

Describing the rabies management system in an Ontario municipality: A mixed methods study of human and companion animal health outcomes

Morgann Reid

A thesis submitted to the
Faculty of Graduate and Postdoctoral Studies
in partial fulfillment of the requirements for the
Master's degree in Health Systems

Telfer School of Management
University of Ottawa

Abstract

Rabies management can be described as successful only if examined through a human health perspective. Negating companion animal health outcomes in rabies management creates systemic failures as cats and dogs are significant within our society and bridge humans and wildlife in rabies transmission. A shifting pet ownership culture has created opportunities for increased rabies risk. This thesis applied the One Health concept to the rabies management system in an Ontario municipality. The One Health concept considers that the health of humans is inherently connected to the health of companion animals and their shared environment.

A mixed methods design informed a visual conceptualization of the rabies management system. Factors influencing human and companion animal health outcomes were identified through multivariable logistic regression models. The human outcome of interest was the recommendation of rabies post-exposure prophylaxis after a potential rabies exposure by a companion animal; the companion animal outcomes were receiving a post-incident rabies vaccine, being euthanized for rabies testing and being placed under observation. Semi-structured interviews were conducted with private veterinarians to understand their perceived role in rabies management.

Rabies management is more complex than linear interactions and processes that occur to protect human health. An explicit link between the human and companion animal health outcomes was found. Companion animal species appeared as an influential factor and indicates that ownership practices differ between cats and dogs. This implies that veterinarians are not effectively leveraged as the link between public health and pet owners. Indeed, veterinarian's approach their rabies management roles based on their prioritization of the seriousness of rabies compared to the risk. Through the application of One Health thinking to the municipal rabies management system, it is clear that there is a public-private divide where mitigating human rabies exposures conflicts with the prevention of rabies in companion animals.

Table of contents

Abstract	ii
List of figures	v
List of tables	vi
Acronyms	vii
Acknowledgements	viii
1. Introduction	1
1.1 Research problem	1
1.2 Purpose.....	3
1.3 Thesis organization	3
2. Literature Review	5
2.1 Epidemiology of rabies	5
2.2 One Health	8
2.3 Rabies management: Humans and companion animals	9
2.3.1 Human health.....	11
2.3.2 Companion animal health	13
2.4 Rabies management as a complex systems problem.....	15
3. Research Questions	18
4. Methodology	20
4.1 Ethics	20
4.2 Mixed method design	20
4.3 Quantitative approach	21
4.3.1 Data collection	21
4.3.2 Data analysis	22
4.4 Qualitative approach	29
4.4.1 Design and sampling.....	29
4.4.2 Data collection	30
4.4.3 Data analysis	30
4.4.4 Role of the researcher	32
4.4.5 Validity	34
4.5 Mixed methods procedure	34
4.5.1 Merging the data: Creating a visualization	34
5. Results	35
5.1 Quantitative results	35
5.1.1 Potential human rabies exposure demographics	35
5.1.1.1 Incident animal species involved in potential human rabies exposures.....	35
5.1.1.2 Cats and dogs involved in potential human rabies exposures.....	36
5.1.2 Alive, available and found cats and dogs involved in potential human rabies exposures	41
5.1.3 Factors associated with human and companion animal health outcomes	44
5.2 Qualitative findings	53
5.2.1 Responsibilities	53
5.2.1.1 Private responsibilities	54
5.2.1.2 Public responsibilities	54
5.2.2 Conflicting roles in rabies management	54

5.2.2.1 Administering rabies vaccines	54
5.2.2.2 Reporting situations involving animal bites and potentially rabid animals	60
5.2.2.3 Communicating with clients	69
5.2.2.4 Mitigation occupational factors	71
5.3 Mixed methods approach	74
5.3.1 Overview of the rabies management system	74
5.3.2 Push-Pull Factors	75
5.3.2.1 Veterinarian: Approach to companion animal rabies management.....	75
5.3.2.2 Owner: Decision to access veterinary care as perceived by veterinarians	80
5.3.3 Describing the rabies management system	85
6. Discussion	90
6.1 Statement of principal findings	91
6.2 Rabies management, humans, companion animals and society.....	92
6.2.1 Implications for public health	94
6.2.1.1 Differences in companion animal species.....	94
6.2.1.2 Human post-exposure prophylaxis	96
6.2.1.3 Companion animal euthanasia for rabies testing	97
6.2.1.4 Companion animal observation periods.....	97
6.2.1.5 Companion animal rabies vaccination after a potential human rabies exposure incident	98
6.2.2 Implications for the veterinary profession	99
6.2.2.1 Veterinarian-public health interaction	100
6.2.2.2 Veterinarian-owner interaction	100
6.2.2.3 Occupational risks.....	103
6.3 Recommendations for the rabies management system	103
6.4 Limitations	104
6.4.1 Limitations: Quantitative	105
6.4.2 Limitations: Qualitative	105
7. Conclusion	107
8. References	109
9. Appendices	115
A. Literature review search strategy	115
B. University of Ottawa ethics certificates	116
C. Veterinarian interview guide.....	118
D. Rabies system graphic elicitation	119

List of figures

Figure 1. Ontario Ministry of Natural Resources and Forestry Wildlife rabies surveillance and control zone in southwest Ontario from December 15th, 2015- August 15, 2018.	7
Figure 2. Visualization of the mixed methods design, adapted from Creswell (2014).....	21
Figure 3. Animal species involved in potential human rabies exposure investigation in Ottawa, Ontario (n=4609) (July 6, 2009 to May 11, 2015).....	36
Figure 4. Process of filtering all potential human rabies exposures to those that involved cats and dogs that were alive, available and found.....	37
Figure 5. Cats and dogs involved in potential human rabies exposures per year (2010, 2011, 2012, 2013, 2014).	38
Figure 6. Overview of the rabies management system.	74
Figure 7. Push-pull factors that influence veterinarians approach to companion animal rabies management in Ottawa, Ontario	76
Figure 8. Push-pull factors veterinarians’ perceived influence owners’ decision to access veterinary care.....	80
Figure 9. Human and companion animal health outcomes in the rabies management system of Ottawa, Ontario.....	87
Figure 10. Human and companion animal health outcomes in the rabies management system of Ottawa, Ontario (left side).	88
Figure 11. Human and companion animal health outcomes in the rabies management system of Ottawa, Ontario (right side).	89

List of tables

Table 1. Health outcomes and explanatory variables relating to potential human rabies exposures investigations by Ottawa Public Health in Ottawa, Ontario.	27
Table 2. Completeness of potential human rabies exposure investigations involving cats and dogs in Ottawa, Ontario (July 6, 2009 to May 11, 2015).	37
Table 3. Characteristics of potential human rabies exposure investigations involving cats and dogs in Ottawa, Ontario (July 6, 2009 to May 11, 2015).	40
Table 4. Characteristics of potential human rabies exposure investigations involved alive, available and found cats and dogs in Ottawa, Ontario (July 6, 2009 to May 11, 2015).	42
Table 5. Comparing characteristics of all cats and dogs involved in potential rabies exposure investigations with cats and dogs that were alive, available and found in Ottawa, Ontario (July 6, 2009 to May 11, 2015).	43
Table 6. Unadjusted and adjusted explanatory logistic regression analysis of human post-exposure prophylaxis recommendation after potential human rabies exposure by a cat or dog, .	46
Table 7. Unadjusted and adjusted explanatory logistic regression analysis of receiving a rabies vaccination of alive, available and found cats and dogs after potential human rabies exposure, Ottawa, Ontario (July 6, 2009-May 11, 2015).	48
Table 8. Unadjusted and adjusted explanatory logistic regression analysis of euthanasia for rabies testing of alive, available and found cats or dogs after potential human rabies exposure, Ottawa, Ontario (July 6, 2009-May 11, 2015).	50
Table 9. Unadjusted and adjusted explanatory logistic regression analysis of observation period of alive, available and found cats or dogs after potential human rabies exposure, Ottawa, Ontario (July 6, 2009-May 11, 2015).	52

Acronyms

CFIA: Canadian Food Inspection Agency

HPPA: Ontario Health Protection and Promotions Act

MOHLTC: Ministry of Health and Long-Term Care

PEP: Post-exposure prophylaxis

Acknowledgements

I would first like to thank my thesis supervisors, Dr. Raywat Deonandan and Dr. Craig Kuziemsky, for their support throughout my thesis. I am deeply grateful for your guidance and for giving me the time and space to learn and pursue this area of research. Ray, thank you for belief in me and your enthusiasm for my work. Craig, thank you for the hours of discussion and reassuring me that this was the process. I have grown in ways I could not have anticipated. My sincere thanks to Drs. Agnes Grudniewicz and Anne Konkle for being on my committee and providing me with exceptional feedback.

I would like to extend my kind thanks to Conrad McCallum for your help with the ethics submission process, and to Melanie Varin, for your statistical guidance.

I would also like to express my sincere thanks to Dr. Joanne Tataryn. Joanne, I cannot begin to describe how much of an impact you have had on me professionally and personally. Not only did you open my eyes to the world of rabies management, but the opportunities you gave me to become engaged were instrumental in my development. Your enthusiasm for public health and zoonosis continually inspires me. Thank you for your mentorship.

My sincere gratitude to Dr. Blanaid Donnelly for all our discussions, academic and other, and your support throughout this process. Thank you for sharing your experiences with me and giving me the opportunity to keep learning.

My deepest appreciation and thanks to Dr. Michelle Lem. Michelle, you have profoundly altered my life in every aspect. You have helped me find my path. Thank you for introducing me to and fostering my immersion the world of One Health and Outreach, for your mentorship and support, and above all, for your friendship.

To my parents, Ken and Audrey Reid, thank you for always providing me with unconditional support and for always having confidence in me and my abilities, even when I questioned it myself. Thank you for reminding me there was a light at the end of the tunnel.

My profound appreciation, thanks and gratitude to my partner, Christopher Smith. Chris, it is because of your unrelenting support, encouragement and patience that I have been able to complete this research and grow in ways that I could not have imagined. Thank you for sharing in the wonderful and uncomfortable process of growth with me. Finally, I would like to recognize our cherished pets, Juniper and Quinn, for they convinced me of the powerful connection between human and companion animal health long before I began this thesis.

I am grateful to the veterinarians that took the time to speak with me and share their insights as well as to Community Veterinary Outreach and Ottawa Public Health for the potential human rabies exposure investigation data.

This thesis was funded in part by the Telfer School of Management Student Research Fund.

1. Introduction

1.1 Research problem

While the definition of public health may vary by institution and agency, one of the most well-regarded definitions, and the essence of which is incorporated into most public health organizations is that “public health is the art and science of preventing disease, prolonging life, and promoting health and efficiency through organized community efforts” (Graham, 2010). From an ethical perspective, however, there has been a call for the field of public health “to move beyond an exclusive preoccupation with humans” and explicitly include the health of animals when addressing public health issues (Rock & Degeling, 2015). This stems from the recognized One Health concept whereby the health of humans is inherently connected to the health of animals and their shared environment (Zinsstag, Schelling, Waltner-Toews, & Tanner, 2011). Further, the One Health approach attempts to optimize health-for-all through reduced mortality and suffering, and positively benefit the economy (Zinsstag et al., 2011). This thesis is guided by the premise that “there can be no public health without animal health and ecosystem health” (Rock & Degeling, 2015). In this thesis, I re-conceptualize a longstanding public health issue, rabies management, to consider the health of humans as well as the health of companion animals in an Ontario municipality.

Rabies is one of the oldest, most feared and fatal zoonotic diseases. Across Canada, and particularly in Ontario, there continue to be rabies cases in both wild and domestic animals each year (Canadian Food Inspection Agency, 2014a, 2018). Of concern is the increasing opportunity for rabies to spread nationally and globally due in part to increased human and animal travel and transportation, urbanization, and climate change (Cumming & Cumming, 2015; Filejski, 2016; Rock & Degeling, 2015; Tataryn & Buck, 2016). This has become a reality with the recurrence of a once eliminated strain of the virus in Ontario in November 2015 (Stevenson, Goltz, & Massé, 2016). Further, there has been increasing interest in translocating or “rescuing” dogs from northern Canadian communities and other rabies endemic regions where the status of rabies vaccination is questionable (Filejski, 2016). For example, in August 2013, a non-vaccinated

“rescued” husky puppy was rehomed from Nunavut to Calgary, Alberta where it was shortly diagnosed with rabies after exposing eighteen people (Curry et al., 2016). Similarly, in December 2014, another puppy was rescued from Nunavut and was to be rehomed in Saskatchewan but became ill in transit and was euthanized for rabies testing, as the only way to diagnose rabies is by examining the brain, the day after arriving in Saskatchewan and tested positive (Curry et al., 2016). Interjurisdictional travel has the potential to change the risk of acquiring rabies for both humans and companion animals. This is especially true for those living in and around urban centres, where the risk has traditionally been minimal due to a low rabies prevalence (Filejski, 2016).

Despite these animal cases, rabies management is regarded as highly effective because human cases are extremely rare. In reality however, considering only this narrow perspective creates the opportunity for systemic failures in the rabies management system, since it ignores companion animal health outcomes. Companion animals, specifically cats and dogs, are a significant aspect of our society and act as the bridge between humans and wildlife in rabies transmission (Rock & Degeling, 2015). To consider the health outcomes of companion animals a by-product of human health is inadequate (Rock & Degeling, 2015; Zinsstag et al., 2011). The existing literature has yet to address how the rabies management system behaves when both human and companion animal health outcomes are considered simultaneously.

This thesis is an example of the application of One Health in a Canadian municipality with low rabies prevalence. It contributes to the existing literature on the connection between human and companion animal health in rabies management. Finally, it provides insight on companion animal health outcomes, investigates the perception of the private veterinarian’s role in rabies management, and ultimately re-conceptualizes the rabies management system. This re-conceptualization suggests evidence-based public health policy modifications to ensure adequate protection and promotion of human and companion animal health.

1.2 Purpose

The purpose of this mixed methods thesis is to investigate health outcomes of both humans and companion animals related to rabies management in Ottawa, Ontario. A convergent parallel mixed methods design was used where quantitative and qualitative data were collected and analyzed separately, and the results of each approach were integrated and interpreted together. In the quantitative portion, a secondary analysis was performed on possible human rabies exposure investigation details collected by the local Public Health Unit. This analysis described the relationship between incident details and human and companion animal health outcomes. In the qualitative portion, semi-structured interviews explored veterinarians' perspectives on rabies management in companion animals in Ottawa, Ontario. The reason for collecting both quantitative and qualitative data is to develop a more comprehensive understanding of the rabies management system, and to contextualize this understanding in a systems approach. This can help inform the applicability of current public health policy and to recommend refinements that would better reflect the current system.

1.3 Thesis organization

This thesis is organized in a monograph style to address the mixed methods research questions. Following the introduction, the literature review (chapter 2) draws from the published and grey literature to identify gaps in knowledge and frame the research. The methodology section (chapter 3) describes the use of a mixed methods design that includes a quantitative and qualitative approach which leads to the creation of the visual conceptualization of the rabies management systems. The results section (chapter 4) first summarizes aspects of potential human rabies exposures recorded from the local public health unit and reports results from the multivariable analysis of the health outcomes. The results section also includes a thematic analysis of semi-structured interviews with veterinarians. The mixed methods results are then synthesized to depict the conceptualization of the rabies management system. The discussion section (chapter 5) summarizes the salient components identified in the rabies management system, contextualizes the findings within the literature and recognizes limitations in the research. Public health policy recommendations are made to reflect the addition of companion

animal health outcomes to human health outcomes in rabies management. The conclusion (chapter 6) summarizes the major findings, contributions to the field, and makes recommendations for future research.

2. Literature Review

The literature review was undertaken to understand the current rabies management system and related human and companion animal health outcomes in the province of Ontario and in a local municipality. A combination of search strategies were employed that included reviewing references in a key textbook and extracting relevant articles, searching the grey literature using government publications and websites, and searching academic databases, including MEDLINE and EMBASE. A textbook, *One Health: The theory and practice of integrated health approaches*, was searched and the references of relevant academic articles were extracted and included. Government publications and websites were manually searched related to rabies management policies including human and animal prevention and control strategies. The search strategy and terms can be found in Appendix A.

2.1 Epidemiology of Rabies

“Animals are part of the fabric of life” all around the world (Rock, Buntain, Hatfield, & Hallgrimsson, 2009). Therefore, it is not surprising that an estimated sixty percent of emerging infectious diseases in humans are transmitted from animals (Jones et al., 2008). These naturally transmissible animal to human diseases, or zoonotic diseases, can be caused by bacteria, parasites, fungi and viruses. There is an increasing opportunity for zoonotic diseases to spread nationally and globally due in part to increased human and animal travel and transportation, animal food production systems and agriculture, modification of ecosystems, urbanization, and climate change (Cumming & Cumming, 2015; Filejski, 2016; Rock & Degeling, 2015; Tataryn & Buck, 2016).

Rabies is an ancient and deadly zoonotic infection that can affect any mammal and cases have been recorded in humans, domestic and wild animals throughout history. Rabies is caused by lyssaviruses, which are several related neurotropic single-stranded RNA viruses, in the Rhabdoviridae family (Public Health Agency of Canada, 2018a). The virus is secreted in saliva and transmission almost always occurs through the bite of an infected animal. The virus travels from the muscle tissue at the location of the bite to the peripheral nerves then to the central

nervous system where it eventually spreads to the brain, causing encephalitis, and death (Public Health Agency of Canada, 2018a). There are distinct strains, or variants, of the virus that are named for the species that the virus disproportionately affects. In some cases, spill-over can occur when the rabies variant is transmitted by an infected animal reservoir to another species (Vercauteren, Ellis, Chipman, DeLiberto, & Shwiff, 2012).

In Canada, one of the first human rabies cases was reported in 1819 near Ottawa, Ontario and was attributed to a dog bite; this suggests that the rabies virus has been circulating in this geographic area for at least the past 200 years (Tabel, Corner, Webster, & Casey, 1974). Since national reporting began in 1924 there have been 25 human rabies deaths, with 23 domestically acquired cases (Public Health Agency of Canada, 2018b). The most recent case of human rabies in Canada occurred in Ontario in 2012, however, the virus was internationally acquired; the most recent domestically acquired case of human rabies occurred in Alberta in 2007 (Public Health Agency of Canada, 2018b). Despite the overall low number of human rabies deaths observed, and the success in preventing further human rabies cases, rabies in animals continues to be a public health issue (Fileski, 2016; Tataryn & Buck, 2016). Dogs were the primary animal reservoir in North America until the mid-1940s when effective canine rabies vaccination became available and the eradication of the canine rabies variant occurred in Canada (Tabel et al., 1974); since then there has been a prominent shift to wildlife rabies reservoirs that vary epidemiologically across the country. It is estimated that there are still 55,000-60,000 human rabies deaths annually in African and Asian countries primarily caused by infected dogs that transmit the canine variant (Lechenne, Miranda, & Zinsstag, 2015).

In Ontario, the most common reservoirs include bats, raccoons, skunks and foxes (Ontario Ministry of Agriculture Food and Rural Affairs, 2018). A great success in Ontario was when the raccoon rabies variant was eliminated in 2008 through enhanced surveillance, trap-vaccinate-release programs and aerial vaccine baiting (Stevenson et al., 2016). However, in December 2015, the first sign of a re-incursion of the raccoon variant into Ontario occurred when a sick raccoon tested positive in the Hamilton region of Southern Ontario after being collected by an Animal Control Officer (Stevenson et al., 2016). The Animal Control Officer confined the raccoon to an individual holding cage beside two dogs, however, the raccoon and one dog

became free and fought (Stevenson et al., 2016). Since then, the Ontario Ministry of Natural Resources and Forestry has identified 442 cases of rabies of both the raccoon and fox variants and has embarked on enhanced surveillance and control (Ontario Animal Health Network, 2018) (Figure 1).

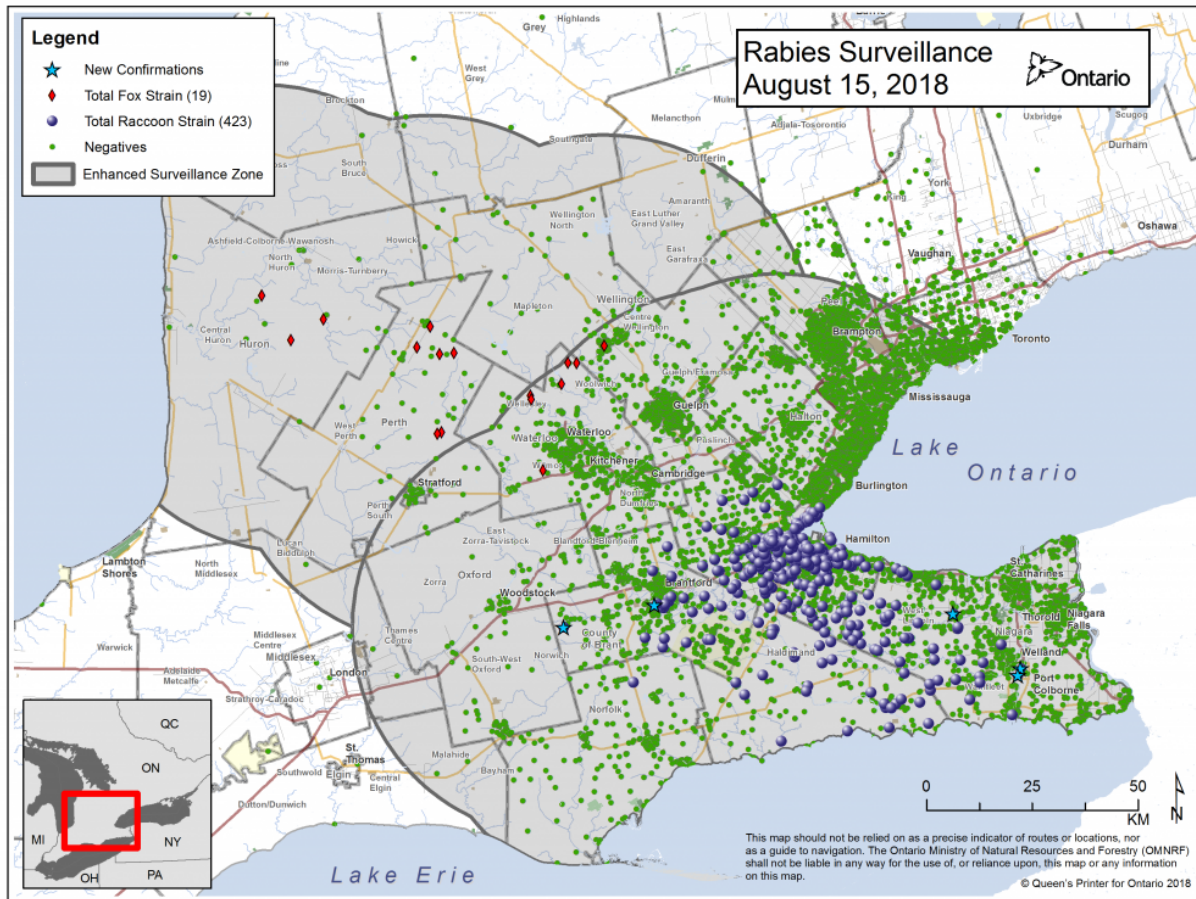


Figure 1. Ontario Ministry of Natural Resources and Forestry Wildlife rabies surveillance and control zone in southwest Ontario from December 15th, 2015- August 15, 2018.

