.7)	
Has your dog been spayed or neutered?				
No	23 (23.0)	13 (56.5)	10 (43.5)	Fisher's Exact Test p = 0.635
Yes	77 (77.0)	37 (48.1)	40 (51.9)	
How old is your dog?				
Puppy (<1 year)	8 (8.0)	5 (62.5)	3 (37.5)	$\chi 2$ = 5.054 p = 0.168
Young Adult (1-3 years)	44 (44.0)	24 (54.5)	20 (45.5)	
Mature Adult (4-6 years)	27 (27.0)	15 (55.6)	12 (44.4)	

Senior (7+ years)	21 (21.0)	6 (28.6)	15 (71.4)	
How often do you bring your dog to a dog park?				
At least daily	27 (27.0)	14 (51.9)	13 (48.1)	$\chi2 = 0.201$ $p = 0.977$
At least weekly	30 (30.0)	14 (46.7)	16 (53.3)	
Every few weeks	10 (10.0)	5 (50.0)	5 (50.0)	
Rarely	33 (33.0)	17 (51.5)	16 (48.5)	
Is your dog currently taking heartworm medication?				
No	96 (96.0)	48 (50.0)	48 (50.0)	Chi-square Test $\chi2 = 0.000$ $p = 1.000$ Fisher's Exact Test $p = 1.000$
Yes - chewable tablet	4 (4.0)	2 (50.0)	2 (50.0)	
Yes - topical	0 (0.0)	0 (0.0)	0 (0.0)	
Yes - injectable	0 (0.0)	0 (0.0)	0 (0.0)	
Has your dog been diagnosed with intestinal parasites?				
No	90 (90.0)	46 (51.1)	44 (48.9)	$\chi2 = 0.444$ $p = 0.505$
Yes - but treated and cleared	10 (10.0)	4 (40.0)	6 (60.0)	
Yes - on current treatment	0 (0.0)	0 (0.0)	0 (0.0)	
Yes - injectable	0 (0.0)	0 (0.0)	0 (0.0)	
When was the last time your dog visited the veterinarian?				
Never	0 (0.0)	0 (0.0)	0 (0.0)	$\chi2 = 4.752$ $p = 0.093$
<6 months ago	52 (52.0)	26 (50.0)	26 (50.0)	
6-12 months ago	33 (33.0)	13 (39.4)	20 (60.6)	

12+ months ago	15 (15.0)	11 (73.3)	4 (26.7)	
Did your dog live in any other state(s) before moving to Las Vegas?				
No	67 (67.0)	30 (44.8)	37 (55.2)	Fisher's Exact Test p = 0.202
Yes	33 (33.0)	20 (60.6)	13 (39.4)	
Has your dog been in a kennel?				
No	57 (57.0)	30 (52.6)	27 (47.4)	$\chi 2 = 4.096$ $p = 0.251$
Yes - within the last 6 months	14 (14.0)	9 (64.3)	5 (35.7)	
Yes - within the last 6-12 months	3 (3.0)	2 (66.7)	1 (33.3)	
Yes - over 12 months ago	26 (26.0)	9 (34.6)	17 (65.4)	
Was your dog a rescue animal?				
No	57 (57.0)	27 (47.4)	30 (52.6)	Fisher's Exact Test p = 0.686
Yes	43 (43.0)	23 (53.5)	20 (46.5)	
Do you have any other pets living in your home that interact with your dog?				
No	36 (36.0)	18 (50.0)	18 (50.0)	Fisher's Exact Test p = 1.000
Yes	64 (64.0)	32 (50.0)	32 (50.0)	

4.1.1 Collection Site. In the canine samples collected and processed (n = 100), we found that intestinal parasites were present in 50 (50%) of the dogs who frequented urban dog parks in Clark County, NV, and the other 50 (50%) of the dogs sampled had no parasite burden. Of the sixteen urban dog parks visited, at least one canine parasite was present from the sample(s) collected at each park. Of the positive samples collected, the Dog Park at Sunset Park yielded the highest prevalence of canine parasites, followed by Desert Breeze Dog Park and Dog Park at Silverado Ranch Park. The Dog Park at All American Park and Centennial Hills Dog Park had moderate prevalence of canine parasites. The Bark Park at Heritage Park, Southern Highlands Dog Park, Craig Ranch Regional Park, and Dog Park at Woofter Family Park yielded some canine parasite prevalence. The remaining seven of the urban dog parks visited had only one canine parasite present. **(Table 2)**.

4.1.2 Breeds. Dog breeds were categorized using the American Kennel Club (AKC) grouping standards (American Kennel Club, 2023). Pitbulls, in particular, are not recognized in any category by the AKC; therefore, pitbulls in this study were grouped together with the *Mixed* breeds category. With that being said, most of the dogs sampled in this study were *Mixed*. We sampled some breeds grouped in the *Toy*, *Working*, and *Herding* breed categories. There was the same number of *Non-Sporting* and *Sporting* dogs sampled. There was also the same number of *Foundation Stock Service (FSS)* and *Terrier* dogs sampled, while the *Hound* group was sampled the least. While there was an inequitable distribution of dogs ($\chi2 = 235.88$, $p < 0.0001$), there were no differences in the proportion of parasitized and non-parasitized dogs as a function of breed **(Table 3)**.

4.1.3 Sex and Spayed/Neutered. There were more male dogs sampled in the study compared to female dogs. There were more dogs who were spayed/neutered than not **(Table 3)**.

4.1.4 Age and Park Time. The most sampled age range for dogs were young adults (1-3 years old), followed by mature adults (4-6 years old), and seniors (7+ years old). Puppies (<1 year old) were the least sampled in this study. Dog owners in Clark County, NV brought their dogs to the park at least weekly. A few participants brought their canines at least daily, and very few brought their pets every few weeks **(Table 3)**.

4.1.5 Heartworm Medication, Parasite Diagnosis, and Veterinary Visits. At the time period of when this study was conducted, dog owners stated that they were not giving heartworm medication to their dogs. However, four participants did in the form of a chewable tablet. In the same time period, most dogs were not diagnosed with intestinal parasites while a few were previously diagnosed, but treated and cleared. Furthermore, most participants brought their canine pets to veterinary clinics for a check up recently (<6 months ago) or at least within the past year (6-12 months ago). Only a few dog owners brought their dogs for a veterinary visit over a year ago (12+ months ago) **(Table 3)**.

4.1.6 Other Locations, Kenneled, and Rescue Animal Status. Most dogs sampled in Clark County urban dog parks were local and did not live in any state other than Nevada, while some did. Dogs were mostly not kenneled at all, and only a few were kenneled over 12 months ago, within the last 6 months, or within the last 6-12 months. Lastly, participating dogs were characterized as being non-rescue animals more than being rescue animals **(Table 3)**.

4.1.7 Other Pets. Most dog owners surveyed stated that their canine companions regularly interacted with other pets (i.e., other dogs, cats, tortoises) in the household, and a few of them said no **(Table 3)**.

4.2 Descriptive Analysis: Frequency and Percent of Canine Parasites

Out of the one hundred samples collected, 50 of them yielded positive for canine parasites. These parasites were categorized into five different groups: Protozoa, Cestoda, Nematoda, Trematoda, and Acanthocephala.

Table 4

Parasite frequency by test type

Group / *Genus species*	**Smear**	**Sugar**	**Salt**
Protozoa			
Amoeba (various)	3	3	0
Cystoisospora	12	9	10
Cryptosporidium	13	6	12
Eimeria	1	0	1
Giardia	4	1	3
Sarcocystis	0	0	0
Toxoplasma gondii	0	0	0
Cestoda			
Diphyllobothrium latum	1	0	0
Dipylidium caninum	1	3	0
Echinococcus	0	0	0
Mesocestoides	0	2	0
Taenia	4	2	2
Nematoda			
Ancylostoma	0	3	5
Angiostrongylus	1	0	0
Baylisaascaris procyonis	0	0	0
Capillaria	0	0	0
Dioctophyma renale	0	0	0
Eucoleus (Capillaria)	0	0	0
Filaroides	0	0	0

Pearsonema	0	0	0
Physaloptera	0	0	0
Spriocerca lupi	3	0	0
Strongyloides stercoralis	1	2	2
Syphacia	0	0	2
Toxascaris leonina	2	0	2
Toxocara canis	7	5	4
Trichuris vulpis	0	0	0
Uncinaria stenocephala	0	0	0
Trematoda			
Alaria	0	0	0
Heterobilharzia americana	0	0	0
Metorchis conjunctus	0	0	0
Nonophyetus salmincola	0	0	0
Paragonimus kellicotti	0	0	0
Spirometra	0	0	0
Acanthocephala			
Macracanthorhynchus	0	0	0

Table 5

Summary of parasite count by species shown as N, percent of parasite count over total group count, and percent of parasite count by species over total positive samples (n = 50).

