The Effect of Capacity for Care on an Animal Shelter’s Admission Trends and Risk Factors Affecting Length of Stay of Cats (*Felis catus*):
A Case Study at the Guelph Humane Society, 2011-2016

by

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ABSTRACT

THE EFFECT OF CAPACITY FOR CARE ON AN ANIMAL SHELTER’S ADMISSION TRENDS AND RISK FACTORS AFFECTING LENGTH OF STAY OF CATS (*FELIS CATUS*): A CASE STUDY AT THE GUELPH HUMANE SOCIETY, 2011-2016

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This thesis is an investigation of the time trends in admission rates and risk factors that affect time-to-adoption of cats at the Guelph Humane Society, from 2011 to 2016, while assessing the effectiveness of the Capacity for Care program. In 2014, the Guelph Humane Society implemented the Capacity for Care program at its shelter to improve the movement of cats through the shelter. The effects of this program are assessed using time series and survival analysis. There was a significant reduction in admissions of adult cats following the introduction of the Capacity for Care program when the analysis was adjusted for kitten admissions. Cats were also 24% more likely to be adopted after the implementation of the Capacity for Care program. This thesis is the first to study the effects of the Capacity for Care program using long-term data, in addition to using statistical methods appropriate for retrospective count data.
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Success is not always linear.
STATEMENT OF WORK DONE

The electronic datasets for Chapters 2 and 3 were obtained from the database used by the Guelph Humane Society, called PetPoint. This database contained all of the variables used in the analysis of data and were passively collected for the Guelph Humane Society’s animal record histories. Dr. Shane Bateman provided any clarification with respect to the Guelph Humane Society data collection. Natasha Janke performed all of the data extractions and data management.

All of the chapters in this thesis were written by Natasha Janke with required revisions and advice concerning analysis provided by her advisory committee of Drs. Olaf Berke, Jason Coe, and Tyler Flockhart. Additional revisions and advice were provided by Drs. Shane Bateman (Guelph Humane Society) and Eyal Klement (Hebrew University of Jerusalem).
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CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Cat overpopulation has become a growing concern among various stakeholders throughout several countries, including the United States and Canada. There has been a large focus on how to humanely reduce the number of cats for which no home or shelter space is available. Some of the issues surrounding cat overpopulation include the concern for the welfare of the cats themselves, the distress to wildlife populations, and various public health issues (Robertson, 2008). “Community cats” including owned, semi-owned, lost, stray and feral cat populations, all have the potential to spend a portion of their lives in an animal shelter. From 2001 to 2011, twice as many cats have been admitted to Canadian shelters than dogs (CFHS, 2012), yet few studies have identified which management practices used in animal shelters will not only improve the welfare of cats while in the shelter, but will also decrease the number of cats entering shelters and improve the outcomes of shelter cats. Approximately 40% of cats that enter animal shelters throughout the United States and Canada are euthanized (CFHS, 2012; Pet Statistics, 2016). If there is potential for this statistic to be lowered through animal shelter management practices, then research into these management practices are imperative.

The Capacity for Care (C4C) program is a management program designed for animal shelters to improve the movement of cats through the shelter to increase the chances of positive outcomes of shelter cats. The goals of the program aim to control for overcrowding by scheduling intakes, decreasing length of stay, increasing adoption rates, and decreasing euthanasia rates (CFHS, 2012). Preliminary results from case studies looking at the effects of the C4C program have been completed in three Canadian Humane Societies and appear to have positive outcomes on the welfare of shelter cats (CFHS, 2012; 2014). These case studies, however, only provide 6 months of data before and after the C4C intervention, signifying that there are no current long term studies that assess the effectiveness of
the C4C program.

This thesis encompasses a literature review which discusses current issues around cat overpopulation and a review of existing research in recent trends in animal shelters throughout Canada and the United States. An overview of the C4C case studies is provided, as well as the identification of gaps in knowledge in the area of animal shelter management and statistical analyses used in this thesis, including time series analysis and survival analysis. Chapter 2 and Chapter 3 of this thesis include two retrospective studies which use long term data collected by the Guelph Humane Society (GHS), in Guelph, Ontario, Canada, to assess the effectiveness of the C4C program on cat intake and length of stay (i.e., time-to-adoption) of cats at the GHS. Chapter 2 also explores long term and seasonal trends in cat intake, while Chapter 3 investigates other risk factors that affect a cat’s length of stay at the GHS.

1.2 LITERATURE REVIEW

1.2.1 Cat Overpopulation

1.2.1.1 Community Cats

Cat overpopulation is an issue faced by many countries where there is an excess number of cats for which no human-supported home is available. In the United States, 3.4 million cats enter animal shelters each year and approximately 1.4 million are euthanized annually (Pet Statistics, 2016). Unwanted cats often end up at animal shelters, where euthanasia rates range anywhere from 36% to 74% (Lord et al., 2006; Marston and Bennett, 2009; Morris et al., 2011; Alberthsen et al., 2013). The Canadian Federation of Humane Societies (CFHS) found that euthanasia rates have varied between approximately 37% and 55% from 2007 to 2013, throughout a sample of animal shelters in Canada (CFHS, 2014). In recent years, there has been an even stronger push, within the animal welfare community, towards humane management methods of unwanted companion animals and a pull away from approaches that involve euthanizing healthy animals. Although there are still supporters for euthanasia as the most effective and humane solution to cat overpopulation (Jessup, 2004; Loyd et al., 2010), a more inclusive and successful approach to address cat overpopulation will likely require a
balance between the interests of all stakeholders, including wildlife conservatives, cat welfare advocates and members of the public (Slater, 2004; Cats and Birds - About the Issue, 2016).

Before studying the effects of certain management strategies, it is important to provide definitions, as terms used to describe cat populations and sub-populations may vary among stakeholders. In addition, cats can move from one sub-population to another within their lifetime, and throughout generations, making it more difficult to compare results from different studies (Slater, 2004). For the purpose of this thesis, the term “community cat” will be used to describe a population of cats that includes owned, semi-owned, lost, stray, abandoned and feral cats. What each of these sub-populations have in common, is that they are not confined within a home and have the ability to roam outdoors for some or all of their lives. In Guelph, Ontario, Canada, ‘community cats’, often called ‘free-roaming cats’ have been found to have the highest density in low-income, highly concentrated residential areas, furthest from wooded areas (Flockhart, 2016). Community cats vary in their level of socialization, even within the same sub-population, adding difficulty to creating definitive categories of cat sub-populations. Owned cats consist of cats which live entirely indoors, are confined to their owner’s property, and those that spend some of their time roaming outdoors. Only those owned cats, which spend time unconfined contribute to the definition of “community cats” as used here. “Semi-owned cats” spend some or all of their time outdoors and can vary in their level of socialization. Toukhatsi et al. (2007) define cat semi-ownership as “intentional provision of food or other benevolent actions that contribute to the health and fitness of a cat, but that do not constitute ‘ownership’ as far as the person undertaking such actions is concerned”. Other terminology used to describe semi-ownership includes “quasi-ownership” where multiple individuals care for a cat that is often a stray (Slater, 2001). Various studies have found a prevalence of cat semi-ownership anywhere between 22% and 44% (Levy et al., 2003; Toukhatsi et al., 2007). “Stray cats” are often previously owned cats that are lost or abandoned and frequently differ in their level of sociability (Slater, 2001). “Feral cats”, on the other hand, are typically unsocialized and untrusting of humans, although some studies use this term to
describe all cats that primarily live outdoors (Levy, 2004).

Finding a free-roaming cat population management strategy that addresses the opinions of all stakeholders is difficult, and it is clear that more research is required in order to get a better understanding of the implications of various strategies. Although concerns regarding community cats may vary by region, some of the most common concerns include (Robertson, 2008):

- animal welfare (including high mortality rate, low life expectancy, attacks from other animals, lack of food and shelter),
- public health (including injuries to the public due to scratching and biting or the spread of zoonotic diseases or simply noise nuisance)
- risk to other animals (killing of birds and small mammals, spread of diseases/injury to owned cats and other species).

While many animal advocates are concerned for the welfare of the cats themselves, wildlife advocates present concerns regarding the cats' predation on wildlife, especially native wildlife species (Peterson et al., 2012; Blancher, 2013; Bonnington et al., 2013; Loss et al., 2013; Wald, Jacobson and Levy, 2013). Overcoming cat overpopulation will most likely require a multifaceted approach in order to consider the concerns of various stakeholders (Slater, 2004).

1.2.1.2 Welfare of Cats

One of the major concerns regarding community cats is the concern for the welfare of the cats themselves. Community cats are extremely vulnerable to vehicle accidents, disease, predation, starvation and adverse climate (Nutter et al., 2004; Slater, 2004; Robertson, 2008). Two studies looking at the survival rate of feral kittens have found that 68%-75% of kittens die before the age of 6 months, with the majority of cases being due to trauma (Nutter et al., 2004; Gunther et al., 2011). Gunther et al. (2011) found the survival rate of kittens in colonies of entirely intact cats was 32% compared to colonies that had undergone Trap-Neuter-Return (TNR) where 76% of kittens survived. This may have
been due to decreased agonistic behaviour seen in neutered kittens, or could be attributed to the increased tolerance of neutered adult cats in the colonies that underwent TNR (Gunther et al., 2011). These results suggest some interventions may provide better alternatives for addressing cat welfare than others.

Determining the quality of life of community cats is a very difficult task, as it may vary drastically depending on various factors including environment, human contact, food source, and presence of disease. There is increasing support that TNR programs lead to an increase in survival rate among community cats, as neutered cats tend to roam less than intact cats, decreasing their likelihood of being hit by a vehicle (Wallace and Levy, 2006; Finkler et al., 2011; Gunther et al., 2011). Wallace and Levy (2006), examined seven large scale TNR programs throughout the United States and found that neutered cats lived on average 2 to 3 times longer than intact cats. Conversely, some studies have shown ownership status as a predictor of survival rather than neuter status of free-roaming cats (Schmidt, 2007; Horn et al., 2011). Centonze and Levy (2002) found that the majority of cat colony caretakers believe that TNR improves the cats’ quality of life, whereas others believe that TNR simply acts as an enabler for cat owners to abandon their cats more easily and avoid the expense of relinquishing their cats to an animal shelter (Jessup, 2004). Although different methods of community cat management are advocated for, there is clearly an overwhelming concern for the welfare of community cats.

Feline Immunodeficiency Virus (FIV) and Feline Leukemia Virus (FeLV) are two of the more common infectious diseases that occur in domestic cat populations. Neither disease is treatable, making them both a major concern for cat populations. Lee et al. (2002) performed a study to determine the prevalence of FeLV and the seroprevalence of FIV in unowned free-roaming cat populations in the United States and found that the overall prevalence of FeLV was 4.3% and the seroprevalence for FIV was 3.5%, both of which are similar to the reported prevalence of owned cats in the United States. In a review by Little et al. (2011), it was found that the prevalence of FeLV and the seroprevalence of FIV
were slightly higher in Canada; seroprevalence of FIV varied from 1.2% to 23% and prevalence of FeLV varied from 2.5% to 7.7%. Despite the findings that unowned free-roaming cats have a similar prevalence as owned cats (Lee et al., 2002), there is still a concern regarding the spread of disease from free-roaming cats, as it has been suggested that there is an increase in prevalence of FIV and FeLV in areas with a high density of cats where aggressive behaviours may be increased (Little et al., 2005). Additionally, Chhetri (2015) found that despite the introduction of the FIV vaccine, there has been no significant trend, increasing or decreasing, on the seroprevalence of infection in Canada between 1999 and 2012.

1.2.1.3 Public Health and Risk to Other Animals

Public health is another area of concern regarding community cat populations. Some major areas of interest include zoonotic diseases, cat bites, feline diseases and various parasites. Although there has been a dramatic decrease of rabies cases since the mandatory vaccination of domestic dogs and cats in several countries, confirmed cases of rabies in the domestic cat are still reported throughout the world (Haider et al., 2008; Blanton, 2012). Despite rabies being preventable, there are still an estimated 50,000 human deaths per year due to rabies worldwide (Haider et al., 2008). Since 1980, 90% of confirmed cases of rabies throughout the United States have been in wildlife and 5% of cases were from domestic cats (Blanton, 2012), unfortunately the report did not distinguish between owned and unowned cats making it difficult to determine the prevalence of rabies in the various sub-populations of the domestic cat. Canada has slightly fewer cases of rabies reported in cats, with less than 3.5% of rabies cases being attributed to domestic cats from 2011 to 2013 (CFIA, 2014).

Although few studies have examined companion animal bites, it has been found that the majority of cat bite incidences involve stray cats (Wright et al., 1990; Patrick et al., 1998); stray cats are rarely vaccinated against rabies (Bottoms et al., 2014). Two studies looking at the characteristics of cat bite victims found that adult females were more likely to be bitten than men and children (Wright et al., 1990; Patrick et al., 1998). Patrick et al. (1998) found that approximately 90% of cats were provoked
by the victim, and almost 80% of cats were either unowned or “free-roaming” owned cats. These studies determined cat bite prevention programs should be aimed to discourage individuals from approaching unrestrained cats.