The recent increase in the prevalence of raccoon rabies presents a significant risk for wildlife, domestic animals and humans. There is an opportunity for interactions among wildlife, and between wildlife and domestic animals. With the changes in climate and urban expansion there is a resulting expansion of habitat range for some wildlife populations (Tataryn & Buck, 2016). A core component of rabies management is continued vigilance related to domestic companion animals, specifically cats and dogs (Fileski, 2016). The most current Canadian cat and dog pet population estimates have found there to be 8.8 million cats and 7.6 million dogs (Canadian Animal Health Institute, 2017). It is unknown how many cats and dogs are involved in potential

rabies incidents across Canada each year and further, the number of cats and dogs that are submitted for rabies testing each year is not published by the Canadian Food Inspection Agency (Canadian Food Inspection Agency, 2018). As cats and dogs are the bridge between human and wildlife the health outcomes of each cannot be looked at in isolation; human health is directly tied to companion animal health because of the shared natural, social, cultural, economic and political environment (Zinsstag, Waltner-Toews, & Tanner, 2015)

2.2 One Health

“One Health” is the long-standing idea that the health of humans, animals and the environment are intimately connected. In the mid-1800s, German physician and father of modern pathology, Rudolf Virchow, recognized the similarities in infectious disease between humans and animals, and named it zoonosis (Cardiff, Ward, & Barthold, 2008). A Canadian physician, William Osler, who is also credited with being the father of modern medicine, briefly studied with Virchow and became an advocate for interdisciplinary collaboration of human and veterinary medicine (Cardiff et al., 2008). Osler went on to teach anatomy and pathology to both human medical students at McGill University Medical School as well as veterinary medical students at the Montreal Veterinary School before its closure (Asokan, 2015; Cardiff et al., 2008).

Unfortunately, the interdisciplinary medical approach Osler and others advocated for did not generate the anticipated traction, and human and veterinary medicine remained divided professions until more recently (Frank, 2008). In the 1960s, Calvin Schwabe re-conceptualized the relationship between human and veterinary medicine and became the modern advocate of One Medicine. One Medicine is the notion that there is no “difference of paradigm between human and veterinary medicine. Both sciences share, as a general medicine, a common body of knowledge in anatomy, physiology, pathology and origins of disease in all species” (Zinsstag et al., 2011). The One Medicine concept, however, emphasizes the clinical and comparative aspect of human and animal medicine, and lacks the foundational framework needed for collaboration at local, national and global levels. Therefore, One Medicine evolved to “One Health” to represent a more holistic definition of health for humans, animals and the environment.

One Health conceptual thinking can be defined as the recognition that there is added value in the “integration of human medicine and veterinary medicine and environmental sciences” that contributes to achieving the optimal health for all (Zinsstag, Waltner-Toews, et al., 2015). There is added value in the integration as opposed to isolation of the disciplines. This added value is in the form of “saved human and animal lives, reduced human and animal suffering, financial savings and improved ecosystem services” (Zinsstag, Mahamat, & Schelling, 2015). Value can also be added through policy decisions that reflect society’s norms in relation to animals and the environment. As each society has their own unique relationship with animals, particularly domesticated animals, the One Health concept includes the context or perspective of the society (Zinsstag, Waltner-Toews, et al., 2015). The inclusion of stakeholders allows for transdisciplinary real-world problem solving. One Health has gained significant acknowledgment from governments and international organizations such as the World Health Organization, World Organization for Animal Health and the Food and Agriculture Organization (Roger et al., 2016).

Problems that exist at the human-animal-environment interface have been partially addressed through One Health conceptual thinking (Vercauteren et al., 2012). Although One Health attempts to integrate disciplines and stakeholders, fragmentation still occurs between disciplines. The governance structure and process of collaboration between disciplines can impede the uptake and active use of One Health conceptual thinking through the creation of systemic barriers (Leung, Middleton, & Morrison, 2012). Systemic barriers may include lack of human resources, restricted budgets, data sharing agreements, and lack of clear success indicators (Leung et al., 2012).

2.3 Rabies Management: Humans and Companion Animals

One Health thinking has been linked with rabies management within Canada, North America, and internationally to reduce the risk of the disease for both humans and companion animals (Aenishaenslin et al., 2014; Cleaveland, Lankester, Townsend, Lembo, & Hampson, 2014). In Canada, rabies management is said to be a shared responsibility between the public, the veterinary community and government authorities at the municipal, provincial or territorial, and federal levels (Canadian Food Inspection Agency, 2014b; Tataryn & Buck, 2016). “Pet owners” have been called “most important actor in the fight against rabies” (Lechenne et al., 2015).

Furthermore, a study in Calgary, Alberta, noted the lack of applied One Health thinking at the municipal level regarding the coordinated efforts of rabies management (Rock, Rault, & Degeling, 2017).

Federally, regulations exist under the *Health of Animals Act* that requires all suspected cases of rabies be reported to the Canadian Food Inspection Agency (CFIA) (Canadian Food Inspection Agency, 2014b). The CFIA also performs rabies diagnostic tests on all human and high consequence animal samples submitted across the country. High consequence samples refer to animal specimens that are suspected of having rabies and have exposed either a human or a domestic animal through a bite or scratch (Canadian Food Inspection Agency, 2014b). In April 2014, there was a shift in role and responsibilities within CFIA that left the provinces and territories responsible for collection and sample submission as well as the management of investigations and quarantine of suspected rabid domestic animals. This is in addition to the existing responsibility of managing rabies and human health (Canadian Food Inspection Agency, 2014b). As jurisdictional legislation, policy and procedures vary across the country, so does each province and territory's rabies management protocol.

In Ontario, rabies is managed through the combined efforts of provincial and municipal government departments, and private veterinarians (Ontario Ministry of Agriculture Food and Rural Affairs, 2018). At the provincial level, the Ministry of Health and Long-Term Care (MOHLTC) is responsible for human health. The Ministry of Natural Resources and Forestry (MNR) manages rabies in wildlife by using oral rabies vaccinations on skunks, raccoons and foxes in addition to live capture, vaccinate and release methods (Middleton et al., 2014). The Ministry of Agriculture, Food and Rural Affairs (OMAFRA) supports response to domestic animal rabies incidents. Private veterinarians can contact OMAFRA for support when domestic animals have potentially been exposed to rabies from another domestic or wild animal (Ontario Ministry of Agriculture Food and Rural Affairs, 2018). Further, only veterinarians are able to administer companion animal rabies vaccinations and report a human bite or contact incident that may result in rabies. Section 134.2 of the federal *Health of Animals Act* requires that rabies vaccines are sold only to veterinarians and under this regulation, directions on immunization certification requirements are also given to veterinarians (College of Veterinarians of Ontario,

n.d.). Under the provincial *Health Protection and Promotion Act* (HPPA), requires that companion animals immunizations are administered by veterinarians (Ministry of Health and Long-Term Care, 2018c). There is a gap in research concerning the lived experiences of veterinarians in rabies management with respect to their interaction with pet owners on the prevention of rabies through vaccinations, interactions with other rabies management agencies or the way in which occupational risks are mitigated. For example, as rabies is an occupational risk to veterinarians, pre-exposure rabies vaccinations are administered to veterinarians to provide immunity to the rabies virus. In order to ensure adequate immunity, however, a serological antibody test that measures immunity, called a rabies titer, is needed. Yet, it is unknown if veterinarians ensure their rabies titer levels are adequate for protection. Overall, within the municipal Canadian context, no published literature related to veterinarian's lived experience related to rabies management could be identified.

2.3.1 Human Health

With respect to human health, the HPPA is the legislation that describes how public health programs and services are organized and delivered to prevent disease transmission and promote health in Ontario (Ministry of Health and Long-Term Care, 2018c). The MOHLTC, under the HPPA, has the legal authority to publish the Ontario Public Health Standards, which outline expectations in the delivery of mandatory and fundamental public health programs and services (Ministry of Health and Long-Term Care, 2018c). The Ontario Public Health Standards are intended for use by each of the 36 Boards of Health in Ontario. The Boards of Health operate at the municipal level as autonomous bodies or as part of regional municipal council. The Boards of the Health are responsible for approving public health policies developed by the local Medical Officer of Health and the health units and advise city councils on public health related issues. The Rabies Prevention and Control Protocol, 2018 is one of the Ontario Public Health Standards published by the MOHLTC (Ministry of Health and Long-Term Care, 2018d). The goal of the Rabies Prevention and Control Protocol, 2018 is to standardize rabies surveillance and response measures to prevent human rabies cases (Ministry of Health and Long-Term Care, 2018d). The protocol describes the minimum expectation each Board of Health must comply with in terms of rabies investigation, risk assessment, animal management, vaccine management, post-exposure

prophylaxis administration and reporting (Ministry of Health and Long-Term Care, 2018a, 2018d). For example, any potential human exposure to a rabid animal must be reported to the local health unit, who will notify the Medical Officer of Health, and begin an investigation within 24 hours to assess both the risk of the individual contracting the rabies virus, and subsequently the risk of developing the virus (Ministry of Health and Long-Term Care, 2018d). The risk assessment is presented to the exposed individual's attending physician, and it is the physician who makes the final decision about whether to administer human rabies post-exposure prophylaxis, which is a series of vaccinations that are given to prevent the spread of the virus (Ministry of Health and Long-Term Care, 2018d).

It was found that in Ontario, although there was a significant decrease in animal rabies cases since the late 1980's, the expected reduction in human rabies post-exposure prophylaxis administration has not occurred but rather has remained constant (Middleton et al., 2014). It was calculated the average rate of human rabies post-exposure prophylaxis administration was 13.9 per 100 000 persons between 2001-2012, which was the same as in the previous decade (Middleton et al., 2014). This is significant considering the conservative estimate of human rabies post-exposure prophylaxis cost, including human resources, is between \$1189 and \$1590 (Middleton et al., 2014). Middleton et al., (2014) contends the discrepancy in animal rabies rates and human rabies post-exposure prophylaxis administration is either because human rabies post-exposure prophylaxis is being administered unnecessarily and or the risk assessment guidelines do not reflect the actual risk of rabies in the area. In Ontario in 2013 exposure incidents involving dogs represented the greatest number of rabies post-exposure prophylaxis administrations while cats were the third largest cause of rabies post-exposure prophylaxis administration (Middleton, Edwin, Johnson, & Warshawsky, 2018). It has been suggested that further animal behaviour information should be collected during human rabies exposure investigations to accurately inform the risk assessment (Middleton et al., 2018). For example, the risk assessment could be altered if the exposure occurred due to a provocation whereby a dog displaced fear related aggression (Middleton et al., 2018).

2.3.2 Companion Animal Health

The HPPA addresses companion animal health for the purpose of preventing zoonotic disease transmission to humans. Dogs and cats that are vaccinated against rabies are much less likely to become rabid if exposed to an infected animal, and thus, cannot transmit the virus to a human (Ministry of Health and Long-Term Care, 2018d). An analysis of potential human rabies incidents by companion animal investigated by the Wellington-Dufferin-Guelph Public Health Unit, found that 27% of exposures involved cats while 73% involved dogs (Bottoms et al., 2014). Ontario is the only province in Canada to legislate rabies vaccination requirements; in other provinces, domestic companion animal rabies vaccinations may be required at the municipal level but is often tied to animal registration by-laws. Regulation 567 (Rabies Immunization) of the HPPA states “individuals having the care and custody of an animal are responsible for ensuring that animals in their care and custody are in compliance with applicable rabies immunization requirements” (Ministry of Health and Long-Term Care, 2018b). For example, within the municipality of Ottawa, Regulation 567 has been in effect since November 30, 1996 (City of Ottawa, 2016). Indeed, this requires that every pet owner access veterinary care, and incur the associated costs to ensure their cat or dog over three months of age is immunized against rabies.

The rabies vaccination rate of companion animals is, however, largely unknown and is difficult to ascertain but the vaccination rate of companion animals involved in human rabies exposure incidents can provide somewhat of an estimate (Bottoms et al., 2014). The most current evaluation found that only 53% of dogs and cats involved in biting incidents in 2010-2011 in the Guelph, Ontario area were vaccinated against rabies (Bottoms et al., 2014). Specifically, cats were vaccinated in 40% of incidents, 44% were unvaccinated and 16% had an unknown vaccination status (Bottoms et al., 2014). With respect to dogs, 59% were vaccinated, 27% were unvaccinated and 14% had an unknown vaccination status (Bottoms et al., 2014). No municipality-level variables were significant predictors for the vaccination status of the companion animal involved in the incident (Bottoms et al., 2014). This is consistent with the estimated companion animal rabies vaccination rates reported in 2000 in the Ottawa, Ontario region (Goodwin, Werker, Hockin, Ellis, & Roche, 2002). It is unknown if pet owners are aware

of the mandatory rabies vaccination requirement within the province. Indeed, there is a gap in the literature regarding the barriers pet owners face in accessing rabies vaccinations, and more broadly, veterinary services. Affordability has been noted to be an area of challenge in accessing veterinary care in addition to lack of proximity and transportation to a veterinary clinic, and time spent in the clinic (Coe, Adams, & Bonnett, 2008; Goodwin et al., 2002). A study in Texas found that the shift from the 1-year to 3-year rabies vaccination significantly increased the proportion of vaccinated cats and dogs even though there was worry from the veterinary community that compliance would decrease as owners would forget to bring their animal to a veterinary for revaccination (Rogers, 2011). This study did not postulate any reasons for the increase, but this is indicative that decreased overall cost for owners is related to vaccine compliance. A recent study in Germany found that the vaccination status of cats was most affected by regulatory requirements where an individual was visiting a cattery or cat show or travelling abroad and then having a detailed veterinary consultation (Gehrig et al., 2018). One way in which access to veterinary care, and subsequent rabies vaccination, has been addressed in the past is through rabies only vaccination clinics. During rabies only vaccination clinics, pet owners can bring their cat or dog to be vaccinated at no cost or at a subsidized rate. No literature related to rabies only vaccination clinics in an urban municipality could be found nor were any clinics offered within the municipality under investigation in this thesis.

Within Ontario municipalities, the local Public Health Unit manages and investigates potential human rabies exposures (Ministry of Health and Long-Term Care, 2018a). Reports of human rabies exposures can come from a variety of sources such as from the exposed individual, hospitals or clinics, police services and the city call line. The direction provided by the provincial government states that “animal rabies immunization requirements in Ontario are primarily enforced by health units conducting investigations after an animal bite to a human has been reported to public health. Only designated individuals under the Provincial Offences Act, such as public health inspectors or municipal by-law officers, can enforce provincial regulations” (Ministry of Health and Long-Term Care, 2018b). For example, under the City of Ottawa’s Animal Care and Control By-Law 2003-77, the local Medical Officer of Health can enforce requirements related to the offending animal suspected of having rabies including rabies

vaccination, 10-day observation periods as well as animal euthanasia for rabies testing (City of Ottawa, 2016).

Typically, a public health inspector, under the authority of the Medical Office of Health, will investigate the incident, coordinate and track an observation period and recommend the companion be vaccinated for rabies after the observation period if necessary (City of Ottawa, 2016). Observation periods are usually done at the pet owner's home but could be carried out at a veterinary clinic or a humane society, yet current literature could not be found describing the observation rates of cats and dogs in various municipalities or the effects of observation periods on pet owners or companion animals. In addition, the rates of rabies vaccination for companion animals received after involvement in a potential human rabies incident could not be established. Further, there have been studies related to pet owner compliance related to overall preventive animal vaccinations, but not specifically related to rabies vaccine compliance. Cat owners were found to be more likely to vaccinate their cat if the owner perceived that infectious disease were of importance (Habacher, Gruffydd-Jones, & Murray, 2010). If at any time during the course of the potential human rabies exposure investigation, including during the observation period, the offending animal appears ill or displays clinical symptoms, then the public health inspector will coordinate for the animal to be euthanized and tested for rabies as the only way to diagnosis rabies is by examining the brain (Ministry of Health and Long-Term Care, 2018a, 2018d). The number of cats and dogs submitted for rabies testing in a given municipality or in a province are not publicly available. Most recently in Ontario, there was 1 rabies positive cat and 1 rabies positive dog in 2012, and another rabies positive dog in 2013 but neither were in the Ottawa area (Canadian Food Inspection Agency, 2014a).

2.4 Rabies Management as a complex systems problem

Human and animals exist together within the natural environment through human-wildlife interactions, and within society, through human interaction with livestock and domesticated companion animals. Health problems at the human-animal-environment interface, such as rabies, can be considered part of the class of problems known as complex problems (Zinsstag et al., 2011). The problem related to rabies is that the current management system solely focuses on

human health outcomes and fails to include companion animal health outcomes. The implication is that human health is not adequately protected as a proportion of the system is not addressed. Based on the literature, it is currently unknown how the rabies management system behaves when both human and companion animal health outcomes are addressed in tandem. It has been noted that the rate of human rabies post-exposure prophylaxis administration has been higher than expected in Ontario and it remains unclear as to the reason why. Factors that are related to human rabies post-exposure prophylaxis recommendation and administration has not been investigated within a municipality or at any level within Canada. Further, there is a lack of evidence regarding rabies related companion animal health outcomes. While it is known that companion animals that are involved in a possible human rabies exposure incident may be vaccinated against rabies after the incident, placed under observation or euthanized for rabies testing, the baseline rates or influential factors for these health outcomes have not been explored in any depth.

Rabies management, as with other complex problems, have many stakeholders and no agreed upon solution (Morrison, 2013). There are multiple stakeholders from various levels of government health and wildlife departments that have a role and responsibility for rabies as well as private veterinarians. While the roles and responsibilities of government are relatively well understood through legislation, the perceived role of veterinarians in rabies management has not been an area of focus. So far, the lived experience of private veterinarians has not been linked to the health outcomes of companion animals and then by extension to human health outcomes in the rabies management system. Complex health problems require multi-faceted solutions that consider the entire system to be effective and sustainable.

One Health can be considered under the broader umbrella of systems thinking (Zinsstag et al., 2011). In the case of public health and especially zoonosis, systems thinking can help lead to effective solutions. Broadly, systems thinking is process-oriented thinking that can be used to address complex problems. There are aspects of systems that behave in complex and unpredictable ways and problems that exist within the system cannot be solved with one solution. Further, a complex problem is not the result of one cause, but rather there are multiple causes (Morrison, 2013). These causes are non-linear, cross-scales in both time and space and

can evolve (Ostrom, 2007). Complex problems and their causes occur in both natural and man-made systems; however, these systems do not operate independently but are part of the same system, called the human-environment system or the social-ecological system (McGinnis & Ostrom, 2014; Ostrom, 2007). Social-ecological systems are complex adaptive systems where social and biophysical agents interact at multiple temporal and spatial scales (Cumming & Cumming, 2015; McGinnis & Ostrom, 2014; Ostrom, 2009). Rabies management can be considered a social-ecological system and by extension, a complex adaptive system. The system is bounded by physical, social and ecological problems that have no direct or indirect relationship to rabies related human and companion animal health outcomes. The interactions and outcomes of the system are specifically related to the health of humans and companion animals as quantitative and qualitative processes (Zinsstag et al., 2011).

3. Research questions

Within the rabies management system, domestic companion animals have been largely neglected despite being the bridge between humans and wildlife in rabies transmission. Specifically, cats and dogs are at the greatest risk of contracting rabies through the bite of an infected wild animal. Humans have the greatest exposure to cats and dogs compared to other companion animals.

To develop a comprehensive and holistic understanding of the rabies management system, the following human and companion animal health outcomes were chosen to guide the research questions:

Human health outcome

1. Human post-exposure prophylaxis recommendation after a potential rabies exposure by a cat or dog

Companion animal health outcomes

2. Cat or dog vaccinated against rabies after a potential human rabies exposure
3. Cat or dog euthanized for rabies testing after a potential human rabies exposure
4. Cat or dog placed under observation after a potential human rabies exposure

These health outcomes were chosen because they are the possible occurrences when there is a potential human rabies exposure by a cat or dog. The health outcomes related to companion animals are not mutually exclusive.

Mixed methods research question:

How can the rabies management system be described with both human and companion animal health included as outcomes in Ottawa, Ontario?

Quantitative research question:

The objective is to explore the relationship between potential human rabies exposures, and human and companion animal health outcomes in Ottawa, Ontario.

The quantitative research question will be guided by the following specific questions:

1. What variables predict if an individual involved in a potential rabies exposure, by a cat or dog, will receive a post-exposure prophylaxis recommendation (PEP)?
2. What variables predict if a cat or dog, involved in a potential human rabies exposure, will be administered a rabies vaccination after the incident?
3. What variables predict if a cat or dog, involved in a potential human rabies exposure, will be euthanized for rabies testing?
4. What variables predict if a cat or dog, involved in a potential human rabies exposure, will be placed under observation?

Qualitative research question:

How do veterinarians perceive their role in companion animal rabies management in Ottawa, Ontario?

4. Methodology

4.1 Ethics

This thesis received ethical approval from the University of Ottawa Social Science and Humanities Research Ethics Board (see Appendix B). Two separate applications were approved for this study. Approval was obtained for the secondary use of data on February 13th, 2017, and the qualitative portion received approval on March 13th, 2017.

4.2 Mixed methods design

Mixed methods research is a research methodology that synthesizes both quantitative and qualitative data to answer research questions in a more in-depth manner than either methodology could accomplish alone (Creswell, 2014). The defining features of mixed methods research are that multiple methods are employed to rigorously collect and analyze both quantitative and qualitative data, and that the results are systematically integrated before being interpreted (Creswell, Klassen, Plano Clark, & Smith, 2011).