Group / *Genus species*	**Parasites**	**Group**	**Positive Samples (*n* = 50)**
Protozoa (64)			
Amoeba (various)*	6	9.4	12.0
Cystoisospora	25	39.1	50.0
*Cryptosporidium**	24	37.5	48.0
Eimeria	1	1.6	2.0
*Giardia**	8	12.5	16.0
Cestoda (13)			
*Diphyllobothrium latum**	1	7.7	2.0
*Dipylidium caninum**	3	23.1	6.0
*Mesocestoides**	2	15.4	4.0
*Taenia**	7	53.8	14.0
Nematoda (22)			
*Ancylostoma**	4	18.2	8.0
*Angiostrongylus**	1	4.5	2.0
Spirocerca lupi	3	13.6	6.0
*Strongyloides stercoralis**	2	9.1	4.0
*Syphacia**	2	9.1	4.0
Toxascaris leonina	2	9.1	4.0
*Toxocara canis**	8	36.4	16.0

*Zoonotic potential; the parasite species can be transmitted from dog to human.

Table 6

Frequency of total single infection or co-infections N (%) for positive samples (n = 50), parasites/parasite combinations found, and counts of parasites/parasite combinations found.

Single Parasite Infection	**Parasites Found**	**Count**
17 (34.0)	Amoeba (various) *Cystoisospora* *Cryptosporidium* *Giardia* *Taenia*	2 3 7 3 2
2 Parasite Infections (Co-Infection)	**Parasite Combinations Found**	**Count**
20 (40.0)	Amoeba (various), *Toxocara canis* Amoeba (various), *Taenia* *Cryptosporidium, Ancylostoma* *Cryptosporidium, Dipylidium caninum* *Cryptosporidium, Syphacia* *Cryptosporidium, Taenia* *Cryptosporidium, Toxascaris leonina* *Cryptosporidium, Toxocara canis* *Cystoisospora, Cryptosporidium* *Cystoisospora, Giardia* *Cystoisospora, Spriocerca lupi* *Taenia, Ancylostoma*	1 1 1 1 2 1 1 3 6 1 1 1
3 Parasite Infections (Co-Infection)	**Parasite Combinations Found**	**Count**
9 (18.0)	Amoeba (various), *Cystoisospora, Cryptosporidium* *Cryptosporidium, Strongyloides stercoralis* *Cryptosporidium, Taenia, Angiostrongylus* *Cystoisospora, Cryptosporidium, Dipylidium caninum* *Cystoisospora, Cryptosporidium, Toxocara canis* *Cystoisospora, Giardia, Mesocestoides* *Cystoisospora, Mesocestoides, Taenia* *Cystoisospora, Spriocerca lupi, Strongyloides stercoralis* *Diphyllobothrium latum, Dipylidium caninum, Ancylostoma*	1 1 1 1 1 1 1 1 1
4 Parasite	**Parasite Combinations Found**	**Count**

Infections (Co-Infection)		
4 (8.0)	Amoeba (various)*, Cystoisospora, Giardia, Toxocara canis* *Cystoisospora, Ancylostoma, Spriocerca lupi, Toxocara canis* *Cystoisospora, Cryptosporidium, Giardia, Toxocara canis* *Cystoisospora, Eimeria, Giardia, Toxascaris leonina*	1 1 1 1

4.2.1 Parasite Frequency by Test Type. We found that out of the three procedures conducted (i.e., fecal smear, sugar flotation, salt flotation), fecal smears yielded the most diverse set of parasite species (n = 13). There were five nematode species, five protozoan species, and three cestode species identified. On the other hand, the sugar flotation procedure yielded a moderate diverse set of parasite species (n = 10); four protozoan species, three cestode species, and three nematode species were identified. Lastly, the salt flotation procedure also yielded a moderate diverse set of parasite species (n = 10); five nematode species, four protozoan species, and one cestode species were identified. No trematode or acanthocephalan parasite species were present in our samples. Finally, parasites most commonly appeared in our fecal smear slides, followed by the salt flotation slides, and the least in the sugar flotation slides **(Table 4)**.

4.2.2 Parasite Count by Group and Positive Samples. Based on our findings of the parasite count by group, most samples had protozoan parasites, some had nematode parasites, and a scarce amount of the samples had cestode parasites present. *Cystoisospora* and *Cryptosporidium* accounted for two of the parasites frequently identified in the protozoan group; about half of the positive samples had at least one of the parasites mentioned present (50% and 48%, respectively). *Toxocara canis* was the most prevalent parasite found in the nematode group, being present in 16% of the positive samples. In the cestode group, *Taenia was* the most frequently identified species, being present in 14% of the positive samples. Out of the sixteen parasite species found, 12 have zoonotic potential **(Table 5)**.

4.2.3 Single and Co-Infections. A majority of the positive samples had two parasite infections, which were counted as co-infections. An adequate number of the samples had a single infection, and a small number of the samples had at least three and a maximum of four co-infections/parasites present. The most common parasites found in both single infections and all co-infection combination categories were *Cystoisospora* and *Cryptosporidium*. *Toxocara canis* was the next parasite commonly observed within the co-infected positive samples found **(Table 6)**.

4.3 Descriptive Statistics, Chi-square Test, and Fisher's Exact Test

For some of the research questions provided (1a, 1b, 3d, 4a, 4b), descriptive statistics were used to observe the frequency and percentages of canine parasite presence or absence. Furthermore, upon conducting a *Chi-square test* (2a, 2c, 3a, 3b, 3c) and/or *Fisher's exact test* (2b, 2d, 3b, 3d), we found that there were no associations between parasite presence/absence against each survey response conducted in the study; therefore, we fail to reject the null hypotheses **(Tables 1 and 3)**.

4.4 Binary Logistic Regression

A *Binary Logistic Regression* analysis was conducted to investigate the potential effects of dog breed, sex, spayed/neutered status, age, frequency of dog park visits, heartworm medication, previous intestinal parasite diagnosis, length of time between veterinarian visits, importation from a different state, kenneled, rescue animal status, and other pets in the household they regularly interact with. The model was not statistically significant ($\chi^2(26) = 35.606$, $p = 0.099$), explaining between 30% (Cox & Snell R Square) and 39.9% (Nagelkerke R Square) of the variance in presence/absence of parasites. The Hosmer and Lemeshow test suggested a good fit to the data ($\chi^2(26) = 6.581$, $p = 0.582$). Based on the model, length of time between veterinarian visits (12+ months) was a significant predictor ($B = 2.455$, $Wald = 6.271$, $p = 0.012$, $Exp\ (B) = 11.642$, 95% CI [1.71, 79.503]), increasing the odds of parasite presence compared to the <6 months ago reference group. These findings indicate that length of time between veterinarian visits (12+ months) is an important factor in determining the likelihood of parasite presence **(Appendix G)**.

Chapter 5: Discussion

5.1 Addressing the Research Questions and Hypotheses

5.1.1 Frequency of Dog Park Visits and Parasite Zoonotic Potential. Canine parasites from the samples collected in select Clark County, NV urban dog parks were positive 50% of the time. The parasites found in each positive categorical group (i.e., Protozoa, Cestoda, Nematoda) are potentially zoonotic. Protozoan parasites such as *Cryptosporidium*, *Giardia*, and various amoeba species can infect both dogs and humans. Additionally, the observed cestodes that have zoonotic potential included *Taenia*, *Dipylidium caninum*, *Mesocestoides*, and *Diphyllobothrium latum*. Finally, five different species of nematodes were found to be zoonotic in this study, including *Toxocara canis*, *Ancylostoma*, *Strongyloides stercoralis*, *Syphacia*, *Angiostrongylus* **(Table 5)**. In the USA, the most commonly diagnosed canine gastrointestinal parasites include roundworms, hookworms, and whipworms (Drake & Carey, 2019). Drake and Carey (2019) found that from a 7-year period examination of data from over 39 million dog stool samples suggested increasing prevalence for roundworms and whipworms, and slightly decreasing prevalence for hookworms. Although the prevalence of these parasite groups were subtle, they found that there was a significant association between seasonality and parasite prevalence (Drake & Carey, 2019). The samples collected in the current study ranged between the January to June months. Drake and Carey (2019) suggested that one of the highest seasonal prevalence for these groups of parasites is during January to February, which falls between the collection period of the current study.

