An Epidemiological Investigation of Euthanasia and Dermatophytosis in Felines in Ontario Animal Shelters

by

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ABSTRACT

AN EPIDEMIOLOGICAL INVESTIGATION OF EUTHANASIA AND
DERMATOPHYTOSIS IN FELINES IN ONTARIO ANIMAL SHELTERS

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University of Guelph, 2013

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This study evaluated factors associated with euthanasia of cats at a shelter. Over 50% of cats admitted were euthanized in 2011. Being male, black or surrendered increased the likelihood of euthanasia, as did spending more than 5 days in the shelter (compared to those who spent less than 5 days). Neutered animals had a greater likelihood of euthanasia with increasing age, plateauing in older cats. Risk factors are important to understand, to develop interventions to lower the euthanasia rate. Dermatophytosis is an important fungal and zoonotic skin infection caused predominantly by Microsporum canis in cats. This study examined dermatophytosis prevalence in three Ontario animal shelters from February to May 2013. Four hundred cats were sampled and no dermatophytes were identified, suggesting that dermatophytosis is rare in cats in Ontario shelters and identification of infected animals is unusual, validating rapid control strategies.
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Declaration of Work Performed

I, Rachael Melissa Mozes declare that all of the work reported in this thesis was performed by me, with the exception of the following:

- Sampling of cats for the ringworm surveillance study at the Guelph Humane Society was performed by Michelle Anderson
- Sampling of cats for the ringworm surveillance study at the Kitchener-Waterloo Humane Society was performed by Amanda Hawkins
- Sampling of cats for the ringworm surveillance study at the Toronto Humane Society was performed by Makyla Smith
- Input of data into Shelter Buddy Database at the Kitchener-Waterloo Humane Society was performed by the staff members of the Kitchener-Waterloo Humane Society
- Laboratory work done by Joyce Rousseau including blots and assisting with the culturing of Mycosel Agar plates with the samples acquired from the three shelters
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CHAPTER 1:

Literature Review
1.0 Shelter Medicine

1.1 Introduction

Shelter medicine has rapidly become a specialty in veterinary medicine (Foley, 2003). In the past, the sheltering of small animals has been addressed through a variety of approaches, such as rescue shelters, as well as government run animal control (Foley, 2003). Shelter medicine originally arose for the purpose of public health and safety issues related to controlling domestic animal-related illness and injury, but it has developed into a field that focuses equally on the health and welfare of a wide range of animals (Foley, 2003). Much of the interest in developing this specialized area of veterinary medicine started with the public and communities with interests in the welfare of animals. In 2002, the Association of Shelter Veterinarians was founded, and at that time, five shelter medicine programs were developed in veterinary schools in the United States (Foley, 2003). Because of the active involvement of the public and concerned veterinarians alike, there have been improvements in the design and function of shelters in many communities all over North America, as residents are becoming dedicated to change the unsanitary warehouse-like structures that once exemplified animal control centres (Foley, 2003). The continuous evolution of shelter medicine can be attributed to society’s recognition of the importance of providing medical care and not euthanizing troubled and sick animals (Burns, 2006). This problem begins with solving the issue of dog and cat overpopulation.

1.1 a. Animal Admittance

Approximately six to eight million dogs and cats are admitted to animal shelters every year in the United States (Lepper et al., 2002; HSUS, 2011). For every dog admitted roughly two cats are admitted (Scarlett, 2008). In many shelters, adolescent animals (six months to two years old) are among the most abundant age group of dogs (Scarlett, 2008). The circumstances for cats are different, as the largest age group are kittens (Scarlett, 2008). Many of these animals, predominantly cats (Scarlett, 2008), are not adopted or reclaimed by their owners and are subsequently euthanized (Marsh, 2010; Marston et al., 2004; Bartlett et al., 2005). Similar data for Canada are not available, but there is no reason to suspect that they are markedly different from the US, on a proportional basis.
Animals that enter the shelter system usually have one of four futures: they are retrieved by their owners, adopted, die as a result of illness or are euthanized (Lepper et al., 2002). It has been estimated that almost USD$1 billion is spent annually by animal shelters to deal with unwanted animals (Marsh, 2010). This is truly unfortunate as these funds could be better spent on understanding methods to deal with the problem of companion animal overpopulation and increase the rate of adoption (Lepper et al., 2002).

1.1 b. Adoption in Shelters

The rate of adoption in a shelter is dependent on a variety of factors. Space restrictions often limit the ability of shelters to hold animals for lengthy periods of time. This issue has been somewhat alleviated with the advent of foster care. Most foster programs help with the costs of taking care of these animals and in turn the foster parents provide the care and attention to these animals in need of both mental and physical recuperation (Nova Scotia SPCA, 2012). Because animals that do not get adopted are often euthanized, many studies have been done to understand and better predict the likelihood of adoption. Many related studies have examined methods to help increase the adoption rate of companion animals (Lepper et al., 2002). For example, rates of adoption and the perceptions of prospective adopters may be improved by educating people about the benefits of adopting an animal (Neidhart and Boyd, 2002). Although the study by Lepper et al. 2002 analyzed popular traits amongst adopters, it is hard to say whether these results are applicable to shelters across the country or the continent. There are gaps in the literature that measured the success of adoption campaigns have been successful, because of the identification of preferred traits of pets.

1.1 c. Euthanasia Rate

The number of cats and dogs euthanized in shelters every year in the United States is estimated to be 10 to 25% of the companion animal population (Lepper et al., 2002). These numbers are staggering, although other studies have shown that the euthanasia rate has dropped in the last thirty years (Marsh, 2010). In 1970, approximately 23.4 million cats and dogs were euthanized in shelters in the United States, while in 2007 4.2 million were euthanized (Marsh, 2010). This drop in euthanasia is almost entirely due to a decreased rate of intakes in animal shelters in the United States, not increases in retrieval or adoption of animals (Marsh, 2010). This could be due to the education of people on the importance of spaying and neutering pets (Scarlett,
2008). Other ways to decrease the rate of euthanasia could be to increase the number of animals reclaimed by owners or increase animals adopted (Marsh, 2010). Anecdotal information from animal shelters suggests that progress has been made to reduce euthanasia, but quantitative data are lacking, especially at the national level. Therefore, tracking the trends is still very difficult (Scarlett, 2008). Regardless of this lack of data, euthanasia rates may drop further with the initiation of stricter spay and neuter regulations (Marsh, 2010). Also, with the advent of no-kill shelters in recent years (Levy and Crawford, 2004), the use of widespread euthanasia to control the pet population has diminished, which could cause further issues with respect to disease control in shelters if shelter populations increase.

Despite the progress that has been made, basic data such as number of animal shelters, and estimates of intakes, adoptions, euthanasia and surrendering of animals are often lacking, complicating efforts to develop and implement feasible solutions to solve overpopulation in shelters (Scarlett, 2008). Only with an adequate understanding of the problem can effective companion animal welfare policies be put in place, to increase adoption and decrease relinquishments and euthanasia (Scarlett, 2008).

1.2 Health Care

Shelter medicine is a unique type of companion animal medicine, as it is predominantly herd health medicine (Hurley and Miller, 2009). The challenge is to design an all-inclusive program to manage, control and decrease the transmission of pathogens in the animal shelter (Newbury et al., 2010) while maximizing adoptability, socialization and welfare. When the majority of the shelter population is healthy, resources are available for animals needing extra care. Due to the sheer numbers of animals entering and leaving the shelter system, shelter veterinarians must understand areas such as epidemiology, public health and preventative medicine, and how to work with the resources available (Burns, 2006). The shelter administration must put in place levels of authority and decision making, which provides both the veterinarians and the shelter staff with the tools and resources to deal with the health and well-being of the animals in the shelter (Newbury et al., 2010). The wellness programs in shelters should focus on enhancing the physical and behavioural health of the shelter animals, all the while preventing the spread of infectious disease (Hurley and Miller, 2009). Shelter medicine is still developing and changing as a specialized area of veterinary medicine and as such there will be differences of opinion among experts on certain practices and protocols, so evidence based medicine is needed (Newbury et al., 2010). With this
in mind, it is important that communication is constant to adjust and change protocols that are not efficient and conduct research to determine better methods to prevent the spread of infection (Hurley and Miller, 2009).

1.3 Pathogen Control

In order to effectively reduce transmission of pathogens within a shelter, veterinarians and shelter staff must have a thorough understanding of how pathogens spread (Newbury et al., 2010). In addition to animal-specific pathogens, zoonotic pathogens are a common challenge for the practice of medicine in animal shelters, with potential negative impacts on human health, animal health, shelter publicity and costs (Weese et al., 2002; Burns, 2006). The risk of zoonotic pathogen transfer in animal shelters can be increased by animals entering the facility from unknown areas (Burns, 2006), a common event in shelters. Other factors that are important to understand with respect to disease control are shedding of pathogens by healthy and diseased animals, incubation periods and carrier states (Sartwell, 1966). By knowing the incubation period of a disease carried by an animal, shelter staff can better deduce if the animal acquired the disease prior to admittance or within the shelter itself (Hurley and Miller, 2009). If the situation is the latter, it is essential that the shelter organize operating procedures to appropriately quarantine animals and sanitize affected areas, to manage the spread of infection (Sinclair, 1999). Without knowing about the pathogen and how it is shed (Sartwell, 1966), shelter staff may unknowingly be exposing healthy animals to threatening pathogens.

In order to successfully combat pathogen spread and outbreaks in a shelter environment, physical and design defects should be promptly identified and fixed (Hurley and Miller, 2009). A shelter that is properly designed should be adaptable to changes and situations such as a disease outbreak or a massive arrival of new animals (Hurley and Miller, 2009). The idea of multiple smaller rooms, as opposed to a few large holding rooms, allows for isolation and quarantine areas and directs the traffic flow through the shelter from healthy areas to areas with sick or diseased animals (Hurley, 2007). Other considerations include proper drainage and nonporous surfaces that can handle constant cleaning (Newbury et al., 2010). In addition to a proper layout to minimize disease spread, proper ventilation and temperature control are vital to prevent further infections (Newbury et al., 2010). Noise control is also important for the reduction of anxiety of shelter animals, which can be facilitated through windows and sunlight (Hurley and Miller, 2009). These simple measures are important to preserving a functional shelter environment.
Another key element of shelter health and disease control is the disinfection program. Each shelter is different in both design and procedures; therefore each institution should tailor their protocols to their specific environment (Newbury et al., 2010). The precise training and supervision of shelter staff should be monitored and assessed regularly to avoid poor practices (Weese et al., 2012).

In addition to supervision of shelter staff and their cleaning and disinfection protocols, attention must be paid to individual animals to reduce stress levels, as stress has been recognized to be a factor in pathogen transmission (Stott, 1981). The welfare of animals can be greatly affected by stress and can present as signs of disease (Stott, 1981). The lack of recognition of indicators of stress can result in animals becoming ill, jeopardizing their possible adoption, as well as the animals that surround them in their environment (Hurley and Miller, 2009).

The control measures described above all (should) come under the auspices of a formal shelter infection control program, that clearly defines those practices, as well as a variety of other related practices.

1.4 Outbreaks

Despite the efforts and procedures put in place by shelter staff and veterinarians, there is always the risk of a disease outbreak. A variety of pathogens can be involved, with dermatophytes, canine parvovirus, feline panleukopenia virus, canine distemper virus and canine infectious respiratory disease complex being among the most commonly reported pathogens or syndromes (Pesavento and Murphy, 2014). Outbreaks can have serious direct impacts on animal health, along with potentially profound indirect effects from control measures, including the potential for depopulation. Outbreaks can also be associated with significant economic costs. Furthermore, some pathogens that can cause outbreaks are zoonotic (e.g. dermatophytes), increasing the risk and potential implications.

1.5 Epidemiology of Disease

Epidemiological methods can be used to help understand disease patterns, rates and trends in shelters, for better understanding of disease and adoption, and to develop and test effective interventions.
1.5 a. Clustering

Disease and health related events can be grouped in time or space (Ward and Carpenter, 2000). Because many of these disease events are clustered, general elements of the environment may be to blame for disease transmission (Ward and Carpenter, 2000). The examination of these common factors may be useful to explain what produces the disease in question (Ward and Carpenter, 2000). This explanation of disease causation has been pivotal to disease control and prevention in both animal and human populations alike (Ward and Carpenter, 2000). The investigation of time and space clustering of disease is possibly an excellent method of creating and analyzing hypotheses of what causes disease (Ward and Carpenter, 2000). By understanding these relationships closely, it is possible to improve protocols and halt the transmission of disease in any environment (Ward and Carpenter, 2000).