This study used a convergent parallel mixed method design to integrate then interpret quantitative and qualitative data (Figure 2). This is a form of mixed method design where both quantitative and qualitative approaches were used independently to collect and analyze data, and then subsequently the results of each approach were merged and interpreted together (Creswell, 2014). In this thesis, the results were merged through the construction of a visualization of human and companion animal health outcomes in the rabies management system (Creswell, 2014). On their own, the quantitative and qualitative approaches are informative, but were inadequate to describe with depth and breadth, the relationships and interactions that contribute to the health outcomes in the rabies management system in Ottawa, Ontario. Further, as this thesis is grounded in One Health conceptual thinking, it calls for applications from the real-world that require integrating information from various disciplines in order to contextualize the system and ultimately add value (Creswell, 2014; Rock et al., 2009; Zinsstag et al., 2011; Zinsstag, Waltner-Toews, et al., 2015). The setting of Ottawa, Ontario was selected for this thesis as it is

the Nation’s capital, is an urban area with green space but at the same time has a low rabies prevalence, and it was possible for the researcher to collect data in this area due to pre-existing relationships with various rabies management partners.

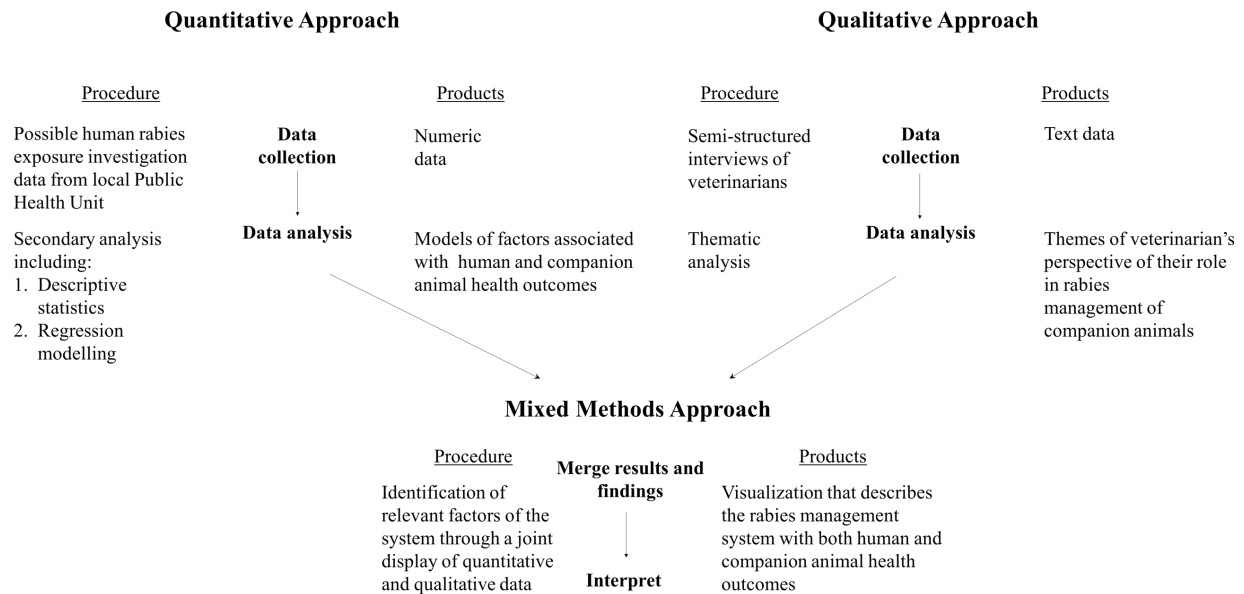


Figure 2. Visualization of the mixed methods design, adapted from Creswell (2014).

4.3 Quantitative approach

4.3.1 Data collection

Information about potential human rabies exposures that occurred in Ottawa, Ontario are investigated by the local Public Health Unit and are recorded electronically in their internal system. For this thesis, various characteristics of these investigations were extracted to a spreadsheet format. The data includes potential human rabies exposure incidents from July 6, 2009 to May 11, 2015. Only certain characteristics were of interest for this thesis (Table 1) based on the relevance in current rabies management policies as well as the availability and quality of the data (Ministry of Health and Long-Term Care, 2018a, 2018d).

4.3.2 Data analysis

A secondary analysis of potential human rabies exposures was conducted to quantify the relationship between human and companion animal health outcomes and potential human rabies exposures in Ottawa, Ontario. The analysis controlled for available demographic and behavioural factors.

In the original dataset, there were two variables pertaining to incident animal species. During the data cleaning process, both of these variables were merged to control for both sample size concerns and uncertainty in coding accuracy. A subset of the dataset was created that included only incidents in which the incident animal was a cat or a dog. The number of potential human rabies exposure incidents involving cats and dogs was plotted against years. The years 2009 and 2015 were excluded as data had not been collected for every month of those years. The quality of the dataset was assessed by looking at the completeness of each variable of interest. Responses that were “unknown” were removed from each variable in the dataset.

Several variables coding for multilevel characteristics were collapsed into dichotomous variables (Table 1). For example, in the original dataset, the variable “exposed person received a post-exposure prophylaxis recommendation” was entered as “No”, “Yes”, and “Yes, but declined.” As I was only interested in if a recommendation occurred, the “Yes” and “Yes, but declined” entries were merged. In addition, the three companion animal health outcomes of interest required that I know the outcome of the incident animal and thus, the incident animal had to be alive, available and found. A new variable was created based on the categorization of three variables: incident animal alive, incident animal available and incident animal found. The variable “Type of animal” was also modified to be dichotomous as “Household Pet” and “Other”, which encompasses companion animals that were considered stray, from the farm or wild. The “Type of exposure” includes whether the exposed person experienced a bite, scratch, saliva or mucous membrane transfer or if their skin was broken. As these are not mutually exclusive, all types of exposure remained, however, each was dichotomized as “Confirmed” or “No”, while responses that were entered as “Suspected” were removed from the analysis.

Descriptive statistics were used to summarize relevant characteristics. The characteristics can be divided into human and companion animal health outcomes, incident companion animal and exposure characteristics. A subset of the data was explored and described that consisted of only cats and dogs that were alive, available and found.

Human and companion animal health outcomes: Exposed person: Post-exposure prophylaxis recommended; Incident animal placed under observation period; Incident animal euthanasia arranged for rabies testing; Incident animal vaccinated for rabies after incident

Incident companion animal characteristics: Type of incident animal; Incident animal vaccinated prior to incident.

Exposure characteristics: Exposed person: Guardian required; Sex; Incident animal alive, available and found; Exposure provoked; Type of exposure: Bite, Saliva, Scratch, Mucous membrane, and Skin broken.

Factors associated with human and companion animal health outcomes

To identify risk factors associated with the human and companion animal health outcomes of interest, four separate multivariable logistic regression models were built. Logistic regression modelling was selected the attributes of the health outcomes were binary (yes, did occur or no, did not occur). The same overall model building process was used for each health outcome. I suspected that the incident animal species may be an effect-modifying variable and decided *a priori* to explore this interaction within each of the health outcome models. Cases with missing data were removed from the analysis. The data analysis for this thesis was generated using SAS software. Copyright © 2018 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

The following model building strategy was used:

Step 1- Univariable logistic regression analysis: Univariate analysis was used to identify potential explanatory risk factors. Each risk factor of interest was modeled against the health

outcome individually and assessed for significance ($\alpha=0.05$). Significant variables were retained for inclusion in the subsequent multivariable model, while insignificant variables were discarded.

Step 2- Multivariable logistic regression analysis: Significant risk factors from the univariable model were included in the preliminary multivariable logistic regression model. Risk factors that were not significant in the preliminary multivariable model were removed and a reduced model was built. The preliminary model and the reduced model were compared using the goodness of fit statistic and deviance and the difference was assessed for significance ($\alpha=0.05$). If the preliminary main effects model performed significantly better than the reduced model, then the excluded variables were reintroduced. If the preliminary main effects model did not perform significantly better than the reduced model, then the removed risk factors remained excluded. This process was repeated until a main effects multivariable model emerged based on which model performed significantly better.

Step 3- Effect modification: The effect modification, or interaction, between incident animal species and other risk factors in the main effects multivariable model were assessed individually. If the risk factor “incident animal species” was not included in the main effects multivariable model, then it was added to the model regardless of its significant level when the interaction was assessed. Significant interaction terms were assessed ($\alpha=0.05$). If the interaction was not significant, then the main effects multivariable model was chosen as the final multivariable model. For interactions that were significant, the goodness of fit statistic and deviance were used to compare the main effects multivariable model to the effect modification multivariable model to determine which model performed significantly better ($\alpha=0.05$). If the effect modification multivariable model performed significantly better than the main effects multivariable model, the incident animal species (cat and dog) were stratified and modeled separately. If the effect modification multivariable model did not perform significantly better than the main effects multivariable model, then the main effects multivariable model was chosen as the final multivariable model.

Step 4- Modeling incident animal species separately: Separate models were fit for incident animal species (cat and dog) using the risk factors that were included in the main effects

multivariable model. The models were not reduced further, and these were considered the final stratified multivariable models for cat and dog.

Model 1: Factors associated with human post-exposure prophylaxis recommendation

Two multivariable logistic regression models were built to explore which factors were associated with a human involved in potential rabies exposure, by a cat or dog interaction, receiving a post-exposure prophylaxis recommendation. I controlled for exposed persons' sex, whether a guardian was required, and if the incident animal was alive, available and found. Risk factors of interest were selected based on their relevance in current rabies management policies and the following were included as potential explanatory variables (Ministry of Health and Long-Term Care, 2018a, 2018d): incident animal species, type of animal, whether exposure was provoked, type of exposure (bite, saliva, scratch, mucous membrane, skin broken), whether the incident animal was vaccinated against rabies prior to the incident, and if the incident animal was placed under an observation period.

Other potential predictor variables that are mentioned in current rabies management policies, such as frequency of rabies in cats and dogs and in other animals in the geographic area, were not included in this analysis as these statistics are not currently publicly available at the municipal level. As well, as this thesis is limited to the Ottawa area, the aforementioned frequencies are assumed to be constants. In addition, information concerning the location of wound for the exposed person was excluded from the analysis as it was not possible to extract and categorize that information from the dataset due to the entry method. History of the incident animal exhibiting aggressive behaviour, as well as having been exposed to another potentially rabid animal or wildlife, were also not included because this information was not available in the dataset.

Model 2: Factors associated with a cat or dog receiving rabies vaccination after potential human rabies exposure

Two multivariable logistic regression models were built to explore what factors are associated with a cat or dog, involved in a potential human rabies exposure, receiving a rabies vaccination after the incident. I included only cats or dogs that were alive, available and found at the time of the potential human rabies exposure investigation. Risk factors of interest included: incident animal species, type of animal, provoked exposure, type of exposure (bite, saliva, scratch, mucous membrane, skin broken), incident animal vaccinated against rabies prior to incident, if the incident animal was placed under an observation period, and if the exposed person received a post-exposure prophylaxis recommendation.

Model 3: Factors associated with a cat or dog euthanasia arranged for rabies testing after potential human rabies exposure

A multivariable logistic regression model was built to identify factors that are associated with cats and dogs involved in a potential human rabies exposure having a euthanasia arranged for the purposes of direct rabies testing of the incident animal. I included only cats and dogs that were alive, available and found at the time of potential human rabies exposure investigation (since, logically, only those would be euthanized). Risk factors of interest included: incident animal species, type of animal, provoked exposure, type of exposure (bite, saliva, scratch, mucous membrane, skin broken), incident animal vaccinated against rabies prior to incident, if the incident animal was placed under an observation period, and if the exposed person received a post-exposure prophylaxis recommendation.

Model 4: Factors associated with a cat or dog being placed under observation after potential human rabies exposure

Two multivariable logistic regression models were built to identify factors that are associated with a cat or dog involved in a potential rabies exposure being placed under observation after exposure. I included only cats or dogs that were alive, available and found at the time of the

public health investigation. Risk factors of interest included: incident animal species, type of animal, provoked exposure, type of exposure (bite, saliva, scratch, mucous membrane, skin broken), incident animal vaccinated against rabies prior to incident, and if the exposed person received a post-exposure prophylaxis recommendation. One risk factor of interest, “type of exposure: mucous membrane” was excluded from the univariable analysis due to the occurrence of a zero-cell count, which renders the statistical analyses moot.

Table 1. Health outcomes and explanatory variables relating to potential human rabies exposures investigations by Ottawa Public Health in Ottawa, Ontario.

Characteristic	Description	Variable	Justification
<i>Human and companion animal health outcomes</i>			
Exposed person: Post-exposure prophylaxis (PEP) recommended	Was PEP recommended for the exposed person by the local Public Health Unit?	Dichotomous dummy (No/Yes)	PEP is recommended based on a risk assessment that considers various factors such as species of the animal, type of exposure, and circumstances of the incident (Ontario, 2013b)
Incident animal placed under observation period	Was the incident animal placed under a 10-day observation period?	Dichotomous (No/Yes)	Dogs and cats that appear healthy after being involved in a potential human rabies should be confined and observed for 10 days after the incident (Ontario, 2013b)
Incident animal euthanasia arranged for rabies testing	Was a euthanasia arranged for the incident animal to be tested for rabies?	Dichotomous (No/Yes)	The incident animal should be euthanized for rabies testing at first indication of rabies infection (Ontario, 2013b)
Incident animal vaccinated for rabies after incident	Was the incident animal vaccinated for rabies after investigation?	Dichotomous (No/Yes)	All cats and dogs are required to be vaccinated against rabies (Ontario); Unvaccinated animals that remain healthy after an observation period should be vaccinated for rabies (Ontario, 2013b)
<i>Explanatory variables</i>			
<i>Incident companion animal characteristics</i>			
Incident animal species	Recoded species of the incident animal	Dichotomous (Dog/Cat)	Controlling for differences in species of companion animal
Type of incident animal	Is the incident animal a household pet or other (stray, wild, farm)?	Dichotomous dummy (Other /Household pet)	Influences risk assessment as household pets are more likely to be vaccinated and spend less time outdoors where they could become infected with rabies; and an encounter with a potentially rabies animal is more recognizable (Ontario, 2013b)

<i>Exposure characteristics</i>			
Exposed person: Guardian required	Was the exposed person under 18 years of age and required a guardian present?	Dichotomous (No/Yes)	Children involved in a potential exposure may have difficulty recounting the event and it may be unreliable (Ontario, 2013b)
Exposed person: Sex	Recorded sex of exposed person	Dichotomous (Male/Female)	Controlling for differences in sex of exposed person
Incident animal alive, available and found	Was the incident animal alive, available and found at the time of the investigation?	Dichotomous dummy (No/Yes) based on the categorization of variables: incident animal alive, incident animal available and incident animal found	Influences risk assessment to determine if PEP is recommended (Ontario 2013b); Companion animal health outcomes are based on if the incident animal is alive, available and found
Incident animal vaccinated prior to incident	Is the incident animal up-to date with rabies vaccination at the time of the potential human rabies exposure?	Dichotomous (No/Yes)	Companion animals with up-to-date rabies vaccinations are less likely to become infected with rabies (Ontario, 2013b)
Exposure circumstance: provoked	Was the incident animal provoked when the exposure occurred?	Dichotomous (No/Yes)	The circumstances surrounding the exposure can indicate if the animal was behaving abnormally. An unprovoked exposure can indicate the animal is rabid (Ontario, 2013b)
Type of exposure: Bite	Was there a bite to the exposed person that involved penetration of the skin by teeth of incident animal?	Dichotomous dummy (No/Confirmed)	The type of exposure will influence the risk assessment to determine if PEP is recommended (Ontario, 2013b)
Type of exposure: Saliva	Was saliva from the incident animal introduced into fresh, open cuts or scratches in the skin or onto mucous membrane of the exposed person?	Dichotomous dummy (No/Confirmed)	The type of exposure will impact the risk assessment to determine if PEP is recommended (Ontario, 2013b)
Type of exposure: Scratch	Was the exposed person scratched by the incident animal?	Dichotomous dummy (No/Confirmed)	The type of exposure will impact the risk assessment to determine if PEP is recommended (Ontario, 2013b)
Type of exposure: Mucous membrane	Was the mucous membrane of the exposed person contaminated by the incident animal?	Dichotomous dummy (No/Confirmed)	The type of exposure will impact the risk assessment to determine if PEP is recommended (Ontario, 2013b)
Type of exposure: Skin broken	Was the exposed person scratched by the incident animal?	Dichotomous dummy (No/Confirmed)	The type of exposure will impact the risk assessment to determine if PEP is recommended (Ontario, 2013b)

4.4 Qualitative approach

Qualitative research refers to methodology that analyzes how a population interprets a specific phenomenon (Trochim, Donnelly, & Arora, 2014). More specifically, this research approach tries to capture a deeper understanding the *how*, *why* and *what* of a phenomenon within a specific context (Creswell, 2014). Qualitative research attempts to describe an individual's understanding and experience of a phenomenon with attention paid to the social, environmental, political and economic context of that individual's life (Trochim et al., 2014). By its very nature qualitative research is inherently interpretive as the researcher is the "key instrument" in the data collection and analysis processes of the individual's understanding and experience (Creswell, 2014). The following details the sampling, data collection and data analysis methods used in this thesis in an attempt to be transparent and trustworthy. A critical evaluation of the researcher's role including her background and experience is included.

4.4.1 Design and sampling

The qualitative component of this mixed methods thesis used semi-structured interviews to explore veterinarians' understanding of and experiences within the companion animal rabies management system in Ottawa, Ontario. A series of 12 individual semi-structured, face-to-face interviews with veterinarians practicing in companion animal clinics within Ottawa were conducted in September and October 2017. The participant sampling strategy was based on convenience sampling (Given, 2008). Veterinarians that were licensed by the College of Veterinarians of Ontario and practicing in a companion animal veterinary clinic within Ottawa were eligible. Veterinarians were recruited by the researcher through e-mail, and subsequently, snowball sampling was used where veterinarians who had participated were asked to refer other eligible veterinarians. The researcher obtained initial e-mail addresses by volunteering alongside veterinarians at veterinary clinics coordinated by Community Veterinary Outreach. Sixteen veterinarians were initially contacted, and eight interviews were conducted. Subsequently, five veterinarians were approached through snowball sampling and four of those veterinarians participated. Of the participating veterinarians, there were 9 females and 3 males. As well, three

veterinarians worked in the same veterinary clinic while two others worked in the same clinic; all other veterinarians worked in separate clinics throughout the city of Ottawa. Each veterinarian who participated was assigned an individual numeric identifier.

4.4.2 Data Collection

A semi-structured interview guide was developed prior to conducting interviews that were based on the research questions and the One Health conceptual thinking (Appendix C) (Gill, Stewart, Treasure, & Chadwick, 2008). The researcher conducted a series of predetermined but open-ended questions that explored veterinarian's understanding and experience within the rabies management system. Questions asked related to 1) their involvement in situations where rabies was suspected in companion animals 2) rabies vaccinations and 3) companion animal rabies management in Ottawa. Probing questions were asked when necessary to guide the participant. The final component of the interview involved the use of graphic elicitation, a technique that asked participants to view and comment on a researcher-prepared visualization of the rabies management system in Ottawa (Copeland & Agosto, 2012). Veterinarians were encouraged to discuss and elaborate on their reaction to the visualization including aspects that were salient, did not belong or were missing (Appendix D). This technique was a compliment to the semi-structured interview process which encouraged further rich dialogue (Copeland & Agosto, 2012). The interviews were audio recorded and transcribed verbatim by the researcher and through a transcription service, DRS Transcriptions.

4.4.3 Data Analysis

Interview transcripts were coded thematically using an inductive approach. In this approach, the coding process was data-driven as a preconceived coding frame was not used (Braun & Clarke, 2006). The resulting themes are “strongly linked to the data themselves” (Braun & Clarke, 2006) with the caveat that the researcher cannot free themselves of their experiences and theoretical biases as discussed in the role of the researcher section. As such, the following analysis steps are written in first person. Qualitative software (NVivo 11) was used to facilitate the coding process.

The six stages of thematic analysis outlined by Braun and Clarke (2006) guided the “active and reflexive” analysis process that was iterative over time. The first stage involved data familiarization; the transcripts were read multiple times and all audio files were listened to again in tandem with the transcript which also ensured transcription accuracy. During these two immersion steps, I was beginning to actively search for patterns in the data and getting a sense of the depth, breadth, and richness of the data.

In the second stage, I began to generate initial data-driven codes and create descriptions of these codes in a codebook. During this time, I coded as many different potential themes as possible and as such, there were many instances where text was coded multiple times. I also purposefully extracted all relevant text surrounding the code as to not lose the context of the coded text. I systematically coded five transcripts and then I, along with a thesis supervisor (CK), evaluated the generated codes and their descriptions. During this process, codes either remained, were renamed to better reflect the description and extracted text, were combined with other codes, or categorized as a related code or a sub-code. For example, in the initial coding process I used the code “careful” to describe veterinarian’s discussions with pet owners regarding the decision to vaccinate their animal for rabies. After evaluating the codes, the “careful” code along with the codes “believe me” and “avoid hassle” were all grouped under the same new “negotiation” code as it better described the interaction between veterinarians and owners.

After all of the initial codes were evaluated, the five transcripts were recoded and then the remaining seven transcripts were coded. Memos were created while coding that contained thoughts about potential themes, relationships between themes, and any oddities. The codes and descriptions were then evaluated again and as before, some remained, were renamed or were removed. In keeping with the same example as above, in this evaluation process the “negotiation” code was renamed “navigating clients” as it was a better descriptor for how veterinarians convey information to owners and try to maintain their trust. This was then renamed to “communicating with clients” as this was the essence of the code.

Stage three consisted of sorting the different codes, and the relevant coded data extracts, into potential theme hierarchies. This was done through iterative thematic mapping. Here, I began to notice relationships between codes and began to identify theme hierarchies.

Stage four involved two steps as recommended by Braun and Clarke (2006). In the first step, I reviewed the coded data extracts to ensure each extract fit within the theme and that overall the data extracts in the theme formed a “coherent pattern.” In some cases, data extracts did not fit well within a theme and were either removed from the theme or were recoded into a more appropriate theme. After this step, the thematic map was updated. The second step involved ensuring that the “thematic map accurately reflected the meanings evident in the data set as a whole” (Braun & Clarke, 2006). I re-read the transcripts and determined that the themes did accurately reflect the data. At that time, I coded any text that had been missed in stage two.

Stage five began by describing each theme individually, including apparent sub-themes. Multiple narratives for each of the themes were selected from the transcripts that provided “vivid examples” and evidence of the theme or sub-theme (Braun & Clarke, 2006). During this process, however, the ‘broader overall story’ needed to be considered, and in collaboration with a thesis supervisor (CK), the thematic map was reoriented (Braun & Clarke, 2006). This did not cause any modification to the description of the themes or sub-themes but rather better explained how the themes fit together. In stage six, the final thematic map and corresponding themes of the analysis were written in relation to the research question.