5.1.2 Associations in Dog Park Location and/or Different Canine Characteristics. The frequency of dog park visits, canine importation from a different state, previously kenneled status, or rescue animal status had no associations with parasite presence or absence **(Table 3)**. We suspected that dogs who frequent dog parks at least daily would have increased risk of parasite acquisition; 51.9% of dogs who frequented dog parks at least daily had parasites present. This finding, however, is quite consistent across the different options available for that specific survey question. We found that 46.7% of dogs who frequented dog parks at least weekly, 50% of dogs who frequented dog parks every few weeks, and 51.5% of dogs who frequented dog parks rarely had parasites. The results from this study suggest that frequency of dog visits does not necessarily correlate to increased susceptibility to parasites, but it does show that dogs who visit dog parks in general are exposed to and are at risk for parasite presence. This finding is similar to what was found in the national DOGPARCS study of which the current study was replicated from (Stafford et al., 2020). Furthermore, it was hypothesized that if a canine has traveled or lived in a different state, there may be a higher likelihood of parasite presence, as well as distributing parasites that are otherwise not prevalent in Nevada. The current study suggests that there was no association between the two variables. Finally, there were no associations between dogs who were previously kenneled and parasite presence and between dogs who were rescued and parasite presence **(Table 3)**. According to Raza and colleagues (2018), shelter dogs are prone to nematode and protozoan parasite species such as *Ancylostoma*, *D. caninum, T. canis*, *T. leonina*, *Giardia*, and *Cryptosporidium*. Increased exposure to parasites via the environment (sheltered and enclosed) and/or diverse dog populations also increases exposure to various stressors; therefore, increasing parasite prevalence and prevalence (Raza et al., 2018). In the current study, these parasites were present in the positive samples found; most notably *T. canis* and

Cryptosporidium, both of which are zoonotic. The aforementioned nematode and protozoan species were prevalent in dogs who were not kenneled or placed in a shelter. This finding is concerning as dogs living in a secluded, more controlled space should have less parasite risk compared to sheltered/kenneled dogs (Raza et al., 2018). The current study's findings also suggest that recently kenneled/sheltered dogs have a higher probability of parasite presence; Nine out of the 14 dogs who were kenneled within the last 6 months were positive for parasites. On the other hand the current study also contradicts this sentiment since 52.6% of dog owners who have not placed their dogs in a kennel still had parasites present **(Table 3)**. Another study found that zoonotic intestinal parasites (e.g., ascarids and hookworms) were more prevalent in shelter dogs compared to dogs living in a house (Campanale et al., 2023). Campanale and colleagues (2023) found that 54% of dogs at admission to the shelter were diagnosed with intestinal parasites, and 43 of the 50 positives in their study were diagnosed with mono/co-infections of both zoonotic (i.e., *Ancylostoma* and *Toxocara* spp.) and non-zoonotic parasites. In the current study, we found that *T.canis* was more frequently observed in co-infected samples than single infection samples; the most commonly identified parasite in the single infection category was *Cryptosporidium*, also a zoonotic parasite of public health concern **(Figure 1)**.

5.1.3 Associations among Different Canine Characteristics Themselves. Similar to our previous findings, dog age, heartworm medication, frequency of veterinary visits, and other pet interactions in the household had no association against parasite presence **(Table 3)**. In order to assess whether different canine characteristics are able to predict parasite burden, a *Binary Logistic Regression* test was used. We found that among the characteristics listed in the current study, a veterinarian visit exceeding 12 months in the past is a predictor for increasing the odds of parasite presence **(Section 4.4)**. This finding is important to note as routine checkups are preventative measures that ensure pets are healthy and free of disease-inducing organisms. It was assumed that regular/on-time veterinary visits can decrease the likelihood of parasite infection. Based on this result, we can predict that the time in which a canine pet visits its veterinarian can either increase or decrease parasite acquisition. While there were no significant differences between dog age and parasite presence in this study, Murnik and colleagues (2023) found that 41.2% of the 386 young dogs sampled were more susceptible to intestinal parasites, specifically *Giardia duodenalis* (29%), *Cryptosporidium* spp. (9.1%), *Cystoisospora* spp. (7.3%), and *Toxocara canis* (6%). This finding is consistent with the current study's findings as well—62.5% of puppies (<1 year old) were positive; however, it is important to note that only a total of 8 dogs were sampled in this age category. Additionally, dogs who are receiving or are currently receiving heartworm medication are assumed to have less susceptibility to parasites (i.e., *Dirofilaria immitis*). The current study is not a good example to assess this assumption as 50% of dogs who are not taking heartworm medication at the time of collection were positive for parasites. However, a study about prevalence of canine heartworm infection in the USA by Self and colleagues (2019) suggests that canine heartworm prevalence has increased locally and regionally. Although *D. immitis* was not positively identified in the current study, there is a possibility that the parasite was overlooked. Precautionary measures are still advised as both domestic dogs and some wild canids (e.g., coyotes, wolves) in the western states were affected by this parasite according to the 2012-2018 trend (Self et al., 2019).

5.1.4 Zoonotic Parasites and Public Health, Veterinary, and Owner Concerns. Some of the protozoan, cestode, and nematode species identified in the current study are potentially zoonotic. *Cryptosporidium*, which was found in 48% of the positive samples, is a concern since infected dogs can contaminate water and food sources with infective oocysts. These oocysts can be transmitted to humans, causing life-threatening conditions to immunocompromised individuals. Infected dogs and humans may show symptoms such as acute, chronic, or intermittent diarrhea (Centers for Disease Control and Prevention, 2024a) **(Table 5) (Figure 1)**. *Giardia*, a different type of protozoan species, was another concerning parasite found that can induce gastrointestinal issues to both dogs and humans. Chronic giardiasis may also occur—general symptoms may persevere, as well as malabsorption and debilitation in severe human cases (Centers for Disease Control and Prevention, 2024b) **(Table 5)**. The cestode *Taenia* was found in the current study's samples. While humans are definitive hosts to some *Taenia* species, contamination of food and water sources from an infected dog can induce mild abdominal issues (i.e., taeniasis). Proglottid (i.e., a reproductive segment of tapeworm) migration can cause appendicitis or bile duct inflammation. Taeniasis from *Taenia solium* can indicate the development of cysticercosis, a condition in which cysts develop in different parts of the body (e.g., muscles, eyes, brain, heart, spine) and cause lumps, blindness, seizure-inducing epilepsy, heart failure, or weakened spinal nerves (Centers for Disease Control and Prevention, 2024c) **(Table 5)**. Nematode species such as *Toxocara canis* are prevalent in young dogs. Humans can acquire the parasite through paratenic hosts like undercooked beef, lamb, and chicken. Other organisms that can potentially be transport/paratenic hosts to *Toxocara canis* are cockroaches and earthworms.

Toxocariasis symptoms can present themselves in multiple ways depending on the region of infection in the human body (Centers for Disease Control and Prevention, 2019a) **(Figure 2) (Subsection *1.3.2.*)**. Like toxocariasis, strongyloidiasis derived from the roundworm *Strongyloides stercoralis*, was scarcely found in the current study's samples, but is important to discuss as larvae can migrate to different organs and cause a multitude of symptoms or show no symptoms at all. Tracheal irritation and dry cough may develop if larvae migrate to the lungs, and if the larvae are swallowed instead, humans may experience severe gastrointestinal issues (e.g., anorexia). Patients receiving a high dosage of corticosteroids or anti-inflammatory drugs can develop hyperinfection syndrome—accelerating autoinfection of strongyloidiasis from the abundance of migrating larvae and causing severe organ complications (Centers for Disease Control and Prevention, 2019b) **(Figure 3)**. Dog owners who take their canine pets outdoors such as a park should be cautious from transmitting parasites via other dogs/pets, paratenic hosts, and the environment (e.g., soil). Zoonotic parasite prevention strategies should follow guidelines indicated in the One Health initiative. The rate and risk of infection to zoonotic diseases are affected by humans, animals, and the environment. The One Health initiative understands that these entities are interconnected. To prevent disease from spreading across a wide range of areas, collaborations among the community, the government, and health agencies at the local, national, and global levels are optimal to eliminate disease transmission overall (Mackenzie & Jeggo, 2019). For instance, health surveillance techniques like systematic surveys should be implemented to monitor animal behaviors, environmental conditions, zoonotic parasite transmission, and human activities. This strategy can help identify factors that increase risk of zoonotic parasite infection, as well as prevent certain parasites from invading non-endemic areas (Otranto et al., 2021). It is also recommended that if dogs interact with different mammals in multiple areas, owners should follow veterinary protocols when symptoms arise. Ensuring that dogs are actively attending their routine checkups is equally as important; if parasites are found, treatment administered from their veterinarian can prevent the severity of potential disease. These precautions can particularly decrease the odds of human infection and environmental contamination.