1.5 b. Surveillance

Disease surveillance is done to understand the patterns of disease occurrence and spread. The goal of disease surveillance is to obtain information to predict, examine and reduce the incidence and impact of sporadic or epidemic disease, as well as learn about the factors that influence these situations. In order to effectively understand disease causation and spread, efforts must be made by shelter staff to record and monitor the health of shelter animals (Hurley and Miller, 2009). Disease can cluster in shared environments (Ward and Carpenter, 2000), therefore it is important that attention be placed on observing individuals within the shelter (Weese et al., 2002). By knowing more about disease occurrence, planning, resource allocation and management, shelters will be better suited to solve problems (Lazarus et al., 2001). Keeping records on surveyed individuals removes reporting bias that is common in reports, removes the inconvenience for medical staff and outbreaks can potentially be avoided by observing the fluctuation in the number of cases (Lazarus et al., 2001). This type of syndromic surveillance has been used to track influenza (Lazarus et al., 2001), but could be beneficial for tracking disease in an animal shelter. Any rapid increase in certain signs pertaining to a shelter pathogen (e.g. diarrhea, coughing, sneezing), could be a warning sign of a possible outbreak (Hurley and Miller, 2009). In this case, steps can be taken to isolate and quarantine affected individuals and disinfect areas that housed these animals (Newbury et al., 2010). The reduction in the spread of one disease can decrease rates of other pathogens spreading by implementing strict cleaning and surveillance protocols.
2.0 Adoption

2.1 Ideal Characteristics

The overriding objective of an animal shelter is to find suitable homes for animals that are admitted. Many animals that are admitted to shelters are of adequate health and behavioural status to be adopted, but are ultimately not adopted and must be euthanized because of a lack of homes (Lepper et al., 2002). Specific characteristics are popular amongst adopters and that may influence the likelihood of an individual animal being adopted. The study by Lepper et al. (2002) looked closely at characteristics such as sex, age, breed, colour and hair length, to determine which ones could persuade possible owners to adopt a pet. The main goals of their study were to identify favourable and unfavourable characteristics, understand the probability of adoption in relation to euthanasia and develop methods to increase the rate of adoption in animal shelters (Lepper et al., 2002). With this information, shelter staff may be able to strategize their adoption procedures. For dogs, it was found that as age increases, the likelihood of adoption decreases, and that altered dogs of either sex were adopted more often than intact individuals (Lepper et al., 2002). The colour of a dog’s coat is a determining factor for many interested adopters. Lepper et al. (2002) verified that black and brindle coloured dogs were less likely to be adopted in comparison to tan and black, while other coat colours such as merle, red and tricolour were favoured over tan and black. This finding is probably more related to breed than colour, as most tan and black dogs are Rottweilers, Dobermans or mixed versions of these breeds. These breeds may be perceived as being more aggressive and therefore seen as undesirable to adopters, especially those with children. The analysis of the colour preferences in the study by Lepper et al. (2002) was limited, as they did not look at whether colour and breed were correlated. Another significant characteristic was breed (Lepper et al., 2002). The reference group was large companion breeds (e.g. Standard Poodle), which were not as favourable as small breed dogs, giant breeds and terrier type dogs (Lepper et al., 2002). However, guarding or fighting breeds, such as Bull and Staffordshire terriers, had a decreased likelihood of being adopted compared to the reference group (Lepper et al., 2002). These findings are consistent with the perceived temperament of these breeds and it is clear that particular breeds may be favoured specifically based on perceptions of behaviour. Other types of breeds such as sled, sporting and herding breeds were equally attractive as large companion breeds in their attractiveness to prospective owners (Lepper et al., 2002). Other factors such as being a purebred and having an injury were associated with an increased and decreased likelihood of adoption, respectively (Lepper et al.,
2002). By shelters focussing their efforts on the breeds, colours and ages that are not as preferrable through adopter education programs, more individuals may be adopted, potentially decreasing euthanasia rates.

The preferences adopters have for dogs are similar in cats. Older cats are not as favourable to prospective owners; however, in contrast with dogs, intact males were preferred over intact females (Lepper et al., 2002; Brown & Morgan, 2015; Fantuzzi et al., 2010). Altered cats were chosen more readily than intact cats and coat colour was also an important characteristic to adopters (Lepper et al., 2002; Alberthsen et al., 2013). The importance of this finding is that efforts must be made to better understand these initial associations, to explore interventions to boost adoption rates. The results of this study may lead to other research being done to understand why adopters favour altered animals. One hypothesis could be that previously altered animals could have been in homes prior to their shelter stay, which could result in better behaviour and an easier adjustment to a new household. It is also generally less expensive and more convenient to adopt a neutered pet. With respect to coat colour, tabby colour, grey, white and colour point were more preferable and black and brown coloured cats were less likely to be adopted (Lepper et al., 2002; Fantuzzi et al., 2010; Brown & Morgan, 2015). Fewer breed-associated effects in adoption were noted in cats, but the rarer breeds and Persians were favoured over the reference domestic short hair cats (Lepper et al., 2002;). It is probable that adopters are more drawn to these breeds, due to their scarcity in shelters. This type of information, collected through surveys and interviews with potential adopters could be crucial to shelter adoption initiatives and educating the public on the benefits of adopting the so-called “unpopular” types of animals (Lepper et al., 2002). For instance, adopting mature animals requires less training and nursing a sick animal back to health, may provide rewarding opportunities to save lives (Lepper et al., 2002).

2.2 Foster Care

Foster care has become a successful way to decrease euthanasia and increase the rate of adoption in animal shelters by increasing the pool of adopters, and having people outside the shelter taking care of, socializing and advertising animals for adoption. Many shelters keep most of their animals in foster care (Humane, 2010) to reduce overcrowding, disease transmission and depletion of resources. During the summer and fall, shelters are filled to capacity and need the
extra space off site to house more individuals (Humane, 2010). Foster programs are a useful approach to deal with limited space to avoid the need to depopulate overcrowded shelters.

2.3 Behaviour and Temperament Assessments

Prior to adoption, it is common for animal shelters to perform behavioural assessments, in order to ensure that the individual is fit to be a companion pet (Mornement et al., 2010). It may be better to test the animals once they have become accustomed to the shelter, as they are often frightened when they enter the environment and may require a period of adjustment, before they can be accurately assessed. However, to avoid the wasting of resources and time, the timing of behavioural tests should be enforced. Often animals are surrendered due to behavioural issues and it is the responsibility of the shelter to properly test the animals to be adopted, to try to ensure the safety of shelter personnel, adopters and the general public (Bollen and Horowitz, 2008). The temperament tests that shelters use most commonly to evaluate dogs assess a broad range of objectionable or potentially dangerous behaviours including aggression, hyperactivity, vocalization and destructiveness (Mornement et al., 2010). However, tests carried out at different shelters are often not the same, even though standard tests form the basis of behavioural testing exist. Dogs who pass these tests are put up for adoption, while those who do not reach expectations are generally euthanized, retested or sometimes placed in a rehabilitation program to improve their behaviour (Mornement et al., 2010). The key to a behaviour test’s reliability is how well it predicts a dog’s behaviour in the future (Taylor and Mills, 2006). The three vital qualities of a good test are reliability, validity and feasibility (Mornement et al., 2010). Despite best efforts, these tests may not encapsulate the full behavioural profile of a dog (Bollen and Horowitz, 2008) so shelters should consider other forms of education and guidance to prospective adopters to ensure the match made between adopter and animal is the best possible (Mornement et al., 2010). Bollen and Horowitz suggest that these tests are not always reliable when evaluations are done prematurely (i.e. not giving animals enough time to adjust to the shelter environment). Also, many of these tests have been assessed and have been found to be unreliable and invalid.
2.4 Post Adoption

2.4 a. Surrender Rate

Due to the lack of specificity and sensitivity of behavioural testing, the tendency for animals to adjust to new homes at variable rates, and owner expectations that are sometimes unrealistic, animals are often surrendered back to animal shelters. Millions of animals are relinquished to animal shelters in the United States every year. (New et al., 2000).

One frequent reason that animals are re-surrendered to shelters is due to behavioural problems (Herron et al., 2007). Often animals begin to display behavioural issues approximately one month after adoption (Lord et al., 2008). For example, dogs that eliminate inappropriately are at an increased risk of being surrendered back to the shelter (Herron et al., 2007). Herron et al. (2007) focussed on pre-adoptive counselling for potential adopters, to improve house training, thus reducing the number of animals re-relinquished to the shelter. Those individuals that were counselled prior to adoption reported that their pets were house-trained when they were interviewed one month after adopting the dog, compared to owners that were not previously educated on house training methods (Herron et al., 2007). However, this study did not explore how the effect of pre-adoptive counselling on house-training affected whether animals were relinquished or not. According to Herron et al. (2007), implementation of pre-adoptive counselling will decrease the rate of surrender and strengthen the animal-human match made at the time of adoption.

2.4 b. Animal Illness

Once an animal is adopted, it is not uncommon for the pet to acquire illness when adjusting to a new home (Lord et al., 2008). This effect is heightened when the adoptive parents do not visit a veterinarian for a physical exam in the first week to month after adoption (Lord et al., 2008). Lord et al. (2008) reported that 60.6% of people who adopted an animal at the Michigan Humane Society during the study period visited a veterinarian after the first week of adoption and 75.8% of people visited a veterinarian after the first month of adoption. They also indicated that dog owners had an increased likelihood of visiting a veterinarian compared to cat owners. Also, they had an increased likelihood of visiting a veterinarian if the pet was very young, had some sort of medical issue or had not become accustomed or adjusted to their new
home well on a moderate to high level, based on the scoring system used in the study (poorly or not at all, fair, moderately well and extremely well) (Lord et al., 2008). These results indicate that animal shelters must put more pressure on adopters to visit a veterinarian soon after they have acquired their new pet to both prevent disease and accurately treat animals. It is possible that pre-adoptive counselling (Herron et al., 2007) about common infections in newly adopted animals and preventative medication (Lord et al., 2008) may be beneficial to increase the likelihood that adoptive parents will book an appointment with a veterinarian shortly after adoption.

3.0 Health and Managing Infectious Diseases

3.1 Shelter Pathogens and Diseases

Disease is unfortunately common in animal shelter environments because of factors such as pathogen carriage by animals admitted to the facility, suboptimal sanitation, overpopulation, animal stress, mixing of large numbers of animals, facility design constraints, inadequate training of personnel and poor protocols to deal with managing infection and outbreaks. Some major issues that plague shelter animals are infectious diarrhea, fungal skin infections and infectious upper respiratory tract diseases (Hurley and Miller, 2009). The ability to create efficient health and disease management protocols is pivotal to the control of transmission of infectious disease, and this can only be done with proper cooperation and communication between shelter and veterinary staff (Hurley and Miller, 2009).

3.1 a. Common Viral Infections

There are many pathogens and diseases that are prevalent in the shelter environment. The following diseases are the most common, as they are easily transferable in overpopulated spaces and/or commonly introduced by incoming animals.

3.1 a. (i) Respiratory Disease

Canine infectious respiratory disease complex (CIRDC), also known as kennel cough, is a disease of the respiratory system that is particularly common in dogs in close quarters (Ellis et al., 2011). The most common of the pathogens related to CIRDC are canine adenovirus type 2 (CAV-2), canine parainfluenza virus (CPIV), canine influenza virus and \textit{Bordetella}
bronchiseptica (Ellis et al., 2011). In addition canine distemper virus, canine respiratory herpesvirus, *Mycoplasma* spp, *Streptococcus zooepidemicus* and the group 2 canine respiratory coronavirus (CRCoV) can all contribute as co-factors to the development of kennel cough (Ellis et al., 2011). Due to the multifactorial nature of this disease, CIRDC can pose a threat to the well-being of many animals within a shelter. The use of off-site and foster homes and vaccinating animals against *Bordetella* may provide a way to limit the spread of kennel cough.

Another emerging shelter pathogen in dogs is canine influenza virus. This virus developed due to interspecies transmission (Parish and Kawaoka, 2005). Canine influenza virus (CIV), an H3N8 subtype of influenza A, appeared in 2000 when a equine influenza virus was spread to dogs in Florida (Kruth et al., 2008; Hayward et al., 2010). H3N8 is transmitted between dogs through the nasal passage or through contact with respiratory fluid (Song et al., 2008). After 2003, greyhounds infected with the pathogen spread the illness to many areas within the United States, which eventually led to the virus appearing in animal shelter populations in different regions of the U.S (Hayward et al., 2010). According to Hayward et al. (2010) the close quarter environment allowed for this virus to spread, even with its lack of efficiency. The shelter environment may hold the key to understanding the constant evolution of this virus and its mutations. Promise to control the spread of this virus may lie with vaccines, isolation and antiviral medication (Hayward et al., 2010); however, CIV transmission has not been identified in Ontario.

Another critical infectious disease frequent in the shelter environment is upper respiratory tract infection (URTI) in cats. This disease is commonly implicated in the sickness and death in cats present in a shelter (Dinnage et al., 2009). The increased prevalence of this disease in shelters is due to introduction of respiratory pathogens with incoming animals, along with the an impaired immune status, stress, lack of vaccination records and the number of cats present in the shelter (Dinnage et al., 2009). If infected cats are not properly isolated, they can transmit this infection to healthy animals and they may be euthanized to prevent an outbreak (Bannasch and Foley, 2005; Dinnage et al., 2009). Many URTD cases are due to feline calicivirus (FCV) and feline herpesvirus-1 (FHV-1), in addition to *Bordetella bronchiseptica, Chlamydia felis* and *Mycoplasma* spp (Dinnage et al., 2009). Fortunately, the signs of URTI are easy to identify, such as sneezing and nasal or ocular discharge, and any animals suspected to be infected are subsequently isolated or sometimes euthanized (Dinnage et al., 2009), but carriers of these pathogens are not always easy to identify if signs of URTI are not present. According to Dinnage
et al. (2009) the likelihood of contracting URTI increases with longer stays in a shelter environment and cats eleven years and older were at an increased odds of contracting the disease, which could be due to age, stress, entering animals being infected or many of these cats having a latent herpesvirus infection. A way to decrease the risk of URTI infections may lie in the isolation of sick animals and tougher admission procedures, such as more extensive physical exams upon entry. As well, lowering cat stress levels and putting in place protocols that effectively minimize infection and loss, may be critical to decreasing the spread of URTD (Dinnage et al., 2009).