4.4.4 Role of the researcher

I assumed the role of “key instrument” in the data collection and analysis of the qualitative research (Braun & Clarke, 2006). In doing so, I also brought my bias and assumptions, expectations and experiences in the data collection and analysis process. I subscribe to the One Health concept that the health of humans, animals and the environment are all inherently connected. Further, I believe that if one aspect of this triad is enhanced the others will be enhanced as well. This concept first demonstrated its applicability to human and animal health through my experiences with the charity Community Veterinary Outreach. Before I began the

MSc program, and throughout my time in the program, I was a research assistant, logistics coordinator and volunteer with Community Veterinary Outreach. Community Veterinary Outreach is a registered charity that provides human health and veterinarian services to homeless and vulnerably housed individuals and their companion animals. The extent of rabies management through Community Veterinary Outreach is to provide the rabies vaccination to the companion animals. From speaking informally with veterinarians' volunteering with Community Veterinary Outreach and through inquiry into rabies policies I began to form the opinion that the rabies management system was largely neglecting companion animal health outcomes. In addition, my experience working at the Public Health Agency of Canada, through my MSc program internship, deepened my understanding of complexities associated with rabies management. I helped to update the Canadian Rabies Management Plan. I became intimately acquainted with various rabies management issues at a national level and to an extent at the provincial level. I did not have a great familiarity with rabies management in companion animals at the municipal level other than through my work with Community Veterinary Outreach.

As such, going into the interviews with veterinarians I did believe that companion animal outcomes in rabies management at the municipal level needed to be further explored and that there was a connection between human and companion animal outcomes. I assumed that veterinarians may also share the view that companion animal rabies management, and companion animal management in general, is largely neglected in this province. This could be because there is no overarching regulatory authority. I assumed that veterinarians were going to identify gaps or barriers in the system. In my analysis, I was likely overly sensitive in identifying system weaknesses compared to system strengths. I expected that the veterinarians I interviewed would have an opinion on this topic as well as other zoonotic diseases and may have an inherent interest in public health. This is because I had previously met a number of the veterinarians interviewed through Community Veterinary Outreach. Thus, my experience and involvement with the Ottawa branch of Community Veterinary Outreach cannot be ignored. It shaped what individuals I had access to for the interviews as well as my views while collecting and analyzing the data. I recognize that I have a bias in that I believe all pet owners, regardless of income, should have access to a rabies vaccine in order to protect human and companion animal health.

4.4.5 Validity

The qualitative approach allows the validity of the findings to be assessed. The data analysis process was extensively detailed and at every stage there was close collaboration with a thesis supervisor (CK). This increased the confirmability of the findings as agreement was reached that ensured that codes and descriptions accurately reflected the extracted data before the next stage of the data analysis would begin. As such, the thematic map was a product of dependable and creditable reiterations that reflected the rich and thick descriptions of the data.

4.5 Mixed Methods Procedure

4.5.1 Merging the data: Creating a visualization

The data collected and analyzed from the quantitative and qualitative approaches were merged together to describe the rabies management system with both human and companion animal health included as outcomes. This was done through a joint display of quantitative and qualitative data whereby a visualization was created that “effectively merged the data into a single visual” (Creswell, 2014). The data was merged to identify and then to describe the most relevant factors of the rabies management system. The most relevant factors could be actors within the system, the history or past experiences of those actors, interactions between actors that includes information sharing or conflicts, the governance systems in play, or the social, economical and political setting as well as associations between the factors (Ostrom, 2007; Ostrom, 2009; McGinnis & Ostrom, 2014). The properties of the visualization were drawn at a high level but are subsequently described in detail as the factors and associations can be “unpacked,” into deeper levels that provide more depth and breadth to the understanding of the system (McGinnis & Ostrom, 2014). Without merging the results, it would not be possible to understand the complexities of the rabies management system or the connections between health outcomes in rabies management and veterinarians.

5. RESULTS

As depicted in Figure 2, quantitative and qualitative approaches were used to independently collect and analyze data, and then the results of each approach were merged through a mixed methods approach. This section is separated into three components that describe the: Quantitative Results, Qualitative Findings and Mixed Methods Approach.

5.1 Quantitative results

The quantitative results first present descriptive demographics statistics on potential human rabies exposures and are followed by logistic regression models of factors associated with human and companion animal health outcomes related to potential rabies exposures.

5.1.1 Potential human rabies exposures demographics

5.1.1.1 Incident animal species involved in potential human rabies exposures

A total of 7716 potential human rabies exposures were reported to and investigated by the local Public Health Unit between July 6, 2009 to May 11, 2015. Of those, 59.73% (n=4609) included the incident animal species (Figure 3). Dogs and cats were involved in 53% of the incidents. Dogs represented the majority of incident animal species involved in potential human rabies exposure at 37.14%, while cats were involved in 16.21% of incidents. Comparatively, the most common wild animal involved in potential human rabies exposures was the bat and was reported in 3.69% incidents.

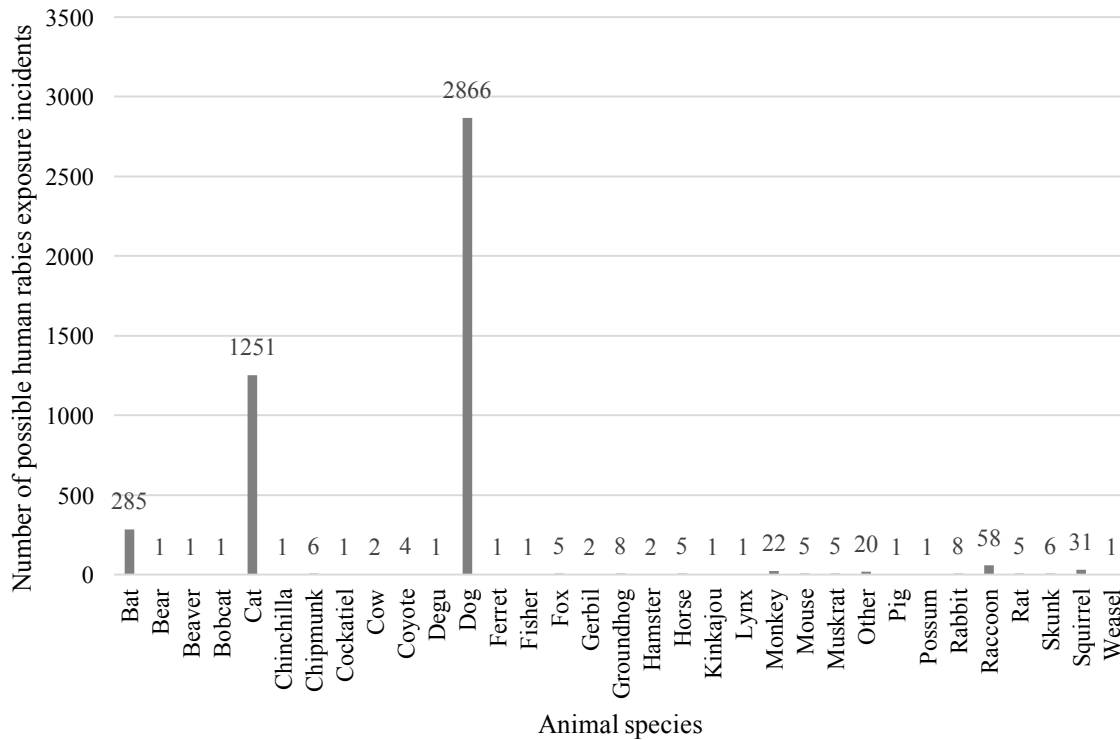


Figure 3. Animal species involved in potential human rabies exposure investigation in Ottawa, Ontario (n=4609) (July 6, 2009 to May 11, 2015).

5.1.1.2 Cats and dogs involved in potential human rabies exposures

Out of a total of 7716 potential human rabies exposures were reported to and investigated by the Public Health Unit between July 6, 2009 to May 11, 2015, approximately 60% of those incidents reported the animal species involved. Dogs and cats were confirmed to be involved in 89% of those incidents where the animal species involved was reported. Among those, almost 65% of those cats and dogs involved were alive, available and found at the beginning of the Public Health Unit’s Investigation (Figure 4).

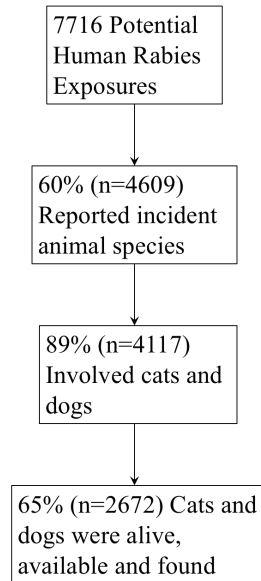


Figure 4. Process of filtering all potential human rabies exposures to those that involved cats and dogs that were alive, available and found

The quality of the data was assessed by looking at the completeness of each characteristics of interest when only cats and dogs were included in the analysis (n=4117) (Table 2). All characteristics have less than 16% of the data missing, with the exception of the “Incident animal vaccinated for rabies after incident,” which is missing almost 47% of data.

Table 2. Completeness of potential human rabies exposure investigations involving cats and dogs in Ottawa, Ontario (July 6, 2009 to May 11, 2015).

Characteristic	Cats and dogs		
	Total	Valid	Missing (%)
Exposed person: Post-exposure prophylaxis recommended	4117	3711	406 (9.86)
Incident animal place under observation period	4117	4002	115 (2.79)
Incident animal euthanasia arranged for rabies testing	4117	4002	115 (2.79)
Incident animal vaccinated for rabies after incident	4117	2207	1910 (46.39)
Exposed person: Guardian required	4117	3778	339 (8.23)
Exposed person: Sex	4117	3932	185 (4.49)
Type of incident animal	4117	3523	594 (14.43)
Incident animal alive, available and found	4117	4022	95 (2.31)
Incident animal vaccinated prior to incident	4117	3485	632 (15.35)
Exposure provoked	4117	3641	476 (11.56)
Type of exposure: Bite	4117	3745	372 (9.04)
Type of exposure: Saliva	4117	3865	252 (6.12)
Type of exposure: Scratch	4117	3892	225 (5.47)

Type of exposure: Mucous membrane	4117	3929	188 (4.57)
Type of exposure: Skin broken	4117	3775	342 (8.31)

The number of potential human rabies exposure incidents involving cats and dogs decreased overall from 2010 to 2014, although there was a slight increase in incidents from 2010 to 2012 (Figure 4). Dogs had more incidents each year than cats, and the difference over time appears funnel shaped. In 2010, dogs were involved in 1.3 times more incidents than cats and this increased every year, to 1.5 times in 2011, 2.8 times in 2012, 3.2 times in 2013 and finally, to 5.1 times in 2014. The number of incidents dogs have been involved in trended upward from 2010 to 2012 where there was a peak number of incidents. While there was a decreased in 2013, however, there was a rise again from 2013 to 2014. The number of incidents involving cats has decreased since 2010 and appears to have done so linearly since 2011.

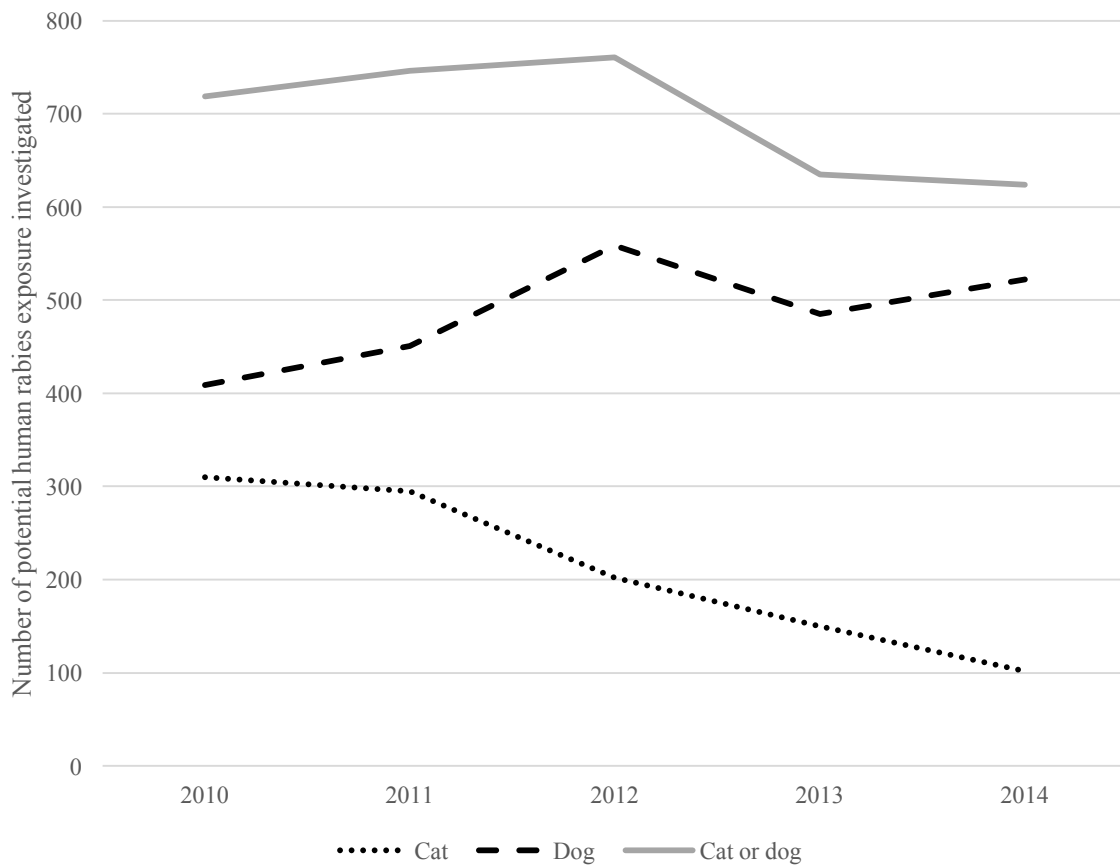


Figure 5. Cats and dogs involved in potential human rabies exposures per year (2010, 2011, 2012, 2013, 2014).

A total of 4117 potential human rabies exposures were reported in Ottawa and confirmed to be due to either a cat or dog between July 6, 2009 and May 11, 2015 (Table 3). No companion animal tested positive for rabies during the time period for which the data was extracted. Out of these exposure incidents, dogs were involved in more incidents at 69.61% (n=2866), than cats at 39.39% (n=1251). Overall, post-exposure prophylaxis was recommended to the exposed person in 12.67% of incidents, with dogs associated with a higher proportion of PEP recommendation than cats. About 66% of cats and dog were alive, available and found at the time of the exposure investigation. The majority of cats and dogs, 67.14%, were placed under an observation period with cats being placed under an observation period more often than dogs. Only 11.99% of companion animals involved in a potential human rabies incident had a euthanasia arranged for rabies testing, however, more cats had a euthanasia arranged than dogs. A greater proportion of cats than dogs, however, were classified as stray, from a farm or wild. After a potential rabies exposure incident about 32% of companion animals were vaccinated against rabies, with 39.61% of dogs being vaccinated compared to 19.02% of cats. Similarly, a higher proportion of dogs, 57%, were vaccinated against rabies prior to the exposure incident compared to 21.38% of cats. Having a guardian required, meaning that the exposed person was less than 18 years of age, was observed overall in 16.33% of incidents. Incidents involving dogs, however, required a guardian 21.18% of the time compared to 5.67% of incidents involving cats. More females than males, 72.21% compared to 27.78% respectively, were involved in incidents with cats. Comparatively, females and males were observed in almost equal proportion for incidents involving dogs. More exposures were considered provoked for cats at 84.57% compared to dog at 49.56%. Overall, bites and having skin broken during the exposure were more common than scratches or saliva and mucous membrane transfer for both cats and dogs.

Table 3. Characteristics of potential human rabies exposure investigations involving cats and dogs in Ottawa, Ontario (July 6, 2009 to May 11, 2015).

Characteristic	Total		Cat		Dog	
	N	Proportion (%)	n	Proportion (%)	n	Proportion (%)
Incident animal species	4117		1251	30.39	2866	69.61
Exposed person: Post-exposure prophylaxis recommended	3711		1146		2565	
No	3241	87.33	1056	92.15	2185	85.19
Yes	470	12.67	90	7.85	380	14.81
Incident animal place under observation period	4002		1228		2774	
No	1315	32.86	333	27.12	982	35.4
Yes	2687	67.14	895	72.88	1792	64.6
Incident animal euthanasia arranged for rabies testing	4002		1228		2774	
No	3522	88.01	945	76.95	2577	92.9
Yes	480	11.99	283	23.05	197	7.1
Incident animal vaccinated for rabies after incident	2207		778		1429	
No	1493	67.65	630	80.98	863	60.39
Yes	714	32.35	148	19.02	566	39.61
Exposed person: Guardian required	3778		1181		2597	
No	3161	83.67	1114	94.33	2047	78.82
Yes	617	16.33	67	5.67	550	21.18
Exposed person: Sex	3932		1209		2723	
Male	1672	42.52	336	27.78	1336	49.06
Female	2260	57.48	873	72.21	1387	50.94
Type of incident animal	3523		1155		2368	
Household pet	2771	78.65	574	49.7	2197	92.78
Other (stray, wild, farm)	752	21.35	581	50.3	171	7.22
Incident animal alive, available and found	4022		1233		2789	
No	1350	33.57	443	35.93	907	32.52
Yes	2672	66.43	790	64.07	1882	67.48
Incident animal vaccinated prior to incident	3485		1085		2400	
No	1885	54.09	853	78.62	1032	43
Yes	1600	45.91	232	21.38	1368	57
Exposure provoked	3641		1147		2494	
No	1435	39.41	177	15.43	1258	50.44
Yes	2206	60.59	970	84.57	1236	49.56
Type of exposure: Bite	3745		1185		2560	
No	437	11.67	275	23.21	162	6.33
Confirmed	3308	88.33	910	76.79	2398	93.67

Type of exposure: Saliva	3865		1196		2669	
No	3473	89.86	1123	93.9	2350	88.05
Confirmed	392	10.14	73	6.1	319	11.95
Type of exposure: Scratch	3892		1201		2691	
No	3270	84.02	791	65.86	2479	92.08
Confirmed	623	16.01	410	34.14	213	7.92
Type of exposure: Mucous membrane	3929		1208		2721	
No	3867	98.42	1196	99.01	2671	98.16
Confirmed	62	1.58	12	0.99	50	1.84
Type of exposure: Skin broken	3775		1183		2592	
No	817	21.64	216	18.26	601	23.19
Confirmed	2958	78.36	967	81.74	1991	76.61

5.1.2 Alive, available and found cats and dogs involved in potential human rabies exposures

There were 2672 reported incidents due to cats and dogs that were alive, available and found after a potential human rabies exposure incident between July 6, 2009 and May 11, 2015 (Table 4). About 70% were dogs, while 30% were cats. Human post-exposure prophylaxis was recommended in less than 2% of incidents involving both cats and dogs. The incident animal was placed under an observation period approximately 88% of the time. Cats had a greater proportion of euthanasia arranged for rabies testing at 6.58% compared to dogs at 2.76%. Cats were reportedly vaccinated against rabies after a potential human rabies exposure in about 27% of incidents while dogs were vaccinated 50% of the time. Again, a greater proportion of cats than dogs were classified as stray, from a farm or wild (55.61% compared to 4.70%). A guardian was required in more potential exposure incidents involving dogs than cats, 24.03% compared to 5.37% respectively. More females than males were involved in incidents involving cats at 71.58% while approximately equal proportions of males and females were involved in incidents involving dogs. Around 28% of cats had been vaccinated against rabies prior to the potential human rabies exposure incident, while approximately 71% of dogs were reportedly already vaccinated. The exposure was cited as provoked in 88.69% of incidents involving cats and in 52.22% of incidents involving dogs. Again, bites and having the skin broken were the most common type of exposures in incidents involving both cats and dogs. There were more bites reported in incidents with dogs than cats, while scratches were more commonly reported in

incidents with cats. Exposures involving the mucous membrane were the least common type of exposure for both cats and dogs.

Table 4. Characteristics of potential human rabies exposure investigations involved alive, available and found cats and dogs in Ottawa, Ontario (July 6, 2009 to May 11, 2015).

Characteristic	Total		Cat		Dog	
	N	Proportion (%)	n	Proportion (%)	n	Proportion (%)
Incident animal alive, available and found: Yes	2672		790	29.57	1882	70.43
Exposed person: Post-exposure prophylaxis recommended	2471		731		1740	
No	2429	98.30	722	98.77	1707	98.1
Yes	42	1.70	9	1.23	33	1.90
Incident animal place under observation period	2672		790		1882	
No	305	11.41	85	10.76	220	11.69
Yes	2367	88.59	705	89.24	1662	88.31
Incident animal euthanasia arranged for rabies testing	2672		790		1882	
No	2568	96.11	738	93.42	1830	97.24
Yes	104	3.89	52	6.58	52	2.76
Incident animal vaccinated for rabies after incident	1536		504		1032	
No	886	57.68	368	73.02	518	50.19
Yes	650	42.32	136	26.98	514	49.81
Exposed person: Guardian required	2480		745		1735	
No	2023	81.57	705	94.63	1318	75.97
Yes	457	18.43	40	5.37	417	24.03
Exposed person: Sex	2590		774		1816	
Male	1083	41.81	220	28.42	863	47.52
Female	1507	58.19	554	71.58	953	52.48
Type of incident animal	2424		748		1681	
Household pet	2018	83.08	416	56.61	1602	95.30
Other (stray, wild, farm)	411	16.92	332	44.39	79	4.70
Incident animal vaccinated prior to incident	2424		702		1722	
No	1005	41.46	503	71.65	502	29.15
Yes	1419	58.54	199	28.35	1220	70.85
Exposure provoked	2446		734		1712	
No	901	36.84	83	11.31	818	47.78
Yes	1545	63.16	651	88.69	894	52.22
Type of exposure: Bite	2482		756		1726	
No	284	11.44	170	22.49	114	6.60
Confirmed	2198	88.56	586	77.51	1612	93.4
Type of exposure: Saliva	2549		762		1787	

No	2270	89.05	710	93.18	1560	87.3
Confirmed	279	10.95	52	6.82	227	12.7
Type of exposure: Scratch	2563		767		1796	
No	2140	83.50	499	65.06	1641	91.37
Confirmed	423	16.50	268	34.94	155	8.63
Type of exposure: Mucous membrane	2589		769		1820	
No	2550	98.49	764	99.35	1786	98.13
Confirmed	39	1.51	5	0.65	34	1.87
Type of exposure: Skin broken	2496		754		1742	
No	552	22.12	134	17.77	418	24.00
Confirmed	1944	77.88	620	82.23	1324	76.00

Comparing the animal and exposure characteristics of all cats and dogs involved in potential rabies exposure investigations (n=4117) with the sub-category of cats and dogs that were alive, available and found (n=2672) showed many similarities (Table 5). The exceptions were that more cat and dogs that were alive, available and found were vaccinated prior to the incident. As well, more cats that were alive, available and found were household pets.