5.2 Comparisons to the DOGPARCS Study

The original DOGPARCS study by Stafford and colleagues (2020) was replicated to conduct the current study. While researchers were able to gather canine stool samples from different metropolitan areas across the USA, this study focused on Clark County, NV urban dog parks. Nevada, specifically Clark County, was not included in the original DOGPARCS study (Stafford et al., 2020). Furthermore, the current study matched the target sample size (n = 100) in each urban location to ensure that the findings were justifiable and consistent with the available literature.

5.2.1 Demographics: Age, Sex, and Neutered/Spayed. In both the current study and the DOGPARCS study, the most commonly represented dog age group was young adults (1-3 years old), and the least commonly represented age group was puppies (<1 year old) (Stafford et al., 2020). There were more male dogs sampled in the current study (58%) and the DOGPARCS study (56.2%), but fewer of the dogs in the current study were neutered (74.1%) in comparison to the DOGPARCS study (84.6%) (Stafford et al., 2020). Fewer female dogs were also spayed in the current study (81%) compared to the DOGPARCS study (89.8%).

5.2.2 Breeds. In this study, dog breeds were categorized using AKC standards (American Kennel Club, 2023). When compared to the DOGPARCS study, the most commonly represented breed was *Mixed*, which is similar to the current study. When we grouped the sampled dogs from the DOGPARCS study using AKC standards, we found that there were more dogs from the *Sporting* (16.4% vs. 3%) and *Herding* (9.6% vs. 8%) groups sampled in the Stafford and colleagues (2020) paper compared to the current study (American Kennel Club, 2023). However, there were less *Toy* (2.8% vs. 14%) and *Working* (5.5% vs. 9%) groups sampled in the DOGPARCS study compared to the current study (Stafford et al., 2020).

5.2.3 Heartworm Medication. Dog owners surveyed in the DOGPARCS study stated that they administered heartworm medication to their canine pets (68.8%), which was substantially greater compared to the participants in the current study (4%), likely owing to area of collection and dependent on prevalence of *D. immitis* and its vector, mosquitoes.

5.2.4 Collection Site Region. Stafford and colleagues (2020) were able to determine the prevalence of intestinal canine parasites at the national level (288 parks from 30 cities). Meanwhile, this study was able to identify the prevalence of such parasites within a county (16 parks from 1 city). Although the DOGPARCS study was able to conduct research across a range of metropolitan cities and park locations, the current study provides information on a specific area that was overlooked in the literature.

5.2.5 Comparison of Parasites Observed. In the DOGPARCS study, Stafford and colleagues (2020) found that protozoa, specifically *Giardia* (13%), was the most commonly identified parasite within their samples. *Eimeria* (1.2%) was also identified, though its prevalence may be underestimated due to identification errors. Although protozoa was the most commonly identified group in the current study, *Giardia* (16%) was not a prevalent species, but *Cystoisospora* (50%) and *Cryptosporidium* (48%) were **(Table 5)**. Nematodes such as *Ancylostoma caninum* and *Trichuris vulpis* were commonly detected in the DOGPARCS study. In the current study, *Toxocara canis* accounted for the most commonly identified nematode, followed by *A. caninum*; we did not find *T. vulpis* in our samples. The DOGPARCS study mentioned that *T. vulpis* and *T. canis* may be underestimated in their samples; however, the current study found a prevalence of *T. canis* **(Table 5)**. Stafford and colleagues (2020) stated that underrepresentation of these nematodes may be in part due to collection time from July and August when *T. vulpis* and *T. canis* are at their lowest prevalence. Interestingly, the samples collected in the current study were obtained from January to June, possibly having an influence on *T. canis* prevalence together with environmental conditions such as weather and parasite survivability in the soil. Moreover, the DOGPARCS study rarely detected cestodes and trematodes, which is quite similar to the current study's findings; trematodes were not observed in the current study. Common tapeworms like *Taenia* and *Dipylidium caninum* were prevalent in the DOGPARCS study but less commonly identified in the current study (Stafford et al., 2020) **(Table 5)**. Location, environmental conditions, or identification errors may account for the lack of trematode and acanthocephalan data in the current study **(Table 4)**.

5.3 Other Interesting Findings

5.3.1 The Community and Parasite Awareness. Urban dog parks in Clark County, NV are owned by the county, and signage/reminders and information are standardized across all the local parks. Dog park rules are posted at every entrance of each dog park; these rules include (but are not limited to) the prevention of dog fights, maintaining dog camaraderie, respecting park visitors, etc. While rules are established, they are often not enforced but mere suggestions for the community to follow. While employees of the parks are stationed at different times during the day, they are not required to constantly oversee the dog parks within a given time. Therefore, park goers and their pet dogs can ignore the rules established and not follow them by any means. For instance, food is not allowed in off-leash areas whatsoever, but some community members do not necessarily follow that rule. The parasites we found in the study can contaminate food and water sources, which pose a threat to both the canine pets and their dog owners alike.

Awareness of canine parasites seems to be lacking in the Clark County community—upon surveying the participants for their dogs' information, discussions about the study and its importance were evident. Many community members were unaware that zoonotic canine parasites exist and can be transmitted to humans. The lack of education is also evident when dog owners allowed their canine pets to drink from a shared water basin. Observations of the off-leash areas also enhance the idea that the community is collectively unconcerned of parasite transmission as most owners remain complacent after gentle reminders.

5.3.2 Heartworm Medication and Mosquitoes. Heartworm is a much greater concern in other parts of the USA, but it has not been a historical issue in Las Vegas, NV. Though, it is important to consider that severe mosquito transmission is increasing in the American Southwest, specifically in Southern Nevada. In fact, *Aedes aegypti* is an emerging vector borne disease threat in Southern Nevada that can transmit a multitude of viruses and diseases, including heartworm (i.e., *D. immitis*) in dogs (Southern Nevada Health District, n.d.). This phenomenon may account for a possible increase in canine heartworm cases, as well as an increase in dog owner precautions, affecting regular veterinary visits and the administration of heartworm medication to their canine pets. At the time of the DOGPARCS study being conducted, the majority of owners (68.8%) reported the use of heartworm medication (Stafford et al., 2020). This is in part due to the time of sample collection during the summer months when mosquitoes are the most active. It is important to note, however, that healthier dogs who are not immunocompromised nor susceptible to parasite acquisition (e.g., puppy <1 year) do not necessarily have protection against infective organisms. Dogs that have been diagnosed, treated, and cleared of previous parasites can experience reinfection if owners are not careful. Though *D. immitis* was not identified in the current study, the American Heartworm Society (n.d.) explains that heartworms have been found in all 50 states, with regions near the Atlantic and Gulf coasts being very high risk areas. There are preventative measures such as chewable, topical, or injectable medications that veterinarians can prescribe to our pet dogs, but there are no vaccines available to completely combat canine heartworm disease (American Heartworm Society, n.d.).

5.3.3 Purebred vs. Mixed Breed Parasite Susceptibility. While there were no associations between parasite presence and each of the questions asked in the survey, there are some interesting findings present in the current study. For instance, parasites were found in n = 30 (51.7%) of dogs in the mixed breed category. Both purebred and mixed breed dogs have the same susceptibility to parasite acquisition, and other factors can influence transmission as well (Forsyth et al., 2023) **(Table 3)**. Though, Forsyth and colleagues (2023) found that it was more likely for purebred dog owners to verbally state that their canine pets have no medical conditions (p = 0.002). Purebred dogs whose owners reported that their canine pets have not been previously diagnosed with intestinal parasites were positive to at least one parasite in the current study (9.2%). Although this statistic in the current study is quite insignificant, it is also important to consider that purebred dogs do not have more or less immunity to parasite acquisition in comparison to mixed breed dogs, refuting the dog owner responses from the Forsyth and colleagues (2023) study.