3.1 a. (ii) Gastrointestinal Disease

Canine adenovirus type-1 (CAV-1) is the main cause of infectious canine hepatitis (ICH) (Pratelli et al., 2001). This infection is characterized by anorexia, lethargy, abdominal pain, vomiting, fever and diarrhea (Pratelli et al., 2001). Subsequently, dogs may have bronchopneumonia, photophobia, conjunctivitus and transient corneal opacity (Pratelli et al., 2001). Due to the development of a vaccine against this pathogen, this disease is not common among those who have been vaccinated, although, in unvaccinated individuals it is common, particularly in puppies less than a year in age (Pratelli et al., 2001). If these dogs are concurrently infected with canine coronavirus (CCV), vomiting and diarrhea can manifest more frequently (Pratelli et al., 2001). Lack of sanitation and management was the cause of an outbreak of CAV-1 and CCV outbreak (Pratelli et al., 2001). A usual infection of CCV is short in length and recovery is quick, but the presence of another bacterial or viral infection can lead to more harmful and sometimes fatal outcomes (Pratelli et al., 2001). The interaction between CAV-1 and CCV may favour persistence of enteric disease in dogs (Pratelli et al., 2001), which can only be prevented through strict management, sanitation and vaccination protocols.

Canine parvovirus (CPV) is a very common cause of disease in young, unvaccinated dogs, as it is very transmissible and is linked to high morbidity and mortality rates (Lechner et al., 2010). Some clinical signs of CPV are vomiting and diarrhea, which can vary from mucoid to bloody, and dehydration can follow along with secondary infection (Lamm and Rezabek, 2008). Death can occur as fast as 24 hours after clinical signs have presented (Lamm and Rezabek, 2008). Vaccinating animals against CPV has been effective; vaccinated animals have shown long-lasting immunity, and it is recommended that all animals are vaccinated to prevent outbreaks of this disease (Lechner, et al., 2010). Unvaccinated animals housed in shelters, increases the likelihood of an outbreak because most of these animals have unknown medical histories and are
in close-quarters, which increases the spread of disease (Lechner et al., 2010). These outbreaks can lead to a great loss of animals available for adoption, depopulation to control the spread of disease, and the shut down of shelters (Lechner et al., 2010). Prompt vaccination upon arrival is a relatively standard practice to reduce the risk of CPV infection in dogs.

**3.1 b. Fungal Infections: Dermatophytosis**

### 3.1 b. (i) Introduction

Another disease that is common in animal shelters is dermatophytosis (ringworm). Ringworm is a fungal skin infection caused by different dermatophytes, most commonly *Microsporum canis*, *M. gypseum* or *Trichophyton* spp. (Cabanes, 2000). It is the most common contagious skin disease in cats and more than 20 different species of dermatophytes have been identified in both cats and dogs (Moriello and Newbury, 2006). Ringworm can be highly infectious, but few animals succumb to this disease and it is typically self-limiting (although natural recovery may require weeks to months) (Moriello and Newbury, 2006). However, the high transmissibility, potential for large outbreaks, and zoonotic risk associated with ringworm create significant concern and often lead to an aggressive control response following identification of infected animals in a shelter.

Ringworm can affect any animal, but cats, especially old, young and ill animals are at the greatest risk of contracting an infection (Moriello, 2004). Dermatophytosis is very widespread in tropical and subtropical climates and the prevalence of the disease is greater during warmer months of the year (Moriello and Newbury, 2006). If animals are allowed both indoors and outdoors, the disease can become endemic in homes or shelters (Moriello and Newbury, 2006).

### 3.1 b. (ii) Prevalence and predisposing risk factors

The prevalence of dermatophyte shedding in dogs with possible lesions is between 4% and 10% (Cabanes, 2000). *Microsporum canis* was the most common fungal species that was identified, followed by *T. mentagrophytes* and *M. gypseum* and together these three made up 96% of the isolated dermatophytes (Cabanes, 1997; Cabanes 2000). Published data regarding dermatophyte shedding in cats in animal shelters are limited (Cabanes, 1997; Cafarchia et al., 2006); however, a prevalence of approximately 2% has been reported in various studies of
clinically normal house and feral cats (Mignon and Losson, 1997; Patel et al., 2005). Another study of colony and pet cats in southeast England reported dermatophytes in 4.3% of clinically normal cats, while 13% of pet and 100% of stray cats were positive in a study in central Italy (Patel et al., 2005; Iorio et al., 2007). A more recent study of stray cats in Italy reported dermatophyte shedding by 5.5% of 273 cats caught as part of a trap-neuter-release program (Proverbio et al., 2014).

Dermatophytes are spread through direct, airborne, environmental or fomite-associated contact with infectious arthrospores that are shed from the haircoat of clinically affected animals, as well as subclinical carriers (Moriello, 2004). After a one to three week incubation period, clinically affected animals can develop pruritis, hair loss and skin abrasions (Moriello, 2004). Younger animals, such as puppies and kittens, are more likely to develop alopecia and skin scaling on the face, mouth, ears and front legs (Moriello and Newbury, 2006; Moriello, 2004). While typically self-limiting, disease can be prolonged and because of the highly transmissible nature to both other animals and humans, infected cats can pose a risk to the shelter population, shelter personnel and adopting families. This risk extends to subclinical carriers, while subclinical carriage may be of no health relevance to the animal; carriers are potential sources of infection for other animals and humans.

Dermatophytosis is an important shelter-associated infection and outbreaks can be devastating. Outbreaks can lead to widespread infection of animals (especially cats), profound disruption of shelter activities, shelter closure, high economic costs associated with disease control measures and human health risks. However, little has been reported about dermatophyte shedding by animals in shelters, and it is unclear whether data pertaining to pet or feral cats adequately reflect this shelter population. Since various animal, geographic, environmental, animal management and related factors could impact the prevalence of dermatophyte shedding in a shelter population, population- and region-specific data are required to ensure that clinical and surveillance results are put into the proper context. Understanding the endemic prevalence of dermatophyte shedding is important for development of routine infection control practices and interpretation of surveillance results, but the variability in reported prevalence data can hamper investigations when local prevalence information is not available.
3.1 b. (iii) Pathogenesis and risk factors associated with infection

The infective phase of a dermatophyte is called an arthrospore (Moriello and Newbury, 2006). Fungal hyphae fragment and the spores are produced by this segmentation. The spores attach to the skin or hair coat of a susceptible host (Moriello and Newbury, 2006). After the spores are on the hair, they must attach to skin and hair follicles to germinate. This can occur within six hours of contact with keratinocytes, which allows for the favourable growth of arthrospores (Moriello and Newbury, 2006). Spores are unable to break through skin unless some kind of trauma or underlying skin pathology is present; however, some studies have shown that mild trauma that can occur during grooming is sufficient (Moriello and Newbury, 2006). Microtrauma caused by factors such as lice, flea, tick or mite infestations can allow for spores to penetrate healthy skin, prompting dermatophytosis (Moriello and Newbury, 2006). Germination of these spores also relies on warm temperatures, which explains the increased presence of ringworm in warm climates (Moriello and Newbury, 2006).

There are many factors that affect the spread of ringworm in a shelter environment. Factors present in animals shelters, such as warmth, moisture, microtrauma, a susceptible host and an exposure source, which may all be present in animal shelters, are all key to infection (Moriello and Newbury, 2006). Another factor that makes ringworm much more prevalent and harder to defeat in shelters is the influx of animals in and out of the shelter, which results in contact with various hosts and the potential for increased exposure to spores (Moriello and Newbury, 2006). Animals that enter shelters are usually under some sort of stress and because of this their immune system may be compromised (Moriello and Newbury, 2006). Viral infections such as feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) make hosts more susceptible to infections, due to compromised immune systems (Moriello and Newbury, 2006). Initial signs of the disease occur on the faces of kittens, an area that is hard to groom, making this an ideal site for infection (Moriello and Newbury, 2006).

Pathogenesis of infection can also be influenced by the cleaning protocols within the shelters. Cleaning in a shelter increases humidity, keeps animals in cages, thus raising the ambient temperature of skin, which can help establish infection (Moriello and Newbury, 2006). In addition, if cleaning procedures are not carried out properly, the infection will spread throughout the shelter. For example, staff may use the same cleaning supplies for sick and healthy animals. Because there are so many factors that affect the probability of infection with ringworm, shelter
Disease management protocols must be updated and evaluated to keep up with the changing shelter population and the environmental factors that plague shelter animals on a daily basis.

3.1 b. (iv) Clinical Signs

Dermatophytes infect the shaft of the hair and cornified epithelium, which destroys the hair shaft and prevents normal keratinization, which presents as hair loss and scaling in animals affected by this disease (Moriello and Newbury, 2006). However, there are many other clinical presentations of feline dermatophytosis that can occur. Pruritis can range from minimal to extreme (Moriello and Newbury, 2006). Bacterial pyoderma and some other disorders can sometimes be confused for dermatophytosis, but any hair loss on the face could be a dermatophyte infection (Moriello and Newbury, 2006). After a one to three week incubation period, skin abrasions can form (Weese et al., 2002). Thick skin crusting can progress on the face, ears and nail areas, with longhaired cats being most likely to present these signs (Moriello and Newbury, 2006). Other skin lesions commonly known as chin acne (comedones) can be present in animals infected with *M. canis* and hyperpigmentation of the skin can also occur (Moriello and Newbury, 2006).

There are other signs of a ringworm infection in animals. For example, in puppies and kittens, alopecia and scaling of the skin occur on the face, mouth, ears and front legs and as the animals age, an unusual patch of alopecia accompanied with or without crust, is a common clinical sign (Moriello and Newbury, 2006). Another possible indication of feline dermatophytosis is the presence of lip ulcers, which are cultured to confirm diagnosis (Moriello and Newbury, 2006). Other infected hairs can be located in the bell of the ear, which may result in redness and scaling (Moriello and Newbury, 2006). Other lesions can form due to infection and fail to heal, becoming wounds, which can be identified by skin biopsy (Moriello and Newbury, 2006). Simply using these clinical signs to diagnose dermatophytosis is not the best way to definitively confirm the infection. To ensure animals are not treated unnecessarily, or euthanized, diagnosis should be performed though other forms of diagnostic testing described below.

3.1 b. (v) Diagnostic Testing

There are various ways to definitively diagnose ringworm. One relatively easy method is to use a Wood’s lamp to test for fluorescence; however, this method has poor sensitivity and
specificity and requires further confirmation due to the occurrence of false positives and a lack of fluorescence of many dermatophyte species and strains (Foil, 1998). This method mostly serves as an initial screening for ringworm infection (Moriello and Newbury, 2006, Moriello, 2001). The lamp screens lesions on the skin for fungal metabolites that will fluoresce with a green colour (M. canis will fluoresce, but not all of its strains) (Moriello and Newbury, 2006, Moriello, 2001). This method is very beneficial to find which hairs or area of the skin should be cultured or examined under the microscope (Moriello and Newbury, 2006, Moriello, 2001). This test is the first step in the diagnostic process to confirm a case of ringworm. To use a Wood’s lamp the lights in the room must be turned off and the light is then passed over the entire body of the animal being tested and for best results the lamp should be kept several inches from skin lesions (Moriello, 2001). There can be false positive results, due to skin scaling, seborrhea and the use of topical ointments, but Wood’s lamps can also monitor the treatment of ringworm and as the infection improves, the glowing area of the hair decreases and approaches the tips of the hairs (Moriello, 2001). Wood’s lamp testing can be useful in monitoring treatment or in an outbreak caused by a strain of M. canis that is known to fluoresce.

Another method to diagnose dermatophytosis is directly examining the hairs and scales where the infection is present using microscopy (trichoscopy) (Moriello and Newbury, 2006; Moriello, 2001). By observing these areas under a microscope, it is possible to see the growth of fungal spores on the outer portion of hairs or the invasion of the hair shaft by fungal hyphae (Moriello and Newbury, 2006). This technique is done by plucking hairs in the glowing area, placing them on a glass slide, dropping a clearing agent (10-20% potassium hydroxide) on the slide (allows for any debris to increase in size for a better view of spores on hairs) and placing a cover slip on top (Moriello and Newbury, 2006; Moriello, 2001). The Wood’s lamp can be used to find the glowing hairs on the microscope slide and then under low power the hairs can be clearly visualized (Moriello and Newbury, 2006; Moriello, 2001). Infected hairs appear enlarged, fuzzy, thick and somewhat filamentous, which indicates fungal hyphae invasion of the hair shaft. Spores appear clear and colourless (Moriello, 2001). This hair examination method is more efficient than a simple Wood’s lamp test, as it confirms that the spores are present on the hairs and treatment can begin earlier, during the time when fungal cultures are being analyzed (Moriello and Newbury, 2006; Moriello, 2001).

Definitive diagnostic sampling of cats and individual lesions of dermatophytosis is via fungal culture. The “toothbrush technique” is recommended, as toothbrush samples collect debris
from the surface of the skin and the comb-like bristles obtain samples from the surface of the fur (Moriello and Newbury, 2006). Early infections are common on the face and the ears and the last place sampled should be the face and inside of the bell of the ear (Moriello and Newbury, 2006). Early lesions in kittens are most common in and around the ears, on the muzzle, and paws and as such, these areas should get extra attention during sampling (Moriello and Newbury, 2006). If obvious lesions are present, the normal part of the body should be cultured first and the lesion covered area last, as this minimizes the chance of unconsciously spreading spores over the body and if cultured last, spores exist in the largest amounts on the tips of the bristles (Moriello and Newbury, 2006). The toothbrush samples are then gently pressed upon fungal media such as mycosel agar, dermatophyte test medium (DTM) and Sabouraud’s dextrose agar, which then can be grown in an incubator for 2 to 3 weeks at temperatures between 24 to 28°C (Moriello and Newbury, 2006). Ringworm positive cultures will appear as white colonies with a red/yellow ring of colour change around them. Positive cultures can be further confirmed by using a microscope to examine the fungal hyphae, which resemble filamentous projections (Moriello and Newbury, 2006, Moriello, 2001).