Table 5. Comparing characteristics of all cats and dogs involved in potential rabies exposure investigations with cats and dogs that were alive, available and found in Ottawa, Ontario (July 6, 2009 to May 11, 2015).

	Incident involving Cats and Dogs	Alive, available and found Cats and Dogs
Outcomes of interest	Human Post-Exposure Prophylaxis Recommended	Cat or dog: -Receiving rabies vaccination after incident -Being euthanized for rabies testing -Being placed under observation
N	4117	2672 64% cat 67% dog
Incident companion animal characteristics		
Species	30% cat 70% dog	30% cat 70% dog
Household pets	50% cat 93% dog	56% cat 95% dog
Vaccinated prior to incident	21% cat 57% dog	28% cat 71% dog
Exposure characteristics		
Exposed person: Guardian required	6% cat 21% dog	5% cat 24% dog
Exposed person: Females involved in incident	72% cat 51% dog	71% cat 52% dog

Exposure provoked	85% cat 50% dog	89% cat 52% dog
Type of exposure: Bite	77% ca 94% dog	77% cat 93% dog
Type of exposure: Saliva	6% cat 12% dog	7% cat 13% dog
Type of exposure: Scratch	34% cat 8% dog	35% cat 9% dog;
Type of exposure: Mucous membrane	<2% cat <2% dog	<2% cat <2% dog
Type of exposure: Skin broken	82% cat 77% dog	82% cat 76% dog

5.1.3 Factors associated with human and companion animal health outcomes

Model 1: Factors associated with human post-exposure prophylaxis recommendation

A multivariable logistic regression model was built to explore factors putatively associated with being involved in a potential rabies exposure incident involving a cat or dog and receiving a post-exposure prophylaxis recommendation (Table 6). I controlled for the exposed person's sex, whether a guardian was required, and the incident animal's alive, available-and-found status. Although the exposed person's sex appeared to be associated with the odds of receiving a PEP recommendation in the univariable model, it was removed in the main effects multivariable model as it did not remain a significant predictive risk factor. Having a guardian required was not significantly associated with receiving a PEP recommendation and was not included in the final multivariable model. Finally, the incident animal being alive, available and found was associated with decreased odds of receiving a PEP recommendation in the univariable model.

The suspected effect modifying factor, incident animal species, was assessed after the main effects multivariable model was built. There was a statistically significant ($p=0.04$) interaction between incident animal species and having the incident animal placed under an observation period. The effect modification model performed significantly better than the main effects model, and the model was stratified according to incident animal species ($D=4.85$, $df=1$, $p=0.027$).

The final multivariable model for cases in which the incident animal was a cat is statistically significant ($X^2= 224.60$, $df=6$, $p<0.0001$); and when assessed for goodness of fit, has strong predictive accuracy (c-statistic=0.94). Having cats that were alive, available and found for the investigation was associated with 83% lower odds of exposed persons receiving a PEP recommendation compared to cats that were not (OR=0.17, 95% Confidence Interval (CI) 0.09-0.53). Cats placed under an observation period (OR=0.06, 95% CI 0.02-0.21) as well as cats that had a euthanasia arranged for rabies testing (OR=0.02, 95% CI 0.002-0.14) significantly reduced the odds of the exposed person receiving a PEP recommendation. The odds of an exposed person receiving a PEP recommendation are 78% (OR=0.22, 95% CI 0.09-0.53) lower when cats involved were considered a household pet compared to those that were considered stray, from the farm or wild. Although both the rabies vaccination status of cats prior to the incident, and whether the exposure was provoked were associated with lower odds of receiving a PEP recommendation, these estimates were imprecise with wide confidence intervals.

The final multivariable model for cases in which dogs were the incident animal is statistically significant ($X^2= 485.09$, $df=6$, $p<0.0001$); and when assessed for goodness of fit, has strong predictive accuracy (c-statistic=0.91). Dogs that were alive, available and found were associated with 88% lower odds of exposed persons receiving a PEP recommendation compared to dogs that were not (OR=0.27, 95% CI 0.14-0.53). The odds of an exposed person receiving a PEP recommendation are 76% (OR=0.24, 95% CI 0.11-0.51) less when a dog is placed under an observation period compared to those not placed under an observation period. Dogs that had a euthanasia arranged for rabies testing (OR=0.04, 95% CI 0.01-0.19) significantly reduced the odds of the exposed person receiving a PEP recommendation. The odds of an exposed person receiving a PEP recommendation are 73% (OR=0.27, 95% CI 0.14-0.52) lower when dogs involved were considered household pets compared to dogs that are strays, from the farm or wild. Dogs that are vaccinated against rabies prior to the incident are associated with 75% lower odds of exposed person receiving a PEP recommendation compared to dogs that were not already vaccinated against rabies (OR=0.27, 95% CI 0.14-0.53). Whether the exposure was provoked appeared to be associated with reduced odds of receiving a PEP recommendation, however this estimate was imprecise.

Table 6. Unadjusted and adjusted explanatory logistic regression analysis of human post-exposure prophylaxis recommendation after potential human rabies exposure by a cat or dog,

Risk factors	Univariable Models:		Main Effects Multivariable Model:		Final Stratified Multivariable Model:			
	Unadjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]	Cat		Dog	
					Adjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]
Incident animal species	n=470		n=212		n=57		n=155	
Dog	Ref		Ref					
Cat	0.49 [0.39-0.62]		0.4 [0.24-0.66]					
Incident animal place under observation period	n=461							
No	Ref		Ref		Ref		Ref	
Yes	0.03 [0.02-0.04]		0.16 [0.09-0.30]		0.06 [0.02-0.21]		0.24 [0.11-0.51]	
Incident animal euthanized for rabies testing	n=461							
No	Ref		Ref		Ref		Ref	
Yes	0.11 [0.05-0.22]		0.03 [0.01-0.09]		0.02 [0.002-0.14]		0.04 [0.01-0.19]	
Exposed person: Guardian required	n=445							
No	Ref							
Yes	0.81 [0.61-1.08]							
Exposed person: Sex	n=463							
Male	Ref							
Female	0.68 [0.56-0.82]							
Type of incident animal	n=309							
Other (stray, wild, farm)	Ref		Ref		Ref		Ref	
Household pet	0.44 [0.34-0.56]		0.27 [0.16-0.45]		0.22 [0.09-0.53]		0.27 [0.14-0.52]	
Incident animal alive, available and found	n=470							
No	Ref		Ref		Ref		Ref	
Yes	0.03 [0.02-0.04]		0.12 [0.07-0.24]		0.17 [0.05-0.54]		0.12 [0.05-0.23]	
Incident animal vaccinated prior to incident	n=343							
No	Ref		Ref		Ref		Ref	
Yes	0.08 [0.05-0.12]		0.27 [0.16-0.46]		0.29 [0.07-1.15]		0.25 [0.142-0.45]	
Exposure provoked	n=421							
No	Ref		Ref		Ref		Ref	
Yes	0.42 [0.34-0.52]		0.63 [0.42-0.94]		0.44 [0.18-1.08]		0.70 [0.44-1.07]	
Type of exposure: Bite	n=441							
No	Ref							
Confirmed	2.41 [1.59-3.66]							
Type of exposure: Saliva	n=446							
No	Ref							
Confirmed	1.78 [1.34-2.36]							
Type of exposure: Scratch	n=450							
No	Ref							
Confirmed	0.62 [0.46-0.84]							
Type of exposure: Mucous membrane	n=455							
No	Ref							
Confirmed	2.15 [1.17-3.95]							
Type of exposure: Skin broken	n=440							
No	Ref							
Confirmed	1.15 [0.89-1.47]							

Model 2: Factors associated with a cat or dog receiving rabies vaccination after potential human rabies exposure

A multivariable logistic regression model was built to identify factors that are associated with a cat or dog, involved in a potential rabies exposure, having received a rabies vaccination after the exposure incident (Table 7). This analysis was limited to cats and dogs that were alive, available and found at the time of the potential human rabies exposure investigation. After the main effects multivariable model was built, the suspected effect modifying factor, incident animal species, was assessed. Both the interaction between incident animal species and type of incident animal ($p=0.0007$), and incident animal species and incident animal vaccinated prior to the incident ($p=0.0004$) were statistically significant. The effect modification model including the type of animal performed significantly better than the main effects model ($D= 10.52$, $df=1$, $p=0.0012$) as did the effect modification model including incident animal vaccinated prior to the incident ($D= 12.32$, $df=1$, $p=0.0004$). The main effects model was stratified by incident animal species.

The final multivariable model for cases involving cats is statistically significant ($X^2= 101.84$, $df=3$, $p<0.0001$), and when assessed for goodness of fit, has reasonable predictive accuracy (c-statistic=0.79). Cats that are considered household pets have 10.57 (95% CI 5.60-19.94) times the odds of receiving a rabies vaccination after a potential human rabies exposure incident than cats who are stray, from the farm or wild. The odds of a cat receiving a rabies vaccination after an incident are 54% (OR=0.46, 95% CI 0.23-0.92) lower for incidents where the exposed person's skin is broken. The rabies vaccination of cats prior to the incident increased the odds of cats receiving a rabies vaccination after the incident although it was imprecise with wide confidence intervals.

The final multivariable model for cases involving dogs is statistically significant ($X^2=20.83$, $df=3$, $p=0.0001$), and when assessed for goodness of fit, has limited predictive accuracy (c-statistic=0.56). Dogs involved in incidents that are reported to be household pets have 2.77 (95% CI 1.33-5.73) times the odds of receiving a rabies vaccination after the incident than dogs who are strays, from the farm or wild. Dogs that are vaccinated for rabies prior to the incident have 40% (95% CI 0.45-0.81) lower odds of receiving a rabies vaccine after the incident than those

dogs that were not previously vaccinated. If the incident results in the exposed person's skin being broken there are reduced odds of dogs receiving a rabies vaccine however, the estimate was imprecise.

Table 7. Unadjusted and adjusted explanatory logistic regression analysis of receiving a rabies vaccination of alive, available and found cats and dogs after potential human rabies exposure, Ottawa, Ontario (July 6, 2009-May 11, 2015).

Risk factors	Univariable Models:		Main Effects Multivariable Model:		Final Stratified Multivariable Model:			
	Unadjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]	Cat		Dog	
					Adjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]
Incident animal species	n=650		n=492		n=111		n=381	
Dog	Ref		Ref					
Cat	0.37 [0.30-0.47]		0.73 [0.54-0.98]					
Exposed person: Post-exposure prophylaxis recommended	n=616							
No	Ref							
Yes	0.6 [0.27-1.31]							
Incident animal place under observation period	n=650							
No	Ref							
Yes	1.34 [0.82-2.12]							
Type of incident animal	n=594							
Other (stray, wild, farm)	Ref		Ref		Ref		Ref	
Household pet	8.15 [5.48-12.11]		7.98 [4.96-12.83]		10.57 [5.60-19.94]		2.77 [1.33-5.73]	
Incident animal vaccinated prior to incident	n=642							
No	Ref		Ref		Ref		Ref	
Yes	1.51 [1.23-1.85]		0.74 [0.57-0.95]		1.53 [0.88-2.66]		0.6 [0.45-0.81]	
Exposure provoked	n=603							
No	Ref							
Yes	0.72 [0.58-0.90]							
Type of exposure: Bite	n=594							
No	Ref							
Confirmed	1.32 [0.94-1.86]							
Type of exposure: Saliva	n=618							
No	Ref							
Confirmed	0.89 [0.64-1.26]							
Type of exposure: Scratch	n=619							
No	Ref							
Confirmed	0.70 [0.53-0.93]							
Type of exposure: Mucous membrane	n=625							
No	Ref							
Confirmed	0.55 [0.21-1.43]							
Type of exposure: Skin broken	n=599							
No	Ref		Ref		Ref		Ref	
Confirmed	0.59 [0.45-0.76]		0.64 [0.46-0.88]		0.46 [0.23-0.92]		0.71 [0.49-1.03]	

Model 3: Factors associated with a cat or dog euthanasia arranged for rabies testing after potential human rabies exposure

A multivariable logistic regression model was built to explore what factors are associated with a cat or dog, involved in a potential rabies exposure, having had a euthanasia arranged for rabies testing (Table 8). This analysis was limited to cats and dogs that were alive, available and found at the time of the potential human rabies exposure investigation. Effect modification was assessed and there were no significant interactions including the incident animal species. The final multivariable model is statistically significant ($X^2=37.18$, $df=2$, $p<0.0001$), and when assessed for goodness of fit, has reasonable predictive accuracy (c-statistic=0.71), however, there is a small sample size. The odds of an incident animal having a euthanasia arranged for rabies testing after a potential human rabies exposure are 86% (OR=0.14, 95% CI 0.07-0.37) lower for cats and dogs have been vaccinated against rabies prior to the incident compare to those companion animals that have not. Cats and dogs that are placed under an observation period are associated with 80% (OR=0.20, 95% CI 0.09-0.47) lower odds of an incident animal having a euthanasia arranged for rabies testing after a potential human rabies exposure than cats and dogs that were not placed under an observation period.

Table 8. Unadjusted and adjusted explanatory logistic regression analysis of euthanasia for rabies testing of alive, available and found cats or dogs after potential human rabies exposure, Ottawa, Ontario (July 6, 2009-May 11, 2015).

Risk factors	Univariable Models:		Final Multivariable Model:	
	Unadjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]
			n=51	
Incident animal species	n=104			
Dog	Ref			
Cat	2.48	[1.63-3.68]		
Exposed person: Post-exposure prophylaxis recommended	n=96			
No	Ref			
Yes	1.24	[0.30-5.22]		
Incident animal place under observation period	n=104			
No	Ref		Ref	
Yes	0.28	[0.18-0.44]	0.20	[0.09-0.47]
Type of incident animal	n=99			
Other (stray, wild, farm)	Ref			
Household pet	0.39	[0.25-0.60]		
Incident animal vaccinated prior to incident	n=96			
No	Ref			
Yes	0.13	[0.08-0.23]	0.14	[0.07-0.37]
Exposure provoked	n=92			
No	Ref			
Yes	1.04	[0.68-1.61]		
Type of exposure: Bite	n=99			
No	Ref			
Confirmed	0.78	[0.44-1.38]		
Type of exposure: Saliva	n=101			
No	Ref			
Confirmed	0.41	[0.17-1.03]		
Type of exposure: Scratch	n=100			
No	Ref			
Confirmed	1.04	[0.61-1.77]		
Type of exposure: Mucous membrane	n=101			
No	Ref			
Confirmed	1.34	[0.32-5.63]		
Type of exposure: Skin broken	n=100			
No	Ref			
Confirmed	1.4	[0.83-2.39]		

Model 4: Factors associated with a cat or dog being placed under observation after potential human rabies exposure

A multivariable logistic regression model was built to explore factors putatively associated with a cat or dog, involved in a potential rabies exposure, having been placed under an observation period (Table 9). This analysis was limited to cats and dogs that were alive, available and found at the time of the potential human rabies exposure investigation. After the main effects multivariable model was built, the suspected effect modifying factor, incident animal species, was assessed. Two interactions were statistically significant: incident animal species and type of incident animal ($p=0.0178$), and incident animal species and the exposed person receiving PEP ($p=0.0038$) were statistically significant. The effect modification model including the type of animal performed significantly better than the main effects model ($D=7.16$, $df=2$, $p=0.03$) as did the effect modification model including PEP ($D=12.82$, $df=2$, $p=0.002$). The main effects model was stratified by incident animal species.

The cat final multivariable model is statistically significant ($X^2= 37.85$, $df=2$, $p<0.0001$), and when assessed for goodness of fit, has reasonable predictive accuracy (c-statistic=0.72). If the exposed person received a PEP recommendation (OR=0.02, 95% CI 0.003-0.13) it significantly reduced the odds of the cat being placed under an observation period. The odds of having a cat placed under an observation period are 84% (OR=0.14, 95% CI 0.06-0.45) lower for cats that are considered household pets than cats that are stray, from the farm or wild.

The dog final multivariable model is not statistically significant ($X^2= 0.1587$, $df=2$, $p=0.997$). Although both the exposed person receiving a PEP recommendation and the dog being a household pet are associated with reduced odds of the dog being placed under a quarantine period, these estimates are imprecise.

Table 9. Unadjusted and adjusted explanatory logistic regression analysis of observation period of alive, available and found cats or dogs after potential human rabies exposure, Ottawa, Ontario (July 6, 2009-May 11, 2015).

Risk factors	Univariable Models:		Main Effects Multivariable Model:		Final Stratified Multivariable Model:			
	Unadjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]	Cat		Dog	
					Adjusted odds (OR)	[95% CI]	Adjusted odds (OR)	[95% CI]
			n=1791		n=553		n=1238	
Incident animal species	n=2367							
Dog	Ref							
Cat	1.10 [0.84-1.43]							
Exposed person: Post-exposure prophylaxis recommended	n=2278							
No	Ref		Ref		Ref		Ref	
Yes	0.30 [0.14-0.64]		0.22 [0.09-0.53]		0.02 [0.003-0.13]		0.73 [0.17-3.18]	
Type of incident animal	n=2148							
Other (stray, wild, farm)	Ref		Ref		Ref		Ref	
Household pet	0.27 [0.16-0.45]		0.36 [0.18-0.73]		0.16 [0.06-0.45]		1.01 [0.36-2.86]	
Incident animal vaccinated prior to incident	n=2229							
No	Ref							
Yes	0.85 [0.63-1.15]							
Exposure provoked	n=2213							
No	Ref							
Yes	0.80 [0.60-1.06]							
Type of exposure: Bite	n=2216							
No	Ref							
Confirmed	0.60 [0.37-0.97]							
Type of exposure: Saliva	n=2265							
No	Ref							
Confirmed	0.93 [0.63-1.37]							
Type of exposure: Scratch	n=2275							
No	Ref							
Confirmed	1.73 [1.17-2.54]							
Type of exposure: Skin broken	n=2223							
No	Ref							
Confirmed	0.85 [0.62-1.17]							

5.2 Qualitative Findings

The qualitative findings begin with an overview of veterinarian's public and private responsibilities related to companion animal rabies management. The responsibilities lay the foundation for veterinarian's role in rabies management, however, the findings suggest that veterinarian's public and private responsibilities can, at times, conflict. This in turn can create conflict within veterinarian's roles in companion animal rabies management. Through the analysis, four themes emerged that captured veterinarian's role in rabies management: 1) administering rabies vaccines to companion animals, 2) reporting companion animal bites and suspect rabid companion animals, 3) communicating with clients and 4) mitigating occupational factors.

5.2.1 Responsibilities

Veterinarian's public and private responsibilities influence their roles in rabies management. As a result, veterinarians can experience conflict in their role within companion animal rabies management because there are instances where both public and private responsibilities cannot be fulfilled simultaneously. The thematic map presented in Figure 5 represents how veterinarians' public and private responsibilities lead to conflict with their role in 1) administering rabies vaccines to companion animals, 2) reporting companion animal bites and suspect rabid companion animals, 3) communicating with clients and 4) mitigating occupational factors.

5.2.1.1 Private responsibilities

Veterinarians have private responsibilities that are rooted within the confines of their practice, or said another way, within their intra-clinic practice. In relation to rabies management, findings gathered from veterinarians suggests this predominantly includes communicating with clients and mitigating occupational factors. Elements of the fee-for-service nature of their veterinary practice as well as clinical decision making for animal health also underpin their role in rabies management.

5.2.1.2 Public responsibilities

Veterinarians' public responsibilities are due to federal, provincial, municipal legislations and regulations. Their public responsibilities are in administering rabies vaccines to animals, and in the requirement to report animal to human bite or contact incidents that may result in rabies, or potentially rabid animals. These public responsibilities occur within clinical practice but also require veterinarians to interact with the other rabies management partners. These public responsibilities can be considered as inter-professional relationships with other, external rabies management partners.

5.2.2 Conflicting roles in rabies management

The following section describes the four roles veterinarians perceive to have related to their public and private rabies management responsibilities: 1) administering rabies vaccines to companion animals, 2) reporting companion animal bites and suspect rabid companion animals, 3) communicating with clients and 4) mitigating occupational factors. Within each role, sub-themes emerged that exemplify the conflict that arises from competing responsibilities. The perceived roles are underlined, and the sub-themes within each role are italicized. Quotations have been bolded for emphasis.

5.2.2.1 Administering rabies vaccines

The public responsibility of veterinarians in administering rabies vaccines is established through federal and provincial legislation and regulations. First, federal legislation prohibits the sale of rabies vaccines to anyone other than a veterinarian with exceptions for some remote communities. Secondly, provincial legislation requires that veterinarians administer rabies vaccinations. This task, however, can be delegated to competent veterinary staff within an accredited veterinary facility.

Administering rabies vaccines: Requirement for rabies vaccine

Under provincial legislation, all healthy companion animals in most areas of Ontario, including Ottawa, must be vaccinated against rabies and their vaccine status must always be kept up-to-date. Therefore, owners must have their companion animals vaccinated against rabies and veterinarians (or those working in a veterinary clinic) are the only ones who can administer the vaccine.

Veterinarians are aware rabies requirements exist for the vaccination of healthy companion animals, however, there is some uncertainty in where the requirement originated (i.e. at the municipal or provincial level). This translates into subsequent communications with owners as veterinarians do mention the requirement if necessary. Some are vague in mentioning where the requirement originated, such as in the quote described below, and may or may not stress the public health implications.

I try to be vague in some ways and I just say that it's a legal requirement for our companion animals and I remind them that we do the minimum amount of vaccinating that we feel offers them the protection that they need but it is a requirement of owning a pet in Ontario and if they say, 'well I don't want to' then we cross that bridge and like, well you can decline and that's on you, but it's my job to say that this is a requirement for you. **I don't get into the who said it was- public health says it was, public health Ottawa says it was, I just kind of say it is a requirement for pets**, for companion animals. –Veterinarian ID9

Moreover, there is discrepancy among veterinarians as to whether they believe owners are aware of any requirement. When 10 out of the 12 veterinarians were asked, 6/10 veterinarians stated they did not believe owners were aware of any requirements, 3/10 did believe that their clients were cognizant, and one reported that it was unclear if owners knew. More than one veterinarian used the legislation as a “tool” (ID8) to communicate the importance of the rabies vaccine.