5.3.4 Benefits of the Study to the Community. After sample collection and laboratory processing, parasite presence/absence was posted in a public facing Google Sheet found in the UNLV Parasitology & Vector Biology (PARAVEC) website, summarizing the parasites identified by date of collection and park location. The parasites were categorized by group: Protozoa, Nematodes (Tapeworms), Cestode (Roundworms), Trematodes (Flukes), and Acanthocephala (Thorny-Headed Worms). The frequency (count) was listed to provide basic information about what types of parasites were found in each urban dog park, as well as share parasite prevalence information. This was created to inform the participants and community members of the results of the study in real-time.

5.4 Limitations

The target sample size for the current study was n = 100, replicating the samples Stafford and colleagues (2020) were able to collect for each metropolitan city. Increasing the sample size may yield additional results not found in the current study. The Clark County, NV urban dog parks visited were limited—samples from 16 different dog parks were sufficient for this study, but it is important to note that only one sample was collected from two of the dog parks due to desolation at the time of collection in the field. The dog parks cover a wide area of the Clark County and Las Vegas area, and the spatial distribution of the dog parks selected allowed for diverse human and canine participants. However, targeting other dog parks that were not included in this study is suggested for more complete results. The time period in which the samples were collected were from January 2024 to June 2024, and the time of collection was mostly in the morning or afternoon. Some samples were acquired during the late afternoon or evening. The population of each dog park was dependent on the time of day; community members were more active during the early mornings between 5:00 AM to 7:00 AM and late evenings between 7:00 PM to 9:00 PM. Future studies should consider sample collection at various times as time against parasite presence may be a variable of interest when looking for associations.

Chapter 6: Conclusion

While the DOGPARCS study was able to identify canine parasite prevalence in multiple regions across the USA, there was no data in the American Southwest; Nevada is regionally considered to be in the American Southwest, making the current study's findings important to the current literature. While no associations were found among each survey question asked (i.e., each variable) against parasite presence, the canine characteristics provided in the current study need to be explored more extensively to accurately determine what factors most influence canine zoonotic parasite acquisition **(Table 3)**. Parasites were found in 50% of the samples, suggesting that there is an uprising in parasite activity and survivability in the Clark County, NV area. Other canine characteristics and environmental factors should also be explored in future research.

In the current study, we found known zoonotic parasites that are detrimental to dog and human health. The literature available suggests that the likelihood of parasite transmission is higher in regions where low resources are present (Duguma et al., 2023). Duguma and colleagues (2023) found that rural residencies, improper hygienic practices, and unclean drinking water increase the odds of intestinal parasite infection among children living in Ethiopia. However, while these findings are plausible for low-resourced countries, metropolitan cities in the USA should theoretically have access to sanitary food and water sources, as well as proper hygienic practices through education. Poverty in the USA increases the risk of parasite acquisition—so much so that minority populations (e.g., African Americans), children, the elderly, pregnant women, and immunocompromised individuals can develop severe medical conditions (Hotez, 2014; Fereirra et al., 2017). It is still unknown why poverty is linked to increased parasite infection in the USA, but it is plausible that a multitude of factors can influence this phenomenon; therefore, it is essential to conduct research that includes poverty as a focal point together with related factors like socioeconomic status, environmental conditions, and behavioral practices (Hotez, 2014). This can help health institutions assess whether these variables have significant associations to parasitic infection. Evidence-based practices can then be implemented through different agencies, raising awareness and ensuring communities are protected from zoonotic parasites.

An area of interest that needs to be addressed is the transmission of parasite infection from the environment, domestic animals, and humans altogether. While there are studies that discuss parasite-induced foodborne/waterborne illness, there are limited studies that observe parasite transmission among all interconnected agents established by the One Health initiative (Otranto et al., 2021). Furthermore, there should be an incentive to involve medical centers such as veterinary clinics and hospitals, and the community in public health matters. Effective prevention strategies cannot be accomplished without these entities working together. The community especially plays an integral role in reducing the risk of parasite transmission. For instance, positive behavioral change that circulates around engagement and empowerment can improve individuals' health with only the cost of their own available resources (Michaelsen & Esch, 2022). A survey study by Sherlock and colleagues (2023) found that some dog owners in the rural and urban areas of Ireland did not dispose of their dog's feces correctly. By using the Behavioral Change Resource Model (BCRM) as a framework for preventative public health measures, individuals can better practice proper canine pet fecal disposal, as well as seek resources that improve both their pet's and their own health more readily (Michaelsen & Esch, 2022; Sherlock et al., 2023). Complacent attitudes towards public health practices can indirectly affect the health of the aforementioned interconnected One Health entities. While the majority of people in the Sherlock and colleagues (2023) study engaged in sanitary and positive health practices (e.g., washing hands, deworming pets), the second-most popular response to reasons for deworming their dogs was “because the vet told me to” (24%). Dog owners responded with “to protect my dog” most of the time (43%), but the former finding indicates the lack of education and awareness as to why deworming their dogs was important. Other reasons listed in the survey that may make this assumption valid include: “to protect myself,” “public health reasons,” or “I do not deworm my dog” (Sherlock et al., 2023). Responding with “public health reasons” may indicate that the individual understands that heartworm is a concern to not only their canine pet, but also to themselves, other humans/dogs/living organisms, and the environment. Farrell and colleagues (2013) mention that identifying the factors that influence parasite transmission to their hosts is crucial to direct the most effective surveillance and monitoring techniques in order to prevent and control parasitic outbreaks. A proactive surveillance framework that identifies underrepresented zoonotic parasite host species and reservoirs, predicts transmission routes and possible human infection, monitors parasite movements within populations is key to decrease the burden of zoonotic diseases and prepare for novel emerging disease events (Farrell et al., 2013).

With that being said, a rather overlooked idea to prevent parasitic infection is the improvement of effective surveillance, monitoring, and response systems through multi-level, collaborative measures. Hao and colleagues (2020) exemplifies the importance of the National Institute of Parasitic Diseases at the Chinese Center for Diseases Control and Prevention, and Chinese Center for Tropical Diseases Research (NIPD-CTDR)’s role in identifying public health problems through surveillance-response systems, understanding epidemic dynamics and how parasitic disease outbreaks occur, and evaluating the effectiveness of interventions upon identifying risk factors. Further, the NIPD-CTDR creates emergency-contingency plans that rely on evidence-based, scientific principles to respond to parasitic disease cases appropriately (Hao et al., 2020). They mention that due to the rapidly changing environments observed globally, there is a need to continuously improve sensitivity and the rapidity of surveillance-response systems, ensuring that outbreaks are controlled at safe levels. This can be achieved through cooperation among the affected agencies. Another area of improvement is increasing biosurveillance for disease control and mitigation in food handling environments—there is a heightened risk of pathogen/disease transmission derived from wildlife to livestock, and eventually to domestic animals and humans (Rodarte et al., 2023). Regional and local health agencies can better determine disease prevalence in specific areas by gathering data, consistently testing for parasite presence in livestock, and protecting livestock sites by enhancing worker/environmental safety, improving training programs of food safety practices, and offering vaccinations to both the livestock animals and human workers (Rodarte et al., 2023).

Lastly, researchers may be interested in looking at dog owners' health and canine pet health—there may be associations among both subjects' characteristics, which may have implications for their health and quality of life. Community partnerships with local and national public health and veterinarian organizations can increase awareness and encourage self or institutional-based education. These entities should consider implementing programs that improve human, animal, and environmental health with the One Health initiative in mind.

Appendix A: IRB Exemption

ORI-HS, Non-Committee Review

Notice of Excluded Activity

DATE: November 9, 2023

TO: Chad Cross
FROM: Office of Research Integrity - Human Subjects

PROTOCOL TITLE: UNLV-2023-486 PARAVEC Urban Dog Park Parasite Study
SUBMISSION TYPE: Initial

ACTION: No Human Subjects Research
REVIEW DATE: November 9, 2023
REVIEW TYPE: ADMINISTRATIVE REVIEW

Thank you for your submission of materials for this proposal. This memorandum is notification that the proposal referenced above has been reviewed as indicated in Federal regulatory statutes 45 CFR 46.