Areas with a high density of cats are also of concern, as they can be a source of parasites, which can be transmitted to both humans and other animals. Some of the most common parasites carried by cats include fleas, ear mites, Bartonella henselae, Toxoplasma gondii, Toxoplasma cati and various other intestinal worms. Villeneuve et al. (2015) sampled cats from 26 animal shelters throughout Canada and found that 32% of cats were infected with a gastrointestinal parasite. Toxoplasma gondii is one of the most discussed parasites because of the ability of cats to spread it to conspecifics, wildlife and livestock, as well as the serious health implications it could have on humans (Lopes, et al., 2014). In immunocompromised human patients, Toxoplasma gondii could cause anything from flu-like symptoms in healthy individuals, to more severe symptoms, such as vomiting, fever, and seizures (Lopes, et al., 2014). Free-roaming cats are of particular concern regarding the spread of T. gondii because it is spread through the environment when cats shed T. gondii eggs with their feces. A study looking at the seroprevalence of T. gondii among feral cats found that while almost 30% of cats were seropositive, only 1% of cats were actually shedding oocytes, suggesting that the majority of cats had a latent infection or were previously exposed and few showed clinical signs (Stojanovic et al., 2011). Regardless, epidemiological studies have identified soil contact and gardening are risk factors for T. gondii (Dabritz et al., 2008). Since there is potential for the prevalence of T. gondii to be relatively high among free-roaming cats, it has been suggested that cat colonies be located away from public parks, wildlife protection areas, and water sources that would mitigate the spread of T. gondii (Dabritz et al., 2008). As for public health measures, it may be important to encourage hand washing after contact with soil, as non-gloved soil related activities have been found to be one of the top risk factors for environmental contamination with T. gondii (Lopes, et al., 2014).
1.2.1.4 Concern for Wildlife

One of the most prominent debates regarding community cats is the debate between individuals concerned with cat welfare and those concerned with the protection of wildlife. This topic has become a heated debate throughout various developed countries world-wide including the United States, Great Britain, New Zealand, Australia, Switzerland and Canada. Studies performed in each of these countries have found that domestic cats are responsible for a large number of avian deaths each year (Lepzyk, Mertig and Liu, 2003; Woods et al., 2003; Baker et al., 2005; Heezik et al., 2010; Tschanz et al., 2011; Loss et al., 2013). Loss et al. (2013) recently estimated the annual number of birds killed by cats per year in the United States to be between 1.3 and 4 billion. Blancher (2013) estimated that cats kill between 100 and 350 million birds per year in southern Canada, which is suggested to be the most important human-related cause of avian mortality in Canada. Additionally, the presence of outdoor cats can result in lower survival rates and decreased reproductive success of birds (Beckerman et al., 2007; Bonnington et al., 2013). These results suggest cats can influence the viability of bird populations through both direct and indirect mechanisms.

Determining common ground between cat welfare professionals and bird conservation professionals can be extremely difficult as discussions often lead to disagreements between the two stakeholders. Wald, Jacobson and Levy (2013) found that members of the public had much more neutral opinions on matters of community cat management when compared to animal welfare and wildlife advocates. These two stakeholders have very different views of the impact of community cats on wildlife, suitable management techniques of feral cat colonies, as well as the efficacy of TNR programs. In a survey sent to “Cat Colony Caretakers” (CCCs) and “Bird Conservation Professionals” (BCPs), Peterson et al. (2012) found that 80% of CCCs responded in favour of collaborating with BCPs to determine a solution, however, only half of the BCPs agreed with this. Although the two stakeholders have polarized views of the problem, there are some areas of agreement between them, including: support for mandatory rabies vaccinations and identification, and greater support for non-
lethal control methods than lethal control methods (Wald, Jacobson and Levy, 2013).

1.2.2 Animals Shelters

1.2.2.1 Shelter Intake

In recent years, there has been an increased focus on reducing the number of animals entering the shelter system. Various studies in the United States have reported observing a decrease in dog admissions, while the number of cat admissions continue to rise (Lord et al., 2006; Morris et al., 2011; 2014). Morris et al. (2011), studied cat intake into shelters in Colorado from 2000 to 2007 and reported a 24% increase in cat intakes for urban areas. Furthermore, Morris et al. (2014) examined the longterm trends of animal shelter intake in four large metropolitan areas in Colorado and found a 53% decrease in cat intakes per 1000 residents between 1989 and 1998, which was followed by an 11% increase of intakes between 1999 and 2010. Lord et al. (2006) saw a 20% increase in cat intakes in Ohio animal shelters between 1996 and 2004. Similarly, the Canadian Federation of Humane Societies (CFHS) report that twice as many cats were admitted to Canadian shelters than dogs since 2001 (CFHS, 2012). However, the most recent report published by the CFHS claimed that cat intake numbers have decreased by approximately 30% from 2011 to 2014 (CFHS, 2015). Various studies have focused on the characteristics of cats entering the shelter system such as, descriptive statistics (breed, sex, neuter states, age), microchip status, source of admission (i.e., entry type; Lord et al., 2009), reason for relinquishment, health status, and sociability (Marston and Bennett, 2009). While information of these characteristics is important, a critical gap in our knowledge is how regional differences and characteristics of shelter itself may drastically affect the composition of the subpopulations of cats entering the shelter system.

1.2.2.2 Euthanasia

Over the past few decades, considerable focus has not only been on decreasing the number of animals that enter the shelter system but also on decreasing the proportion of animals that are euthanized. Euthanasia rates of cats in animal shelters have varied between approximately 37% and 55% since
2007 in Canada (CFHS, 2014) and between 36% to 74% in the United States and Australia (Lord et al., 2006; Marston and Bennett, 2009; Morris et al., 2011; Alberthsen et al., 2013). In Canada there have been twice as many cats euthanized than dogs for the past 20 years (CFHS, 2015). The 2014 report by the Canadian Federation of Humane Societies states that the euthanasia rate of cats appears to have been decreasing since 2008, however when only studying the number of healthy cats that have been euthanized during the same time period, this number actually increased in 2013 and 2014 compared to 2012 (CFHS, 2015). The explanation for this increase in healthy animals being euthanized in the CFHS (2015) report, is that animals entering shelters are often kept in crowded and stressful conditions causing them to become ill during their stay and are euthanized before being adopted. This justification powerfully accentuates the need for a new management approach in animal shelters, which will be reviewed further in this thesis.

Studies that reported an increase in cat intakes also found an increase in euthanasia rates (Lord et al., 2006; Morris et al., 2011; 2014). Lord et al. (2006) reported a 14% increase in the number of cats euthanized in Ohio animal shelters between 1996 and 2004. Morris et al. (2011), found that euthanasia rates increased by 72% in urban shelters in Colorado from 2000 to 2007, whereas the rural shelters saw no change. Marston and Bennett (2009) and Alberthsen et al. (2013) studied risk factors for euthanasia based on the characteristics of cats entering shelters. Both studies found that kittens were less likely to be euthanized than any other age group, and that strays and cats that had not been spayed or neutered prior to admission were much more likely to be euthanized (Marston and Bennett, 2009; Alberthsen et al., 2013). Alberthsen et al. (2013) also found that males were less likely to be euthanized than females. Based on the drastic differences in euthanasia rates alone, it is clear that there is a need for additional research to understand the various factors that impact a shelter’s euthanasia rates.

1.2.2.3 Length of Stay (LOS)

Length of Stay (LOS) in the shelter is the amount of time it takes for an outcome to occur once an animal has been admitted to a shelter. In Canadian shelters, the average LOS of cats is 49 days and the
median LOS is 27 days (CFHS, 2015). LOS can vary for each cat based on a variety of risk factors (Marston and Bennett, 2009; Brown and Morgan, 2014). Gouveia et al. (2011) found that the longer a cat’s length of stay, the more likely it is to develop negative behavioural characteristics, such as increased inactivity and increased negative encounters. These results, however, are difficult to compare to other cat behaviour studies, as it compares the behaviour of cats that have spent more than 7 years in a shelter to cats that have spent less than 7 years in a shelter (Gouveia et al., 2011), which is not the typical amount of time that cats spend in the average North American animal shelter. Kry and Casey (2007) found that temperament was the most important factor considered by adopters when selecting a shelter cat which implies that improving housing conditions is an ideal starting point when considering strategies to decrease LOS and expedite adoptions of shelter cats. Not only can housing improvements enhance the overall welfare of cats in a shelter environment, but improved housing can subsequently lead to decreased risk of disease (CFHS, 2012), which in turn, helps decrease LOS and increase adoption rates because cats remain visible to the public in adoption rooms rather than spending time out of sight in recovery rooms.

Various studies have looked at the effect of enrichment on cat stress levels and found that cats that are provided with a perch and/or a hiding place, exhibit lower stress scores than cats in unenriched cage environments, demonstrating the importance of using enrichment to improve the welfare of cats in a shelter environment (Gourkow and Fraser, 2006; Kry and Casey, 2007; Vince et al., 2014). Another study by Dinnage et al. (2009) looked at the relationship between LOS and the risk of cats developing Upper Respiratory Tract Disease, and found that the cumulative probability increased from 21% after one week in a shelter to 80% after the second week. Additionally, Dinnage et al. (2009), suggest utilizing foster care programs to reduce stress and risk to kittens while they await adoption.

1.2.3 Capacity for Care (C4C)

The Capacity for Care (C4C) program is a shelter management program developed to ensure animal shelters follow the “Guidelines for Standards of Care in Animal Shelters” created by the Association of
Shelter Veterinarians (Newbury et al., 2010). The goal of the program is to enable shelters to meet the needs of all animals entering the shelter without compromising the physical and/or mental well-being of the animals. One of the main goals of C4C, is for shelters to ensure that the Five Freedoms of Welfare are being met at all times; these freedoms are the

- freedom from hunger and thirst,
- freedom from discomfort,
- freedom from pain, injury or disease,
- freedom from fear and distress and
- freedom to express normal behaviours (Karsten, n.d.).

In addition to these five freedoms, the C4C program has added a sixth freedom for shelter medicine:

“the freedom from euthanasia for animals that are neither suffering irremediably nor dangerous to the community” (Karsten, n.d.).

Managing a shelter at or below the shelter’s daily capacity is one of the main goals of the C4C program. In order to achieve this goal, the C4C program advocates the following three approaches to a shelter’s management strategies: 1.) decrease intake 2.) expand the physical capacity of the shelter and 3.) reduce the length of stay. Expanding capacity can be extremely difficult to achieve as it requires financial resources and physical space that is often not available, therefore this goal will not be discussed any further. Although the C4C program has largely focused on cats, the concepts behind the program remain pertinent to all species within a shelter.

Maintaining an environment that promotes good mental and physical health and ensures that animals are comfortable, provides a more welcoming atmosphere, not only to potential adopters but also to the shelter staff and volunteers. Several studies have examined the effects of cage enrichment on stress levels of cats in a shelter environment, and have found that cats who are in more enriched cage environments are adopted sooner and have lower stress levels than cats who are provided with the bare
minimum in a shelter setting (Vince et al., 2014; Gourkow and Fraser, 2006; Kry and Casey, 2007).

Furthermore, Stella et al. (2014) found that the environment of the adoption room itself, in regards to temperature, lighting and noise, as well as the consistency of husbandry routines can be equally as important as the environment of individual cages when considering the well-being of cats in a shelter environment. In order to maintain a shelter that can meet the needs of all animals, one must ensure that the shelter does not exceed its daily capacity at any given time (“Calculating Shelter Capacity”, 2015). Wenstrup and Dowidchuk (1999) surveyed 186 animal shelters in the United States and found that on average, shelters only had the capacity for <3% of animals entering the shelter system, leaving an average of 9.5 days for an outcome to occur. As a result, 65% of cats and 52% of dogs were euthanized, 34% of which were due to insufficient capacity (Wenstrup and Dowidchuk, 1999).

The housing guidelines for cats in shelters using the C4C program include a recommendation for double compartment cages for singly housed cats (Karsten, n.d.). Having two compartments allows each cat to have its litter in a separate compartment from its food, water, and sleeping area. It is also recommended that cages provide cats with an area to perch, as well as an area to hide. It is commonly found that cats in unenriched cages, will use their litter box to hide behind or even flip them upside down in order to arrange a hiding space (Gourkow and Fraser, 2006). The objective of improving housing conditions as part of the C4C program is to improve the welfare of shelter cats by decreasing disease rates, decreasing LOS and increasing adoption rates. These outcomes are based on the assumption that shelters maintain their daily capacity and do not allow overcrowding to occur (CFHS, 2014).

1.2.3.1 Strategies to Reduce Shelter Intake

The capability of a shelter to successfully reduce its intake of cats strongly depends on the demand for shelter space, as well as the sub-populations of cats entering the shelter (owner-relinquished vs. stray vs. feral) and even the age of the cats that enter the shelter. The C4C management program provides several suggestions to reduce or at least control the admissions of cats into the shelter system. One of
the simplest to integrate into a shelter’s management practice is to begin a scheduled intake program. This requires individuals to make an appointment to relinquish their pet or bring in a stray, allowing shelters to accept animals as capacity becomes available (“Shelter Intake and Pathway Planning”, 2015). Scheduled intake appointments allow the shelter to obtain relevant information about the relinquished animal, for example, health concerns, age, behaviour around children or other animals, veterinary history, etc. (CFHS, 2014). Additionally, it allows the potential for pets to stay in the care of their owner until the shelter is capable of providing them with the best possible care. Another approach to reduce intake includes providing positive alternatives to relinquishment. Behavioural issues are commonly found to be within the top three reasons for owner relinquishment of cats to animal shelters (Salman et al., 2000; Casey et al., 2009). On the one hand, it could be beneficial to educate owners on behaviour modification techniques earlier to prevent the relinquishment based solely due to behavioural problems (Horwitz, 2014). It could also be beneficial to promote programs such as Meet Your Match® (OSPCA, 2015), which help match the behavioural characteristics of the animals with the interest of the potential adopters. This will help ensure that potential adopters are aware of the behavioral characteristics of cats, and are well informed on how to introduce new animals into a household. To ensure new or potential owners know that taking on ownership of an animal is a lifelong commitment; therefore, education should be maintained as a priority.