Administering rabies vaccines: Enforcement of the rabies vaccine

Veterinarians largely do not perceive their role to be that of the enforcer of rabies vaccines, but rather to tell owners of the requirement. One veterinarian (ID6) explicitly tells owners: "I am not the police; I am just the facilitator." Veterinarians were of the opinion that rabies vaccination enforcement only occurred when there was a public health issue with the companion animal, such as an animal bite incident, or when proof is required to access a service, such as grooming, or for cross border travel. Veterinarians have found this creates conflict when discussing the requirement with owners as it causes owners to question the seriousness of the virus and risk in this area as emphasized in the quote below.

They should be vaccinated against rabies and if they decline or ask questions we simply let them know that **we are not responsible for enforcing government regulation**. If they want to live in Ontario and they have a pet, they are required to a rabies vaccine. If they decline to break that rule, we're not going to say anything. That is not our job... **Because it's not enforced I think a lot of people don't take it seriously**. People don't take it seriously, it's not enforced, and they're never exposed to cases of rabies, so they couldn't say, "Oh, shoot. Maybe we should take this." -Veterinarian ID12

Administering rabies vaccines: Necessity of the rabies vaccine

Although veterinarians state the legislative requirement of the vaccine and may mention the public health aspect, there are variations in the degree to which veterinarians view the rabies vaccine as a necessity for the animal's health. Veterinarians in this area are not exposed to cases of companion animal rabies but regularly deal with other infectious canine diseases, like parvovirus. As a result, as one veterinarian notes below, this may lead to difficulties for veterinarians understanding the risks themselves and communicating that risk to owners:

I think more veterinarians need to know or struggle with talking about why, the risks, the exposures, the epidemiology, what's the risk in this area and knowing that for wherever they practice, and say, "This is why I'm telling you that this is required, and

this is what you should know about your own exposure." And that kind of information I think is more salient to veterinarians and maybe something they struggle with a little bit more... -Veterinarian ID7

Veterinarians differed when asked about rabies only vaccination clinics. Veterinarians did recognize the public health role of rabies only vaccination clinics. As the quotation below highlights however, the struggle associated with not providing additional medical care during those clinics and knowing that the majority of the owners were not going to seek further medical care was also acknowledged. Overall, veterinarians did voice that the rabies vaccine was probably better than nothing at all.

We end up often seeing animals who don't otherwise visit veterinary clinics and **that presents a bit of a challenge to the veterinarian because you'd like to do a real thorough exam and you may notice something that needs further work up and your hands are tied there.** They're just there for the low-cost rabies vaccination. So, there's that concern from the veterinarian's point of view. At the same time, I guess, if **we're protecting you know a broader range of animals from being exposed to rabies then that's a benefit too. So, I guess I see pros and cons.** -Veterinarian ID4

Finally, from an animal health perspective, veterinarians' question if rabies vaccinations are appropriate for all animals. This was particularly true of more senior animals who have been previously vaccinated and likely have adequate titers, or in animals with weakened immune systems.

Administering rabies vaccines: *Perceived owner acceptance of the rabies vaccine*

Veterinarians do acknowledge the risk of acquiring rabies in this area is low but when necessary, will try to persuade clients to have their pets vaccinated for rabies. This is more to mitigate public health observation periods or rabies testing than because they are concerned the pet will acquire rabies. Specifically, preventing observation by having a rabies vaccination was

mentioned by more than one veterinarian as a reason they list to convince clients to vaccinate their pet against rabies as demonstrated in the quotations below.

If I still get pushback then I say we are actually protecting the animal because if they bite a person or scratch somebody, then **there can be a quarantine that's imposed on them, so we wouldn't want that** and usually they'll come around. -Veterinarian ID1

At the same time, some veterinarians felt like having the animal properly vaccinated provided a sense of security for themselves as a clinician if something were to happen. In the quotation below, the veterinarian describes this and how they explain to owners the public health implications of an unvaccinated animal. The desire to protect oneself as a clinician was expressed in relation to rabies and to other zoonotic diseases as well, such as leptospirosis.

And for me because it's rabies, because I don't want my patients quarantined or **I don't want it on my head that an animal wasn't vaccinated properly for rabies** and now somebody, a human is at risk. I'm sticky about it. I'm really sticky about it... If you can at least put forward a piece of paper that says he's vaccinated for rabies... That gives you that extra bit of security. And that's how I handle people who are like, "Oh, he's indoors only. He doesn't really need it." **I still want them covered.** -Veterinarian ID10

Overall, veterinarians said that some owners will not vaccinate or hesitate because they do not see the need, they fear vaccine reactions, or due to cost. Veterinarians perceived a difference in acceptance of the rabies vaccine between the owners of cats and those who owned dogs as described in the quotations below. Further, 11/12 veterinarians explicitly mentioned that resistance was most commonly met from cat owners, particularly by indoor cat owner. Indoor cat owners question the need for the vaccine given the lifestyle of their cat and because the risk in this area is low. Veterinarians struggled when discussing the risks with these owners because they too acknowledged that the risk of exposure or acquisition of rabies in this area is also low. At the same time, they are trying to explain that rare events can occur, such a bat entering the house or a cat getting out.

Dog owners don't decline, they're comfortable with it, they get it, they may even if they know its low risk, they get it. That's all part of having a dog and they accept that. I never run into obstacles with that. **Indoor cats are my only other group that we have problems with...They just think that there is no chance whatsoever that their pet will be exposed, and they are probably correct.** There is pretty much no chance that they, you know, they think they will never get out and a bat's not going to get into my apartment and I'm like, 'yeah, that is probably true' but yet, you know. **So that's on you if you wish to decline but it's still up to me to tell you you're supposed to.** But I think the risk is as close to zero as it can be. -Veterinarian ID9

Administering rabies vaccines: Cost of the rabies vaccine

Even though only veterinarians can administer rabies vaccinations, veterinarians did not believe the cost of the rabies vaccine itself was the issue for owners but rather the cost of the veterinary exam. Veterinarians noted that if owners were attending the veterinary exam, then the cost of the rabies vaccine was usually not questioned. One veterinarian, however, described reducing the price of the rabies vaccine if owners were struggling with cost to ensure the protection of public health: "I must admit that I discount, often, rabies vaccination. Just sneak them here and there. With the client's knowledge, of course" (ID8). There was also mention of veterinarians volunteering their time to a local organization, Community Veterinary Outreach, and providing free vaccinations and veterinary care. Ultimately, veterinarians left the decision on whether to vaccinate for rabies with the owner who was incurring the associated costs. As a result, conflict was felt regarding the obligation to protect human and animal health while balancing the financial limitations of the owner as highlighted below.

Sometimes I am torn between my responsibility to the pet verses society...For society, there is society's health and wellness, life and death at stake, and then societies limited resources...Its money. -Veterinarian ID6

Veterinarians did mention that in rabies vaccination clinics the cost is essentially eliminated as veterinarians are volunteering their time thereby removing the exam fee. In the past, it was

acknowledged that veterinarians were more uncomfortable with the rabies vaccination clinics as it was perceived as a loss of income as business is being taken away; however, this perception has changed, and it is not thought to threaten income as veterinarians understand many of the owners attending a clinic do not normally access veterinary care.

My profession has a conflict of interest. My professions believe in preventive medicine, and obviously rabies is a fatal disease and it needs to be prevented. My profession believes very strongly that **veterinarians are the people that should be doing the work.** And when somebody else does it, we have a conflict because we're losing income.
-Veterinarian ID12

5.2.2.2 Reporting situations involving animal bites and potentially rabid animals

The public responsibility of veterinarians in reporting human biting or contact incidents that could result in rabies is established under federal and provincial legislation and regulations. The federal regulations also expect veterinarians to use their professional judgement to determine if animal to animal bites could potentially result in rabies and to report such an event if there is a risk of rabies transmission.

The provincial regulations require veterinarians use professional judgement of how rabies is transmitted to determine if any bite or other animal contact to a person might result in rabies and to report such an event if there is a risk. Veterinarians are also expected to ask owners if their animal has been involved in a biting or contact incident within the 10 days preceding a planned rabies vaccination. If so, the animal should not be vaccinated, and the biting incident should be reported to the local public health unit. Additionally, veterinarians are expected to ask owners if their animal has been involved in a biting or contact incident within the 10 days preceding a euthanasia. If the animal has been involved in an incident, the animal should not be euthanized until public health authorizes the procedure. The local Public Health Unit will authorize the euthanasia if there is a clear and significant animal welfare concern associated with keeping the animal alive for the quarantine period.

Reporting: Reporting requirements

Veterinarians are aware there are reporting requirements related to animal bites and situations involving potentially rabid animals. Data collected in this study, however, suggests, that not all veterinarians have a correct understanding of the legislations and their role in reporting. In fact, more than one veterinarian described not having a full understanding of the rules associated with the reporting requirements.

We were never one hundred percent clear on the rules... I mean I think the awareness is there. We all know that it's really bad and if there's a case or if a suspect or again with these bite incidents like that, we need to do something but exactly what to do and especially balancing that with I guess ethical concerns with regards to like a suffering animal who needs to be euthanized like **which takes priority**. -Veterinarian ID3

Reporting: Shift in federal and provincial responsibilities

Confusion regarding reporting procedures was related to the shift in roles and responsibilities between the Canadian Food Inspection Agency (CFIA) and the province in 2014. Overall, this has made it difficult for veterinarians to understand which agency holds authority in the various situations faced as described in the first quotation below. One veterinarian commented that “right now the whole sort of oversight of rabies is so divided” (ID1). That is not to say confusion regarding the policies did not exist when the CFIA was largely responsible for companion animal rabies management. It was, however, less of an issue for veterinarians because they would contact and notify their CFIA district veterinarian of an incident or suspect rabies case and be instructed on how to proceed. There was no need for veterinarians to understand the subtleties of the legislations or regulations.

So, that transition initially wasn't easy to begin with but at least you had veterinarians that you were talking with. Now, it's not veterinarians at all and so it is even more challenging and then there is **often not somebody that is available to even speak to you** in those moments. - Veterinarian ID5

Even though veterinarians knew who to contact and how to contact them when the CFIA was responsible, the ensuing interactions were not always positive. More than one veterinarian reported being met with hostility when attempting to contact the agency to either seek clarification or to report an incident.

I got in trouble because he was like, “this is for times you have a rabies outbreak. Don't use this number,” and so **somebody reamed me out.** -Veterinarian ID1

Veterinarians recalled that they were told they were being paranoid because rabies was such a low risk in this area so there was no possibility the animal had rabies, or that the situation was not emergent, so they should not have bothered to call. One veterinarian recounted that the district veterinarian “cussed me out” (ID11) and as a result did not want to contact the agency again the future as detailed in the quotation below. This created tension and frustration for veterinarians as they were trying to follow the policies they knew existed but felt they, and the potential for rabies, were not taken seriously.

So, then I'm like while I'm following policy. Thanks for helping. I will then place myself in quarantine... I'm like hopefully this dog doesn't have rabies. **You as the district veterinarian should not have done that** because, what I am not going to next time-I am not going to call you thinking that it's rabies. What if it is? -Veterinarian ID11

Reporting: Reporting bite or contact incidents between an animal and a human

Since the shift in federal and provincial responsibilities in 2014, veterinarians were cognizant that the local public health unit needed to be contacted to report a bite or contact incident between an animal and human. Veterinarians, however, emphasized various difficulties in the process of contacting the local public health unit. Most commonly, veterinarians found it challenging to know who to contact within the local public health unit, and how to contact them as one veterinarian describes in the quotation below. There were also challenges in finding an individual who had adequate knowledge and expertise about the next steps. More than one

veterinarian described creating a protocol or bookmarking a website to help themselves contact the correct individual when there was an issue, but veterinarians mentioned even after the process of creating it there were still elements that were unclear.

I called Public Health and asked and **it was also after hours so it's a little awkward...**I found it very difficult to reach someone who could tell me what I was supposed to do with it, but I mean euthanizing the cat on our own and **pretending it didn't happen also didn't seem like the right thing to do**-either even though obviously it probably doesn't have rabies but what am I supposed to do. Finding out what you're actually supposed to do when you're faced with these cases, and when you actually have an index of suspicion is harder. I don't think anyone really knows. –Veterinarian ID9

Veterinarians also commented there was often a delay in response from the public health unit. This was compounded by the working schedule of veterinarians as many veterinarians do not work a standard hour week; most work shifts with hours overnights, on weekends or will work at numerous clinics. This delayed establishing contact with public health and exchanging information. One veterinarian explained that when she did eventually speak with someone at the local public health unit to seek clarification “were very rude and abrupt and not very helpful” because she “shouldn't have to call them to get this information because we should all know this” (ID2).

Another veterinarian felt that the delays in communication with public health increased their work load as it required that other veterinarians at the clinic to be knowledgeable about the incident as they may have to be the new “point person” (ID5) because they were the only veterinarian at available at the clinic when public health responded:

Now we don't really know who we're supposed to contact and oftentimes there is nobody to be contacted because we don't often work 9-5 hours as veterinarians and so **there is often a waiting period which is not realistic** when you're dealing with bites, attacks and so on. You often leave a message and the people contacting you back don't have as much knowledge than you and so it's very difficult when you're talking with someone from the

human sector about animal health or even just someone that doesn't even have any health background. **They're just policy people, they don't really have an understanding for what you're going through**, so it's been challenging all the way around. So, now we don't really know what we're supposed to do, unfortunately. - Veterinarian ID5

Reporting: *Reporting bite or contact incidents with no human exposure*

Not all veterinarians had a complete understanding of who to contact or what to do in cases where an animal was potentially rabid but there was no human exposure. This occurred when an animal may have been exposed to rabies from a wild animal. One veterinarian struggled with what medical action should be taken to help the animal as they were not aware of any guidelines:

What's unclear in our world is what the guidelines are for a pet whose been bit by wildlife and we have no idea... There is no clear consensus on that. Some vets are automatically giving a rabies vaccine whenever wildlife is involved, some aren't you know... I feel like as a profession **we don't really have any clear-cut guidelines** on what we're supposed to do. -Veterinarian ID9

It was acknowledged that these situations do not occur often, and when they do occur veterinarians handle them on a case-by-case basis which made it more challenging to know when to report. Two veterinarians explicitly the referenced training module created by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) pertaining to these types of situations and commended their efforts to explain a complex system, but one veterinarian felt the process was still too complicated while the other veterinarian questioned how many other veterinarians had seen the module.

Reporting: *Public health as the lead*

Veterinarians believed variations in reporting procedures across municipalities contributed to their confusion. Although veterinarians expressed an openness to engage in collaborations with public health and human health professionals with respect to rabies and other emerging health

issues, such as Lyme disease, they did not take the initiative to form these relationships. For example, one veterinarian described how having a better understanding of rabies prevalence across municipalities would be “very useful to know but it never comes to us in any way and we don't seek it out” (ID9). One veterinarian believes that the lack of initiative to create better public health partnerships is due to demanding schedules as described below.

It's very dependent on where you're practicing. So, you almost have to take the initiative yourself and say, "Okay, this is where I live. This where I practice. Let me see who's involved here in public health, who are you? What are you doing? What should I know about in terms of your new initiatives?" And **veterinarians-just because of busyness-wouldn't even think to do that unless someone reached out to them.** -Veterinarian ID7

Ultimately, veterinarians thought the local public health unit should be responsible for creating clear, easy to understand reporting and handling guidelines as the public health unit is responsible for investigating incidents. There was no consensus on how veterinarians would like guidelines disseminated as they already felt inundated with information, e-mails, and requests from several parties about a variety of topics. Veterinarians also described how they would like the public health unit to lead in the development of mechanisms to better communicate and share information between the public health unit and human health professionals.

Reporting: Questioning observation practices

Veterinarians questioned the public health practice of ordering an animal observation period (sometimes referred to as quarantine) at the owner's home. In particular, veterinarians felt the risk and seriousness of rabies were undermined when a potentially rabid animal was sent home with owners who could then expose more people. Veterinarians felt conflicted in cases where animals were sent home with owners when the animal had previously displayed aggression and bitten someone as this was seen as a risk in and of itself.

And there are bite instances where **we've had to actually send people home with their pet that has bitten somebody** and we have to wait a full ten days before public health will give us the okay to go ahead and euthanize them because they want to ensure... We, a couple of times, **euthanized them [companion animals] without talking to them [public health] and I got in lot of trouble** for that just a lot of over the phone kind of things-hand slapping. -Veterinarian ID2

Although veterinarians rarely believed there was a risk of rabies, many simultaneously mitigated occupational exposures by prohibiting animals to be observed at their clinic as explained in the quotation below. Further, veterinarians extended this concern to their staff and did not want to jeopardize staff safety or add to their workload.

It's not worth forty dollars a day and the risk-rabies aside-just that someone's going to get bit. Like if this is a dog that bites, we don't want him here. **I don't know who takes these dogs** but knowing where these dogs are supposed to go and how they're supposed to quarantine would be very useful and who does that, because **we're not putting our staff at risk**, not that we think they're going to get rabies but still... If an aggressive dog does have to stay in hospital for treatment, it takes so much work to manage these dogs that we're are not offering that as a service. -Veterinarian ID9

Veterinarians did not know how owners would find alternatives if placing their animal under observation at home was not an option with the exception of relinquishment to the humane society, which veterinarians felt would be difficult for owners. Veterinarians acknowledge that observation periods for large a dog that needs a great deal of exercise or a cat that is used to going outside is very difficult and stressful for owners. One veterinarian described a situation that occurred to a colleague where an owner elected for euthanasia over quarantine because it was too difficult to keep the animal in the house:

It's hard for some clients. It's very hard. I know one case where high risk for rabies intact, male cat, never been to a vet before, acting very aggressively within the last two weeks. The vet offered to send them home and quarantine or euthanize him instead. And they

were in the risk area. And I know this through our confidential means, and **the owner elected for euthanasia because she said she just couldn't quarantine and she couldn't keep him in the house. And the tests came back negative.** And so that then leads to bad feelings and complaints and things. But the vet did what was appropriate, but for many owners they find that quarantine extremely difficult. And not even necessarily physically difficult, emotionally difficult. And so, quarantine is not the be all and end all.
-Veterinarian ID10

Reporting: Animal bites preceding euthanasia

Veterinarians described the most common situation where they would contact public health was when a companion animal bite a human before the animal was to be euthanasia. Veterinarians rarely had a high index of suspicion of rabies in these situations and knew there were required to follow policies but often felt the policies were impractical. Veterinarians struggled as they balanced animal welfare, emotional owners, and difficult communication with the local public health unit:

This wasn't a pet that we could quarantine for fourteen days. I didn't think it was humane for that pet...**Sometimes you have to make a call regardless of what the public health rules are to euthanize a pet that they want to quarantine but it's not realistic to do so.** So, you just ultimately have to make a call. But it's hard to make those decisions on the fly when you don't have the governing body being able to either support you or accessible. -Veterinarian ID5

Veterinarians expressed it was in these situations where they felt policies were most in conflict with practicality. One veterinarian said, "I think the chance of making a mistake and having a person come down with rabies is so low that it's worth giving us that room, that leeway for interpretation, because I think being practical in a lot of respects is important" (ID3).

Reporting: Authoritative decision makers

Veterinarians often defined their role as protecting the welfare of the animal and supporting the owners when they thought policies were not feasible. This was evident in situations when veterinarians were not satisfied with the timeliness of the local public health unit's return in communication, when the animal's welfare was at stake, or if the veterinarian thought that the owner was being forced into an unfair situation. It was common for veterinarians to take an authoritative stance and to euthanize the animal without approval and face repercussions. Bite before euthanasia scenarios were also particularly difficult for veterinarians because they had to deal with emotional owners, which one veterinarian describing it as "traumatizing" (ID1). More than one veterinarian described having support staff, such as a receptionist, screen owners who were looking to have their animal euthanized to determine if a bite incident occurred within the past 10 days. This was done by asking the owner on the phone or through a questionnaire on a consent form, but veterinarians noted that it was up to the owner to be truthful. Below, one veterinarian recounted a situation where an owner had decided to euthanize their aggressive dog after it attacked a child. The issue occurred when the public health authority in charge wanted to observe the dog at the owner's home for 10 days instead of euthanizing it right away and sending the specimen for rabies testing. The veterinarian described how she took charge of the situation as she thought it was too devastating for the owner to count down the days until the dog was euthanized:

So, you're thinking, "Okay, nine more days with Brutus. Eight more days with Brutus." Like it's awful. It's killing them [owners] to watch him. They knew he was going to have to be euthanized at the end of it. And I said, "I recognize you gave that order, but I could not ask my clients to sit and watch their dog."... And that was an unfair request to make of them, they were willing to make the decision [to euthanize] anyway. **And so, it was kind of ballsy to do. But... It needed to be done at some point. Let's get this done and stop everybody suffering.** -Veterinarian ID10

5.2.2.3 Communicating with clients

Communicating with clients: Conveying information

Veterinarians perceive their duty includes conveying a board range of information to owners about animal health and behaviour. Veterinarians struggle, however, as there is limited time in appointments to discuss all health aspects and also feel that owners had unrealistic expectations of what knowledge could reasonably be transferred.

I think that veterinarians are always having a **dilemma about the time crunch, the appointments, and how much they can reasonably transmit at one appointment**...But veterinarians I think are getting better at spreading them out over a period...But infectious disease is a big part of it. So, the parasite side of things, but also explaining enough about vaccinations for infectious disease. Rabies, it's a good question. I'm not sure that people talk about rabies so much in terms of what it is and the nuts and bolts of the physiology of the disease itself. -Veterinarian ID7

Further, veterinarians perceived that many owners have an inaccurate information regarding rabies, other zoonotic diseases and the associated risks. Veterinarians felt obligated to teach owners and correct their misunderstandings but were sometimes met with resistance. Indeed, one veterinarian commented that “I've had people try to tell me rabies doesn't exist” (ID5). In fact, veterinarians largely believed they know more about risks associated with rabies and other zoonotic diseases, such as Lyme and leptospirosis, and better communicated these risks to owners than physicians as the quotation below explains. Veterinarians also felt that owners were trusting other sources of information, such as breeder or pet stores, and were constantly “bumping heads” (ID10) with owners about this information.