The Office of Research Integrity - Human Subjects (ORI-HS) has determined this request does not meet the definition of 'research with human subjects' according to federal regulations, and there is no further requirement for IRB review.

Note: Since this project does not meet the definition of 'research with human subjects', please replace the terms "research" and "study" to "project" in the consent form, recruitment materials, or any other project-related materials. Also remove the following language from the consent form/information sheet: "*For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted, contact the UNLV Office of Research Integrity – Human Subjects at 702-895-0020 or via email at IRB@unlv.edu.*"

Any changes to the excluded activity in this proposal could require IRB review. Please contact ORI-HS to discuss any anticipated changes.

If you have questions, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 702-895-2794. Please include your project title and project ID in all correspondence.

Office of Research Integrity - Human Subjects
4505 Maryland Parkway . Box 451047 . Las Vegas, Nevada 89154-1047
(702) 895-2794 . IRB@unlv.edu

Appendix B: Survey Questionnaire

PARAVEC Urban Dog Park Parasite Study

Please write the response or circle the appropriate choice.

Sample ID	
Dog Park	
Date	
Time	
What breed is your dog? (*If mixed breed, please list known breeds*)	
What is the sex of your dog?	1. Female 2. Male
Has your dog been spayed or neutered?	1. No 2. Yes
How old is your dog?	1. Puppy (<1 year old) 2. Young Adult (1-3 years old) 3. Mature Adult (4-6 years old) 4. Senior (7+ years old)
How often do you bring your dog to a dog park?	1. At least daily 2. At least weekly 3. Every few weeks 4. Rarely
Is your dog currently taking heartworm medication?	1. No 2. Yes - chewable tablet 3. Yes - topical 4. Yes - injectable
Has your dog been diagnosed with intestinal parasites?	1. No 2. Yes - but treated and cleared 3. Yes - on current treatment
When was the last time your dog visited the veterinarian?	1. Never 2. < 6 months ago 3. 6-12 months ago 4. 12+ months ago
Did your dog live in any other state(s) before	1. No

moving to Las Vegas?	2. Yes (LIST:________________________)
Has your dog been in a kennel?	1. No 2. Yes - within the last 6 months 3. Yes - within the last 6-12 months 4. Yes - over 12 months ago
Was your dog a rescue animal?	1. No 2. Yes
Do you have any other pets living in your home that interact with your dog?	1. No 2. Yes (LIST:________________________)

Appendix C: Informational Sheet Given to Participants

INFORMATIONAL HANDOUT
Departments of Epidemiology & Biostatistics and Environmental & Occupational Health

TITLE OF PROJECT: PARAVEC URBAN DOG PARK PARASITE PROJECT

INVESTIGATOR(S): DR. CHAD L. CROSS; MR. MIKLO ALCALA, MPH STUDENT

For questions or concerns about the project, you may contact **Dr. Cross** at **702.720.4541**

PURPOSE OF THE PROJECT
You are invited to participate in a project. The purpose of this project is to assess and document the potential presence of canine (i.e., dog) parasites in urban dog parks in Clark County, NV.

PARTICIPANTS
You are being asked to participate in the project because you fit these criteria: (1) You have agreed to allow us to collect fecal samples from the ground at the site of defecation of your pet; (2) you have agreed to provide us information about your pet.

PROCEDURES
If you volunteer to participate in this project, you will be asked to do the following: Complete a one-page survey about your pet.

BENEFITS OF PARTICIPATION
There may not be direct benefits to you as a participant in this project. However, we hope to learn about the potential presence/absence of canine parasites in urban dog parks.

RISKS OF PARTICIPATION
There are risks involved in all projects. This project may include only minimal risks. *You may feel uncomfortable answering survey questions.*

COST /COMPENSATION
There may not be financial cost to you to participate in this project. The project will take less than 5 minutes of your time. You will not be compensated for your time.

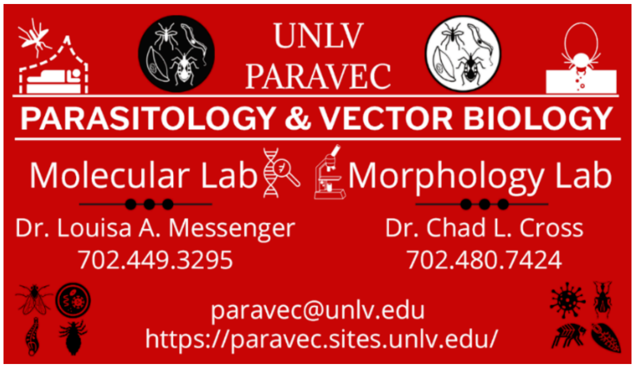
CONFIDENTIALITY
All information gathered in this project will be kept as confidential as possible. No reference will be made in written or oral materials that could link you to this project. All records will be stored in a locked facility at UNLV for 3 years after completion of the project. After the storage time the information gathered will be destroyed per UNLV guidelines.

VOLUNTARY PARTICIPATION
Your participation in this project is voluntary. You may refuse to participate in this project or in any part of this project. You may withdraw at any time without prejudice to your relations with

UNLV. You are encouraged to ask questions about this project at the beginning or any time during the project.

PARTICIPANT CONSENT:

I have read the above information and agree to participate in this project. I have been able to ask questions about the project. I am at least 18 years of age. A copy of this form has been given to me.



Appendix D: Fecal Smear Procedure

UNLV PARAVEC

UNLV | SCHOOL OF PUBLIC HEALTH

Standard Operating Procedures (SOP) for <u>Fecal Smear</u>

1. **Introduction / Scope / Purpose**

This SOP describes the process of parasite microscopic identification by observing parasite eggs and *Giardia* cysts using a direct fecal smear.

2. **Equipment**

- Compound microscope: 10x and 40x objectives are most commonly used
- Microscope slides and coverslips
- Wood stir sticks

3. **Reagents/Consumables**

- Standard physiological saline solution

4. **Safety Information**

- Refer to Material Safety Data Sheets (MSDS) for chemical hazard information.
- Refer to Control of Substances Hazardous to Health (COSHH) Assessment for each chemical used.

5. **Hazard Information**

- Operators should wear a lab coat, gloves, and eye protection during the extraction procedure.
- All local HSE regulations relating to storage, transport and disposal of potentially toxic and biological material must be followed.

6. **Procedure**

a) Place a small drop of saline solution on a microscope slide.
b) Take a very small amount of feces on the end of a stir stick and gently mix into the saline drop.
c) Push aside any large granules (e.g., bits of dog food filler in the feces) and place coverslip over the drop.
d) Examine with 10x and 40x magnification under compound microscope.

Appendix E: Sugar/Salt Fecal Flotation Procedures

Standard Operating Procedures (SOP) for <u>Fecal Flotation</u>

1. Introduction / Scope / Purpose

This SOP describes the process of parasite microscopic identification using standard zinc sulfate flotation procedures to observe certain parasite eggs and *Giardia* cysts.

2. Equipment

- Centrifuge: Preference for swing-arm or swing-bucket rotor if available. Stationary centrifuge can work, but tubes should be vertical for extraction.
- Centrifuge tubes: Round bottom
- Compound microscope: 10x and 40x objectives are most commonly used
- Microscope slides and coverslips*: Standard size (*coverslips are optional, as reading can be taken direction from a loop sample)
- Paper cups: Unwaxed paper cups (~ 4 oz. or "bathroom drinking cup" size). Plastic or styrofoam cups are not to be used, as they cannot be adequately folded to pour contents.
- Wood stir sticks: Often 2 provide better leverage and stirring capability
- Cheesecloth or tea strainer: Two-ply cheesecloth generally works best if available.
- Nichrome loop: 28-gauge wire with 4-5 mm loop
- Bunsen or alcohol burner
- Vortex mixer
- Plastic wash bottle with tap water

3. Reagents/Consumables

- Zinc sulfate solution at 1.18 s.g. (can substitute Magnesium sulfate, Sheather's Solution, etc.; see Solutions SOP)

4. Safety Information

- Refer to Material Safety Data Sheets (MSDS) for chemical hazard information.
- Refer to Control of Substances Hazardous to Health (COSHH) Assessment for each chemical used.

5. Hazard Information

- Operators should wear a lab coat, gloves, and eye protection during the extraction procedure.
- All local HSE regulations relating to storage, transport and disposal of potentially toxic and biological material must be followed.