As a part of the C4C program, shelters can also offer an adoption program called the ‘Barn Cat’ program. This program allows cats that would normally occupy shelter space, and typically be euthanized because these cats show aggression issues or are semi-feral, to be adopted by an individual looking for a traditional barn cat on rural properties (Saxon, 2014). Such strategies allow the C4C program to promote their sixth freedom; to eliminate unnecessary euthanasia. In addition to the Barn Cat program, the implementation of a Trap-Neuter-Return (TNR) program (or a Shelter-Neuter-Return program or Return-to-Field, as some call it) may also help in the reduction of unwanted litters within a community and potentially reduce the number of unwanted litters admitted to the shelter. As the name
states, TNR programs involve cats getting trapped, neutered (and frequently vaccinated simultaneously), and then returned to the site at which they were captured (Levy et al., 2002). The success of TNR programs is controversial (Jessup, 2005; Longcore et al., 2009). Although several studies have found that TNR programs have successfully decreased feral cat populations (Hughes and Slater, 2002a; Levy et al., 2002; Castillo and Clarke, 2003; Mendes-de-Almeida et al., 2011), it can be difficult to compare the effectiveness of different programs based on variances in study designs. For example, some TNR programs remove kittens young enough to be socialized and put them up for adoption (Hughes and Slater, 2002a; Levy et al., 2002), whereas others release kittens back into the colony after being neutered (Gibson et al., 2002). Despite differences in study designs, shelters which participated in TNR programs have seen an increase in welfare of cats through decreased euthanasia of feral cats (Hughes et al., 2002b, Wallace and Levy, 2006), as well as increased kitten survival rates (Gunther et al., 2011).

1.2.3.2 Factors Affecting Adoption and Length of Stay (LOS)

One of the main goals of the C4C program is to reduce an animals’ length of stay (LOS) by increasing adoption rates, which is why it is so important to understand factors that affect an adopter’s choice of cat. Although behaviour of the cat has found to be an important aspect for potential adopters (Weiss et al., 2012; Dybdall and Strasser, 2014), there are several traits that can be important in adopting a cat from an animal shelter. Traits that have been previously studied include; breed, coat colour, coat pattern (Brown and Morgan, 2014), source/entry type (Dybdall and Strasser, 2014), age (Weiss et al., 2012, Zito et al., 2015), position within adoption room, and presence of toys (Gourkow and Fraser, 2006; Fantuzzi, Miller and Weiss, 2010). Behaviour has been found to primarily influence cat adopters’ choices (Fantuzzi, Miller and Weiss, 2010, Weiss et al., 2012). As such, it is important for shelters to consider approaches to decrease cat LOS in a shelter because as cats live in long-term confinement they can develop behavioural traits that may be negatively viewed by adopters (Gouveia, Magalhaes and de Sousa, 2011). Not only can an increased LOS lead to negative behavioural traits, but it can also
increase risk of disease and reduce the overall welfare of shelter cats (Dybdall and Strasser, 2014). Research into factors that affect adoption rates, and correspondingly length of stay, can be of use to shelters in order to increase the welfare of shelter cats.

Brown and Morgan (2014) found that younger and lighter coloured cats were adopted sooner than older, darker coloured cats. Kitten adoptions, however, were not associated with coat colour. It was also found that coat pattern and breed influenced LOS for both adult cats and kittens (Brown and Morgan, 2014); ‘exotic’ breeds had the shortest LOS, while no difference was found between Domestic Short Hair (DSH), Domestic Medium Hair (DMH) or Domestic Long Hair (DLH) cats. Brown and Morgan (2014) reported potential for human error in the designation of breed due to the number of different people entering data, which was not controlled for in their analysis. This however, was not of concern to the researchers and likely indicated a lack of bias towards designation of breed as there was no knowledge of the data being used for analysis at the time of collection (Brown and Morgan, 2014). Inconsistent coding of coat colour was also a concern for Kogan, Schoenfeld-Tacher and Hellyer (2013), therefore these authors aggregated their data into three categories for coat colour: black, primarily black and other. Black cats took approximately 3 days longer to adopt than primarily black cats and 2-6 more days to adopt than cats with other coat colours (Kogan, Schoenfeld-Tacher and Hellyer, 2013). Onodera, Uchida and Kakuma (2014), found age (kitten vs adult) to be the most important factor considered by adopters when choosing a shelter cat; this was followed by coat colour, sex and health of the cat. Conversely, an observational study by Fantuzzi, Miller and Weiss (2010), found that coat colour did not influence the number of times a cat was viewed or the amount of time that a cat was viewed by adopters. It was found that cats at eye level, as well as cats with toys present in the cage had the greatest viewing times (Fantuzzi, Miller and Weiss, 2010). Another factor that has been found to affect LOS, is the source of admission (i.e., entry type) of a cat to the shelter; Dybdall and Strasser (2014) found that cats labelled as ‘strays’ took on average 6 days longer to get adopted than owner surrendered cats. Although behaviour may affected the LOS of stray cats versus owner
surrendered cats, there were no differences in social behaviour of the cats based on source of entry (Dybdall and Stresser, 2014). Rather, it was suggested that there was a negative connotation associated with the term ‘stray’ which affected the adopter’s choice of cat (Dybdall and Stresser, 2014). Weiss (2012), on the other hand, found that information regarding a cat’s life prior to arriving at the shelter was the least important information to affect their choice of cat.

Although there is only a small amount of research regarding the factors that influence an adopter’s selection of cat, it is clear that there are several important elements to be considered when creating strategies to decrease length of stay of shelter cats. Based on published results, cats with the shortest LOS are likely to be young, light in colour (Brown and Morgan, 2014), owner surrendered (Dybdall and Strasser, 2014), and in a cage at eye level with toys in their cage (Fantuzzi, Miller and Weiss, 2010). Conversely, risk factors for cats having the longest LOS include being a domestic breed, adult cat, with a black coat (Brown and Morgan, 2014), as well as being a ‘stray’ (Dybdall and Strasser, 2014), housed in a cage lower than eye level without any toys present (Fantuzzi, Miller and Weiss, 2010). Cat’s behaviour has been reported to influence the choice of cat (Weiss et al., 2012; Dybdall and Strasser, 2014), however, it is not always possible to study the effects of behaviour on LOS, especially in a retrospective study, unless data regarding behavioural traits have been collected routinely.

1.2.3.3 Case Studies

In 2012, a report regarding the cat overpopulation problem in Canada was released, containing an initial description of the first C4C case study in Canada, which was used as a pilot program at the Vancouver Branch of the British Columbia SPCA (CFHS, 2012). As a part of this case study, the average daily adoption numbers were used to determine the number of cats and kittens that could be cared for humanely, including those within the adoption process, to determine the shelter’s capacity (CFHS, 2012). In 2014, another report was released by the Canadian Federation of Humane Societies, as two more Canadian Humane Societies (i.e., Guelph Humane Society and Prince Edward Island Humane Society) participated in programs to pilot the C4C program. In all three case studies, shelters
found that staying within the shelter’s capacity allowed staff to clean more efficiently and spend more time socializing with the cats and their potential adopters (CFHS, 2012; CFHS, 2014). This, along with the ubiquitous decrease in disease (shown through a drastic decrease in the number of cats in isolation) and increase in adoptions, not only increased the morale of staff and volunteers, but shaped a healthier environment for the cats (CFHS, 2012; CFHS, 2014). In all three case studies, it was agreed that communication and commitment by staff to stay within the shelter’s capacity was one of the most important aspects to successfully incorporating the C4C program into a shelter (CFHS, 2012; CFHS, 2014). An overview of which programs were implemented and the changes observed after applying the C4C program can be found in Table 1.1 and Table 1.2, respectively. Further details of these case studies can be found in the CFHS’s 2012 and 2014 reports (CFHS, 2012; 2014).

The data used in the Guelph Humane Society and PEI Humane Society case studies to compare the changes before and after C4C was implemented consisted of only 6 months’ worth of data (CFHS, 2014). Although these data were appropriately adjusted for seasonal variation, only descriptive statistics are provided to compare details before and after the implementation of the C4C program (CFHS, 2014). One of the main goals of this thesis is to perform a more complete statistical analysis to determine the effects of the C4C program. It is vital that data be analyzed for a longer time period to evaluate the trends more accurately (CFHS, 2014). It is furthermore important that an appropriate method of analysis be used given the data available. For example, it is possible that data collected on a regular time-scale may be autocorrelated in time; i.e., a current observation may be dependent on the previous observation. If this were to be true, it would be necessary to analyze the shelter intake data using methods for time-dependent data. Animal shelter data is often collected on a daily, weekly, or monthly basis, consequently the data could potentially defy the rule of independence.
1.2.4 Analyses

1.2.4.1 Time Series Analysis

Data collected on a regular time scale are often autocorrelated in time, meaning there is a correlation between data points collected on a fixed time scale. For example, cats admitted to an animal shelter in July are more likely to be correlated with cats admitted in August than they would be with cats in November. This data therefore requires a time series modelling approach, as the data defies the rule of independence required when using a basic biostatistical method such as linear regression. More specifically, a time series approach for data with serial dependence will result in less biased standard errors for regression coefficient estimates (Dunsmuir and Scott, 2015). For discrete data such as counts of cats admitted to a shelter, a linear regression model is often not suitable, rather Poisson or negative binomial models may be more appropriate for count data modeling and analysis. A Generalized Linear Auto-Regressive Moving Average (GLARMA) model can be used for data that is autocorrelated in time, and is available for data with a Poisson distribution (the variance is equal to the mean), which is often typical of count data (Dunsmuir and Scott, 2015). A negative binomial GLARMA model can also be fit if over-dispersion (the variance is larger than the mean) is present in a Poisson GLARMA Model.

Although time series models have most often been used in economics, it is becoming a more popular approach in other areas that involve time-dependent data, including epidemiology. Time series analysis has recently been used in the fields of personal emergency health services (Chen and Yip, 2015) and public health (Lal et al., 2013). Some studies applied time series analysis to investigate trends in animal populations, such as the evaluation of animal conservation efforts (Keith et al., 2015), and more recently, temporal patterns in FIV and FeLV seroprevalence of cats (Chhetri, 2015). Chapter 2 of this thesis includes the use of a time series model to analyze animal shelter intake data in order to provide insights into any longterm trends in admissions, seasonal effects of admissions as well as any covariates associated with cat admissions to the Guelph Humane Society.
1.2.4.2 Survival Analysis

Survival analysis involves the examination of the time it takes for an event of interest to occur. It is often used in medical literature and epidemiological research (Flynn, 2012) where the event of interest is frequently death or occurrence of disease. Often used in the analysis of data from clinical trials, or observational studies, the analysis compares survival times based on one or more covariates. An important aspect that is considered when applying a survival analysis is the concept of censoring. Censoring occurs when the exact survival time of an individual is unknown (Kleinbaum and Klein, 2002). For example, censoring could occur due to a loss of follow-up, the study ending prior to the event occurring, or the event of interest occurring due to an unrelated cause. One of the key assumptions when using censored data, is that the survival time of individuals who are censored is independent of the reason they are censored (Collett, 2003). The Kaplan-Meier estimator (Kaplan and Meier, 1958) is commonly used as a descriptive method for comparing two treatment groups using a Kaplan-Meier plot, whereas Cox Proportional-Hazard regression models (Cox, 1972) are generally used for the statistical analysis of survival data as it examines the relationship between the survival distribution and covariates of interest. Chapter 3 of this thesis uses survival analysis with a focus on time-to-adopter as the event of interest, to examine which characteristics of cats at the Guelph Humane Society affected their Length of Stay (LOS) in the shelter.

1.2.5 REFERENCES


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|www.nature.com/naturecommunications


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Table 1.1. Overview of Programs Implemented During Capacity for Care Case Studies

<table>
<thead>
<tr>
<th>Programs Implemented</th>
<th>Guelph Humane Society</th>
<th>PEI Humane Society</th>
<th>BCSPCA Vancouver Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Portalization” of Cages</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Scheduled Intake</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fast-Tracking Adoptable Cats</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Shorter Adoption Forms/Fewer Restrictions</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Barn Cat Program</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Shelter-Neuter-Return</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Categorical Pricing</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Adoption Specials/Events</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Cage Enrichments (e.g. curtails, elevated beds)</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>Aim to Run At or Below Shelter Capacity</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 1.2. Overview of Changes Observed After Implementation of Capacity for Care Program

<table>
<thead>
<tr>
<th>Changes Observed After Implementation of C4C</th>
<th>Guelph Humane Society</th>
<th>PEI Humane Society</th>
<th>BCSPCA Vancouver Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory of Cats</td>
<td>Decreased</td>
<td>Decreased</td>
<td>N/A</td>
</tr>
<tr>
<td>Intake</td>
<td>Decreased</td>
<td>Increased</td>
<td>N/A</td>
</tr>
<tr>
<td>Cats in Sick Bay</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Euthanasia</td>
<td>Decreased</td>
<td>Increased</td>
<td>N/A</td>
</tr>
<tr>
<td>Adoption</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Length of Stay (LOS)</td>
<td>Increased</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Cost</td>
<td>&lt;$1000</td>
<td>N/A</td>
<td>$0</td>
</tr>
</tbody>
</table>
CHAPTER 2
THE EFFECT OF CAPACITY FOR CARE ON CAT ADMISSION TRENDS
AT THE GUELPH HUMANE SOCIETY, 2011-2015
(Prepared in the format of Journal of Applied Animal Welfare Science)

2.1 ABSTRACT
In recent years, there has been a growing concern regarding homeless cat populations. Shelters are constantly overwhelmed by the influx of unowned cats and are seeking solutions to enhance positive outcomes for those animals. In 2014, the Guelph Humane Society implemented the Capacity for Care program at its shelter to expedite the movement of cats through the shelter through decreasing the average animal’s length of stay by scheduling intakes to control for overcrowding, and by implementing strategies to increase adoption rates. This study investigates the time trends in admission rates of cats to the Guelph Humane Society, to assess the effectiveness of the Capacity for Care program, using a Generalized Linear Auto-Regressive Moving Average model. Between January 2011 and December 2015, a total of 3295 live cats were admitted to the Guelph Humane Society. When the analysis was adjusted to account for admissions of kittens, there was a significant reduction in admissions for adult cats (p<0.01) following the introduction of the Capacity for Care program. The results also display a strong seasonal peak in total admissions over the summer months.