I think we communicate zoonotic diseases way better to people than their doctors do, funny enough. Jeez that's kind of stupid. And doctors tend to blame a lot of stuff on pets that actually is not warranted, which **I also think is they're not well educated at all**

with zoonotic disease. A lot of the education comes from us, we're the ones and not all vets are good at relating that information either. -Veterinarian ID2

Communicating with clients: *Maintaining client trust*

Veterinarians perceived that some owners mistrust the veterinary profession. Specifically, veterinarians said these owners thought that veterinarians prioritized income over the health of the animal. This was in relation to rabies vaccines, but also to other vaccines and services. It was noted by one veterinarian the “actual cost of the [rabies] vaccine that we're giving to them is negligible in our business plan” (ID9) and cost is associated with the examination fee or other core vaccinations. However, as one veterinarian stated: “A lot of clients view us as sales people who sell stuff to them that they don't need. Rightly or wrongly so. And as vets we struggle with it every single time” (ID11). This was difficult for veterinarians as they did acknowledge their conflicted relationship with owners. This was associated with operating in a fee-for-service model in which they did need to consider income and as a result must limit services and appointment times.

Veterinarians did sense a shift occurring in their relationships with owners as owner's expectations of veterinary medicine evolve. Veterinarians credit better communication with owners regarding the importance of wellness exams over just vaccines as a contributor to the shift.

I think it's improved in the last ten years where **there's been more transparency of the veterinary profession** acknowledging over vaccinations, changes to every three-year protocols where lots of animals aren't being vaccinated every year. The public knows that. They know some of the history and justification behind it now. -Veterinarian ID7

Further, the same veterinarian thought that “people are a little more knowledgeable now that the cost of the actual vaccine isn't really what we care about... You're paying for time, for consult, for knowledge” (ID7). Another veterinarian described how her clinic has taken proactive steps to move away from the “conveyor belt” (ID10) appointment time model in order to have a better

“relationship” and “trust” with owners by allotting my time for appointments and spacing out animal vaccinations so that overall cost per visit to the owner was less.

5.2.2.4 Mitigating occupational factors

Mitigating occupational factors: Reflection on role in rabies management

Administering rabies vaccinations was viewed by veterinarians as their contribution to rabies management. Not all veterinarians, however, had deeply reflected upon their role in rabies management. Consider one veterinarian’s opinion: “I don't think that we do manage it at all, we give the vaccine and then I think most of us try to avoid thinking about it as much as possible” (ID9). While another veterinarian had thought deeply about their position within rabies management:

I think, especially veterinarians, **we do a lot of the managing** of it because it's, you know, it's prevention. It is vaccination. I mean, I know, I realize there are other way to eliminate a disease, but in the case of rabies, vaccination has had the biggest impact in reducing human exposure... When you say rabies management-it's interesting, because that's what I think of-**us, you know, in the trenches doing our thing.** -Veterinarian ID1

Veterinarians differed in their concern of rabies if a human bite or contact incident occurred. As one veterinarian mentioned, they were more concerned about the occurrence of bite than the risk of the human acquiring rabies: “honestly on my end, as a veterinarian, the rabies component has the less important of those two” (ID12). Another veterinarian, however, was more “diligent” because “I feel we have an obligation too as a health risk and a public health risk” (ID5). Thus, the findings suggest that some veterinarians are more concerned with the risk of rabies associated with a bite or contact incident than others.

Mitigating occupational factors: Services to unvaccinated animals or animals with unknown histories

Veterinarians were considerate of how to mitigate both their own occupational risks along with that of their staff. This was primarily accomplished by prohibiting animal rabies observation in clinics. Further, two veterinarians mentioned declining certain services, like nail trims or grooming, where a pet could easily bite without a rabies vaccine as the veterinarian explains below. In situations when veterinarians did deal with an animal with an unknown history they would be more cautious and use, for example, a cat box to prevent bites and restrain the animal until it can be sedated.

We often won't do nail trims if the dog or cat doesn't have rabies vaccine because **I have to protect our staff**. It is very mandatory in our building as a public health situation and we will decline service to certain people, especially if we don't know you here Joe Blow off the street, you need to produce your rabies vaccine. -Veterinarian ID5

Mitigating occupational factors: Veterinarian's rabies titers

Veterinarians were cognizant of the need to ensure rabies titer were at adequate levels because they were trained to be aware and or had a personal experience that made them more cautious. Consider this veterinarian's experience where a feral cat bit the joint in their hand, and the cat was subsequently euthanized and tested for rabies:

I knew I was in trouble right away in terms of the unknown history part...But **I was anxious to hear about those results** because I hadn't been boosted since school. And so, I became a lot more diligent about watching my titer. -Veterinarian ID7

Veterinarians did, however, have different experiences dealing with their physician regarding their rabies titers. These experiences could be divided into two broader categories: 1) the veterinarian-initiated conversations or 2) the physician-initiated conversations. When veterinarian initiation the conversation they often felt that the physician was not very

knowledgeable about the risks associated with rabies or their profession and they had to largely manage themselves. One veterinarian described her physician, “My physician, she's open to anything and very, very good that way. I wouldn't say she's particularly knowledgeable or inquiring. She allows me to manage myself pretty much” (ID7). It was common that the physician would defer to the veterinarian but would not question the need for a rabies titer check requisition. Indeed, veterinarian echoed, “It was an easy conversation because she just said, “you're the expert, what you need?”” (ID5). In situations where the physician initiated the conversation, veterinarians perceived the physician was contributing to the management of their rabies titers. For example, one veterinarian said, “my doctor is very on top of that” (ID2) and another said, “he brought it up, because he knows me” (ID12).

Veterinarians did not have an understanding if all members of their veterinarian team had rabies vaccines or which positions were required to have a rabies vaccine. One veterinarian described creating a policy where staff were required to be vaccinated as well as students or volunteers who were going to touch the animals:

I have told the staff that they all need to be vaccinated...Regular vet clinics often have co-op students and volunteers and they don't make them have rabies vaccines. I started a co-op program here with high school students...They are not necessarily going into the vet tech or veterinary schooling, yet I don't want them interacting; **I don't anything about these cats and dogs. I don't know anything about these clients.** They come in saying that they have had a rabies vaccine and I have no proof of anything and do I need a dead teenager on my hands? -Veterinarian ID6

5.3 Mixed Methods Approach

5.3.1 Overview of the rabies management system

This section merged the quantitative results and qualitative findings. The result is a high-level visualization of the relationship between human and companion animal health outcomes, and how veterinarians and pet owners influence both (Figure 6). It was found that veterinarians and pet owners experience push-pull factors that impact their role and decision making around rabies management. Further, the results show a clear public-private divide in the rabies management system. The human health outcomes exist within the public purview of provincially funded healthcare. Meanwhile companion animal health outcomes span public and private health systems. However, the push-pull factors that veterinarians and pet owners experience are private. This is because companion animal rabies vaccinations can only be administered by a veterinarian and pet owners must decide to access care and incur the associated costs. Veterinarians do not operate in isolation or without consent from pet owners. This public-private divide may lead to variation within the rabies management system in both the prevention through rabies vaccinations as well as in the reporting of potential human rabies exposures. The findings suggest, however, that the push-pull factors can be modified and in turn, can influence human and companion animal health systems.

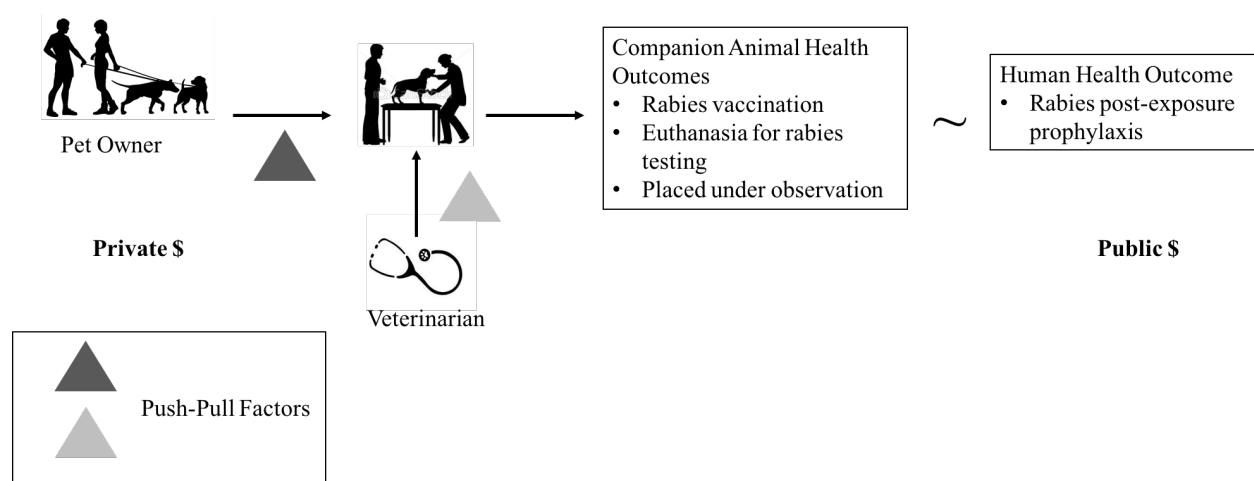


Figure 6. Overview of the rabies management system.

5.3.2. Push-Pull Factors

5.3.2.1 Veterinarian: Approach to companion animal rabies management

Veterinarian: Prioritize: Seriousness and risk of rabies

The seriousness of rabies is founded on the fatality of the disease while the risk of acquiring rabies in Ottawa is extremely low. Indeed, veterinarians are diligent and proactive when mitigating their own occupational rabies risk even though they do not perceive there to be a high risk of rabies, and in some cases, will recommend but not enforce rabies vaccinations for owners who object to the vaccine and their pets. Veterinarians will mitigate their risk by ensuring they have an adequate rabies titer, by prohibiting animal quarantine within their clinics, directing staff not to touch an animal that showed signs of neurologic illness, and or refusing services to animals that do not have rabies vaccine certificates. One veterinarian explained that “not that we think they're going to get rabies but still” (ID9) when asked about why they do not quarantine in their clinic. This suggests that veterinarians prioritize the seriousness and risk of rabies differently with respect to their occupational risk compared to the vaccination of pets.

Veterinarians’ approach to their public and private rabies management responsibilities is dictated by how the individual veterinarian prioritizes the seriousness of rabies compared to the risk of rabies. That is, in a given situation, the weight a veterinarian gives to the seriousness of rabies compared to the low risk of acquisition will determine how that individual will prioritize their public responsibilities compared to their private responsibility. Occasionally, the public and private responsibilities will conflict, which perpetuates veterinarians conflicting roles in companion animal rabies management. These conflicting roles are manifested through the administration of vaccinations, reporting animal bites and suspect rabies animals, communicating with clients and mitigation occupational factors.

I guess I just look at it [rabies] as being like the mother of all zoonotic diseases, just in terms of severity but thankfully at least here it's very rare and so it's this **weird balance where it's so unlikely to happen but at the same time you can't ignore it because of the consequences.** -Veterinarian ID3

Figure 7 depicts how this prioritization of the seriousness compared to the risk of rabies is the bottom layer, or the foundation, on which occupational factors and then policies and authorities is nested. That is to say, veterinarian's individual prioritization of the seriousness compared to the risk of rabies influences how they handle operational constraints which in turn also influences how they interpret rabies management policies and how they interact with rabies management authorities. These push-pull factors are the preconceptions and background that veterinarians bring with them to the veterinarian-owner interaction and thus influences how veterinarians approach companion animal rabies management.

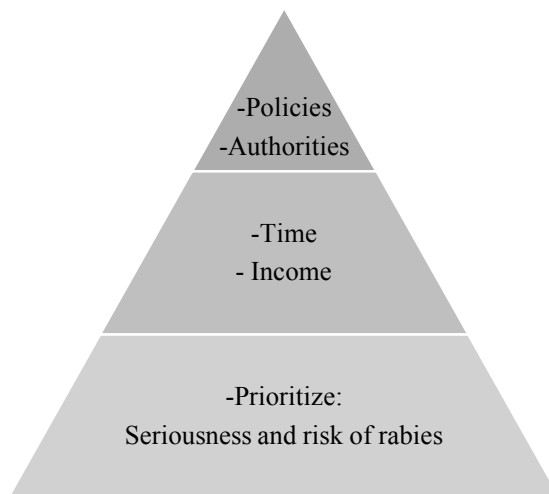


Figure 7. Push-pull factors that influence veterinarians approach to companion animal rabies management in Ottawa, Ontario

Veterinarian: *Time and income*

The prioritization between the seriousness and risk of rabies also influences how much time veterinarians will invest in convincing their client that their animal needs a rabies vaccination. Limited appointment times are a reality of a veterinarian's profession because of the fee-for-

service model that is used. This was difficult for veterinarians as they acknowledged their conflict in operating in a fee-for-service model whereby consideration needed to be given to income and as a result services and appointment times must be limited. Veterinarians view the risk of acquiring rabies as very low and may even concede that the animal may benefit more from a vaccine for a disease that is more prevalent in this area but will still recommend the rabies vaccine as the consequences and public health implications outweigh the low risk of acquisition. It is dependent on the weight the individual veterinarian places on the seriousness compared to the risk that will determine how they approach the interaction with the owner regarding vaccinating.

Veterinarian: Policies and authorities

Federal and provincial policies

Federal legislations prohibit the sale of rabies vaccines to anyone other than a veterinarian with exceptions for some remote communities. Secondly, provincial legislation requires that veterinarians administer rabies vaccinations. This task, however, can be delegated to competent veterinary staff within an accredited veterinary facility. Under provincial legislation, all healthy companion animals in most areas of Ontario, including Ottawa, must be vaccinated against rabies and their vaccine status must always be kept up-to-date. Therefore, owners must have their companion animals vaccinated against rabies, and veterinarians (or those working in a veterinary clinic), are the only ones who can administer the vaccine.

Fundamentally, veterinarians want to ensure companion animals have an adequate level of immunity but must negotiate with owners regarding the rabies vaccination of pets because owners incur the cost. Veterinarians have not taken the stance of enforcing or policing owners to vaccinate their pets against rabies but rather will negotiate. The degree to which they negotiate is influenced by the veterinarian's prioritization between the seriousness and the risk of rabies and the time they have.

Veterinarians are also responsible for reporting animal to human biting or contact incidents that could result in rabies is established under federal and provincial legislation and regulations. The federal regulations also expect veterinarians to use their professional judgement to determine if animal to animal bites could potentially result in rabies and to report such an event if there is a risk of rabies transmission. The provincial regulations require veterinarians use professional judgement of how rabies is transmitted to determine if any bite or other animal contact to a person might result in rabies and to report such an event if there is a risk. Additionally, veterinarians are expected to ask owners if their animal has been involved in a biting or contact incident within the 10 days preceding a euthanasia. If the animal has been involved in an incident, the animal should not be euthanized until public health authorizes the procedure. Public health will authorize the euthanasia if there is a clear and significant animal welfare concern associated with keeping the animal alive for the quarantine period.

Veterinarians struggle in situations where there has been a bite or contact incident that could result in rabies particularly when there is human involvement preceding an animal euthanasia. In some cases, veterinarians have not followed the Public Health Unit's processes and have acted without approval because they did not perceive the risk of rabies as high, and instead prioritized the welfare of the animal or the emotional welfare of the owners. Therefore again, how veterinarians act regarding policies is influenced by their prioritization between the seriousness and risk of rabies.

Authorities

In Ontario, veterinarians are self-regulated through the College of Veterinarians of Ontario. As such, veterinarians are involved in determining the rules that govern their profession and are also accountable for their own behaviour. The College of Veterinarians of Ontario, which is given its role and authority through the *Veterinarians Act*, “regulates the practice of veterinary medicine in Ontario to protect the public interest. This is done, in part, through licensing veterinarians, inspecting and accrediting veterinary facilities, quality assurance programs, and establishing professional and ethical minimum standards of practice.” As per their website, “the College of

Veterinarians of Ontario distributes information concerning rabies in Ontario to assist in reducing the risk of human and animal exposure to the rabies virus.”

The American Animal Hospital Association (AAHA) is an organization that accredits companion animal veterinary hospitals in Canada and the United States and produces rabies vaccination standards and guidelines. In addition, pharmaceutical companies, such as Zoetis and Merial, that produce and distribute rabies vaccines contain dosage and administration directions that dictate how the vaccine should be used.

Informational authorities

There are numerous informational authorities that disseminate information pertinent to rabies in Ontario and Canada. Veterinarians may reference these informational authorities to remain informed about current outbreaks, rabies in various species, and current management guidelines. These include the Ontario Veterinary Medical Association, the Ontario Animal Health Network, the Worms and Germs Blog, and the Canadian Veterinary Medical Association.

Border security

Veterinarians are also concerned about the lack of regulation around rescue organizations who are importing animals with unknown histories from various countries. Border security was identified as being very relaxed, and “pathetic” (ID10) as “a lot of people are not looking at rabies certificates.” The same veterinarian recounted how owners may have the rabies certificate, but the border security is not verifying and thus, there is lack of enforcement for animals entering Canada. This contributed to veterinarians feeling as though rabies and other zoonotic diseases were not being taken seriously and as a country, were underprepared if something highly pathogenic did enter. Border security was also issue when veterinarians were helping owners export their animals to other countries. Veterinarians found it difficult to understand what documentation was needed and described making mistakes that caused owners to return to the clinic to obtain corrections.

5.3.2.2 Owner: Decision to access veterinary care as perceived by veterinarians

Veterinarians perceive that numerous push-pull factors influence an owner's decision to access veterinary care. Figure 8 depicts the societal context that found owner's recognition and then the need for veterinary care. Put another way, the owner's decision to access veterinary care is built upon the owner's recognizing the need for veterinary care which is in turn nested upon societal influences. These factors encompass the preconceptions and background that owners bring with them to the veterinarian-owner interaction and thus influence the owner's decision to invest in vaccinating their companion animal against rabies and to disclose the occurrence of a bite or contact incident.

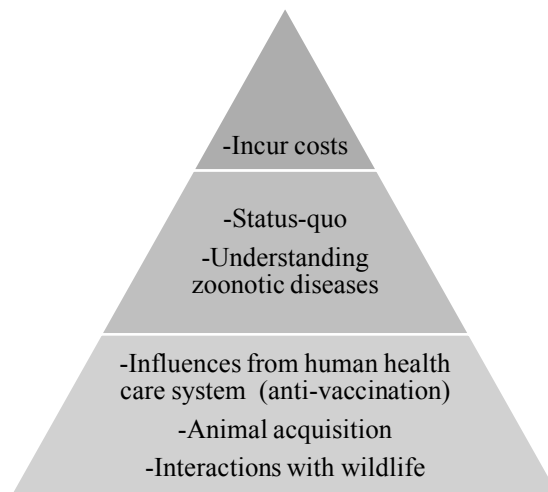


Figure 8. Push-pull factors veterinarians' perceived influence owners' decision to access veterinary care.

Owner: Societal context

Influences from human health care system

Veterinarians have experienced elements of the human health system in practice. This has manifested out of concern about over-vaccination and the anti-vaccination movement. When asked what owners list as reasons for not vaccinating their animals, one veterinarian answered: "they're listening to some media that's saying we're over vaccinating... They're afraid of

reactions and their breeder told them not to” (ID10). Further, another veterinarian thought that when owners decline vaccines for their pets, “it's the same as anti-vaxxers in human medicine where unfortunately research scientists and physicians started the whole issue long ago. Some people carry on with that misunderstanding. So sometimes they think vaccines are bad” (ID8).

Veterinarians differ on their approach to dealing with clients who are proponents of the anti-vaccination movements but often try to explain the functions of a vaccine and explaining the public health impacts of establishing cohort health and the public health implications of rabies. It was noted by more than one veterinarian that occasionally owners will not engage in further conversation regarding vaccines and at that point the veterinarian feels there is no use pressing. As one veterinarian explains below, especially because the risk of rabies is so low it is not a productive use of time and energy to try to convince an owner who will not listen:

As much as I care about animals - look if I was pediatrician with a person who wasn't going to vaccinate their child against communicable diseases I would be sitting there and investing. I don't do that here. The real risk of that animal ending up killing the kid in the house with rabies is very very very small. So **that is just not where I'm putting my energy** and anyway I don't think I could persuade them because it is not a five-minute conversation. -Veterinarian ID6

Animal acquisition

Veterinarians perceive that the culture of pet acquisition is largely in favour of “rescuing” an animal over buying an animal. One veterinarian describes:

The whole societal philosophy of rescue is good, rescue equals good, **rescue equals doing something good for society**, rescue equals I don't buy. I provide for somebody who already needs a home. -Veterinarian ID7

The observed increase in rescue animals has, however, left veterinarians questioning where people are actually getting their pets from and the vaccination status of these animals.

Veterinarians mentioned that owners are mainly acquiring their animals from rescue

organizations, other individuals, such as a neighbour, through online contacts, and breeders, but many owners classify their animal as a “rescue.” The surmounting issue is that these new owners, with the exception of those that purchased their pet from a breeder, do not actually know where their pet is coming from. What is more, veterinarians state that there are variations in what rescue organizations provide in terms of vaccinations.

Every pet is a rescue these days, it seems. And sadly, people are not always truthful. I'd say that **there are a few very good rescue organizations that do their best** to make sure that pets get seen, vaccinated, cared for or kept inside at least and vaccinated. -
Veterinarian ID8

With the use of the internet, people are able to acquire an animal very quickly and from diverse geographical areas, and often have little knowledge of the animal's life and medical history. As the quotation below illustrates, this can be a source of contention for veterinarians and the term “rescue” or “rescue agency” may be considered a misnomer:

A dog yesterday came in, it's an "online" Kijiji purchase. The people- they meet somebody in a parking lot and the dog is exchanged, **they pay their money and they've got their rescued animals...**The Catahoula rescue agency. I've got Catahoula from these people and they brought it up through Southern California. My dog, they rescued. When you actually look at the paperwork to get it across the border it was one of 40 animals that came across. **It's not a rescue agency. It's an import breed agency** that is overpopulated in the northern part of the North America and under populated somewhere else. -Veterinarian ID12

Veterinarians are unclear if owners that do purchase their pet from a breeder ensure that the breeder is of quality. One veterinarian has experienced that owners make an emotional decision regarding pet acquisition while neglecting the viral, bacterial and parasitic risks associated with their decision:

They want a particular animal and they go and look for it. And they search it on the internet. Sometimes they are available, sometimes they are not available. Sometimes they will wait until a good source has an animal available, some are like ‘I want an animal now.’ And just get it from wherever. So, it’s an **emotional choice and you get a lot of disease from backyard breeders.** -Veterinarian ID11

While veterinarians have encountered some excellent breeders, they more often report dealing with animals from irresponsible breeders with little medical knowledge that are not vaccinating the animals before selling them to owners. For instance, one veterinarian said: “we get lots of breeders telling our clients, "Oh, don't do rabies until he's at least six months"” (ID10). This veterinarian continued to say that “breeders are pulling a lot of information off the internet or chitchat at dog show.” Another veterinarian thinks that some breeders are overstepping their knowledge regarding animal health which is contributing to public misunderstanding:

...There are good breeders out there that vaccinate. But **there are much more irresponsible breeders out there than good breeders...** Very very irresponsible breeders. They don’t vaccinate. -Veterinarian ID11

Interactions with wildlife

Veterinarians question the public’s knowledge about interactions with wildlife and the associated risks. This was especially noted because Ottawa has a great deal of urban wildlife and there has been a continual spread of housing development into more rural areas. Further, veterinarians do not sense that owners have a good grasp of rabies risks associated with bats, and what steps to take if a bat were to enter the home.