Fungal culture can still result in false negatives due to poor culture technique, improper handling of toothbrush samples and overgrowth of the plate, due to other contaminants (Moriello and Newbury, 2006). Toothbrush samples also need to be kept at room temperature and away from extreme temperatures to avoid damage to the samples (Moriello and Newbury, 2006). There are a variety of fungal media that are available to culture M. canis. Media such as Rapid Sporulation Medium (RSM), Sabouraud’s dextrose agar and dermatophyte test medium (DTM) can be used (Moriello and Newbury, 2006). The plates need to be at least three times the size of the toothbrush head to allow for the fungi to be inoculated properly and for the right amount of nutrients to be available for growth (Moriello and Newbury, 2006). Plates should be observed on a daily basis in order to identify different fungal pathogens, as those that are pale in colour should be suspected as pathogens if they cause the media to change to a red colour (Moriello and Newbury, 2006). However, this colour change does not definitely identify dermatophytes (Moriello and Newbury, 2006) and subsequent testing (e.g. microscopy) is required.

Dermatophytosis can also be diagnosed via skin biopsy. Although the genus and species cannot be identified from the biopsy, special stains can be used to emphasize the fungal hyphae (Moriello, 2001). Several tissue samples need to be collected as the infection is difficult to locate, so areas with crusts attached should be sampled, as spores are mainly widespread in the most
superficial layer of skin (Moriello, 2001). This diagnostic testing method should be carried out in conjunction with fungal culture, in order to identify the fungus to be able to properly treat the disease (Moriello, 2001). Of all the methods to diagnose ringworm, fungal culture is still the “gold standard” (Moriello and Newbury, 2006; Moriello and DeBoer, 1991); however, all the other diagnostic tests such as PCR have strengths and using them together often allows for the best diagnosis and the ability to treat dermatophytosis efficiently and promptly (Moriello and Newbury, 2006).

3.1 b. (vi) Treatment

There are a few different methods that can be used to treat animals infected with dermatophytosis. Infected animals are usually confined to a cage until their condition improves, but the toys in the cage should only be plastic as the risk of transmission by fomites, such as toys is high (Moriello and Newbury, 2006). It is important to handle infected animals properly by wearing protective clothing, to decrease the chance of disease transmission and staff caring for these animals should not be looking after animals in the general population outside of the shelter (Moriello and Newbury, 2006). An isolation room should be designated for animals infected with dermatophytosis and disposable gloves and clothing should be worn when inside and disposed of before entering another area of the shelter (Moriello and Newbury, 2006). Shelter staff should also be vigilant about hand hygiene and minimizing the amount of traffic in and out of isolation rooms where the infected cats are kept (Moriello and Newbury, 2006).

Ringworm is more common in cats with long hair, so by cutting their coats short, there is the chance of removing infective matter from their fur to prevent the infection of their surroundings (Moriello and Newbury, 2006). By using a Wood’s lamp to recognize infected hairs and lesion covered areas, the infected material present on their bodies can be removed and prevent prolonging infection and contaminating the shelter environment (Moriello and Newbury, 2006). The removal of infective material is the first step in treating these cats, followed by systemic and topical treatment (Moriello and Newbury, 2006, Sparkes et al., 2000).

Dermatophytosis is treatable and curable through the use of antifungal and topical agents (Moriello and Newbury, 2006, Sparkes et al., 2000). Most studies have concluded that the use of topical shampoos and treatments are only meant to reduce the environmental contamination by dermatophytes and are unable to reduce the clinical signs associated with dermatophytosis
(Sparkes et al., 2000). However, Paterson (1999) examined the efficacy of a medicated shampoo (2% chlorhexadine and 2% miconazole), with or without an oral antifungal medication, griseofulvin and found that the shampoo alone lowered the contamination of the environment and helped to eliminate clinical signs faster, as opposed to just using the griseofulvin on its own (Paterson, 1999). Similarly, Sparkes et al. (2000) examined the effectiveness of griseofulvin with or without medicated shampoo and compared this to a control group with no therapy in order to determine the optimal treatment regimes for feline Microsporum canis. The authors concluded like the Paterson (1999), that the combination of topical and systemic treatments drastically reduced the number of lesions (Sparkes et al., 2000).

Other topical agents that have proven effective are lime sulfur, a common treatment agent and enilconazole (same drug class as miconazole) (Moriello and Newbury, 2006). It is recommended that topical therapy be done twice a week, along with oral medication taken daily for three to four weeks (Moriello and Newbury, 2006). The lime sulfur can be applied to the infected cats using a garden sprayer, with a half gallon treating 10 to 15 cats (Moriello and Newbury, 2006). The sprayer must be held close to the surface of the cat’s skin, so their coat can be covered, including the hair and skin follicles, while sponging with lime sulfur is done to coat the ears and face (Moriello and Newbury, 2006). Moriello and Newbury (2011) recommended itraconazole as the oral medication, as opposed to griseofulvin as it is very effective, it works for several weeks after being administered and fewer side effects are linked to its use. This type of therapy should be monitored via fungal culture for a month after treatment and once two negative fungal cultures are found at weekly intervals, the treatment for dermatophytosis can stop (Moriello and Newbury, 2006).

### 3.1 b. (vii) Environmental Factors and Prevention

Dogs and cats in shelters are an important potential source of human infection; studies have indicated the best way to prevent zoonotic ringworm is to identify and isolate affected animals, while ensuring shelter staff maintain their own hygiene and disinfect the shelter environment (Weese et al., 2002). Contamination of the shelter environment is of major concern to the health of the animals residing there and the shelter staff who run the facility (Moriello and Newbury, 2006).
Ringworm is a zoonotic disease, so it is very important for shelter staff to be vigilant and aware of hand hygiene and environmental cleanliness in order to reduce the spread of infection to other animals and themselves, especially by way of fomites and air currents (Moriello and Newbury, 2006). Lesions are often hard to find or are not present, so if proper precautions are not taken to actively screen and survey for ringworm in shelters, infected animals may be adopted out of the shelter, resulting in a public health issue (Moriello and Newbury, 2006). This can also lead to public relations problems if it results in public complaints. These events reduce shelter personnel morale, as well as deter people from adopting animals out of a shelter (Moriello and Newbury, 2006).

Shelter resources and protocols determine infectious disease management and some shelters use euthanasia to deal with dermatophytosis, which is effective, but not appropriate approach to deal with an outbreak or a few cases of ringworm (Moriello and Newbury, 2006). Animals infected with ringworm are shedding spores constantly and by bringing them into the shelter environment without testing them for ringworm, the spread of this fungal skin infection is inevitable (Moriello and Newbury, 2006). Ringworm affects animals that are up for adoption, mainly puppies and kittens and by euthanizing these animals, the number of adoptable animals decreases (Moriello and Newbury, 2006). Euthanizing young animals for a disease that is treatable becomes both an emotional and political issue for the shelter staff and community (Moriello and Newbury, 2006). Although euthanasia is the only option for shelters with little to no resources for treatment, the best way to prevent ringworm in shelters is to have an active surveillance program and educate shelter staff to recognize clinical signs to diagnose animals upon entry, so they can be isolated and treated before the spread of infection occurs (Moriello and Newbury, 2006).

Proper surveillance and monitoring of animals within the shelter is important to diagnose and isolate possible infected animals, to prevent the spread of pathogenic fungi and other infectious diseases. This will hopefully allow for animals to find refuge at shelters, without further being infected with other pathogens, which could prolong their stay at the shelter due to illness. The decontamination of shelters environments will help keep the rate of infection within the shelter low, preventing the risk of disease outbreaks and reducing the need to resort to mass euthanasia, to control the spread of infection. Some shelters have used Swiffer cloths to culture certain areas of the shelter to monitor the cleaning of these areas, as these cloths can be analyzed for various pathogenic fungi (Moriello and Newbury, 2006). By observing cleaning methods in
the shelter, these efforts can hopefully be improved, keeping the rate of infection down between animals and shelter staff.

Surveillance and monitoring of animals in the shelter allows for staff to begin to collect prevalence data for ringworm and other common shelter pathogens, which can help flag a rise in infection, as well as review and alter shelter disease management protocols to better prepare for a potential case. With the data collected, shelters might be able to get a better understanding of what diseases are affecting the population and carry out the proper precautions to avoid a future outbreak.

4.0 Euthanasia

4.1 Euthanasia Rates

The purpose of animal shelters is to maintain the health and welfare of animals (Marston et al., 2004). A large number of animals do not get adopted or reclaimed by their rightful owners (Lepper et al., 2002), and many of the shelters are not able to sustain an overpopulated shelter (Marston et al., 2004) and must euthanize many animals. In 1995, a study in the United States found that 38% of incoming animals and 48% of surrendered dogs were euthanized and 17% of surrendered animals were euthanized by request of their owners (Marston et al., 2004).

4.1 a. Animal Assessments

Euthanasia statistics are rough and may under-estimate the incidence of these events due to a lack of participation by certain shelters in surveys (Bartlett et al., 2005). Most of the time, shelters assess animals upon admission for physical characteristics, temperament and health status, in order to decide the fate of the animal (Marston et al., 2004). Due to the preferences of prospective adopters, many animals are euthanized simply because of undesired characteristics such as colour, age, breed and size (Lepper et al., 2002). Lepper et al. (2002) found that stray dogs and individuals with problematic behaviours were less likely to be adopted, so the probability of euthanasia increased. Unfortunately, certain breeds are not preferred due to their personality traits, making them undesirable and decreasing their chance of adoption. Animals with severe medical ailments or improper behaviour are often subject to euthanasia immediately (Marston et al., 2004). Other factors that contribute to the euthanasia rate in shelters are
overcrowding and space restrictions (Grimm, 2009). Despite what research has been conducted, it is still unclear what can be done to effectively reduce the rate of euthanasia in animal shelters, while not exhausting shelter resources. There is a gap in the literature regarding how animal characteristics, such as age, breed, physicality, colour, behaviour and space restrictions contribute together to the probability of an animal being euthanized. Research focussed on these areas, will help to make strides in educating the general public about overpopulation problems (Scarlett, 2008) and public health issues concerning zoonotic diseases (Burns, 2006), there is hope to reduce animal euthanasia rates.

4.2 Outbreaks

The biggest risk of housing so many animals together in close quarters is the chance for disease transmission. If proper precautions (sanitation and isolation) to remove an individual that may increase the risk of spreading infection are not followed, a disease outbreak may ensue, causing shelters to make difficult choices and euthanize many animals who may have contracted the disease to not jeopardize the health of the rest of the shelter population (Newbury et al., 2010).

4.2 a. Isolation and Length of Stay

By putting animals in isolation immediately and surveying them for a specific amount of time, it may be possible, provided that space is available, to protect healthy animals from being exposed to a pathogen. Another factor that contributes to the likelihood of animals contracting disease is the amount of time they remain in the shelter (Hurley, 2007). By reducing the amount of time animals spend in shelters, the chance of getting ill is lowered, resources are saved on treating animals and less crowding also reduces stress (Hurley, 2007). However, there are other methods of lowering the number of animals in a shelter, such as treating animals to keep them healthy and adoptable (Hurley, 2007). Furthermore, euthanasia procedures put a strain on shelter resources, lower shelter staff morale, and cause public relations issues (Hurley, 2007).

Other methods might also be employed to decrease the amount of time animals spend in shelters. Promotional adoption events have the potential to increase the rate of adoption and decrease the risk of the adoptable animals contracting a disease (Hurley, 2007). Foster care is another way to reduce overcrowding within a shelter, lower the chance of acquiring an illness and
increase the rate of adoption (Humane, 2010). If shelters are diligent in using off site facilities and foster homes to provide safe temporary homes for vulnerable animals, the risk of an outbreak may be lowered.

There is a gap in the literature of studies that have followed animals forward in time, from the moment they enter the shelter, to the point when they are adopted, reclaimed or euthanized. Since every animal has a different background and health status, it would be helpful to understand what happens to animals that remain in the shelter and their journey through the system. With this knowledge, shelters may be better able to understand the process of disease transmission within the shelter and how disease control management and procedures can be improved to benefit the animals admitted there (Hurley, 2007).

4.2 b. Efforts to Decrease Disease Transmission

Disease control and management is important to have in place in animal shelters. However, outbreaks are very serious and delicate situations that may require veterinarians and shelter staff to make choices to benefit the shelter population as a whole and not focus on individuals. The isolation of infected animals in an outbreak situation is crucial and if possible the further intake and adoption of animals in and out of the shelter should be slowed or stopped completely to decrease the risk of exposing a larger percentage of animals to disease (Newbury et al., 2010). Euthanizing many animals in an outbreak situation should be the last resort and every other method to reduce the perpetuation of the disease outbreak should be exhausted, before this choice is made (Newbury et al., 2010). The shelter must consider all aspects of the outbreak including sickness, death due to illness and the health and welfare of the community nearby in order to be sure that euthanasias is the only viable option to prevent further disease transmission (Newbury et al., 2010).
Thesis Objectives

As emphasized above, many factors influence the rate of euthanasia in shelters such as overpopulation, animal behaviour, the preferences of adopters (age, sex, breed, colour, size), injury and infectious diseases. Despite this, there have been few studies describing the incidence of euthanasia and the risk factors associated with this practice and risk factors. Knowing disease and euthanasia patterns is critical for the development of effective strategies to reduce the risk of disease, promote adoption and decrease euthanasia procedures in shelters.