Keywords: Cat Overpopulation, Capacity-for-Care, Shelter Intake, Time Series, Count Data.

2.2 INTRODUCTION
In recent years, there has been an increased focus on reducing the number of companion animals entering the shelter system. Since 2001, there have been twice as many cats admitted to Canadian shelters as dogs (CFHS, 2012). Studies in the United States have reported observing a decrease in dog admissions to animal shelters, while the number of cat admissions continue to rise (Lord et al., 2006; Morris et al., 2011; 2014). The Canadian Federation of Humane Societies (CFHS) (2012) reported
similar results to the United States, after gathering intake data from shelters throughout Canada, though a recently published report by the CFHS claimed that cat intake numbers decreased consistently from 2011 to 2014 (CFHS, 2015a). While it is extremely important to monitor the progress of animal shelters throughout the country, it is essential for shelters to also monitor the progress in their own community. In addition to each community having a unique animal population structure, communities differ in their human population structure and the various socioeconomic factors affecting animal ownership and relinquishment.

Insufficient capacity, particularly for cats, remains an issue for a number of shelters across the United States and Canada, with the number of healthy cats being euthanized continuing to be of concern (CFHS, 2014). In an attempt to increase the welfare of shelter cats and promote healthy alternatives to unadoptable cats, several shelters in the United States and Canada have implemented the Capacity for Care (C4C) shelter population management program. In 2014, the Guelph Humane Society (GHS) was one of two Canadian animal shelters designated as a pilot site by the CFHS for the implementation of C4C (CFHS, 2015b). The C4C program is intended to improve rate of adoptions, in order to decrease length of stay and reduce illness among shelter animals, with the ultimate goal being for the population to remain at or below the shelter’s capacity at all times (CFHS, 2012; Karsten, n.d.). The C4C program includes several strategies to control the flow of animals through the shelter system including reducing intake, expanding the physical capacity of the shelter, and reducing length of stay. The current study focuses on reducing intake, which is just one aspect of the C4C population management program. Strategies used to reduce the intake of cats includes using appointment-based relinquishments, while providing alternative strategies to intake and reducing unwanted litters in the community, through programs such as ‘Shelter-Neuter-Return’ (CFHS, 2015b). Another program which can be used as an alternative strategy to shelter admission is the ‘barn cat program’, where unsocialized stray cats are rehomed as barn cats rather than being admitted to a shelter (CFHS, 2012).

Cats entering the shelter system are often categorized based on where they were acquired, but
these sub-populations can be further categorized by age. Several studies have examined shelter cat admissions based on age and found that there is a distinct 'kitten season' which occurs at the beginning of spring – around March-April (Scott, Levy and Crawford, 2002; Nutter et al., 2004; Wallace and Levy, 2006). A study by Marston and Bennett (2009) in Australia, found evidence of a seasonal peak in admissions during the warmest time of year (December – April), however, once kittens were accounted for, there was little variation found in cat admissions. Wallace and Levy (2006) studied pregnancy trends in feral cats throughout several U.S. cities and found that despite geographical variation, the incidence of pregnancies in feral cats peaked around March-April. These findings display the importance of acknowledging the various sub-populations of cats that comprise the shelter population.

Each community may differ in the types and proportions of sub-populations of cats that enter the shelter system, signifying that interventions will be community-specific.

Data collected over time are often autocorrelated, meaning there is a correlation between data points collected on a fixed time scale. These data therefore require a time series modelling approach, as the data defies the rule of independence required when using a regular generalized linear model. Time series models are often used in economics, and more recently in the fields of personal emergency health services (Chen and Yip, 2015) and public health (Lal et al., 2013). Although some studies have used time series analysis to investigate animal conservation efforts (Keith et al., 2015), and more recently to investigate temporal patterns in FIV and FeLV seroprevalence (Chhetri, 2015), the current study is the first to use time series analysis to investigate animal shelter admissions data. Performing a time series analysis using animal shelter intake data will provide information about, and insights into, any long-term trends in admissions, seasonal effects of admissions as well as the characteristics of the cats that comprise the shelter population. Determining which sources represent the majority of shelter admissions can help ensure that the most effective management strategies are being used to overcome cat overpopulation. For example, if a large proportion of kitten admissions are coming from owned cats, then strategies could be aimed towards earlier neutering of owned cats. Shelter intake data
collected by the GHS provide a unique opportunity to study temporal trends in cat overpopulation and simultaneously investigate the effectiveness of the C4C management program, which has yet to be evaluated using data from multiple years.

The goal of this study is to investigate cat overpopulation at the GHS. The primary objective of this study is to determine the long-term trends in admissions and the effect of the implementation of the C4C program on cat admissions. Concomitantly, this study will analyze seasonality of admissions to determine the seasonal peak values in cat admissions at the GHS. Lastly, the present study aims to investigate the sub-populations of cats entering the shelter, including age and source of admission.

2.3 MATERIALS AND METHODS

Data for this study were collected from the GHS between January 2011 and December 2015. All cat admissions during this time period were extracted from the GHS’s data management system, i.e. PetPoint (www.petpoint.com). Data were collected by the GHS staff upon intake of animals and were subsequently input into Petpoint. The C4C program was implemented at the GHS in August 2014. Some of the key elements that were implemented as part of the C4C program at the GHS are highlighted in Table 2.1. Components of the C4C program which are believed to have an impact on cat admissions include scheduled intakes rather than open admissions, and strategies which help reduce the number of unwanted cats in the community, such as the ‘barn cat program’ and the ‘shelter-neuter-return program’ (Karsten, n.d.). Furthermore, portals were created between two cages, providing a singly housed cat with two cage spaces, allowing separation of food and water from each cat’s litter box, in addition to minimizing disruptions while cleaning (CFHS, 2015b; Karsten, n.d.). Portalization of cages also allows for fewer cats on the adoption floor at one time, creating a less overwhelming experience for potential adopters due to the number of options and thus it is hoped that they are less likely to fall victim to ‘decision paralysis’. Further details regarding the C4C case study at the GHS are provided by the CFHS (2015b) report entitled “Capacity for Care (C4C) Case Studies”, while details regarding the population management strategies that formulate the C4C program are described by
Karsten (n.d.).

Data obtained from the GHS shelter records used in the current study included the animal identification number, date of admission, age, sex, neuter status, and intake type. Incomplete cases were maintained in the dataset, as covariates were not used in the statistical analyses. Cases with a missing variable were included in the dataset for the purpose of descriptive statistics and were categorized as “unknown”. For the purpose of this study, adult cats are those greater than six months of age and kittens are those six months of age or younger on their date of admission. Cats with ‘yes’ in the spayed/neutered column were assumed to have been altered prior to their entry into the GHS.

Exploratory analysis of the time series of admissions data was completed using Seasonal Time Series Decomposition using Loess (STL) which is a smoothing procedure that decomposes a time series into trend, seasonal, and remainder components (Cleveland et al., 1990).

A Generalized Linear Auto-Regressive Moving Average (GLARMA) model (Dunsmuir and Scott, 2015) was used to analyze the data, as this type of modeling can account for the auto-correlation in time series of monthly intake counts. Since the data consists of counts, a Poisson GLARMA model was fit and if overdispersion (i.e. greater variability than expected) was found to be present using the deviance test, then a Negative Binomial GLARMA model was fit to account for it. Backward elimination was used to select variables for the final model. The model fit was assessed using the Akaike Information Criterion, Likelihood Ratio Test, PIT Histogram and (Partial) Autocorrelation Function plots. The time trend was modeled using a function of calendar time in months ranging over the entire study period, i.e. 1 to 60. To account for potential seasonal effects due to environmental conditions, 11 dummy variables were generated to represent the effects of February to December, using January as the reference month in the model. The intervention effect due to the C4C program was included in the model using an indicator variable.

Initial analyses indicated a seasonal trend due to kittens, therefore the time series of adult cat admissions was also analyzed (i.e. excluding admission counts of kittens) to determine the effect of
kittens on seasonal variation. All statistical analyses were performed using R and RStudio statistical software (R Core Team, 2016; RStudio Team, 2016). A significance level of 5% was maintained for all tests and confidence interval estimates.

2.4 RESULTS

There were a total of 3895 records of cat admissions to the GHS during the study period. Based on the unique identification numbers provided by the GHS, some cats were admitted more than once, however, only their first admission was used for the current analysis. In total, there were 99 duplicates in the dataset; 39 of which were returned adoptions, while the remainder were thought to be strays and were picked up by an Animal Control Officer. There were 505 cats (13%) categorized as ‘Dead on Arrival’. These cats were removed from the dataset. As a result, a total of 3291 cats in the dataset were aggregated to 60 monthly counts for analysis. A significant decreasing secular trend (i.e. decreasing long-term linear trend) in the number of cat admissions to the GHS was found throughout the entire study period. The number of monthly cat admissions to the GHS ranged from 15 to 118 throughout the study period, with a mean of 55 and a median of 52 cats. The mean number of cats admitted to the GHS in the year prior to the C4C intervention (August 2013-July 2014) was 52 cats per month. The mean intake of cats in the year post C4C intervention (August 2014-July 2015) was 37 cats per month.

Descriptive statistics regarding the breakdown of age, sex, and neuter status can be found in Table 2.2. As can be seen in Table 2.3, a large proportion of admissions were taken in as strays (79.9%), while only 16.4% of cats admitted were surrendered by their owner/guardian. The remaining admissions were either transferred in from another shelter (0.3%), seized by officials (1.4%), or serviced in due to an emergency involving the owner of the animal (2.0%). Approximately 37% of cats admitted were kittens and the majority of the cats admitted were sexually intact (63.7%). Table 2.4 displays the proportion of owner/guardian surrendered cats and strays which were spayed or neutered upon arrival at the GHS.

Time series analysis resulted in a negative binomial GLARMA model being the best fitting
While a secular downwards trend and a seasonal component were detected in the monthly admission rates, the C4C program intervention was not found to have an effect, when analyzing the dataset of all live cat admissions to the GHS. The final negative binomial GLARMA model included a significant seasonal component; see Table 2.5. There was a significant increase in the intake of cats at all months, except for February. The month of July experiences the highest peak on average, with 218% more cats taken in compared to January. The seasonal component of the time series admissions data can be observed in the second quadrant of Figure 2.2; which provides a visualization of the time series decomposition of all live cat admissions using STL.

The dataset of cat admissions to the GHS for the same study period was analyzed excluding kittens. A total of 1723 adult cats were admitted between 2011 and 2015. Figure 2.1(b) displays the observed versus predicted data from the final model excluding kittens. This analysis revealed that there remains a significant decreasing secular trend in admissions, and less seasonal variation was found in monthly cat counts of adults, compared to the analysis which included kittens; see Table 2.6. Furthermore, this dataset revealed a significant decrease in adult cat admissions to the GHS after the implementation of the C4C program ($\beta = -0.277, P < 0.01$; Table 2.6); in absolute abundance this equates to an 8% decrease in adult cats per year being admitted to the GHS during the study period, and a 24% reduction in intake of adult cats after the implementation of C4C (August 2014-December 2015). The trend and seasonal components of this dataset are shown in Figure 2.3. Figure 2.4 displays the intake of adult cats and kittens, where a strong seasonal peak can be seen each year.

2.5 DISCUSSION

To our knowledge, this study is the first to use time series methods to evaluate animal shelter admissions data, in addition to being the first study to evaluate the effects of the C4C program on shelter intake using data from multiple years. The results suggest that there has been a decreasing secular trend in cat admissions to the GHS between January 2011 and December 2015, as well as a
strong seasonal swing in kitten admissions that peaks over the month of July. When the dataset was re-analyzed excluding kittens, there was a significant decrease in adult cat intake associated with the C4C intervention.

The current study contained a total of 60 months of data, 43 months prior to the C4C and 17 months post-intervention. In addition, the model presented here adjusts for season and trend, both of which are important to consider when collecting time-dependent data. The trend component showed a significant secular decrease in all cat admissions at the GHS throughout the entire study period. It was found that cat admissions decreased approximately 16% with each additional year, when all live cat admissions were analyzed (see Table 2.5). The secular decreasing trend in cat admissions in this study is in agreement with the results from the ‘Animal Shelter Statistics’ report released by the CFHS (2015a), showing decreases in cat admissions in Canada since 2011. Although the exact causes of this decrease are undetermined, the CFHS (2015a) suggests that spay/neuter efforts, educational initiatives as well as increased networking between shelters may have contributed to the gradual decrease in shelter cat admissions countrywide. However, it should be noted that the CFHS does not report certain changes that occur at shelters, such as, changes to intake policies which may affect admission numbers over time. In addition, this report contains data from only 52% of Canadian Humane Societies and SPCAs (CFHS, 2015a), therefore there is potential for response bias toward shelters that have been successful in their efforts to decrease intake and improve outcomes being more likely to respond to the survey.