6. Procedure

6.1 Preparation

a) Comminute approximately 1 g of fecal specimen in 5 mL of flotation solution (***if using water, see differences in centrifugation) in a paper cup using 1-2 wood stir sticks until very well mixed
b) Place a double layer of cheesecloth (or tea strainer) on the second paper cup, bend the first mixing cup to have a small spout, and pour the contents of the first cup through the cheesecloth.
c) Wash pouring cup and cheesecloth with a small amount of water from washing bottle
d) Repeat steps 6.1(a)-6.1(c) if you want multiple replicates

6.2 Centrifugation

a) Pour contents of cup into test tube(s)
b) Balance centrifuge with equal volumes of water as needed
c) Spin tubes for 5 minutes at 1500 rpm

   <u>***If comminuted with water instead of flotation solution (6.1(a))</u>:

   i) Decant supernatant
   ii) Add 3 mL of flotation solution and resuspend remaining pellet with stir sticks and then mix briefly with vortexer
   iii) Fill tube to within 1 cm of rim with zinc sulfate solution
   iv) Spin tubes for 5 minutes at 2500 rpm

6.3 Extraction & Examination

a) Stand up tubes vertically for 5-10 minutes (or leave in centrifuge if using a swing-arm rotor)

   <u>If using loop method</u>

   i) Quickly flame a nichrome loop and allow to cool
   ii) Dip loop into center of tube and transfer contents to a microscope slide; usually 2 loops will suffice
   iii) NOTE: It is generally not necessary to cover samples with a coverslip, but specimens must be examined quickly or the solution will begin to crystalize on the slide

   If using coverslip method

   i) Fill tubes to top to create a reverse meniscus
   ii) Place coverslip on top of tube for 5-10 minutes

    iii) Remove coverslip (pull straight up vertically) and place on microscope slide

b) Examine with 10x and 40x magnification under compound microscope

Appendix F: Parasite Collection Sheet for PARAVEC Lab Processing

Dog Park Study Data Collection Sheet

ID

Group / ***Genus species***	**Smear**	**Sheather's**	**$MgSO_4$**
Protozoa			
Amoeba (various)			
Cystoisospora			
Cryptosporidium			
Eimeria			
Giardia			
Sarcocystis			
Toxoplasma gondii			
Cestoda			
Diphyllobothrium latum			
Dipylidium caninum			
Echinococcus			
Mesocestoides			
Taenia			
Nematoda			
Ancylostoma			
Angiostrongylus			
Baylisascaris procyonis			
Capillaria			
Dioctophyma renale			
Eucoleus (*Capillaria*)			
Filaroides			
Pearsonema			
Physaloptera			
Spirocerca lupi			
Strongyloides stercoralis			
Syphacia			
Toxascaris leonina			
Toxocara canis			
Trichuris vulpis			
Uncinaria stenocephala			
Trematoda			
Alaria			
Heterobilharzia americana			
Metorchis conjunctus			
Nonophyetus salmincola			
Paragonimus kellicotti			
Spirometra			
Acanthocephala			

Group / *Genus species*	**Smear**	**Sheather's**	**$MgSO_4$**
Protozoa			
Amoeba (various)			
Cystoisospora			
Cryptosporidium			
Eimeria			
Giardia			
Sarcocystis			
Toxoplasma gondii			
Cestoda			
Diphyllobothrium latum			
Dipylidium caninum			
Echinococcus			
Mesocestoides			
Taenia			
Nematoda			
Ancylostoma			
Angiostrongylus			
Baylisascaris procyonis			
Capillaria			
Dioctophyma renale			
Eucoleus (*Capillaria*)			
Filaroides			
Pearsonema			
Physaloptera			
Spirocerca lupi			
Strongyloides stercoralis			
Syphacia			
Toxascaris leonina			
Toxocara canis			
Trichuris vulpis			
Uncinaria stenocephala			
Trematoda			
Alaria			
Heterobilharzia americana			
Metorchis conjunctus			
Macracanthorhynchus			
Other			

Appendix G: Binary Logistic Regression Results

Variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B) Lower	Upper
What breed is your dog?								
Foundation Stock Service (FSS) (Reference Group)			3.436	8	0.904			
Herding	0.889	1.829	0.236	1	0.627	2.433	0.068	87.708
Hound	21.549	40192.97	0	1	1	2282501795	0	
Mixed	0.064	1.616	0.002	1	0.968	1.066	0.045	25.304
Non-Sporting	1.963	2.179	0.811	1	0.368	7.119	0.099	509.835
Sporting	21.755	22429.907	0	1	0.999	2805186320	0	
Terrier	0.436	2.422	0.032	1	0.857	1.546	0.013	178.192
Toy	-0.477	1.699	0.079	1	0.779	0.621	0.022	17.331
Working	-0.788	1.978	0.159	1	0.691	0.455	0.009	21.977
What is the sex of your dog?								
Male (Reference Group)	-0.446	0.544	0.673	1	0.412	0.64	0.22	1.859
Has your dog been spayed or neutered?								
Yes (Reference Group)	-0.794	0.811	0.958	1	0.328	0.452	0.092	2.216
How old is your dog?								
Puppy (<1 year) (Reference Group)			6.497	3	0.09			
Young Adult (1-3 years)	0.126	1.082	0.014	1	0.907	1.135	0.136	9.453

Mature Adult (4-6 years)	-0.371	1.273	0.085	1	0.771	0.69	0.057	8.363
Senior (7+ years)	-2.025	1.307	2.398	1	0.121	0.132	0.01	1.712
How often do you bring your dog to a dog park?								
At least daily (Reference Group)			1.641	3	0.65			
At least weekly	-0.419	0.703	0.356	1	0.551	0.657	0.166	2.607
Every few weeks	-0.611	0.996	0.376	1	0.54	0.543	0.077	3.822
Rarely	0.361	0.714	0.256	1	0.613	1.435	0.354	5.82
Is your dog currently taking heartworm medication?								
No (Reference Group)	1.661	1.51	1.21	1	0.271	5.265	0.273	101.511
Has your dog been diagnosed with intestinal parasites?								
No (Reference Group)	-0.622	0.897	0.48	1	0.488	0.537	0.093	3.116
When was the last time your dog visited the veterinarian?								
<6 months ago (Reference Group)			7.889	2	0.019			
6-12 months ago	-0.38	0.727	0.273	1	0.602	0.684	0.165	2.844
12+ months ago	2.455	0.98	6.271	1	0.012	11.642	1.705	79.503
Did your dog live in any other state(s) before moving to Las Vegas?								
No (Reference Group)	0.832	0.598	1.936	1	0.164	2.297	0.712	7.411
Has your dog been in a kennel?								
No (Reference Group)			2.607	3	0.456			
Yes - within the last 6 months	0.288	0.793	0.132	1	0.717	1.334	0.282	6.315

Yes - within the last 6-12 months	-0.584	1.639	0.127	1	0.722	0.558	0.022	13.855
Yes - over 12 months ago	-1.097	0.772	2.017	1	0.156	0.334	0.073	1.517
Was your dog a rescue animal?								
No (Reference Group)	0.856	0.704	1.476	1	0.224	2.353	0.592	9.359
Do you have any other pets living in your home that interact with your dog?								
Yes (Reference Group)	0.094	0.596	0.025	1	0.875	1.098	0.341	3.533

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Curriculum Vitae

Miklo Alcala

Recruitment Coordinator

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SUMMARY

Public health professional with more than six years of experience working in the academic field, managing, coordinating, and collaborating with local, state, and global organizations to improve the health of multiple populations.

EDUCATION

Public Health, MPH | Current GPA: 3.969 **Aug 2024**
University of Nevada, Las Vegas

Infection Prevention Graduate Certificate **May 2023**
University of Nevada, Las Vegas

Anthropology, BA **Dec 2020**
University of Nevada, Las Vegas

LANGUAGES

Fluent in Tagalog, including reading, writing, speaking, listening, & translating.

WORK EXPERIENCE

Recruitment Coordinator, **Oct 2023 - Present**
UNLV School of Public Health, Las Vegas, NV

- Contact prospective students through email, phone calls, virtual/in-person meetings, etc. to discuss SPH programs.
- Manage recruitment efforts with SPH and other university departments (e.g., Central Admissions, etc.) to ensure enrollment rates are consistent and consolidated with the UNLV Recruitment Management Team.
- Attend external and internal events held by SPH and various departments in the university to increase enrollment in all SPH programs.
- Present, update, and maintain information of SPH programs.
- Ensure student retention in SPH programs and UNLV, build relationships, and update student numbers/data.