The objectives of this thesis are the following:

1. Describe euthanasia of cats admitted to an animal shelter.
2. To identify factors that affect the chance of a cat being euthanized.
3. To describe the fate of cats in the shelter system.
4. To evaluate the prevalence of dermatophyte shedding by cats admitted to selected Ontario shelters.
References


Dohoo, I., Martin, W., Stryhn, H. (2009). "Veterinary Epidemiologic Research" (pp. 2-5).


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CHAPTER 2:

An epidemiological investigation of euthanasia in an Ontario animal shelter
2.0 Abstract

Every year roughly six to eight million dogs and cats are admitted to animal shelters in the United States, and a large percentage of these are ultimately euthanized. Understanding factors associated with euthanasia is important to optimize adoption and resource utilization. This study evaluated factors associated with euthanasia in an animal shelter in Kitchener-Waterloo, Ontario, Canada. Shelter data from 3,737 cats admitted to the shelter between January and December of 2011 were evaluated. Overall, 1,989/3,737 (53%) of admitted cats were euthanized. Male cats had greater odds of being euthanized than females (OR: 1.63, 95% CI: 1.29-2.05, P < 0.001) and surrendered cats were more likely to be euthanized than strays (OR: 38.0, 95% CI: 14.8-97.69, P <0.001). Black cats were more likely to be euthanized than cats of another colour (OR: 1.45, 95% CI: 1.16-1.80, P < 0.001). Cats that spent more than five days in the shelter were more likely to be euthanized than those that spent less than 5 days in the shelter (OR: 1.57, 95% CI: 1.25-1.97, P < 0.001). Cats that spent more than 20 days in the shelter were less likely to be euthanized than those that spent less than 5 days in the shelter (OR: 0.26, 95% CI: 0.19-0.34, P < 0.001). Age, an age quadratic term, neuter status and interactions among these variables were statistically significant; the odds of unneutered animals being euthanized was high and relatively stable across age groups, but in neutered animals the odds of being euthanized increased with age before plateauing in older cats. With over 50% of the cats admitted to the shelter in 2011 euthanized, it is important to understand the contributing risk factors that predispose shelter cats to euthanasia and what changes can be made to the shelter system and in owner education to lower the incidence of euthanasia.

2.1 Introduction

Approximately six to eight million dogs and cats are brought into animal shelters in the United States every year (Lepper et al., 2002; HSUS, 2011). Animals that enter the shelter system are ultimately retrieved by their owners, adopted, die due to illness, or are euthanized (Lepper et al., 2002). In the US alone, almost 1 billion dollars are spent annually by animal shelters to care for and subsequently euthanize animals that are unable to be adopted (Marsh, 2010).

An estimated 10% to 25% of the companion animal population that are admitted to shelters are euthanized annually in the United States (Lepper et al., 2002). One study noted that as many as 57% of the cats admitted to shelters in Michigan in 2003 were euthanized (Bartlett et al., 2015). Because of the large number of admitted animals, combined with finite numbers of potential homes and finances, shelters often must assess animals when they are admitted for
physical characteristics, behaviour and health status, in part to determine whether the animal should be made available for adoption (Marston et al., 2004). While many animals are deemed unadoptable and euthanized, a large number of potentially adoptable animals are also ultimately euthanized. A variety of factors may influence this outcome, including shelter capacity, animal health, and preferences of prospective owners for certain pet characteristics such as colour, age, breed and size (Lepper et al., 2002). Studies by Lepper et al. (2002) and Fantuzzi et al. 2010 investigated what characteristics were desirable to adopters, to understand the probability of an animal being adopted or euthanized and to give shelters strategies to promote all different types of animals as companions. It was found that younger cats, neutered males, white and grey coloured cats and rare breeds, such as Siamese cats, were more likely to be adopted than euthanized. More research and information on the preferences of adoptive owners may help shelters understand and improve their strategies to adopt animals that are currently perceived to be less desirable.

Despite extensive research and exploration, information about factors that influence adoption and euthanasia is still limited, hampering efforts to increase adoption and decrease relinquishment and euthanasia, while optimizing shelter resources. There is a gap in the literature concerning how characteristics such as age, sex, breed, source, total time in shelter, colour, altered status, jurisdiction, time of year and number of times in shelter contribute to the probability of an animal being euthanized. The objective of this study was to evaluate associations between euthanasia of cats admitted to an animal shelter and these characteristics.

2.2 Methods

Data Collection

Cats admitted to the Kitchener-Waterloo Humane Society (KWHS) in Kitchener, Ontario, Canada between January and December 2011 were studied through retrospective evaluation of data from the shelter’s electronic records system. All cats admitted to the shelter during this period were followed. Factors such as sex, altered status (neutered/spayed, intact), source, jurisdiction of origin, age, total time in shelter, coat colour, the last season the cat was kept by the shelter, number of times in shelter, and breed were recorded. The variable “times in shelter” was dichotomized as “readmission” and categorized as either “yes” or “no”. The variable “last season the cat was kept by the shelter” was defined as the last reported season when the
animal was present in the shelter prior to readmission. Seasons were defined as follows: winter (December-March), spring (April-May), summer (June-August), and fall (September-November).

Statistical Analyses

i. Descriptive statistics:

The proportion of animals that were euthanized and the proportion of animals among categories of the following independent variables was estimated: sex (male, female, unknown), breed (purebred, non-purebred), source (stray, surrender, euthanasia request, shelter offspring), total time in shelter (less than 5 days, 5 to 20 days, more than 20 days), colour (black, other), altered status (yes, no, unknown), jurisdiction (urban [Kitchener-Waterloo area], out of area/unknown, small town/rural [areas around the Kitchener-Waterloo area]), the last season the cat was kept by the shelter (winter, spring, summer, fall), and number of times admitted to the shelter (readmitted, not readmitted). The proportion of animals euthanized among the categories of these independent variables and their respective exact 95% confidence intervals were also estimated.

ii. Univariable analysis:

Univariable logistic regression models were constructed to estimate the association between a cat being euthanized and the independent variables listed above. Continuous independent variables were assessed as to whether the variable had a linear relationship with the log odds of the outcome using a lowess curve (i.e., locally weighted regression). If the lowess curve indicated there was a quadratic relationship, the square term of the variable was included with its main effect in subsequent models. However, if the relationship was non-linear, but not quadratic, a transformation to linearize the relationship was performed or the variable was categorized. Prior to multivariable logistic regression modeling, the correlation was assessed among independent variables using various correlation coefficients to avoid issues associated with collinearity. Correlations greater than 80% (i.e., r>|0.8|) were considered problematic and only the variable with the most complete information was included in subsequent multivariable modeling.
iii. Multivariable analysis:

All significant variables based on a liberal p-value (i.e., p<0.20) in the univariable analysis were considered for inclusion in the multivariable model. A multivariable model was then fitted using a manual backwards step-wise approach to create a main effects model using a significance level of $\alpha=0.05$ while retaining confounding variables regardless of statistical significance. Confounding was assessed by examining the change in the coefficients for the remaining statistically significant variables in the model, once the potential confounding variable was removed. If the coefficient for one of these variables changed more than 20%, the removed variable was considered a confounder, assuming it did not appear to be an intervening variable based on a logical causal pathway, and retained in the main effects model. Next, interactions between the following variables were then assessed based on their biological plausibility: sex and breed, breed and age, sex and age, total time in shelter and age, season and age, and reproductive status and age. Variables were retained in the final multivariable model if they were statistically significant ($\alpha=0.05$), acted as a confounding variable, or were part of a statistically significant interaction term. The statistical significance of categorical variables, including interaction effects involving categorical variables, was assessed using likelihood ratio tests. Predicted curves were generated for any significant interaction terms involving continuous variables to interpret the relationship between the independent variables and the probability of euthanasia. For any categorical variables that had multiple levels (e.g., season), or interactions involving categorical variables, contrasts were generated to assess pairwise differences among categories of a variable or different covariate patterns among interacting variables.

Model fit was assessed using a Hosmer-Lemeshow goodness-of-fit test. Pearson residuals, leverage, delta chi-square, delta-beta and delta deviance graphs were assessed visually to identify any potential outliers or highly influential observations. If there were observations that fit the model poorly or had extreme influence on the model, recording errors were investigated and the model was refit without the observation to determine its impact on the interpretation of the model. All statistical analyses were performed using Stata 13.0 (StataCorp LP, College Station, Texas, USA).
2.3 Results

In total 5,439 animals were admitted to the shelter in 2011; 3,737 (69%) were cats. Only animals that had sufficient data were included in the statistical analyses. Animals were dropped from the final analyses if they did not have sufficient data with respect to the variables that were included in the final multivariable model. 3435 cats were included in the final multivariable model. Approximately, 48% of cats were female, 45% were male and the remaining 8% were of an unknown or unrecorded sex. At the time of admission 39% of cats were altered, 18% were not and the status of 43% were unknown. The cats admitted to the shelter came from various sources: 78% were strays, 11% were surrendered to the shelter, 8% were euthanasia requests and 3% were shelter offspring. This shelter received admissions from various jurisdictions, and 88% of admitted cats were from urban/suburban areas in Kitchener-Waterloo, 3% came from out of the area or were from an unknown jurisdiction and 9% came from smaller towns or rural areas in and around the Kitchener-Waterloo area. Of the cats admitted to the shelter, 28% were black and 72% were a variety of other colours. Various breeds of cat were admitted into the shelter, but 97% were non-purebreds such as domestic short, medium and longhaired cats. Twenty-three percent of cats left the shelter (adoption, reclamation or euthanasia) in winter, 21% in the spring, 24% in the summer and 31% in the fall. Ninety-eight percent of cats that were adopted or claimed were not readmitted during the study period, while 2% were readmitted to the shelter. Overall, 1,989 (53%) of these cats were euthanized. The incidence of euthanasia by each independent variable are presented in Table 2.1. No disease outbreaks were identified during the study period.

Sex, age, age squared, source, total time in shelter, colour, altered status, jurisdiction, the last season the cat was kept by the shelter, and the number of times the cat had been in the shelter were significantly associated with euthanasia in the univariable analysis (Table 2.2).

The following variables and interaction terms were included in the final multivariable model: sex, age, age squared, source, total time in shelter, colour, altered status, jurisdiction, the last season the cat was kept by the shelter, age X altered status and age squared X altered status (Table 2.3). The predicted curves generated for the interactions involving age and neuter status showed that if a cat was unaltered or of an unknown altered status, the likelihood of being euthanized was high regardless of age (Figure 2.1). However, among neutered animals, the odds of euthanasia were low for young animals and increased with age while eventually leveling off for older cats. Male cats were significantly more likely to be euthanized than females (Table 2.3).
As well, male cats were significantly more likely to be euthanized than those of an unknown sex (Table 2.3). There was no significant difference in the odds of euthanasia between female cats and cats of unknown sex (Table 2.3). Cats that were surrendered to the shelter and admitted as euthanasia requests were significantly more likely to be euthanized than stray cats (Table 2.3). There was no significant difference in the odds of euthanasia between shelter offspring and stray cats (OR: 1.29, 95% CI: 0.69-2.40, P=0.430). Cats that came from out of the area or small town/rural jurisdictions were significantly more likely to be euthanized than cats that were admitted from local urban (Kitchener-Waterloo) areas (Table 2.3). Cats that came from out of the area or unknown areas were significantly more likely to be euthanized than those that came from a small town or rural areas (OR: 3.13, 95% CI: 1.39-7.05, P = 0.006). Black cats were significantly more likely to be euthanized than cats of any other colour (Table 2.3). Cats that were last in the shelter in the spring, summer and fall months were significantly more likely to be euthanized than those cats that were last in the shelter during the winter (Table 2.3). Cats that were last in the shelter in the spring were at significantly lower odds of being euthanized than those that were in the shelter in the summer (OR: 0.73, 95% CI: 0.55-0.98, P = 0.03). There was no significant difference in the odds of being euthanized for those cats that were last in the shelter in the summer (OR: 1.18, 95% CI: 0.91-1.54, P = 0.20) and spring (OR: 0.87, 95% CI: 0.66-1.13, P = 0.30) compared to those who were last in the shelter in the fall months. Cats that spent between 5 to 20 days in the shelter were significantly more likely to be euthanized than those cats that spent less than 5 days in the shelter (Table 2.3) and cats that spent greater than 20 days (OR: 6.12, 95% CI: 4.64-8.06, P <0.001). Cats that spent more than 20 days in the shelter were at significantly lower odds of being euthanized than those that spent less than 5 days in the shelter (Table 2.3).

The Hosmer-Lemeshow test was not significant ($\chi^2=11.11; \ df=9; \ p=0.20$) indicating the model fit the data. A small number of observations appeared to have a large influence on the model or fit the model poorly. However, their removal did not change the interpretation of the model and no recording errors justified their removal.

2.4 Discussion

This study highlights the characteristics that have contributed to the increasing odds of euthanasia in shelter cats. There have been only a small number of published studies that have researched this issue (Lepper et al., 2002), which highlights the importance of these data. The
high risk of euthanasia noted here (53%) is consistent with another study in North America (Bartlett et al., 2005) and highlights the importance of this topic. As is evidenced by this study, euthanasia is common and certain cat characteristics, and regional, seasonal and demographic variables impact the probability of being euthanized in this shelter.