While diligent efforts by the GHS may certainly play a role in the secular decreasing trend in cat admissions seen during the study period, there could also be external causes, which have led to a decrease in admissions. In 2014, it was observed that numerous owned cats whose owners allow them to roam outdoors in Guelph were disappearing and it has been suggested that coyotes were responsible for the loss of these cats (Levenson, 2014). Concurrent with the decrease in cat admissions to the GHS were record-breaking cold winters in Southwestern Ontario, Canada, where Guelph is located. One
could therefore hypothesize that free-roaming cats and kittens are likely to have reduced survival rates during recent winters, potentially contributing to the decrease in shelter admissions. In addition, during the study period, the City of Guelph changed their garbage disposal system (Warren, 2015), switching from bags to lockable plastic bins that obstruct animals from eating garbage. The effect of the change in garbage disposal could result in less food available for free-roaming cats and perhaps a lower survival rate, resulting in fewer admissions to the GHS.

In 2015, the CFHS released a report regarding the C4C Case Study at the GHS. This report showed a 25% decrease in cat admissions from 6 months prior to the C4C program compared to 6 months after, adjusted for seasonality (CFHS, 2015b). Data from a longer period of time provides the opportunity to show more precise results and be more forgiving of small fluctuations in data (CFHS, 2015b). We found that the C4C intervention variable was not significant in the time series model for all live cat admissions. This signifies that the C4C program did not have a significant effect on the total cat admissions to the GHS when all age groups were considered. Although intake is expected to decrease with the intake diversion techniques used in the C4C program, an increase in intake could also be projected if there is a consistent demand for shelter space (CFHS, 2015b), for example, if the shelter were to be overwhelmed with litters of unwanted kittens. Nevertheless, when the dataset was reanalyzed after removing kittens, C4C showed a significant reduction in admissions of adult cats (see Table 2.6). After the C4C program was implemented, the GHS saw a 24% decrease in adult cat admissions during the study period (see Table 2.6). These results suggest that the C4C program resulted in a decreased intake of adult cats.

With respect to the seasonal component of the time series (Figure 2.2, second quadrant), only one seasonal peak was observed. As Marston and Bennett (2009) suggest, this may indicate that there is not a significant quantity of queens having a second litter each year, or a second seasonal peak would be expected approximately 3 months after the first. It is, however, possible that a second litter has been absorbed by the community revealing no effect on the admissions at the GHS. The adult cat time series
(i.e. excluding kittens) was also modelled using harmonic swings. Similar to the results of Marston and Bennett (2009), seasonal peaks were much more apparent in the data of kitten admissions compared to adult admissions (Figure 2.4). This suggests that the significant seasonal swing found when all ages are included in the dataset can be attributed to what is commonly known as a “kitten season”.

The most recent report released by the CFHS (2015a) displays the sources of admissions for the average Canadian shelter. The GHS has taken in an average of 79.2% stray cats between 2011 and 2015, whereas the intake of strays into the average Canadian shelter during the same time period has varied between 49%-63% over a similar time period (CFHS, 2012; 2013; 2014; 2015a). The second main source of cat admissions at the GHS is from owner surrenders, which comprise 16% of the total intake. This is a much lower proportion than that for the average Canadian animal shelter, which ranged from 22-34% owner surrendered cats during a similar time period (CFHS, 2012; 2013; 2014; 2015a).

One of the common limitations that arises when collecting shelter intake data is that it is not always possible to determine whether a cat categorized as a “stray” is truly a stray, or has been semi-owned, or if it is an owned outdoor cat (Marston and Bennett, 2009). Furthermore, without any data collected on the level of socialization (and thus likelihood of the cat not being feral), it is difficult to speculate retrospectively whether cats categorized as strays have been owned or semi-owned during their lifetime. Based on the findings of the current study we emphasize the importance of increasing spay/neuter efforts within the community, as only 15.4% of cats admitted to the GHS were known to have been previously spayed or neutered on their date of admission. Table 2.4 displays the proportion of owner/guardian surrendered cats and strays which were spayed or neutered upon arrival at the GHS. Approximately 37% of cats admitted to the GHS during the study period were kittens 6 months of age or younger and the majority (83.2%) of these kittens were taken in as strays. Thus, increasing efforts to reduce the number of free-roaming cats having litters could make a significant impact on the number of cats entering animal shelters. Programs such as the ‘Barn Cat Program’ and the ‘Shelter-Neuter’Return’
program (also called TNR), which are both aspects of the C4C program, could be utilized to further reduce the free-roaming cat population. Although the topic of TNR can be quite controversial (Jessup, 2004), and some have found it to be ineffective in reducing the homeless cat population (Castillo and Clarke, 2003), others have found a combination of approaches, including adoption of homeless kittens, to be successful in reducing the homeless cat population (Levy, Gale and Gale, 2003). We believe a combination of approaches will be required for successful reduction of homeless cats in the City of Guelph. Additionally, it would be beneficial for the GHS to track whether or not queens are admitted together with their kittens when collecting data. Previous research by Marston and Bennett (2009) found significant differences in the types of cats admitted by Animal Management Officers versus members of the public. For example, Animal Management Officers were more likely to admit entire colonies, whereas members of the public were more likely to admit kittens without queens (Marston and Bennett, 2009). If members of the public are admitting litters from an owned cat as “strays”, then perhaps an incentive could be made to encourage these individuals to have their queens spayed. At minimum, collecting this type of data will allow the GHS to have a better idea of the proportion of queens that are still at large in the community.

This study was the first to evaluate the effects of the C4C program, as implemented at the GHS, using long-term data while adjusting for trend and seasonality. We detected a long term decreasing secular trend, which was not previously considered in evaluating the C4C program by comparing intake data for six months before and after the start of the C4C program at the GHS (CFHS, 2015b). Our results demonstrate the importance of breaking down data based on categories such as age, admission source and neuter status, in order to provide more depth to the analysis of shelter admissions data. Excluding kittens from the analysis, the C4C program is associated with a significant decrease in intake of adult cats. The current study measures only one impact of the C4C program (i.e. cat admissions) and future studies should also focus on how the C4C program affects other outcomes of shelter cats including the presence of disease while in the shelter, and the overall welfare of cats while
in the shelter. In addition, research examining the impact of C4C on owned and unowned free-roaming cat populations outside of the shelter should be considered. Unfortunately, the results from this study cannot easily be generalized to other shelters, as each community may differ in factors that influence shelter admissions, as well as the animal population itself. Our study provides a good foundation for other shelters to evaluate the effects of the C4C program in their context.

2.6 ACKNOWLEDGEMENTS

This research was supported through an MSc Scholarship from the Ontario Veterinary College and funds from the OVC Pet Trust Foundation.

2.7 REFERENCES


Chen, F. and Yip, PSF. (2015). The influence of cold weather on the usage of emergency link calls: a case study in Hong Kong. BMC Medical Informatics and Decision Making. 15(66) DOI


Table 2.1: Overview of Key Elements that were Implemented During Capacity for Care Case Study at the Guelph Humane Society in August 2014. Data compiled from the Canadian Federation of Humane Societies (2015b).

<table>
<thead>
<tr>
<th>Elements Implemented</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Portalization” of Cages</td>
<td>Portals are created between adjacent cages, creating double compartment cage. Allows cats to chose where to spend their time, creates a separation of food and water from litter box, and minimizes disruptions while cleaning.</td>
</tr>
<tr>
<td>Scheduled Intake</td>
<td>Appointment-based relinquishment is used to help ensure that a shelter does not go over capacity, permitting cats to have adequate space while they await an outcome. It also provides an opportunity to discuss alternatives to relinquishments or acquire information about a cat’s medical history.</td>
</tr>
<tr>
<td>Fast-Tracking Adoptable Cats</td>
<td>Fast-tracking the most adoptable cats (for example, juveniles), decreasing the stray-hold period and providing earlier health examinations and vaccinations.</td>
</tr>
<tr>
<td>Shorter Adoption Forms/Fewer Restrictions</td>
<td>Fewer adoption restrictions, including shortening the application process to encourage a prompt adoption process.</td>
</tr>
<tr>
<td>Barn Cat Program</td>
<td>Rehomes cats that are not adoptable through the shelter system and places them in with families looking for a ‘barn cat’. These cats are spayed/neutered before being placed, ensuring that they do not contribute to the growing cat population.</td>
</tr>
<tr>
<td>Shelter-Neuter-Return</td>
<td>Healthy feral cats that are unadoptable through the shelter system are spayed/neutered and vaccinated, then returned to their home location. If it is not possible to place them in their home location then they are rehomed through the Barn Cat Program.</td>
</tr>
<tr>
<td>Categorical Pricing</td>
<td>Implementation of categorical pricing to promote the adoption of cats that are considered to be ‘less desirable’.</td>
</tr>
<tr>
<td>Adoption Specials/Events</td>
<td>Holding adoption events or specials to prevent the inventory of cats from exceeding the shelter’s capacity, especially if there are cats waiting to be relinquished.</td>
</tr>
<tr>
<td>Cage Enrichments (e.g. curtains, elevated beds)</td>
<td>Increasing cat welfare while in the shelter through improved cage enrichment by incorporating cat toys, elevated beds, cat curtains, etc.</td>
</tr>
<tr>
<td>Aim to Run At or Below Shelter Capacity</td>
<td>Ensuring that management, staff and volunteers are committed to ensuring that the shelter remains at or below capacity at all times. This could involve changes in shelter policies.</td>
</tr>
</tbody>
</table>

Table 2.2: GHS Admissions Breakdown Based on Age, Sex and Neuter Status
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakdown by Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitten &lt;= 6 months</td>
<td>1221</td>
<td>37</td>
</tr>
<tr>
<td>Adult &gt;6 months</td>
<td>1723</td>
<td>52.3</td>
</tr>
<tr>
<td>Unknown</td>
<td>351</td>
<td>10.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3295</td>
<td>100</td>
</tr>
<tr>
<td><strong>Breakdown by Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1488</td>
<td>45</td>
</tr>
<tr>
<td>Female</td>
<td>1580</td>
<td>48</td>
</tr>
<tr>
<td>Unknown</td>
<td>227</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3295</td>
<td>100</td>
</tr>
<tr>
<td><strong>Breakdown by Neuter Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutered/Spayed</td>
<td>2099</td>
<td>63.7</td>
</tr>
<tr>
<td>Intact</td>
<td>690</td>
<td>20.9</td>
</tr>
<tr>
<td>Unsure</td>
<td>3295</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission Source</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Owner/Guardian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surrender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitten &lt;=6 months</td>
<td>178</td>
<td>5.4</td>
</tr>
<tr>
<td>Adult &gt;6months</td>
<td>315</td>
<td>9.6</td>
</tr>
<tr>
<td>Age Unknown</td>
<td>48</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>541</td>
<td>16.4</td>
</tr>
<tr>
<td>Stray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitten &lt;=6 months</td>
<td>1021</td>
<td>31.0</td>
</tr>
<tr>
<td>Adult &gt;6months</td>
<td>1330</td>
<td>40.3</td>
</tr>
<tr>
<td>Age Unknown</td>
<td>284</td>
<td>8.6</td>
</tr>
<tr>
<td>Total</td>
<td>2635</td>
<td>79.9</td>
</tr>
<tr>
<td>Serviced In</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitten &lt;=6 months</td>
<td>3</td>
<td>0.1</td>
</tr>
<tr>
<td>Adult &gt;6months</td>
<td>48</td>
<td>1.5</td>
</tr>
<tr>
<td>Age Unknown</td>
<td>13</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>2.0</td>
</tr>
<tr>
<td>Seized/Custody</td>
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<td></td>
</tr>
<tr>
<td>Kitten &lt;=6 months</td>
<td>13</td>
<td>0.4</td>
</tr>
<tr>
<td>Adult &gt;6months</td>
<td>27</td>
<td>0.8</td>
</tr>
<tr>
<td>Age Unknown</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>1.4</td>
</tr>
<tr>
<td>Transfer In</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitten &lt;=6 months</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>Adult &gt;6months</td>
<td>3</td>
<td>0.1</td>
</tr>
<tr>
<td>Age Unknown</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>3295</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2.4: Breakdown of Spay/Neuter Status of Owner/Guardian Surrendered Admissions vs. Strays

<table>
<thead>
<tr>
<th>Source</th>
<th>Spay/Neuter Status</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Owner/Guardian Surrendered</strong></td>
<td>Yes: 156</td>
<td>Yes: 28.8</td>
</tr>
<tr>
<td></td>
<td>No: 337</td>
<td>No: 62.3</td>
</tr>
<tr>
<td></td>
<td>Unsure: 48</td>
<td>Unsure: 8.9</td>
</tr>
<tr>
<td></td>
<td>Total: 541</td>
<td>Total: 100</td>
</tr>
<tr>
<td><strong>Stray</strong></td>
<td>Yes: 331</td>
<td>Yes: 12.6</td>
</tr>
<tr>
<td></td>
<td>No: 1682</td>
<td>No: 63.8</td>
</tr>
<tr>
<td></td>
<td>Unsure: 622</td>
<td>Unsure: 23.6</td>
</tr>
<tr>
<td></td>
<td>Total: 2635</td>
<td>Total: 100</td>
</tr>
</tbody>
</table>

Table 2.5: Regression coefficients of the final negative binomial GLARMA model on the monthly cat admissions at the Guelph Humane Society. Dataset includes all live cat admissions between January 2011 and December 2015.