PARAVEC Laboratory Research Associate, **Aug 2023 - Present**
UNLV School of Public Health, Las Vegas, NV

- Expand canine parasitology research for thesis project titled: "PARAVEC Urban Dog Park Parasite Study" in Clark County, NV.
- Collect field samples in urban dog parks.
- Conduct quantitative research using multiple data analysis programs such as SPSS.

- Conduct laboratory processes including fecal smear and flotation methods.
- Analyze samples using parasitology & vector biology ID techniques.
- Conduct literature reviews, write reports, and present findings.

Evaluation Associate/Graduate Research Assistant, **Aug 2021 - Aug 2023**
UNLV School of Public Health, Las Vegas, NV

- Conducted interviews and focus group discussions with project personnel/community partner organizations and community members, evaluating health perceptions and identifying underserved populations' needs.
- Analyzed data using SPSS (quantitative) and the Delve Tool (qualitative) to supplement evidence for reports.
- Provided reports on the CDC Public Health Disparity Grant process evaluation to the Nevada Department of Health and Human Services, improving health prospects in various communities.
- Participated in community outreach events and conducted process observations/walkabout surveys to determine if health programs are providing sufficient education and resources to the public.

LEAP Intern & Project Lead, **Jun 2023 - Aug 2023**
Kirk Kerkorian School of Medicine at UNLV, Office of Compliance, Las Vegas, NV
- Led and created an emergency management plan at the university medical school.
- Conducted literature reviews on emergency preparedness as it relates to a university setting.
- Created resourceful and informative materials (e.g., brochures, websites, presentations) about emergency preparedness and violence prevention.
- Created health policies about the electronic health record system offline/downtime procedures and trauma response to crises.
- Planned and led executive leadership meetings with stakeholders as well as local, state, and national organizations.

COVID-19 Contact Tracer, **Mar 2021 - May 2021**
UNLV School of Public Health, Las Vegas, NV
- Contacted individuals diagnosed with COVID-19 to determine exposure, assess symptoms, refer testing options according to protocols, and provide instructions for isolation or quarantine.

Student Worker Aide, **Jan 2018 - Feb 2021**
UNLV Financial Aid & Scholarships Office, Las Vegas, NV
- Scanned and imaged documents to be saved in the university's online filing portal.
- Worked at the front desk and interacted with students/guardians to help them with their financial aid needs.
- Provided support organizing scholarship checks, including the mailing of scholarship checks back to donors, for efficient scholarship awarding.
- Contacted scholarship donors through telephone and email to communicate any discrepancies found while working with the scholarship monies.
- Participated in university tabling events to provide financial aid and scholarship education and resources to students.

SELECT AWARDS AND HONORS

Member **Sep 2022 - present**
University of Nevada, Las Vegas, Asian Pacific Islander Alliance (APIA)

HRSA Scholarship Awardee **2022 - 2024**

Francisco Sy Endowed Graduate Scholarship **2023 & 2024**
University of Nevada, Las Vegas, School of Public Health

RESEARCH EXPERIENCE

Professional Reports
"Annual report of the process evaluation for the CDC public health disparity grant: Annual July 2022-June 2023" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Kumra, P., Chatterjee, A., & Bonsu, L.

"Annual report of the process evaluation for the CDC public health disparity grant: Annual July 2021-June 2022" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Klenczar, B., Mojtahedi, Z., & Anupreet Arora

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 4 April-June 2023" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Kumra, P., Chatterjee, A., & Bonsu L.

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 3 January-March 2023" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Kumra, P., & Chatterjee, A.

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 2 October-December 2022" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Kumra, P., & Chatterjee, A.

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 1 July-September 2022" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Kumra, P., & Chatterjee, A.

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 4 April-June 2022" by Sharma, M., Awan, A., Raich, S., **Alcala, M.**, Klenczar, B., Mojtahedi, Z., & Anupreet Arora

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 3 January-March 2022" by Sharma, M., Awan, A., Raich, S., Klenczar, B., & **Alcala, M.**

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 2 October-December 2021" by Sharma, M., Awan, A., Raich, S., Klenczar, B., & **Alcala, M.**

"Quarterly report of the process evaluation for the CDC public health disparity grant: Quarter 1 July-September 2021" by Sharma, M., Awan, A., Raich, S., Klenczar, B., & **Alcala, M.**

Presentation Titles
"A model-based community-based participatory research for COVID-19 recovery activities in Nevada" by Awan, A., Nwando, G., Raich, S., **Alcala, M.**, Klenczar, B., & Sharma, M.

"An analysis of evidence level derived from a community-based participatory evaluation (CBPE) program to reduce COVID-19 disparities in Nevada" by Awan, A., Raich, S., **Alcala, M.**, Mojtahedi, Z., Kumra, P., Chatterjee, A., Arora, A., Nwando, G., & Sharma, M.

"Analytical application of the community-based participatory research utilizing the RQFSM model for evaluating health disparity reduction efforts in rural Nevada" by Nwando, G., Awan, A., Raich, S., **Alcala, M.**, Kumra, P., Chatterjee, A., & Sharma, M.

"Assessment of a practice-based process evaluation model: A qualitative analysis of second-year COVID-19 public health efforts in Nevada" by Awan, A., Raich, S., **Alcala, M.**, Kumra, P., Chatterjee, A., Nwando, G., & Sharma, M.

"Integration of an RQFSM (reach, quality, fidelity, satisfaction, management) process evaluation model to understand the successes and failures of community-based public health initiatives" by Awan, A., Raich, S., **Alcala, M.**, Mojtahedi, Z., Kumra, P., Chatterjee, A., Arora, A., Nwando, G., & Sharma, M.

"Mixed methods process evaluation for RQFSM Model for assessing disparity-related efforts in Nevada" by Awan, A., Raich, S., **Alcala, M.**, Kumra, P., Chatterjee, A., & Sharma, M.

"Navigating the past for a South Asian paradigm of mental health: A chronological literature review to address population gap" by Awan, A., **Alcala, M.**, Kumra, P., & Sharma, M.

"Planning a quality improvement community-based participatory evaluation of public health disparity reduction efforts in Nevada" by Awan, A., Nwando, G., Raich, S., **Alcala, M.**, Klenczar, B., & Sharma, M.

"Soil-transmitted helminths in the United States: using big data to characterize patients and analyze disease trends" by Cross C.L., Carrier, B., **Alcala, M.**, Messenger, L.A.

"Strategizing a quality improvement evaluation framework to reduce public health disparities in Nevada" by Awan, A., Nwando, G., Raich, S., **Alcala, M.**, Klenczar, B., & Sharma, M.

"Utilizing community-based participatory research based on the RQFSM model for evaluating health disparity reduction efforts in rural Nevada, 2021- 2022" by Raich, S., Awan, A., Nwando, G., **Alcala, M.**, Kumra, P., Chatterjee, A., & Sharma, M.

National and International Presentations

American Society of Parasitologists (ASP), Denver, CO	Jun 2024
American Public Health Association (APHA) Annual Meeting & Expo, Atlanta, GA	Nov 2023
American Public Health Association Annual Meeting and Expo, Boston, MA	Nov 2023
American Public Health Association Annual Meeting and Expo, Atlanta, GA	Nov 2023
Ankara International Congress on Scientific Research-VIII, Ankara, Turkey	Jun 2023
46th Annual Rural Health Conference, 2023 Rural Health Equity Conference, San Diego, CA	May 2023
Society of Public Health Education (SOPHE) Annual Conference 2023, Atlanta, GA	Mar 2023

Local and Regional Presentations

2023 Research Forum & Symposium, Las Vegas, NV	Apr 2023
Rural Nevada Public Health Summit 2023, Minden, NV	Apr 2023
Nevada Minority Health and Equity Coalition 2022 Impact Summit, Las Vegas, NV	Nov 2022
Southern Nevada Diversity Summit, Las Vegas, NV	Oct 2022
Nevada Public Health Association Conference, Las Vegas, NV	Sep 2022

SKILLS

Leadership | *Communication* | *Cultural Competence* | *Research* | *Program Management* | *Data Analytics*
Microsoft Office | SPSS | Qualtrics | Canva |