Most cats that entered the shelter were strays, which was not surprising. Most of the animals came from urban areas, likely due to the larger human population in these areas, therefore increasing the number of cats owned by the people that reside there and the greater likelihood someone would identify and report a stray cat. More non-purebred cats came into the shelter than purebreds, something that may simply reflect the breed distribution of cats in the region or be associated with increased care of purebred cats. As well, this may be related to the fact that pure bred cats are not as common in the pet population.

The time a cat spends in the shelter is a crucial variable to understand. Specifically, the length of time in days, the frequency at which they return to the shelter and the season that they are last in the shelter are important variables to examine. The largest portion of cats spent less than 5 days in the shelter, followed by 5 to 20 days and then over 20 days. Those that spent between 5 to 20 days in the shelter were more likely to be euthanized than those that spent less than 5 days in the shelter. This could reflect that those animals that spent less than 5 days in the shelter may have been more likely to be picked up by their owners during this window of time or that these animals are more desirable and therefore adoptable, so they leave the shelter more quickly. In contrast, cats that spent greater than 20 days in the shelter were less likely to be euthanized than those that spent fewer than 5 days. This is interesting and perhaps somewhat counter-intuitive, as those cats could perhaps be considered less adoptable since they had not been adopted during the first 20-day period. This may have resulted from these cats being placed in foster care and still remaining listed as cats in the shelter system. It could also reflect the tendency for some shelters to keep cats in the shelter that have remained for this long, as they may require additional training and socialization in order to be adopted successfully.

Most cats were only admitted to the shelter once during the study period. Some animals may be re-admitted if they are not contained by their owners (and are re-captured as strays) or if they are surrendered because of problems in the post-adoption period. Re-admission had no significant effect on euthanasia in our multivariable model. It is also possible that this population consisted of cats both at higher risk (e.g., unsuccessful adoption surrenders) and lower risk (e.g.,
indoor/outdoor cats that get recaptured as strays, but are cared for pets that are identifiable and retrieved by their owners) for euthanasia. Readmission had a significant sparing effect in the univariable model, but this effect may have been confounded by age and source, which was controlled for in our multivariable model. The source of an animal entering a shelter has not been examined previously in the literature; however, this may be an important element to explore in future studies. This could be done by not only citing the sources of the animals entering the shelter, but specifying their reason for admittance in detail, if this information is known.

The distribution of the number of cats that were last kept in the shelter over the four seasons was relatively equal; however, those that left the shelter in the spring, summer and fall were more likely to be euthanized than those cats that were last in the shelter during the winter season. Caution should be used in interpreting these seasonal effects, because this study was only one year in length and there was no replication of seasons.

Male cats were more likely to be euthanized than females, suggesting a preference towards adopting females. This may be due to the belief that male cats tend to be more aggressive than females (Lindell et al., 1997). However, some studies have found an increase in male adoptions when looking at sex neuter interactions (Fantuzzi et al., 2010; Lepper et al., 2002). Aggressive concerns may relate mainly to intact males, and there may be a perception that neutered males especially, are less aggressive than females (Finkler et al., 2011). The interaction between sex and neuter status was tested in our study, and it was not significant so this perception may not be valid. However, future studies should further explore the relationship between sex and adoptability in other jurisdictions, with more consideration of the impact of altered status, particularly since this is a modifiable variable (i.e., male cats can, and typically are, neutered prior to adoption).

Cats surrendered to the shelter and those that were euthanasia requests were more likely to be euthanized than those that came in as strays. The euthanasia requests have an increased likelihood of euthanasia compared to strays, as these animals specifically came in to be euthanized, as specified by their owners. This is consistent with another study that found that stray cats were more likely to be adopted (Lepper et al., 2002). Those that came in as surrenders may have not been wanted for a variety of reasons such as problematic behaviours, illness or old age, financial concerns of the owners or allergies, so this may be why they would be more likely to be euthanized.
Cats that came from out of the area from unknown regions, and small towns were more likely to be euthanized than those from urban areas. This could be due to their poorer health status or possible feral-like behaviour making these animals poorly socialized and possibly not even put up for adoption in the first place. This could be due to a lack of proper veterinary services in these smaller towns and areas, as well as the more free-range type lifestyle that these cats may be accustomed to on farms.

Black cats were more likely to be euthanized than cats of other colours and other studies have also noted this finding as well, but explanations have varied (Lepper et al., 2002). To potential adopters, the appearance of a black cat may make it hard to distinguish certain facial features that would be evident with a lighter colour, making them less desirable. One study looked at how potential adopters perceive personality based on coat colour and one significant finding was that orange cats were considered friendlier than cats of other colours (Delgado et al., 2012). This has been noted by various shelter organizations that have examined adoption patterns for black dogs and cats, such as the American Society for the Protection of Cruelty to Animals (ASPCA) (Woodward et al., 2012). This is especially true with the growing trend of using the internet to market animals available for adoption, as black cats may not photograph well. The Royal Society for the Prevention and Cruelty to Animals (RSPCA) in the United Kingdom has examined this further. Based on an article published in July of 2014, 70% of the 1000 abandoned cats that were in the care of the RSPCA were black in colour (RSPCA, 2014). The hypothesis was that these cats are not as popular and are not adopted as frequently because their black colouration makes them more difficult to photograph and it is also more difficult to recognize them as individual cats, due to their lack of visible markings.

The effect of age on the odds of being euthanized significantly varied with the neuter status of the cats in this shelter. For animals that were unaltered or of unknown neuter status, the odds of being euthanized appeared to be high across age categories, while for neutered animals the odds of euthanasia increased with age with the effect of age levelling off for senior cats. This is consistent with the findings of another study that demonstrated that the likelihood of adoption decreased gradually with increasing age (Lepper et al., 2002; Fantuzzi et al., 2010). These interactions may reflect that neutered animals are less of a hassle to avoid the cost of the surgical procedure, eliminating the possibility of spraying behavior of that they may be less expensive to adopt. The change in the odds of euthanasia for neutered animals with age may simply reflect the preference of people to adopt younger animals (Lepper et al., 2002).
There are many factors that influence whether or not a cat will be euthanized in the shelter. It is apparent that many people who adopt animals from shelters have discernible preferences for animals of certain colour, age, sex and breed (Lepper et al., 2002), factors that would correspondingly influence the risk of euthanasia in the shelter. These could be changed with proper education and other interventions that could be done at the shelter level to optimize the adoptability of cats that are identified as being more difficult to adopt. Possible interventions that could be done include using the information collected from this study to focus the shelter’s efforts and resources on those animals that are considered adoptable but harder to home. For instance, increased education or marketing on the benefits of adopting older cats and black cats might help reduce rates of euthanasia in these animals. Other interventions such as the use of foster programs, which keep the animals out of the shelter and allow for proper socialization and training in a household environment, which may be less stressful and comforting to these cats, would also be helpful. This relates to the finding in this study of animals being euthanized due to their length of stay in the shelter, so advocating the use of foster homes would be beneficial to reduce the length of stay in the shelter. This is especially important during the 5 to 20 day window, when the likelihood of euthanasia is increased. This could be improved with better record keeping by shelter staff with regards to fostering, to understand why animals that remain for more than 20 days are less likely to be euthanized.

This study only examined data from one shelter, so it is hard to discern whether or not these results can be generalized to other shelters in Ontario, or in Canada and the United States. Given the location of this shelter in a smaller city, this may also affect the likelihood of extrapolating these results to larger facilities in major cities across the country. As well, there is a limitation with this study, as there was no specific indication as to why a cat was euthanized. This would be useful information to obtain from shelters for future studies. As well, information on stray returns to owners would be helpful.
2.5 Acknowledgements

This study was funded by an OVC Fellowship scholarship received by the author. The author would like to acknowledge the participation and assistance by the staff of the Kitchener-Waterloo Humane Society in collecting and providing access to shelter data. The author would also like to acknowledge Dr. Cheryl Yuill, for her help in designing this study during her tenure as the Veterinary Director of the Kitchener-Waterloo Humane Society. The author declares that there are no conflicts of interest.
2.6 References


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Table 2.1: Descriptive statistics of categorical variables associated with euthanasia among cats from a shelter in Kitchener-Waterloo, Ontario (2011).

<table>
<thead>
<tr>
<th>Categorical Variable Name</th>
<th>Type</th>
<th>Frequency (%)</th>
<th>Percent Euthanized (Confidence Interval (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Female</td>
<td>1759 (47.5)</td>
<td>53.72 (51.4 – 56.1)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>1657 (44.7)</td>
<td>48.76 (46.3 – 51.2)</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>291 (7.90)</td>
<td>70.79 (65.2 – 76.0)</td>
</tr>
<tr>
<td>Altered</td>
<td>No</td>
<td>667 (18.0)</td>
<td>62.52 (58.7 – 66.2)</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>1601 (43.2)</td>
<td>76.20 (74.0 – 78.3)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>1439 (38.8)</td>
<td>22.37 (20.3 – 24.6)</td>
</tr>
<tr>
<td>Source</td>
<td>Stray</td>
<td>2766 (77.6)</td>
<td>52.46 (50.6 – 54.3)</td>
</tr>
<tr>
<td></td>
<td>Surrender</td>
<td>379 (10.6)</td>
<td>95.51 (92.9 – 97.4)</td>
</tr>
<tr>
<td></td>
<td>Euthanasia Request</td>
<td>294 (8.25)</td>
<td>38.44 (32.8 – 44.2)</td>
</tr>
<tr>
<td></td>
<td>Shelter Offspring</td>
<td>125 (3.51)</td>
<td>26.40 (18.9 – 35.0)</td>
</tr>
<tr>
<td>Jurisdiction</td>
<td>Urban</td>
<td>3263 (88.0)</td>
<td>50.44 (48.7 – 52.2)</td>
</tr>
<tr>
<td></td>
<td>Out of Area/Unknown</td>
<td>93 (2.51)</td>
<td>78.49 (68.8 – 86.3)</td>
</tr>
<tr>
<td></td>
<td>Small Town/Rural</td>
<td>351 (9.47)</td>
<td>68.38 (63.2 – 73.2)</td>
</tr>
<tr>
<td>Colour</td>
<td>Other</td>
<td>2669 (72.0)</td>
<td>50.77 (48.9 – 52.7)</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>1038 (28.0)</td>
<td>58.18 (55.1 – 61.2)</td>
</tr>
<tr>
<td>Total Time in Shelter (Days)</td>
<td>&lt;5</td>
<td>1394 (37.6)</td>
<td>72.02 (69.6 – 74.4)</td>
</tr>
<tr>
<td></td>
<td>5 – 20</td>
<td>1345 (36.3)</td>
<td>61.12 (58.5 – 63.7)</td>
</tr>
<tr>
<td></td>
<td>&gt;20</td>
<td>968 (26.1)</td>
<td>13.74 (11.6 – 16.1)</td>
</tr>
<tr>
<td>Season Left Shelter</td>
<td>Winter</td>
<td>816 (22.8)</td>
<td>43.75 (40.3 – 47.2)</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>759 (21.3)</td>
<td>58.50 (54.9 – 62.0)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>873 (24.4)</td>
<td>58.08 (54.7 – 61.4)</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>1124 (31.5)</td>
<td>57.83 (54.9 – 60.7)</td>
</tr>
<tr>
<td>Times in Shelter</td>
<td>Not Readmitted</td>
<td>3590 (98.3)</td>
<td>54.18 (52.5 – 55.8)</td>
</tr>
<tr>
<td></td>
<td>Readmitted</td>
<td>63 (1.72)</td>
<td>20.63 (11.5 – 32.7)</td>
</tr>
<tr>
<td>Breed</td>
<td>Purebred</td>
<td>105 (2.83)</td>
<td>55.24 (45.2 – 65.0)</td>
</tr>
<tr>
<td></td>
<td>Non-Purebred</td>
<td>3602 (97.2)</td>
<td>52.78 (51.1 – 54.4)</td>
</tr>
</tbody>
</table>
Table 2.2: Results of univariable logistic regression models concerning demographic characteristics and other factors that were associated with euthanasia among cats from a shelter in Kitchener-Waterloo, Ontario (2011).

<table>
<thead>
<tr>
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<tr>
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<td>Purebred</td>
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Table 2.3: Results of multivariable logistic regression analysis concerning demographic characteristics and other factors that were associated with euthanasia among cats from a shelter in Kitchener-Waterloo, Ontario (2011).

<table>
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<th>Confidence Interval</th>
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<tr>
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<td>Altered (No) X Age (Squared)</td>
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<td>Altered (Yes) X Age (Squared)</td>
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<td>0.049</td>
<td>0.96 – 1.00</td>
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</table>

*3435 cats used for this multi-variable model*
Figure 2.1: Predictive curves, based on the multivariable logistic regression model on risk factors for cat euthanasia illustrating the interaction between neuter-status and age.
CHAPTER 3:

Dermatophyte surveillance in cats in three animal shelters in Ontario, Canada
3.0 Abstract

Dermatophytosis (ringworm) is a fungal and zoonotic skin infection caused predominantly by Microsporum canis, M. gypseum and Trichophyton spp. It is highly transmissible and while normally self-limiting, ringworm can be highly problematic because of the potential for outbreaks in populations such as animal shelters and because of the potential for human infection. This study examined the prevalence of dermatophyte colonization in cats admitted to three Ontario animal shelters from February to May 2013. Four hundred cats were sampled within 48 hours of admission using a standard toothbrush sampling technique and dermatophyte culture was performed. Dermatophytes were not identified in any of the 400 cats (0-0.9% one-sided, 97.5% CI exact). These results suggest that dermatophyte shedding is rare in cats in animal shelters in the regions of Ontario that were assessed. Consequently, identification of infected animals, particularly multiple animals, represents an unusual occurrence that may justify prompt and intensive control measures.