| Linear Model Coefficients: | Estimate | Std.Error | z-ratio | Pr>|z|< | Risk Ratio |
|-----------------------------|----------|-----------|---------|------|-------------|
| Alpha                       | 35.22    | 11.69     | 3.012   | <0.01|             |
| AR(1)                       | 0.03109  | 0.03636   | 0.855   | 0.392|             |
| January (Intercept)         | 361.840 | 48.32696  | 7.487   | <0.01|             |
| trend                       | -0.17809 | 0.02401   | -7.418  | <0.01| 0.84        |
| February                    | -0.02783 | 0.15237   | -0.183  | 0.85 | 0.97        |
| March                       | 0.42759  | 0.15403   | 2.776   | <0.01| 1.53        |
| April                       | 0.49225  | 0.15327   | 3.212   | <0.01| 1.64        |
| May                         | 0.88647  | 0.14915   | 5.944   | <0.01| 2.43        |
| June                        | 0.99666  | 0.14827   | 6.722   | <0.01| 2.71        |
| July                        | 1.15714  | 0.14676   | 7.885   | <0.01| 3.18        |
| August                      | 1.00988  | 0.14858   | 6.797   | <0.01| 2.74        |
| September                   | 1.04701  | 0.14886   | 7.033   | <0.01| 2.85        |
| October                     | 0.70409  | 0.15309   | 4.599   | <0.01| 2.02        |
| November                    | 0.69268  | 0.15280   | 4.533   | <0.01| 2.00        |
| December                    | 0.42533  | 0.15168   | 2.804   | <0.01| 1.53        |
Table 2.6: Regression coefficients of the final negative binomial GLARMA model on the monthly cat admissions at the Guelph Humane Society. Dataset excludes kittens 6 months of age or younger admitted to the GHS between January 2011 and December 2015.

| Linear Model Coefficients: | Estimate | Std.Error | z-ratio | Pr(>|z|) | Risk Ratio |
|-----------------------------|----------|-----------|---------|----------|------------|
| AR(1)                       | -0.04379 | 0.01961   | -2.233  | 0.02     |            |
| AR(2)                       | -0.06300 | 0.01977   | -3.186  | <0.01    |            |
| (Intercept)                 | 177.83243| 27.61502  | 6.440   | <0.01    |            |
| trend                       | -0.08680 | 0.01372   | -6.326  | <0.01    | 0.92       |
| Intervention                | -0.27653 | 0.05295   | -5.223  | <0.01    | 0.76       |
| February                    | -0.06124 | 0.15299   | -0.400  | 0.69     | 0.94       |
| March                       | 0.30766  | 0.15096   | 2.038   | 0.04     | 1.36       |
| April                       | 0.38829  | 0.12969   | 2.994   | <0.01    | 1.47       |
| May                         | 0.45539  | 0.12943   | 3.519   | <0.01    | 1.58       |
| June                        | 0.35319  | 0.13347   | 2.646   | <0.01    | 1.42       |
| July                        | 0.49068  | 0.12992   | 3.777   | <0.01    | 1.63       |
| August                      | 0.54317  | 0.13054   | 4.161   | <0.01    | 1.72       |
| September                   | 0.53781  | 0.12975   | 4.145   | <0.01    | 1.71       |
| October                     | 0.22172  | 0.13780   | 1.609   | 0.11     | 1.25       |
| November                    | 0.50792  | 0.14410   | 3.525   | <0.01    | 1.66       |
| December                    | 0.33665  | 0.14188   | 2.373   | 0.02     | 1.40       |
Figure 2.1: a.) (above) Observed admissions versus predicted admissions from GLARMA model using a dataset including all live cat admissions between January 2011 and December 2015. b.) (below) Dataset excluding kittens 6 months of age or younger admitted to the GHS between January 2011 and December 2015.
Figure 2.2: Seasonal Decomposition of Time Series by Loess using a dataset including all live cat admissions between January 2011 and December 2015. Top panel (Observed data): Represents a monthly time series of all live cat admissions to the Guelph Humane Society; Second panel (seasonal component): represents the seasonal pattern of cat admissions per 12 months. The values at 0 indicate no seasonal variation, values above 0 indicate an increasing seasonal pattern, while values below 0 indicates a decreasing seasonal pattern; Third panel (trend component): represents the STL fitted trend of cats admitted to the shelter; Fourth panel (residuals): represents the remainder after trend and season were fit to the time series.
Figure 2.3: Seasonal Decomposition of Time Series by Loess using a dataset excluding kittens 6 months of age or younger admitted to the GHS between January 2011 and December 2015. Top panel (Observed data): Represents a monthly time series of adult cat admissions to the Guelph Humane Society; Second panel (seasonal component): represents the seasonal pattern of cat admissions per 12 months. The values at 0 indicate no seasonal variation, values above 0 indicate an increasing seasonal pattern, while values below 0 indicates a decreasing seasonal pattern; Third panel (trend component): represents the STL fitted trend of cats admitted to the shelter; Fourth panel (residuals): represents the remainder after trend and season were fit to the time series.
Figure 2.4: Admissions of Adult Cats (>6months) and Kittens (<=6months) to the Guelph Humane Society, 2011-2015
CHAPTER 3

RISK FACTORS AFFECTING LENGTH OF STAY OF CATS IN AN ANIMAL SHELTER:

(Prepared in the format of Preventative Veterinary Medicine)

3.1 ABSTRACT

There is a strong need for animal shelters to determine strategies to decrease the incidence of healthy animals being euthanized due to a lack of space. Thus, the Capacity for Care program was implemented at the Guelph Humane Society during August 2014. One objective of the Capacity for Care program is to decrease length of stay of cats within the shelter to improve individual welfare and increase the number of successful adoptions. The current study uses passively collected data from the Guelph Humane Society between 2011 and 2016. A Cox Proportional Hazard regression model was used to determine factors affecting a cat’s time-to-adoption (length of stay). Cats were 24% more likely to be adopted after the implementation of the Capacity for Care program compared to before (p<0.001). Exotic breeds were 64% more likely to be adopted than domestic shorthairs (p<0.01), while males were 20% more likely to be adopted than females (p<0.001) and adult cats were 13% more likely to be adopted than kittens (p≤0.01). This study provides evidence that the Capacity for Care program is associated with a reduced length of stay for cats and increased their likelihood of adoption; suggesting it is a suitable program to improve cat welfare and address cat overpopulation.

Keywords: Cat Overpopulation, Capacity for Care, Animal Shelter, Length of Stay, Survival Analysis

3.2 INTRODUCTION

Animal shelters have the common goal of providing a safe and comfortable environment for homeless animals, while attempting to either rehome or reunite animals with their owners. In the United States, it has been estimated that approximately 1.3 million cats are adopted from animal shelters each year, however, approximately 40% of cats that enter shelters are euthanized (Pet Statistics, 2016). Likewise,
in Canada, a recent animal shelter statistics report found that Canadian animal shelters had a euthanasia rate of 27% in 2014, of which 1.5% were healthy animals (CFHS, 2015). The euthanasia rate of cats appears to have been decreasing since 2008, however when only considering the number of healthy cats that have been euthanized during the same time period, the euthanasia rate increased in 2013 and 2014 compared to 2012 (CFHS, 2015). The rationalization for the increased euthanasia rate of healthy animals in the Canadian Federation of Humane Societies (CFHS; 2015) report, is that healthy animals entering shelters are often kept in crowded and stressful conditions causing them to become ill during their stay and as a result they are euthanized before being adopted. This justification powerfully accentuates the need for a new management approach in animal shelters, which will decrease the incidence of healthy animals being euthanized.

An animal’s Length of Stay (LOS) in a shelter is the amount of time it takes for an animal to be adopted, once it has been admitted to a shelter. It has been observed that as a cat’s LOS increases, the more likely it is to develop negative behavioural traits (Gouveia, Magalhaes and de Sousa, 2011) and risk of contracting a disease (Dinnage et al., 2009; Dybdall and Strasser, 2014), which may decrease its likelihood of being adopted (Gouveia, Magalhaes and de Sousa, 2011). Considering that a cats’ behaviour has been found to primarily influence potential adopters’ choice in selecting a cat (Kry and Casey, 2007; Fantuzzi, Miller and Weiss, 2010, Weiss et al., 2012), it is important for shelters to adopt strategies that will not negatively influence cat behaviour and that will positively contribute to decreasing each animal’s LOS in a shelter.

In an attempt to decrease the LOS of shelter cats and improve the overall welfare of animals in their care, several shelters in Canada and the United States have begun to implement the Capacity for Care (C4C) shelter management program. The fundamental goal of the C4C program is to increase the adoption rate and reduce illness among shelter animals by maintaining the shelter cat population at or below the shelter’s capacity at all times (CFHS, 2012). The C4C program promotes several strategies to control the flow of animals through the shelter system including: reducing intake through appointment
based relinquishments, expanding the physical capacity of the shelter, and reducing LOS by reducing overcrowding and providing alternatives to unadoptable cats (Karsten, n.d.). The C4C management program suggests that improving housing conditions is an ideal starting point when introducing the C4C program into a shelter (Karsten, n.d.). Not only can housing improvements enhance the overall welfare of cats in a shelter environment, but improved housing can subsequently lead to decreased risk of disease, which in turn, helps decrease LOS and increase adoption rates because cats remain visible to the public in adoption rooms rather than spending time out of sight in recovery rooms. The housing guidelines for cats in shelters using the C4C program include a recommendation for double compartment cages for singly housed cats (Karsten, n.d.). Having two compartments allows each cat to have its litter in a separate compartment from its food, water, and sleeping area. The creation of portals between adjacent cages for a singly housed cat also allows for fewer cats on the adoption floor at one time, creating a less overwhelming experience for adopters trying to select a cat. It is also recommended that cages provide cats with an area to perch, as well as an area to hide.

Although behaviour of the cat has been found to be an important aspect for potential adopters (Weiss et al., 2012; Dybdall and Strasser, 2014), there are several traits that can positively or negatively affect the LOS of a cat in an animal shelter and its likelihood for adoption. Traits that have been previously studied include; breed, coat colour, coat pattern (Brown and Morgan, 2014), source/entry type (Dybdall and Strasser, 2014), age (Weiss et al., 2012, Zito et al., 2015), position within adoption room, and presence of toys (Gourkow and Fraser, 2006; Fantuzzi, Miller and Weiss, 2010). Given these previous findings, these factors must be controlled for in any statistical analysis that is aimed at drawing inference about the effect of C4C on LOS.

Brown and Morgan (2014) found that younger cats were adopted sooner than older cats and Onodera, Uchida and Kakuma (2014) found that age (kitten vs. adult) was the most important factor considered by adopters when choosing a shelter cat. Therefore, it could be expected that age is positively correlated with LOS in the current study. The second most important factor considered by
adopters when choosing a shelter cat has been found to be coat colour (Onodera, Uchida and Kakuma, 2014). It has been found that black cats take the longest to adopt, followed by primarily black cats and finally by other coat colours, with black cats taking approximately 2-6 days longer to adopt than cats with other coat colours (Kogan, Schoenfeld-Tacher and Hellyer, 2013). Brown and Morgan (2014) also found that lighter coloured cats were adopted sooner than darker coloured cats. As for breeds, Brown and Morgan (2014) found that ‘exotic’ breeds had the shortest LOS, whereas there was no difference found between Domestic Short Hair (DSH), Domestic Medium Hair (DMH) or Domestic Long Hair (DLH) cats.

Another factor which has been found to affect LOS is entry type/source of cats to shelters (Dybdall and Strasser, 2014). Dybdall and Strasser (2014) found that cats labelled as ‘strays’ took approximately 23% longer to get adopted than ‘owner surrendered’ cats. Although numerous studies have focused on physical characteristics of cats (Brown and Morgan, 2014; Kogan, Schoenfeld-Tacher and Hellyer, 2013), various studies have demonstrated the importance of using enriched cage environments to improve the welfare of cats in shelters by reducing stress levels and encouraging innate feline behaviours (Gourkow and Fraser, 2006; Kry and Casey, 2007; Vince et al., 2014). Additionally, Dinnage et al. (2009), suggest utilizing foster care programs to reduce stress and risk to kittens while they await adoption, which is also one aspect of the C4C program. Research into factors that affect adoption rates, and correspondingly LOS, can be of use to shelters in order to increase the health and welfare of shelter cats. Understanding factors that affect an adopter’s choice of a cat is an important aspect that can influence a shelter’s management strategies to increase cat adoption rates and reduce LOS, yet, few studies have researched this topic.

In 2014, the Guelph Humane Society (GHS) was one of two Canadian animal shelters designated as a pilot site by the CFHS for the implementation of C4C (CFHS, 2015b). The goal of this study was to examine LOS of cats at the GHS using data collected passively by the GHS between 2011 and 2016. Survival analysis involves the examination of the time it takes for an event of interest, such
as adoption, to occur. It is routinely used in clinical trials and observational studies to compare survival times conditional on the outcome of one or more covariates which are typically called risk factors. The primary objectives of this study are to describe the LOS of cats entering the GHS sheltering system, to investigate known risk factors for the LOS of cats in shelters, such as, age, breed, coat colour, intake type, and sex and finally, to investigate the effect of the newly implemented C4C program on LOS of cats at the GHS.

3.3 MATERIALS AND METHODS

3.3.1 Description of Data

Data for this study was passively collected at the GHS between January 2011 and July 2016, as part of a routine data collection. All cat admissions, along with their outcomes, during this time period were extracted from the GHS’s data management system, i.e. PetPoint (www.petpoint.com). Data obtained from the GHS shelter records used in the current study included the animal identification number, date of admission, age, sex, neuter status, intake type, outcome, breed, coat colour, and adoption location. LOS is the amount of time it takes for an outcome to occur once an animal has been admitted to a shelter and was calculated, in days, for each cat admitted to the GHS. For the purpose of this study, “kittens” were categorized as being six months of age or younger and “adults” were those greater than six months of age on their date of admission.

3.3.2 Capacity for Care at the Guelph Humane Society

The C4C program was implemented at the GHS in August 2014. Some of the key elements that were implemented as part of the C4C program include fast-tracking cats to the adoption floor, removing tight restrictions for adoption and shortening the adoption application process (CFHS, 2015b); all elements introduced at the GHS for the C4C program are included in Table 3.1. The housing guidelines for C4C (Karsten, n.d.) were also followed, thus portals were created, connecting two pre-existing, adjacent cages, permitting cats to roam between the cages, while also allowing for separation of food and water from the litter box (CFHS, 2015b). Further details regarding the C4C case
study at the GHS are provided by the CFHS (2015b) report entitled “Capacity for Care (C4C) Case Studies”.

3.3.3 Statistical Analysis

Due to the nature of the data, a Cox Proportional-Hazard regression model (Cox, 1972), and Kaplan-Meier estimators (Kaplan and Meier, 1958) were used, as censoring occurred for cats whose exact survival time (LOS) were unknown. Censored cats were those that either remained in the shelter at the end of the study period or were transferred out of the shelter before getting adopted (for example, to another shelter), thus their time-to-adoption was unknown. Duplicates in the dataset were examined to ensure that records containing the same identification number were not clerical errors, but were actual re-entries of cats, and were kept in the dataset for analysis (N= 25). Exploratory analysis of the time-to-adoption survival data was performed using Kaplan-Meier estimators (Kaplan and Meier, 1958) as a preliminary analysis. The Kaplan-Meier estimator is commonly used as a descriptive method for comparing two treatment groups. The log-rank test was used to compare the survival distributions of each covariate individually, before adding all covariates to the model for analysis. Variables that remained significant at the 20% level of significance remained in the model. Cox Proportional-Hazard regression models (Cox, 1972) are generally used for the statistical analysis of time-to-event data in relation to covariates of interest. Therefore, Cox Proportional-Hazard modeling was used to perform statistical analyses of the LOS data in this study. Backwards selection was used to identify the best fitting model for the data. The Grambsch-Therneau test was applied to ensure that the assumption of proportional hazards was not violated; i.e., the hazard functions of two groups remain constant over time (Grambsch, 1994). DFBETAs were checked as a diagnostic tool to search for any highly influential observations in the Cox Proportional-Hazard regression model. All statistical analyses were performed using R and RStudio statistical software (R Core Team, 2016; RStudio Team, 2016). A significance level of \( \alpha=0.05 \) was maintained for all tests and confidence interval estimates.

3.4 RESULTS
There were a total of 4,089 records of cat admissions to the GHS between January 2011 and July 2016. Of these records, 1,945 records were extracted, containing only those cats who were adopted or censored, i.e. excluding cats that were either euthanized (1069), dead on arrival (531), reunited with their owners (478), died in shelter (64) and missing outcome data (2). Only complete cases (i.e., cases with no missing data) were used in the analysis, leaving 1,600 records to be analyzed. Of these 1,600 cats, 1,479 cats were adopted and 121 were censored as they were transferred out of the shelter or remained in the shelter at the end of the study. LOS ranged from 0 to 352 (see figure 3.1) days with a median of 33 days and a mean of 42 days.

All unconditional associations with the median cat LOS (i.e., the number of days until adoption), can be found in Table 3.2 for each independent variable. The median LOS decreased from 37 days to 32 once the C4C program was implemented in August 2014 ($p \leq 0.01$). The median LOS was found to be 37, 31 and 26 for domestic short hairs, domestic medium/long hairs, and exotic breeds, respectively ($p \leq 0.01$). Additionally, males were found to be adopted 7 days sooner than females ($p \leq 0.01$), and cats that were spayed/neutered prior to their admission to the GHS were also adopted 7 days sooner than intact cats ($p=0.015$). Kaplan-Meier curves for the variables breed, sex and C4C can be found in figure 3.2 (a-c).

A Cox Proportional Hazard Model was applied to assess the effect of the proposed predictor variables. The results of this model are displayed in Table 3.3, showing the significance and hazard ratios of the final model. It was found that cats were 24% more likely to be adopted after the implementation of the C4C program compared to before ($p \leq 0.001$). The variables ‘coat colour’ and ‘intake type’ remained in the model despite their lack of significance because the effect size and direction of these predictors was of interest in this study, due to prior studies that linked these variables to LOS. ‘Neuter status’ was removed from the model after checking for confounding, as it was not significant at the 5% significance level and has not been previously found to affect LOS of cats in shelters. All remaining variables were found to be significant. Adults were found to be 13% more likely
to be adopted than kittens ($p \leq 0.01$). DMH and DLH were found to be 19\% more likely to be adopted at any given time compared to DSH ($p=0.012$), while exotic breeds are 64\% more likely to get adopted than DSH ($p \leq 0.01$). It was found that male cats are approximately 20\% more likely to be adopted than female cats ($p \leq 0.001$). In summary, DSH, female, kittens prior to the C4C had the longest LOS, whereas exotic, male, adults had the shortest LOS, following the C4C.

3.5 DISCUSSION

The C4C program focuses efforts on reducing LOS and increasing adoptions, in addition to reducing the risk of disease. One of the goals of this study was to determine if the C4C program had an effect on the average LOS of cats at the GHS. It was determined that cats are 24\% more likely to be adopted after the implementation of the C4C program compared to before. In addition, the average LOS significantly decreased from 37 to 32 days, from before to after the implementation of C4C. Some of the elements of the C4C program which could be expected to result in a decreased LOS of cats include fast-tracking adoptable cats to the adoption floor, creating shorter adoption forms/fewer restrictions, the shelter-neuter-return program, the introduction of categorical pricing and adoption specials/events. Additionally, some of the key elements, including portalization of cages, improved cage enrichment and the goal to run at or below the shelter’s capacity, may have a positive influence on the welfare of cats while in the shelter. Various studies have looked at the effect of enrichment on cat stress levels and found that cats that are provided with a perch and/or a hiding place, exhibit lower stress scores than cats in standard cage environments, demonstrating the importance of using enrichment to improve the welfare of cats in a shelter environment (Gourkow and Fraser, 2006; Kry and Casey, 2007; Vince et al., 2014). Furthermore, cat behaviour has been reported to influence an adopter’s choice of cat (Weiss et al., 2012; Dybdall and Strasser, 2014), though this was not possible to analyze in the current study given the data provided.

The current study used variables which have been consistently collected at the GHS and therefore focused on physical characteristics of cats. The results of this study suggest that breed and sex
significantly affect the rate of adoption for cats at the GHS, a result that has been confirmed for other shelters by previous studies as well (Brown and Morgan, 2014; Onodera, Uchida and Kakuma, 2014). Additionally, this was the first study using survival analysis to assess the intervention effect of the C4C program, which is shown here to be associated with an increased likelihood of adoption.

In the current study, age as a predictor for LOS was dichotomized with kittens being less than 6 months old and adults being all cats greater than 6 months of age. LOS was found to be significantly different for the two age groups different. Brown and Morgan (2014) found that younger cats were adopted sooner than older cats, therefore it was hypothesized that younger cats would have a shorter LOS than adult cats. Contrary to previous findings (Brown and Morgan, 2014), the present study found that adult cats have an increased rate of adoption compared to kittens (HR=1.13). Several kittens were born in care at the GHS or were admitted within a few days of being born and were most likely required to stay in the care of the GHS or a foster home until they were old enough to be adopted. Time spent weaning is included in the LOS, which could potentially explain why adults were found to have a significantly shorter LOS than kittens at the GHS, as kittens are generally not weaned until about six or seven weeks of age (Kitten Behaviour Basics, 2016).

Similar to the results of Kogan, Schoenfeld-Tacher and Hellyer (2013), black cats were found to take an average of 6 days longer to adopt than other coat colours, although this result was not significant. Breed was found to significantly affect the LOS for cats at the GHS. The DMH and DLH cats were 19% more likely to be adopted at any given time compared to DSH cats, while exotic breeds were 64% more likely to get adopted than DSH cats. Brown and Morgan (2014) also found that ‘exotic’ breeds had the shortest LOS, however, their study found no difference between DSH, DMH or DLH cats. Kogan, Schoenfeld-Tacher and Hellyer (2013) and Brown and Morgan (2014) reported concerns of inconsistent coding of coat colour and designation of breed due to the number of different people entering data, which could not be controlled for in their analysis. Inconsistent coding could also present concerns for the current study, as it is based on historic, passively collected data, therefore
shelter staff were not given specific directions for categorizing variables.

Onodera, Uchida and Kakuma (2014) found that sex was the third most important variable for adopters when choosing a cat and more than half of the adopters preferred female cats. Conversely, the current study found that male cats were approximately 20% more likely to be adopted, and when not controlling for other variables, were adopted an average of 7 days sooner than females. In addition, cats that were intact at their time of entry into the shelter had an average LOS of 37 days compared to 30 days for cats that were already spayed/neutered upon entry into the shelter (See Table 3.2). Neuter status, however, had no significant effect on LOS of cats at the GHS and was removed from the Cox Proportional Hazard Model. It is possible that the difference in average LOS between the neutered and intact categories is due to the process of getting the intact cats neutered before they are adopted, as it is mandatory for animals to be neutered before getting adopted from the GHS. Another factor that has been previously found to affect LOS, is entry type/source of cat to the shelter. Dybdall and Strasser (2014) found that cats labelled as ‘strays’ took approximately 23% longer to get adopted than owner surrendered cats. Weiss (2012), on the other hand, found that information regarding a cat’s life prior to arriving at the shelter was the least important information to affect the adopters’ choice of cat. Although there were no significant differences found between the ‘intake types’ in the current study, strays were found to have the longest median LOS. This could be due to the fact that stray cats are more likely to be in need of medical treatment or are observed for behavioural issues, causing them to take longer to be placed on the adoption floor.

Fantuzzi, Miller and Weiss (2010) studied characteristics that influence the number of times a cat is viewed as well as the amount of time that a cat was viewed by adopters. In their study, it was found that cats at eye level, as well as cats with toys present in the cage had the greatest viewing times (Fantuzzi, Miller and Weiss, 2010). Shelters could use the results of Fantuzzi, Miller and Weiss (2010) in combination with the results of the current study in order to focus efforts and management practices to decrease the LOS of cats that are at risk of having a longer time-to-adoption (LOS) based on the
characteristics they portray. Additionally, Dinnage et al. (2009), suggest utilizing foster care programs to reduce stress and risk to kittens while they await adoption.

There are some study limitations which should be noted regarding the current study. Firstly, there is potential that a portion of records which were excluded from analysis should have been included as censored data. For example, if a cat was available for adoption but died of natural causes while in the shelter, or if a cat was available for adoption but was subsequently euthanized due health issues which developed while in the shelter. Unfortunately, given the data provided, it was not possible to determine whether cats that died or were euthanized were ever available for adoption to the public and should have been considered censored individuals. On further examination of the LOS of these particular categories of cats, it is not likely that the majority of these cats were available for adoption. More specifically, the mean LOS of euthanized cats was 8 days (median = 6, range = 0-175), while the mean LOS of cats that died in shelter was 10 days (median = 6.5, range = 0-47). Nonetheless, there is some potential bias on survival time if cats that should have been considered censored were excluded from the analysis. A closer review of cats that were placed in the barn cat program revealed that the mean LOS of this group of cats was 48 days, with a median of 27 and a range of 9 to 211 days. While this program is highly valuable, as it provides homes for cats which would have otherwise been euthanized, there is potential for improvement. This program was created to provide homes for stray cats which do not have the temperament to be adopted into a typical home, hence, it would be advantageous to move these cats through the shelter faster, not only reducing their LOS but also providing space for cats that have more potential to be adopted.

This study was the first to examine the effects of the C4C program on the LOS of cats, using long term data. The results supported the intended benefits of the C4C program on LOS, as it not only led to a significant decrease in the median LOS of cats, but was also found to be associated with cats being 24% more likely to be adopted from the GHS, compared to prior to the C4C. This is the first study, to best of the authors’ knowledge, to use survival analysis to study the time-to-adoption of
shelter cats using several physical characteristics as covariates. Although the findings of the current study are specific to the GHS animal shelter and thus may not be generalized to other shelters, it is possible that the results of the current study may apply to shelters with similar characteristics as the GHS. This study provides a good foundation for the GHS to examine their current adoption strategies and how to decrease the LOS of cats at risk for a longer time-to-adoption based on the covariates examined. Additionally, the results of this study provide support for the C4C program, and encourage further examination of this program using long-term data from shelters who have also implemented the C4C program.

3.6 ACKNOWLEDGEMENTS

This research was supported through an MSc Scholarship from the Ontario Veterinary College and funds from the OVC Pet Trust Foundation.

3.7 REFERENCES


Dybdall, K. and Strasser, R. (2014). Is There a Bias Against Stray Cats in Shelters? People’s


Table 3.1: Overview of Key Elements that were Implemented During Capacity for Care Case Study at the Guelph Humane Society in August 2014. Data compiled from the Canadian Federation of Humane Societies (2015b).