3.1 Introduction

Dermatophytosis (ringworm) is a common and highly transmissible fungal skin infection of various animal species. It is of particular concern in cats, and outbreaks of dermatophytosis can be highly problematic in animal shelters. Over 20 distinctive species of dermatophytes have been found in cats and dogs, with Microsporum canis, M. gypseum and Trichophyton spp predominating (Moriello and DeBoer, 1991; Moriello, 2004).

Dermatophytes are spread through direct, airborne, environmental or fomite-associated contact with infectious arthrospores that are shed from the haircoat of clinically affected animals, as well as subclinical carriers (Moriello, 2004). After a one to three week incubation period, clinically affected animals can develop pruritis, hair loss and skin abrasions (Moriello, 2004). Younger animals, such as puppies and kittens, are more likely to develop alopecia and skin scaling on the face, mouth, ears and front legs (Moriello and Newbury, 2006; Moriello, 2004). While typically self-limiting, disease can be prolonged and because of the highly transmissible nature to both other animals and humans, infected cats can pose a risk to the shelter population, shelter personnel and adopting families. This risk extends to subclinical carriers; while subclinical carriage may be of no health relevance to the animal, carriers are potential sources of infection for other animals and humans.
Dermatophytosis is an important shelter-associated infection and outbreaks can be devastating. Outbreaks can lead to widespread infection of animals (especially cats), profound disruption of shelter activities, shelter closure, high economic costs associated with disease control measures and human health risks. Additionally, depopulation is sometimes used as a control measure, although this should rarely, if ever, be required. Therefore, prevention and control of dermatophytosis is an important component of animal shelter infection control. One component of dermatophyte control that can be used is screening of animals for dermatophyte shedding. This can occur in response to clinical signs, as a routine infection control tool or as an outbreak response measure. Typically, this involves collection of hair samples by toothbrush sampling for fungal culture (Moriello and Newbury, 2006; Moriello and DeBoer, 1991). For any surveillance activity, having a plan to use the results is critical and a key component of that is being able to put any results into an epidemiological and clinical perspective. Dermatophyte surveillance is an important component to understand the epidemiology of dermatophytosis and dermatophyte shedding in the population. Published data regarding dermatophyte shedding in cats in animal shelters are limited (Cabanes, 1997; Cafarchia et al., 2006); however, a prevalence of approximately 2% has been reported in various studies of clinically normal house and feral cats (Mignon and Losson, 1997; Patel et al., 2005). Another study of colony and pet cats in southeast England reported dermatophytes in 4.3% of clinically normal cats, while 13% of pet and 100% of stray cats were positive in a study in central Italy (Patel et al., 2005; Iorio et al., 2007). A more recent study of stray cats in Italy reported dermatophyte shedding by 5.5% of 273 cats caught as part of a trap-neuter-release program (Proverbio et al., 2014). However, little has been reported about dermatophyte shedding by animals in shelters, and it is unclear whether data pertaining to pet or feral cats adequately reflect this shelter population. Since various animal, geographic, environmental, animal management and related factors could impact the prevalence of dermatophyte shedding in a shelter population, population- and region-specific data are required to ensure that clinical and surveillance results are put into the proper context. Understanding the endemic prevalence of dermatophyte shedding is important for development of routine infection control practices and interpretation of surveillance results, but the variability in reported prevalence data can hamper investigations when local prevalence information is not available. The objective of this study was to determine the prevalence of dermatophyte shedding in cats admitted to three Ontario animal shelters.
3.2 Methods

Study design

A prospective observational study was designed involving cats at three animal shelters in Ontario, Canada, with data collected from February to May 2013.

Sample population

The three animal shelters in southern Ontario, Canada (Guelph Humane Society, Kitchener-Waterloo Humane Society and Toronto Humane Society) were enrolled. The average number of cats admitted to these shelters annually was approximately 1000 to 4000. One shelter, Toronto Humane Society, was from a large metropolitan area, while the Guelph and Kitchener-Waterloo Humane Societies were located in smaller (approximately 100 000 population) cities with animals admitted from both urban and adjacent rural areas. All cats that were admitted to the shelters during the study period (February to May 2013) were eligible for enrolment until the target sample size was achieved. Cats that were too sick, injured or fractious to safely and humanely sample were excluded. For the Toronto and Kitchener-Waterloo shelters, 150 cats were serially enrolled. Because of a lower admission rate during the study period 100 animals were enrolled from The Guelph Humane Society. The University of Guelph Animal Care Committee approved this study.

Sampling

Sampling was performed within 48 hours of admission. Clean, unused toothbrushes were brushed over the surface of the entire haircoat for at least 1 minute, with particular attention to the head and face (Moriello and Newbury, 2006). A new set of nitrile gloves was worn for each animal during handling and sampling of each animal.

If skin lesions were present, the clinically unaffected part of the body was sampled first followed by the lesion-covered areas, using the same toothbrush. Toothbrushes were immediately placed in individual sealable plastic bags. Samples were stored at room temperature and transported to the study laboratory.
Laboratory techniques

Working within a biosafety cabinet, toothbrushes were inoculated onto Mycosel agar, which was incubated at 25.8 °C. The plates were checked once a week for three weeks for the presence of colonies (Figures 3.2, 3.3, 3.4) with an appearance similar to that of dermatophytes. A control strain of *M. canis* (ATCC 9865) was cultured in parallel (Figure 3.5). Suspicious colonies were examined cytologically by using adhesive tape to tape collect material from the colony. Methylene blue stain was used to evaluate the cytological appearance under the microscope (Moriello and Newbury, 2006). Suspicious colonies were also subcultured onto Mycosel agar for purification and further cytological and molecular testing. Additionally, the degree of non-dermatophyte growth was recorded subjectively as no growth (NG), low contaminant growth, moderate contaminant growth or high contaminant growth (Moriello and Newbury, 2006).

Fungal identification was performed using a dermatophyte-specific PCR assay (Faggi et al., 2001). Colony material was collected and DNA was extracted using a commercial kit (InstaGene Matrix, BioRad Laboratories, Montreal, Canada). One loopful of fungal colony was gathered from the plate, suspended in 1 mL of molecular biology grade water (nuclease free, deionized, distilled filtered with 0.1uM filter, Hyclone Laboratories Inc. Logan, Utah, USA) and centrifuged for 1 minute at 12,000 rpm. The supernatant was removed and 200 µL of InstaGene matrix was added to the pellet, vortexed and then incubated at 56°C for 15 to 30 minutes. The tube was then vortexed at high speed for 10 seconds, placed in a 100°C boiling waterbath for 8 minutes and vortexed again at high speed for 10 seconds. The tube was then spun for 2 to 3 minutes at 10,000-12,000 rpm. The remaining amount of supernatant was stored at -20°C.

The dermatophyte PCR technique to amplify fungal DNA was adapted from the study by Faggi et al., (2001). The amplification reactions were done in volumes of 25 µL containing 25 ng of template DNA, 12.5 µL KAPA (includes the reaction buffer (10 mM TRis-2HCl [pH 8.3], 50 mM KCl), 1.5 mM MgCl₂, 200 µM (each) dATP, dCTP, dGTP, dTTP), 1.0 µL MgCl₂ (25 mM), 2.5 µL Fungi primer GACAGACAGACAGACA (1µM/µL), 60 µL H₂O and 3 µL of DNA. The PCR was then performed with a pre-denaturation cycle at 93°C for 2 minutes, followed by 39 cycles in the DNA Thermal Cycler (Perkin-Elmer Cetus), 1 minute of denaturation at 93°C, 1 minute of annealing at 50°C and 1 minute of extension at 72°C and then a final extension at 72°C for 7 minutes.
The PCR products were separated by gel electrophoresis in 1% agarose gel and visualized under UV light after staining with Gel Red (Biotium Inc.) (Figures 3.6a, 3.6b) (Faggi et al., 2001). Positive (M. canis ATCC9865) and negative controls were included with each run.

Additionally, 18S rDNA universal fungal PCR was performed in a volume of 50 µL, which contained 2 µL of template DNA, 10 pmol of both primers, 0.3 µL of Taq DNA polymerase, 20 µL of KAPA, which includes 5.0 µL of 10X buffer, 3.0 µL of MgCl₂ and 200 µM of each dNTP (Wu et al., 2002). The PCR amplifications were performed using the following protocol; denaturation at 94°C for 3 minutes, 35 cycles at 94°C for 45 seconds, annealing at 56°C for 50 seconds and extension at 72°C for 90 seconds, followed by a concluding extension for 5 minutes at 72°C (Wu et al., 2002). PCR products were sequenced by terminal dye sequencing and identified using the Basic Local Alignment Search Tool (BLAST) (http://blast.ncbi.nlm.nih.gov/Blast.cgi).

Descriptive statistics

Dermatophyte prevalence and 95% confidence intervals were calculated using STATA version 11 and 97.5% one side exact confidence intervals were reported because one half of the confidence interval was bounded. Animal ID, name, age, sex, neutered, breed, source, hair length, date of admission and skin lesions (yes/no: if yes skin conditions were described) were recorded and described.

3.3 Results

Descriptive statistics of the study population are listed in Table 3.1. Dermatophytes were not identified in any of the 400 samples during the study period [(0-0.9% one-sided, 97.5% CI exact). The 97.5% one-sided exact confidence interval for the two shelters from which 150 cats were sampled was 0-2.4%, with the value being 0-3.6% at the shelter where only 100 cats were sampled (0-3.6% one sided, 97.5% CI exact)]. Positive control samples tested in parallel all yielded M. canis. Dermatophytosis was not identified in any animal in any of the three shelters during the study period.

While dermatophytes were not identified, various other fungi were isolated. Overall, 60.8% (95% CI: 55.7-65.5%), 15.8% (95% CI: 12.3-19.7%), and 8.5% (95% CI: 6.0-11.7%) of samples
had low, moderate and high levels of non-dermatophyte growth.

3.4 Discussion

Dermatophyte colonization was not identified in any cat in this study, despite sampling a large number of cats from different shelters, suggesting that dermatophyte colonization is rare in cats admitted to shelters in this region. Reasons for the very low prevalence of ringworm in cats in the shelters sampled in the current study are not clear, but there are many possible reasons. Poor sample quality is a potential explanation for failure to isolate dermatophytes, but the abundant fungal organisms of other types that were found here suggest that sampling was adequate. Another potential explanation is overgrowth of dermatophytes and other fungi on plates. However, heavy growth of other fungi was uncommon, so it is unlikely that competing overgrowth played a significant role in the low prevalence. The culture medium that was chosen is a commonly used medium for isolation of other fungi (Moriello and Newbury, 2006) and the control *M. canis* strain grew well, ruling out problems with media selection and quality. Therefore, while no sampling and culture method can be assumed to be 100% sensitive, it is likely that the lack of dermatophyte isolation in this study is representative of the state of this feline population.

The results of this study have given insight into the endemic prevalence of colonization in cats admitted to three Ontario animal shelters. With the 0% prevalence identified here, it is apparent that dermatophyte colonization is uncommon in cats in this population. According to shelter staff, clinical ringworm is relatively uncommon in these shelters (personal communications), but are identified sporadically. Because of the potential for outbreaks in shelters and zoonotic transmission to shelter personnel or adopting families, an aggressive response to identification of clinical ringworm is often taken. As part of this, testing of some or all of the cats in the population is often undertaken. Understanding the baseline dermatophyte prevalence through studies such as this is critical for proper interpretation of outbreak testing. Specifically, the endemic colonization prevalence must be understood to put outbreak screening results into perspective. Based on the data from this study, finding any colonized cats or at most a prevalence exceeding 2-4%, based on the prevalence and confidence intervals estimated, could be considered an unusual situation and justify a comprehensive response. This would be in contrast to areas with high endemic rates where finding colonized cats would more likely reflect the endemic nature of the disease rather than an abnormal situation.
The limitations of this study must be considered. Since all of the shelters included in this study were located in Ontario and spanned a total distance of approximately 100 km, the geographic distribution of these shelters is small and the types of cats entering these shelters must be considered. One shelter was from a large urban area, while the other two were from smaller (approximately 100,000 population) cities with animals admitted from both city and adjacent rural areas. While this offered some variability, the results may not be able to be extrapolated to different regions of Ontario or other provinces and areas in Canada. In addition, shelters can be highly variable in terms of physical layout, caseload, staffing, baseline infection control practices and various other factors. All three shelters studied here were anecdotally considered to be well-resourced and well-operated facilities, and results could be different in shelters with greater economic, infrastructure, personnel or operational challenges. Also, testing was performed during one time of year (February to May 2013), so seasonal variability could not be assessed and it is possible that the prevalence could be different during warmer times of the year (Moriello and Newbury, 2006; Cafarchia et al., 2006; Cabanes, 1997). Cafarchia et al., (2006) determined that the higher prevalence of dermatophytes on dogs in Southern Italy may be due to the warmer climate, which could influence environmental survival and host susceptibility (i.e. skin damage). Sampling in the winter and spring months in Ontario only gives the prevalence rate for these seasons, so it is difficult to extrapolate these results to determine the annual prevalence of ringworm in these shelters.