<table>
<thead>
<tr>
<th>Elements Implemented</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Portalization” of Cages</td>
<td>Portals are created between adjacent cages, creating double compartment cage. Allows cats to chose where to spend their time, creates a separation of food and water from litter box, and minimizes disruptions while cleaning.</td>
</tr>
<tr>
<td>Scheduled Intake</td>
<td>Appointment-based relinquishment is used to help ensure that a shelter does not go over capacity, permitting cats to have adequate space while they await an outcome. It also provides an opportunity to discuss alternatives to relinquishments or acquire information about a cat’s medical history.</td>
</tr>
<tr>
<td>Fast-Tracking Adoptable Cats</td>
<td>Fast-tracking the most adoptable cats (for example, juveniles), decreasing the stray-hold period and providing earlier health examinations and vaccinations.</td>
</tr>
<tr>
<td>Shorter Adoption Forms/Fewer Restrictions</td>
<td>Fewer adoption restrictions, including shortening the application process to encourage a prompt adoption process.</td>
</tr>
<tr>
<td>Barn Cat Program</td>
<td>Rehomes cats that are not adoptable through the shelter system and places them in with families looking for a ‘barn cat’. These cats are spayed/neutered before being placed, ensuring that they do not contribute to the growing cat population.</td>
</tr>
<tr>
<td>Shelter-Neuter-Return</td>
<td>Healthy feral cats that are unadoptable through the shelter system are spayed/neutered and vaccinated, then returned to their home location. If it is not possible to place them in their home location then they are rehomed through the Barn Cat Program.</td>
</tr>
<tr>
<td>Categorical Pricing</td>
<td>Implementation of categorical pricing to promote the adoption of cats that are considered to be ‘less desirable’.</td>
</tr>
<tr>
<td>Adoption Specials/Events</td>
<td>Holding adoption events or specials to prevent the inventory of cats from exceeding the shelter’s capacity, especially if there are cats waiting to be relinquished.</td>
</tr>
<tr>
<td>Cage Enrichments (e.g. curtains, elevated beds)</td>
<td>Increasing cat welfare while in the shelter through improved cage enrichment by incorporating cat toys, elevated beds, cat curtains, etc.</td>
</tr>
<tr>
<td>Aim to Run At or Below Shelter Capacity</td>
<td>Ensuring that management, staff and volunteers are committed to ensuring that the shelter remains at or below capacity at all times. This could involve changes in shelter policies.</td>
</tr>
<tr>
<td>Name of Variable</td>
<td>Categories</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>C4C</td>
<td>Before C4C (Referent)</td>
</tr>
<tr>
<td></td>
<td>After C4C</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Kitten (Referent)</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
<tr>
<td>Breed</td>
<td>Domestic Shorthair (Referent)</td>
</tr>
<tr>
<td></td>
<td>Domestic Medium &amp; Long Hair</td>
</tr>
<tr>
<td></td>
<td>Exotic</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
<tr>
<td>Coat Colour</td>
<td>Black (Referent)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Female (Referent)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
<tr>
<td>Intake Type</td>
<td>Owner Surrendered (Referent)</td>
</tr>
<tr>
<td></td>
<td>Stray</td>
</tr>
<tr>
<td></td>
<td>Other (Returned, Seized, Transferred in)</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
<tr>
<td>Neuter Status</td>
<td>Intact (Referent)</td>
</tr>
<tr>
<td></td>
<td>Neutered/Spayed</td>
</tr>
<tr>
<td><strong>Log-Rank Test</strong></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.2: Cox Proportional Hazard Model with LOS as outcome.

<table>
<thead>
<tr>
<th>Name of Variable</th>
<th>Categories</th>
<th>Exp (Coef)</th>
<th>SE (Coef)</th>
<th>Lower .95</th>
<th>Upper .95</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4C</td>
<td>Before C4C (Referent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>After C4C</td>
<td>1.2361</td>
<td>0.05811</td>
<td>1.1030</td>
<td>1.385</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Age</td>
<td>Kitten (Referent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>1.1292</td>
<td>0.05404</td>
<td>1.0157</td>
<td>1.255</td>
<td>0.024*</td>
</tr>
<tr>
<td>Breed</td>
<td>Domestic Shorthair (Referent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic Medium &amp; Long Hair</td>
<td>1.1940</td>
<td>0.07095</td>
<td>1.0390</td>
<td>1.372</td>
<td>0.012*</td>
</tr>
<tr>
<td></td>
<td>Exotic</td>
<td>1.6368</td>
<td>0.18886</td>
<td>1.1304</td>
<td>2.370</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Coat Colour</td>
<td>Black (Referent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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Figure 3.1: Frequency of Length of Stay (LOS) of cats in days at the Guelph Humane Society, 2011-2016
Figure 3.2 Kaplan-Meier Curve of (a) Males versus Females (b) DSH, DMH/DLH and Exotic Breeds and (c) before and after C4C program
4.1 DISCUSSION, LIMITATIONS AND CONCLUSIONS

In recent years, cat overpopulation has been reviewed progressively by various stakeholders throughout numerous countries. Reports in both the United States and Canada have revealed a decrease in dog admissions while cat admissions continue to rise (Lord et al., 2006; Morris et al., 2011; 2014), and twice as many cats have been admitted to shelters than dogs (CFHS, 2012). Between 2012 and 2014, the Canadian Federation of Humane Societies (CFHS) (2015a) found that the number of healthy animals being euthanized has been increasing. On average, approximately 40% of cats that enter shelters are euthanized in the United States (Pet Statistics, 2016), while 27% are euthanized in Canada (CFHS, 2012); emphasizing the importance of developing management strategies for shelters to reduce the number of animals being euthanized. In recent years, the Capacity for Care (C4C) program has been developed and implemented in order to improve the movement of cats through the shelter system and help encourage positive outcomes for these cats.

Chapter 1 of this thesis described current issues around cat overpopulation, including; concerns for the welfare of the cats themselves, the distress that outdoor cats can cause to wildlife, and various public health issues triggered by cat overpopulation. An overview of the current literature describing recent trends in intake and outcomes of cats is provided in Chapter 1 of this thesis as well. A major focus of this thesis is the effect of the C4C program on the intake and outcome of shelter cats. Therefore, Chapter 1 describes the C4C program in detail, including the changes made to the Canadian shelters which participated the C4C case studies (i.e., the Guelph Humane Society, the PEI Humane Society and the BCSPCA Vancouver Branch) and the animal welfare outcomes associated with these changes observed at each shelter. The C4C program includes several strategies to control the flow of animals through the shelter system including: reducing intake, expanding capacity, and reducing the length of stay (LOS) (Karsten, n.d.). The C4C program is intended to increase the
adoption rate and reduce illness among shelter animals, with the fundamental goal to remain at or below the shelter’s capacity at all times, while providing healthy alternatives to unadoptable cats (CFHS, 2012). The principal goal of this thesis was to analytically assess the effects of the C4C program on cat intake and LOS, using long term data provided by the Guelph Humane Society (GHS). Past case studies examining the C4C program have only provided descriptive statistics (CFHS, 2012; CFHS, 2014) calling into need a robust statistical analysis of these data. An important aspect of the study design in this thesis was the application of modern and appropriate statistical methods relevant to the data from the GHS.

Chapter 2 of this thesis was the first to present an evaluation of the effects of the C4C program on shelter intake using data from multiple years, in addition to being the first study to use time series methods to evaluate animal shelter admissions data. In 2015, the CFHS released a report showing a 25% decrease in cat admissions from 6 months prior to the C4C program compared to 6 months after, adjusted for seasonality (CFHS, 2015b). This study demonstrated the use of data from a longer time period (Chapter 2), which provided the opportunity for more precise results compared to only using data from one year (CFHS, 2015b). The results of Chapter 2 suggest that there has been a decreasing secular trend in cat admissions to the GHS between January 2011 and December 2015, as well as a strong seasonal effect in kitten admissions that peaks over the month of July. A significant decrease in adult cat intake was found to be associated with the C4C intervention, once kittens were excluded from the analysis (Chapter 2). This suggests that the C4C program did not have a significant effect on the total cat admissions to the GHS (i.e., kittens and adults), but was associated with a significant decrease in intake of adult cats to the GHS. Further, the annual seasonal effect was no longer significant when kittens were excluded from the dataset (Chapter 2). After the C4C program was implemented, the GHS saw a 24% decrease in adult cat admissions during the study period (Chapter 2).

Limitations of the study presented in Chapter 2 relate to the use of secondary data as available from the GHS. Considering that homeless cat populations comprise several subpopulations (for
example; strays, ferals and owned, lost cats) and is not solely cats within a shelter, there is an entire population of cats for which no accurate data exists unless they have entered the animal shelter at some point during the study period. Although the impact of the C4C program on cat intake at the GHS could be measured, the available data did not allow for a measurement of the effect of the C4C program on homeless cat populations outside of the GHS. Additionally, this study investigates trends and effects of the C4C on one animal shelter, therefore, it would be beneficial for future projects to increase the sample size of shelters to corroborate the results found in the current study and generalize the findings. This study provides a good foundation for other shelters to evaluate the effects of the C4C program in their context, as well as it verifies the use of time series analysis when utilizing long term data collected by animal shelters which are likely to be autocorrelated in time.

Chapter 2 provides an assessment of the impact of the C4C program on cat admissions, and it is recognized that other effects of the C4C program on shelter cats are equally important. Euthanasia rates of cats in animal shelters in Canada varied between approximately 37% and 55% from 2007 to 2013 (CFHS, 2014) and between 36% to 74% in the United States and Australia (Marston and Bennett, 2009; Morris et al., 2011; Alberthsen et al., 2013). Results from studies looking at the trend in animal shelter outcomes reveal that there is a need for strategies that will help improve the outcomes of shelter animals (Marston and Bennett, 2009). Chapter 3 of this thesis therefore focused on the effect of the C4C program on the length of stay (LOS) (i.e., time-to-adoption) of cats at the GHS. One of the primary changes made to an animal shelter introducing C4C, is that double compartment cages are created for singly housed cats (Karsten, n.d.). Improved housing, in addition to staying within a shelter’s capacity, is expected to not only improve the welfare of the cats and reduce the risk of disease but is also expected to increase adoptions, as less crowded conditions create a less overwhelming experience for potential adopters (CFHS, 2012), reducing the risk of ‘decision paralysis’.

The aim of Chapter 3 of this thesis is to determine the effects of the C4C program on LOS of cats at the GHS, while also investigating known risk factors that affect LOS of cats in animal shelters,
using passively collected data at the GHS. Due to the nature of the data available, survival analysis was used, as cats whose LOS was unknown were censored. Specifically, censored cats were those that either remained in the shelter at the end of the study period or were transferred out of the shelter before getting adopted (i.e., to another shelter), thus their LOS was unknown. A Cox Proportional-Hazard regression model was used to investigate the effects of the covariates that were available in the data provided by the GHS, including; coat colour, breed, sex, age, and C4C (i.e. whether the cat entered the shelter before or after the C4C program started). Traits that have been previously found to be risk factors for LOS include; breed, coat colour, coat pattern (Brown and Morgan, 2014), source/entry type (Dybdall and Strasser, 2014), age (Weiss et al., 2012, Zito et al., 2015), cage position within adoption room, and presence of toys (Gourkow and Fraser, 2006; Fantuzzi, Miller and Weiss, 2010).

Length of stay at the GHS was measured in days and ranged from 0 to 352 days, with a median of 33 days and a mean of 42 days (Chapter 3). It was determined from the Cox regression model that cats were 24% more likely to be adopted after the C4C program compared to before (HR= 1.24; Chapter 3). In addition to C4C, the covariates sex, breed, and age were found to be predictors for LOS of cats at the GHS. Male cats were found to be 20% more likely to be adopted than females (HR= 1.20; Chapter 3). This result is in contrast to the findings from Japan, where Onodera, Uchida and Kakuma (2014) found that more than half of the adopters preferred females. Domestic medium hairs (DMH) and domestic long hairs (DLH) were found to be 19% more likely to be adopted at any given time compared to domestic short hairs (HR= 1.19), while exotic breeds were 64% more likely to get adopted than DSH (HR= 1.64). Brown and Morgan (2014) also found that ‘exotic’ breeds had the shortest LOS, however, their study found no difference between DSH, DMH or DLH cats.

Previous findings by Brown and Morgan (2014), found that younger cats were more likely to be adopted than older cats. Conversely, the results in Chapter 3 of this thesis found that adult cats (aged six months and older), were 13% more likely to be adopted than kittens (aged 6 months or younger; HR= 1.13). It was hypothesized that this was due to the time spent weaning kittens, as many of the
kittens admitted to the GHS were admitted within a few days of being born, or were born at the GHS. Therefore, newborn kittens would have been required to stay at the GHS until they were ready for adoption, causing an artificially longer LOS. Coat colour and intake type remained in the model despite their lack of significance (Chapter 3), as it was of interest to compare the effect size and direction to previous findings. Similar to the findings of Kogan, Schoenfeld-Tacher and Hellyer (2013), black cats were found to take an average of 6 days longer to be adopted than other coat colours, although this result was not significant (Chapter 3). Weiss (2012) found that information regarding a cat’s life prior to arriving at the shelter was the least important information to affect their choice of cat, however, Dybdall and Strasser (2014) found that cats labelled as ‘strays’ took approximately 23% longer to get adopted than owner surrendered cats. In Chapter 3, stray cats had the longest median LOS, however, ‘entry type’ was not found to be a significant risk factor for LOS at the GHS.

This study (Chapter 3), was the first to examine the effects of the C4C program on the LOS of cats, using long term data, in addition to being the first study to use survival analysis to study the time-to-adoption of shelter cats. Results of the current study, along with studies that have found similar results (Kogan, Schoenfeld-Tacher and Hellyer, 2013; Brown and Morgan, 2014; Dybdall and Strasser, 2014) should be used to focus efforts and management practices on decreasing the LOS of cats that are at risk of having a longer time-to-adoption (i.e., LOS) based on the characteristics they portray. Finally, Chapter 3 provides preliminary results which suggest that the C4C program is a risk factor associated with reduced LOS.

Future studies should focus on investigating the effects of the C4C program on LOS of shelter cats at a variety of shelters, in order to increase the generalizability of the results. The results of Chapter 3 provide an excellent foundation for the GHS to examine their current adoption strategies and examine different approaches to decrease the LOS of cats at risk for a longer time-to-adoption based on the covariates examined. In using retrospective data, the studies in this thesis were only able to analyze variables available in the GHS dataset. It is important to note the potential for other variables
to have an effect on the intake of cats into the GHS, as well as their LOS at the shelter. There could be both external and internal factors at the GHS which were not available to the studies presented here; for example, changes in management values or the opening/closing of another shelter. In conclusion, this thesis provides a foundation for future studies to evaluate the effects of the C4C program, including the use of proper methodology for the data available.

4.2 REFERENCES