A clear understanding of the epidemiology of dermatophytosis (and other infectious diseases) is a key component of shelter disease control. Monitoring studies such as this, while potentially time consuming and costly, can provide critical data for development and interpretation of infection control measures. Data from this study indicate that dermatophyte shedding is rare in cats presented to shelters in this region; this is an important finding for interpreting surveillance data and setting thresholds for comprehensive disease control activities.
3.5 Acknowledgements

The author would like to thank The Guelph, Kitchener-Waterloo and Toronto Humane Societies for their cooperation and for sampling the cats at their respective shelters. The author would also like to thank Joyce Rousseau for performing the laboratory techniques (DNA Extraction, PCR, gel electrophoresis) and her help in identifying the fungal growth on the plates. Rachael Mozes was supported by an OVC Scholarship, while this study was supported by Dr. Weese’s Canada Research Chair grant. The author declares that there are no conflicts of interest.
3.6 References


Figure 3.1: Map of Southern Ontario highlighting Kitchener (red), Guelph (green) and Toronto (blue). http://www.ugdsb.on.ca/world/article.aspx?id=31715.
Figure 3.2: Guelph Humane Society sample 95 after week 1 of growth on Mycosel Agar.

Figure 3.3: Guelph Humane Society sample 95 after week 2 of growth on Mycosel Agar.

Figure 3.4: Guelph Humane Society sample 95 after week 3 of growth on Mycosel Agar.
**Figure 3.5:** The *Microsporum canis* positive culture plate growth.

**Figure 3.6 a:** PCR amplification of the fungal DNA extracted from Mycosel Agar plates.
Figure 3.6 b: PCR amplification of the fungal DNA extracted from Mycosel Agar plates.
Table 3.1: Descriptive statistics on the three shelter populations that participated in the study.

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<td>DM</td>
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<td>2</td>
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CHAPTER 4:

Discussion and Conclusions
4.0 Discussion

Introduction

An animal shelter is a dynamic environment, which allows for the possibility of disease outbreaks, making data collection and analysis a vital aspect in preventing disease spread and animal mortality. Many interesting results were obtained after conducting these two studies about the factors that affect the outcome of euthanasia and the surveillance of dermatophytosis. This type of information will be helpful to the shelters involved in these studies and to other interested shelters in evaluating their policies and procedures to deal with euthanasia and ringworm. As well, understanding these aspects of shelter medicine at a deeper level can help to pave the way for further research to better understand the shelter system and how it can be enhanced to further benefit animal welfare.

Chapter 2: An epidemiological investigation of euthanasia in an Ontario animal shelter

Despite the fact that a large percentage of cats in shelters are euthanized, few studies have examined this topic (Lepper et al., 2002). The rate of euthanasia of cats in the Kitchener-Waterloo Humane Society in 2011 was 53%, a number that is consistent with many other shelters and highlights the importance of this issue.

Time spent in shelters accounts for significant use of resources and as these data show, is also related to the likelihood of euthanasia. Most cats spent less than 5 days in the shelter, and cats that spent between 5 to 20 days in the shelter were more likely to be euthanized than those that spent less than 5 days in the shelter. This could be that most of the cats that spent less than 5 days were more likely to be picked up by their owners during this time frame, or that these animals were more desirable to be adopted. This could also depend on the behavior assessment protocols of the shelter, as most initial behavior assessments are less reliable, which could account for the increased likelihood of euthanasia during the 5-20 day period. It would be reasonable to assume that after the initial period has passed and a cat has not been returned home or adopted, that euthanasia rates would increase. Interestingly, this was not the case, as cats that spent more than 20 days were less likely to be euthanized. This phenomenon requires further study, both from the standpoint of why these cats were less likely to be euthanized and for ways to speed the adoption process and reduce the resource demands of longer stays. This could have resulted from these cats being placed in foster homes and still listed in the shelter system (e.g., kittens that are highly adoptable but are not available for adoption until reaching a certain age),
cats that had desirable traits but required time to become adoptable (e.g., health problems or behavioural issues) or retention of cats that have not been adopted, but which shelter staff are determined to rehome. The institution of foster programs has been instrumental in the socialization and preparation for adoption by keeping animals out of the shelter and in a home environment. This is also a less stressful existence for these animals as opposed to being kept in a shelter cage or enclosure. Discerning these potential causes will be important for understanding these results and optimizing approaches to adoption.

Many factors determine whether or not a cat will be euthanized in an animal shelter and these would in turn influence the likelihood of euthanasia in the shelter.

Cats that left the shelter in the spring, summer and fall were more likely to be euthanized than those cats that left the shelter in the winter. Male cats were more likely to be euthanized than females, which may be due to a preference towards the adoption of females. Cats surrendered to the shelter and euthanasia requests were more likely to be euthanized than those that entered as strays. Cats that came from out of the area and smaller towns were more likely to be euthanized than those that came from larger cities and towns. Black cats were more likely to be euthanized than cats of other colours. For those animals that were unaltered or the neuter status was unknown, the odds of being euthanized was high across age categories, while those that were neutered had an increased chance of being euthanized as they aged with the increasing trend leveling off for senior cats.

In order to change these preferences of potential adopters and alter the rate of euthanasia, proper education and shelter level interventions are necessary. These could include using data gathered from studies such as this, to determine where the problem areas lie in a specific shelter and target and focus shelter resources on these issues. The education of the public about the advantages of adopting an older cat and those of undesirable colours may help to lower the euthanasia rates in these cats. As well, instituting promotions and adoption discounts may be an incentive for some people to adopt these older or unpopular coloured cats.

The principal of data collection is instrumental in the improvement of shelter success and adoption rates. It is vital that the data are collected properly and regularly, by individuals trained to do so. Collection of the data was completed in this study by shelter staff. There were several different people entering data for animals that came through the shelter in 2011. This led to
differences in spelling and wording of certain animal characteristics. Difficulties obtaining clear and accurate data hamper both formal research and shelter-directed data analysis. A way to improve data entry and shelter databases is to provide more relevant drop down menus and reduce the entry of free text. This removes the problem of different spelling and capitalization so when data are exported from the database to be analyzed, the amount of work needed to “clean” the dataset is reduced. These are simple ways to improve shelter data collection and research to be able to quickly monitor any changes in the population. Staff need to recognize that these data are not just records for individual animals, but part of the process of improving the operation of the shelter and increasing the welfare of the animals.

Surveillance and prevention are an integral part of shelter medicine. In order to accurately track and monitor trends in the shelter, proper data collection and dissemination is vital. The data record systems should be equipped with notifications if there are any patterns emerging that are worth further examination and these should be part of automated protocols. Shelter staff should also be trained to actively survey and observe shelter animals, as well as learn to talk to potential adopters about the benefits of adopting an atypical animal. This same data system would be useful as well to look for infectious disease patterns and examine the epidemiology and spread of illness within the shelter. Certain clinical signs such as fever, coughing or sneezing could be noted in the system to allow for pattern recognition and analysis to occur and to tabulate how many of these ailments there are, whether or not it is above the normal amount and if so, this creates an alert in the system to inform staff of a potential outbreak situation (Lazarus et al., 2001). This type of information and data are very important to shelters to improve surveillance, resource management and to standardize data collection databases such as Pet Point or Shelter Buddy, to be able to flag disease within the shelter. These sorts of changes would be invaluable in an outbreak investigation to protect shelter animals from disease and to better understand the nature of the shelter population.

This study only examined data from one animal shelter so it is difficult to determine whether these results can be extrapolated to other shelters in Ontario, Canada or other regions. There is also the issue of the shelter being located in a smaller city, which would make it harder to relate these results to larger shelters in other major cities in Canada. The study is also limited in that no specific reasons are listed as to why a cat was euthanized, making it more difficult to interpret certain results or model a more specific outcome. This would be extremely useful and something to think about adding to shelter records in the future, which would be helpful to
determine which risk factors increase or decrease the likelihood of euthanasia and subsequently adoption. For future studies, it would be beneficial to enroll additional shelters and measure the impact of shelter level effects.

Chapter 3: Dermatophyte surveillance in cats in three animal shelters in Ontario, Canada

Dermatophytosis is a significant problem in many animal shelters and can result in large and sustained outbreaks, mass euthanasias, negative publicity and profound resource demands. It can be a devastating disease, due to the tendency and ease of rapid spread, as well as the implications for animal welfare and the zoonotic risk to shelter staff. Screening of cats for dermatophyte shedding is a common response to known or suspected outbreaks; however, interpretation of the results is compromised by limited information about endemic prevalence. Without understanding the endemic prevalence, it is difficult to determine when an outbreak is truly present and to monitor the outbreak response. With a 0% prevalence of ringworm found at all three participating shelters, the conclusion can be made that dermatophyte shedding is very rare in shelters in this region. Even though the three shelters were located in different parts of Ontario, both city and rural, geographically they are not that far apart, so a similar prevalence is not surprising for all three of these regions. Knowing the prevalence of a disease such as ringworm is important for shelters, as this can help to create a baseline of how many cases of different diseases there are in the shelter. If the prevalence or incidence exceeds normal levels, the shelter staff can act to prevent or shorten a potential outbreak.

This surveillance study is a model for other studies that can be done to improve the knowledge of what diseases are prevalent in the shelter and affect the population. If animals are actively surveyed and tested upon admission to the shelter, staff can isolate and better allocate resources to treat any sick animal to prevent a possible outbreak. Knowing the local incidence and/or prevalence of various diseases, such as ringworm, upper respiratory tract infections and parvo virus, that plague shelters can help with the allocation of funding to be able to treat the animals affected properly and promptly. For example, if there was a database that kept track of all animals that have been infected with different diseases across Ontario or even at the national level, the epidemiology of these diseases could be tracked and analyzed to predict possible outbreaks. This type of information is vital to protect the shelter population and reduce the need for euthanasia procedures. Also, because many of the diseases that affect shelter animals are zoonotic (ringworm, rabies, etc.), knowing what diseases plague the shelter population can help to protect the surrounding community from being infected and lower the risk of an outbreak. As
well, adoption rates should be improved if the overall health of those animals is improved through increased disease surveillance and improved timing of interventions.

4.1 Conclusions

The results of these studies have many implications for shelter medicine. The euthanasia study was focused on cats, so examining the euthanasia rate of dogs would be beneficial to get a better general picture of the shelter and their success in lowering the rate of euthanasia, while better understanding what raises the rate of adoption. Comparing and contrasting the patterns seen between the different species would be interesting to examine and reveal differences in managing the adoption process between species. The continued collection of data and analysis is essential to continued success in lowering euthanasia and increasing adoption. The ringworm study examined three different shelters, so it is reasonable to extrapolate these results to other facilities that are of the same size and similar locations. These types of surveillance studies are essential in preventing outbreaks and their continued success is only as good as the shelter staff that observe and analyze patterns and trends in disease daily.

Current Recommendations and Future Studies

Shelter medicine requires consistent and proper observation and surveillance. This type of herd health medicine is necessary to determine areas of vulnerability and problems that may arise. Having proper data collection software and systems is essential in order to survey and monitor the status of animals admitted to the shelter. Not only is this data collection essential to the safety and well being of the animals in the shelter, but also to the shelter staff and the public near the shelter location.
Appendix 3.1: Ringworm surveillance protocol sheet for shelter staff.

University of Guelph

Ontario Veterinary College
Department of Pathobiology

Ringworm Surveillance Study

Rationale:
We are conducting ringworm sampling in shelters, as we hope to determine the endemic rate of colonization in cats admitted to Ontario shelters. Our impression is that it’s quite low, which would impact the interpretation of screening results during outbreaks and the management of irregular ringworm cases. We would like to sample 150 cats at the KWHS within 48h of admission.

Protocol and Instructions

Fungal culture is still the best for diagnosis of dermatophytosis. Using the toothbrush technique is recommended for culturing cats and individual lesions. Toothbrush samples collect debris from the surface of the skin and the comb-like bristles obtain samples from the surface.

1. Please wear gloves to avoid contaminating the sample and use a new set of gloves between each cat. Be sure to toothbrush culture the entire hair coat thoroughly until the bristles are full of hair or the cat has been combed for at least 1 minute.

2. Early infections are common on the face and the ears. The last place sampled should be the face and inside of the bell of the ear. Take care when combing around the cats eyes.

3. Early lesions in kittens are most common in and around the ears, on the muzzle, and paws. These areas should get extra attention during sampling.

4. If obvious lesions are present, culture the normal part of the body first and the lesion last. This minimizes the chance that toothbrushing mechanically spreads spores over the body. Dermatophyte lesions start locally and then spread, and you do not want to facilitate the spread of infection. Second, if cultured last, spores are present in the largest numbers on the tips of the bristles.

5. For storage of the culture samples, once the sample has been collected, place the toothbrush in a Ziploc bag and number it to correspond with the record sheet for that specific cat. Keep toothbrush samples at room temperature and protect them from heat extremes, especially high temperatures.
Appendix 3.2: Toronto Humane Society poster to inform shelter staff and visitors of the study.

**University of Guelph**

**Ontario Veterinary College**
Department of Pathobiology

**Ringworm Surveillance Study**

Toronto Humane Society

We are conducting ringworm sampling in shelters, as we hope to determine the endemic rate of colonization in cats admitted to Ontario shelters.

The impression is that the rate of colonization is very low, which can help to interpret screening results during outbreaks and the management of irregular ringworm cases.

We are sampling 150 cats at the Humane Society within 48 hours of admission.

We will be using a toothbrush sampling technique, which is not invasive and does not harm the cats whatsoever.
Appendix 3.3: Sample data collection sheet for surveillance cat records.

University of Guelph

Ontario Veterinary College
Department of Pathobiology

Ringworm Surveillance Study

**Cat Record Sheet**

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<th>Sample Number</th>
<th>Animal ID</th>
<th>Name</th>
<th>Age</th>
<th>Gender</th>
<th>Breed</th>
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<th>Hair Length</th>
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