We see a lot of **bats in homes** and rabies is here, so there is certainly that component that sometimes we forget about it. And because Ottawa is so **urban wildlife**, we're displacing a lot of the wildlife animals and so they learn to live urbanely and become friendly that they are a higher risk. -Veterinarian ID5

Owner: *Recognize need for veterinary care*

Status-quo

Veterinarians do think that in general, the public has heard about rabies, especially over other canine and feline diseases, because of its legacy as a fatal zoonotic disease. This was noted through the remarks of this veterinarian: “I think it's because it's [rabies] been so widely publicized in years past, it's just something people know about” (ID1). Rabies has been associated with “old Yeller scenarios” (ID8) and is a “feared” (ID1) zoonotic disease because of the “horrendous death” (ID1). For that reason, owners may be under the impression that the rabies vaccine is all that is required from a veterinarian or is superior to other vaccines but do not understand the risks associated with other canine or feline diseases that are more prevalent in this area. There is a worry among veterinarians that owners are given a false sense of security if only the rabies vaccine is given as described in the quotation below.

Most of them [owners] seem to accept it [rabies vaccine] as the most important... They really seem to want to come in for their rabies shot and they seem to forget about the other ones that they are going to be exposed to far more frequently... **That is actually the vaccine I care the least about it- is the rabies from what they're actually going to come into contact with...**-Veterinarian ID9

Veterinarians have also been emphasizing the value of yearly wellness examinations over vaccines themselves. Veterinarians face challenges in messaging as clients continue to focus on vaccinations, with one veterinarian commenting that vaccines are “what drives most people in the door” (ID2) and another saying owners are “hell bent” (ID11) on vaccination. It is possible that owners have been “institutionalized” (ID11) into believing that the value of veterinary medicine is in vaccinations. At the same time, veterinarians did express a desire for other partnering rabies management agencies, such as the local public health unit, to take more of a leadership role in messaging the need for rabies vaccinations to the community and the legislative requirements for pet owners.

Understanding zoonotic diseases

The understanding of zoonotic disease transmission and risk is a topic that veterinarians felt the public does not adequately grasp. Veterinarians also felt that the public is somewhat complacent regarding the risk of rabies and that more education is necessary to demonstrate the seriousness of the virus. This is related to owners' recognition that veterinary care is a method of preventing companion animal zoonotic diseases.

I think it would be the **complacency that it's really not a threat**, the risk is low, and again just sort of a **lack of education**, I think, about of diseases and how they spread and how we can contact them and just different sort of things that we're protecting the pet against which isn't really just rabies... -Veterinarian ID1

Owner: Decision to access veterinary care

Veterinarians acknowledged that the cost of the veterinary exam is prohibitive for some owners. Therefore, owners must decide to access veterinary care and incur the associated costs. If the owner decides to pursue veterinary care for their pet, they will be a part of an owner-veterinary interaction where a subsequent decision will take place to determine if the pet is administered a rabies vaccine or the disclosure and then reporting of a bite or contact incident will occur. If, however, the owner decides not to access veterinary care, then the pet will not be vaccinated against rabies. The caveat to this is that some owners may qualify for community charitable services, such as Community Veterinary Outreach, and access veterinary care through that avenue.

5.3.3 Describing the rabies management system

The mixed methods visualization (Figure 9-11) details the interactions that exist between the actors of the system and the processes that influence human and companion animal health outcomes in rabies management. Overall, the visualization depicts how veterinarians and pet owners influence both human and companion animal health outcomes in rabies management.

The results suggest human and companion animal outcomes have some dependence on one another. The companion animal being euthanized for rabies testing and the companion animal being placed under observation impact a human PEP recommendation occurring. Meanwhile, the animal being placed under observation is salient to the decision to euthanize the animal for rabies testing. Lastly, a human receiving a PEP recommendation appears to be important to the animal being placed under observation.

Two other factors that are putatively associated with human and companion animal outcomes are directly connected to veterinarians or veterinary care: whether the animal is vaccinated prior to the incident and whether the animal is a household pet. This is because only veterinarians are authorized to vaccinate animals against rabies. Prior to this however, pet owners must access veterinary care and incur the associated costs. Thus, veterinarians and pet owners are tied to both human and companion animal health outcomes.

Veterinarians and pet owners are influenced by various push-pull factors (denoted by grey triangles) that affect their role or decision making related to companion animal rabies management and can create variability within the rabies management system. The findings suggest that the role of veterinarians is built upon their public and private responsibilities, and includes administering rabies vaccines to companion animals, reporting companion animal bites and suspect rabid companion animals, communicating with clients, and mitigating occupational factors.

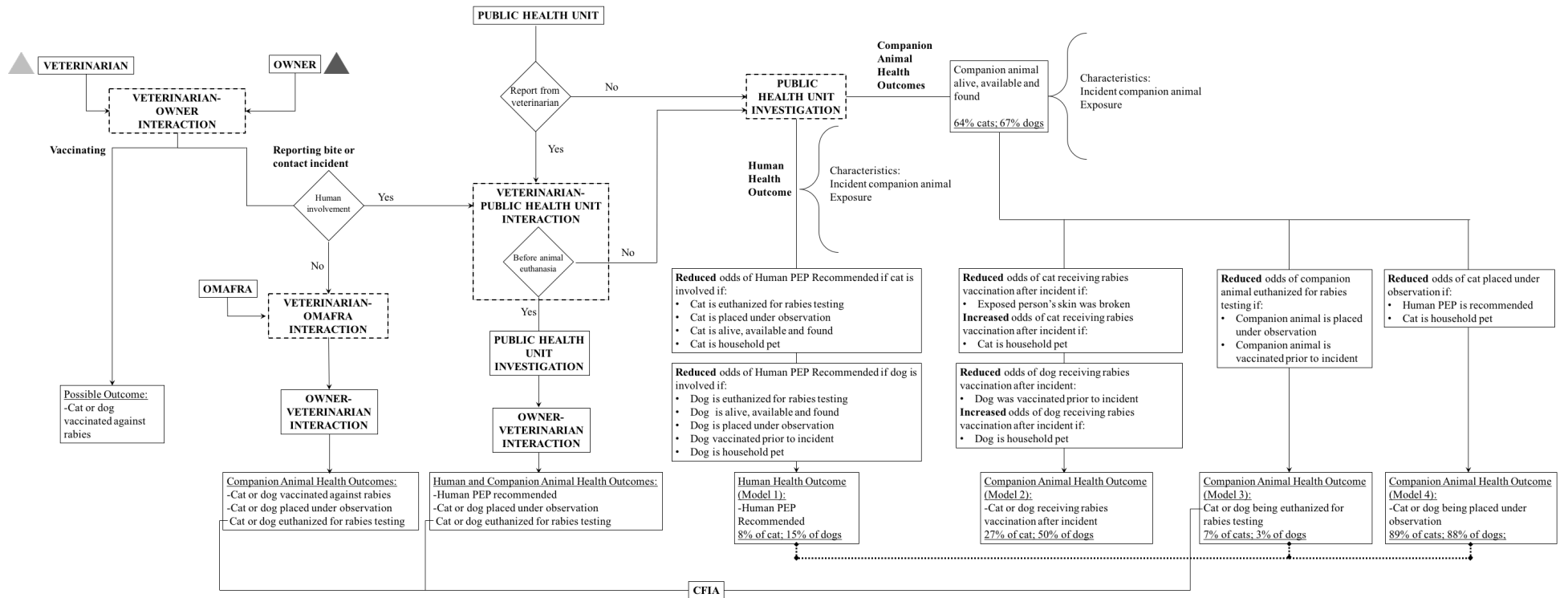


Figure 9. Human and companion animal health outcomes in the rabies management system of Ottawa, Ontario.

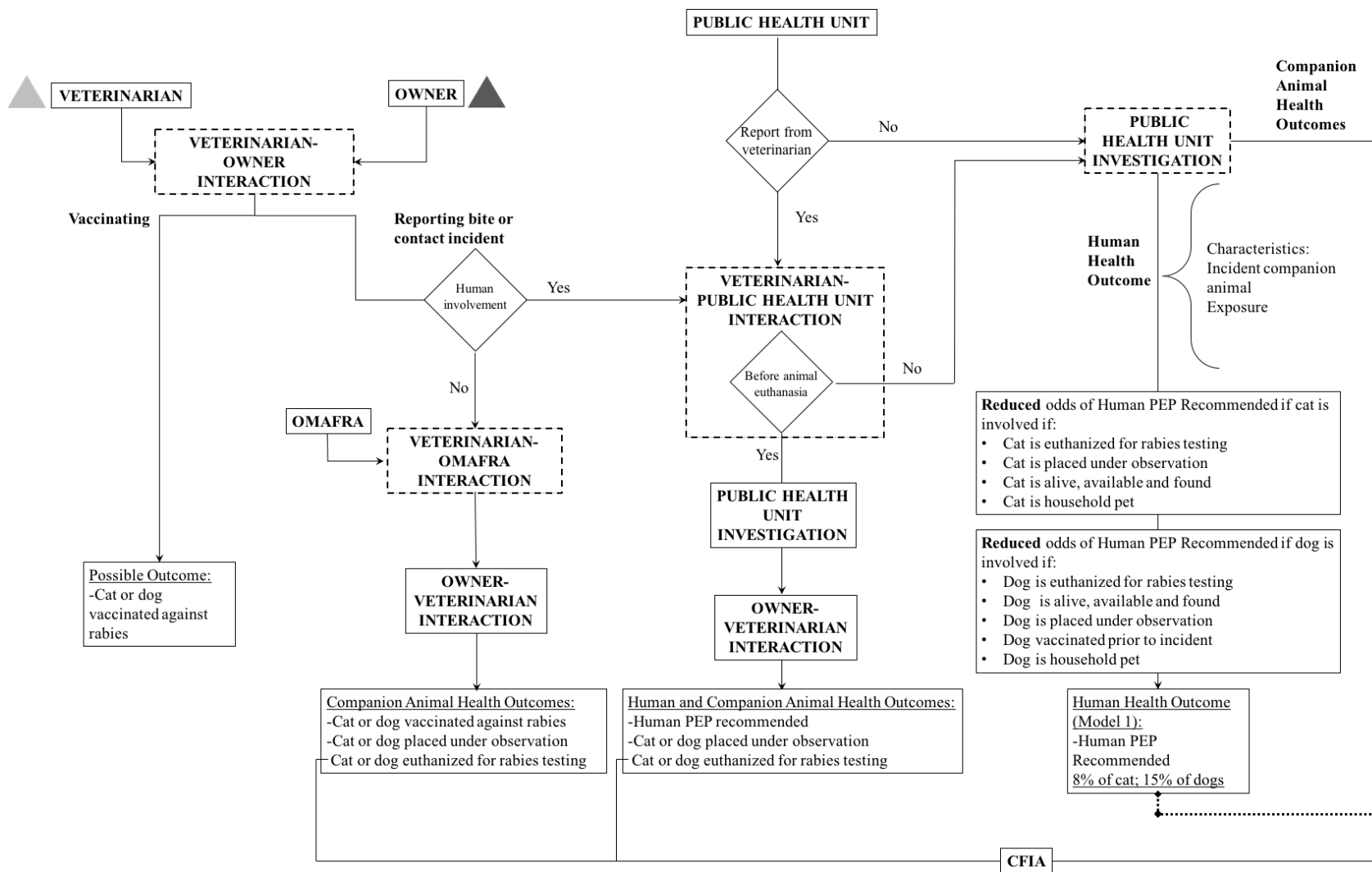


Figure 10. Human and companion animal health outcomes in the rabies management system of Ottawa, Ontario (left side).

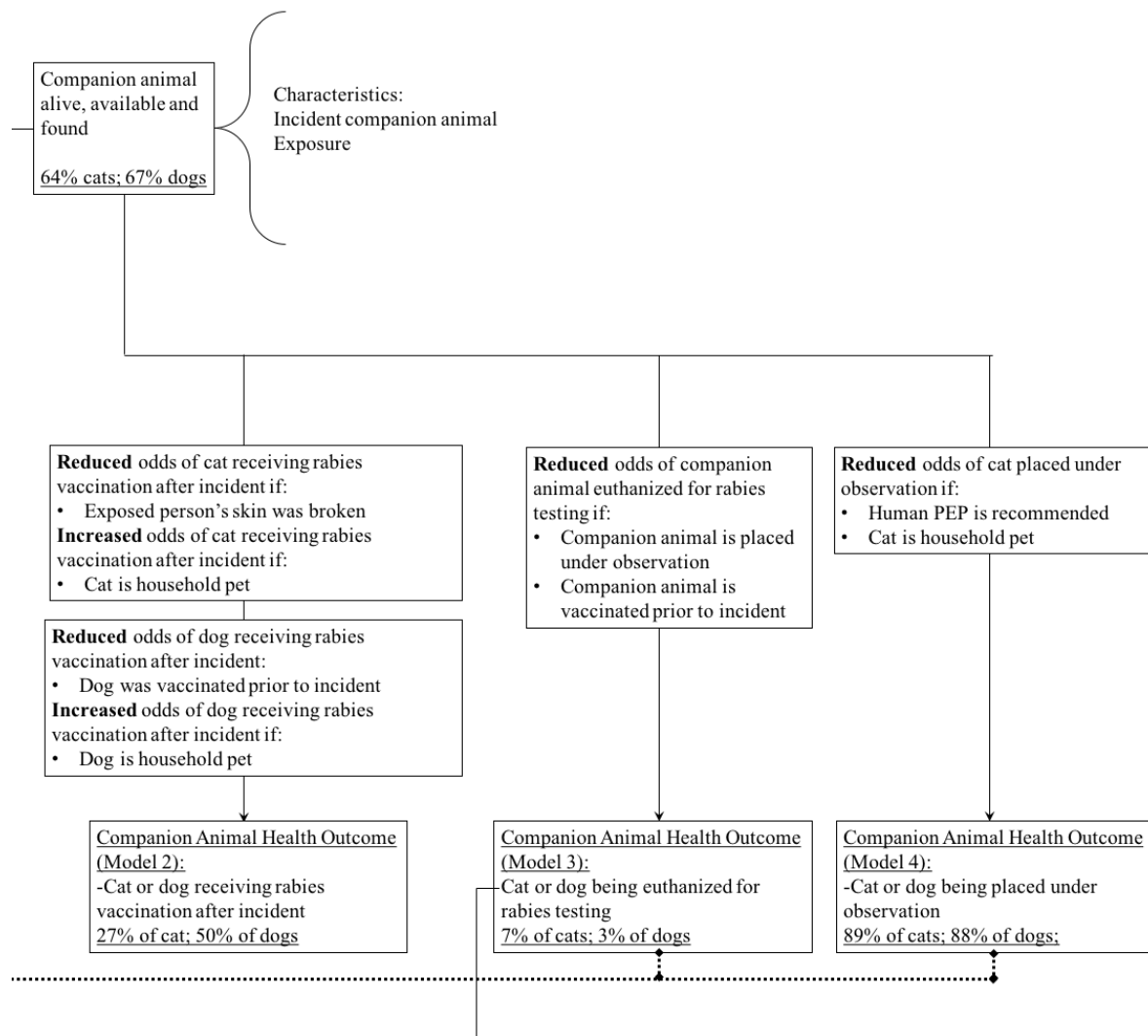


Figure 11. Human and companion animal health outcomes in the rabies management system of Ottawa, Ontario (right side).

6. Discussion

The One Health concept recognizes that the health of humans is inherently connected to the health of animals and their shared environment; it is a concept that attempts to optimize health-for-all (Zinsstag et al., 2011). The focus of rabies management has largely been to protect human health by preventing human rabies cases. The way this has been achieved has been to prevent companion animal cases. If, however, the rabies management system solely focuses on human health outcomes then a proportion of the system is missing: companion animal health outcomes. By negating the companion animal rabies management system, the indication is that human health is not actually being adequately protected. Therefore, when companion animal health outcomes are included along with human health outcomes a more complete understanding of the rabies management system is accomplished. The implication is that human health can be improved and at the same time so can companion animal health. This thesis aimed to identify the factors that influence human and companion animal health outcomes in rabies management in order to visualize this conceptualized rabies management system in Ottawa, Ontario. This section presents the principal findings of the quantitative, qualitative and mixed methods approaches and provides a response to the research questions in the context of the current literature. This is followed by recommendations that attempt to foster improved human and companion animal health outcomes in rabies management and in society. The limitations of the methodological approaches are discussed.

The research questions asked in this thesis were:

1. Mixed methods: How can the rabies management system be described with both human and companion animal health included as outcomes in Ottawa, Ontario?
2. Quantitative: To explore the relationship between potential human rabies exposures, and human and companion animal health outcomes in Ottawa, Ontario related to human post-exposure prophylaxis recommendation, and a companion animal receiving a post-incident rabies vaccine, being euthanized for rabies testing and being placed under observation.
3. Qualitative: How do veterinarians perceive their role in companion animal rabies management in Ottawa, Ontario?

6.1 Statement of principal findings

The findings suggest that there is a public-private divide in the rabies management system which influences both human and companion animal health outcomes. The human health outcomes exist within the public purview of provincially funded healthcare. Meanwhile companion animal health outcomes span public and private health systems. The results suggest there was a relationship between human and companion animal health outcomes in the data collected during potential human rabies exposures. Specifically, there appears to be a relationship between an exposed person receiving a post-exposure prophylaxis recommendation, and a companion animal involved in a potential human rabies incident being euthanized for rabies testing, and companion animal involved in a potential human rabies incident being placed under observation. Further, there were select incident companion animal and exposure incident characteristics that were found to be putatively associated with increased or reduced odds of a human or companion animal health outcome occurring. In particular, the companion animal species, cat or dog, appears to be influential.

Veterinarian's role is, however, private as they operate in a fee-for-service business model. The roles veterinarians have in rabies prevention and reporting is critical, however, due to their public and private responsibilities their roles sometimes conflict which leads to variations in practice depending on how an individual veterinarian prioritizes the seriousness of rabies compared to the risk. My findings suggest there are four main roles veterinarians have regarding companion animal rabies management: 1) administering rabies vaccines to companion animals, 2) reporting animal bites and suspect rabid animals, 3) communicating with clients and 4) mitigating occupational factors. Further, it was found that veterinarians experience push-pull factors that impact their role and decision making around rabies management.

Veterinarians do not operate in isolation or without consent from pet owners; since companion animal rabies vaccinations can only be administered by a veterinarian, pet owners must decide to access care, disclose information, and incur the associated costs. Veterinarian's also perceived that pet owners also experience push-pull factors that influence

their decision to access veterinary care. The public-private divide may lead to variation within the rabies management system in both prevention through rabies vaccinations as well as in the reporting of potential human rabies exposures. Overall, the results indicate that human and companion animal health outcomes are connected to veterinarians and pet owners within the rabies management. Ultimately, however, the findings suggest that the push-pull factors experienced by veterinarians and pet owners can be modified and in turn, can influence human and companion animal health outcomes in rabies management.

6.2 Companion animals, rabies management and society

Rabies management is more complicated than a linear concept of interactions and processes that occur to protect human health. My findings contribute to the growing body of literature of the One Health concept whereby human and companion animal health outcomes are inherently connected. The current rabies management system, appears to be an aggregate of multiple interactions and processes with no overarching authority. The system appears to be effective at preventing human rabies cases because the prevalence of rabies in this geographical area is low, but it does not appear to consider the health outcomes of companion animals. In order to adequately consider companion animal health outcomes, we must contextualize pet ownership along with governmental regulations within society. Findings from this thesis suggest that society's veterinary care and pet acquisition practices, and related limited governmental regulations around pet ownership influence rabies management and associated human and companion animal health outcomes.

There is no indication of an overarching authority on rabies management but rather a trend towards species-specific health management. Consequently, there is an obvious need to better leverage the veterinary community as the bridge to pet owners in rabies prevention, but also when dealing with potential human exposure incidents. I argue the current rabies management system has formed in this way because of the public-private divide. The reporting and investigation of human rabies exposures, and subsequent necessary medical follow up, fall under the public purview. Prevention of rabies through companion animal rabies vaccination administered by veterinarians is private and as such, pet owners must

decide to access and incur the associated costs. This leads to variation in the prevention and reporting interactions and processes within the rabies management system whereby human and companion animal health outcomes are dependent more on a pet owner and veterinarian's understanding of and approach to rabies management.

Participants in this thesis perceived that societal influences, such as the anti-vaccination movement in the human health care system, a general understanding of zoonotic diseases, and maintaining the status-quo may contribute to the decision. Further, the notion that the rescue of animals is a societal good is prevalent, and as the demand for rescue animals grows there is a depletion in the availability in a urban locations which results in prospective owners looking elsewhere and potentially compromising health or ethical procurement standards. We do not have information on pet acquisition practices in the Canadian context, but in the United States, dogs were most commonly sourced from family or a friends, followed by breeders, shelter or rescue groups, pet store, or were found (Volk, Felsted, Thomas, & Siren, 2011). Cats were most commonly found as strays, followed by being sourced from friends or family, shelters or rescues, pet stores or breeders (Volk, Thomas, Colleran, & Siren, 2014). Rescue groups have begun to translocate animals, dogs in particular, from other countries, some of which are rabies endemic. A Report of the Canadian National Canine Importation Working Group identified that gaps exist regarding the monitoring and control of companion animal translocation into and within Canada and included rabies as a significant risk with severe consequences (*Report of the Canadian National Canine Importation Working Group*, 2016). There is also concern that owners that acquire pets from shelters or rescues will not be knowledgeable about the need for veterinary care because the pet will likely already have received traditional "starter services", such as first vaccination or neutering, which may have questionable validity (Volk et al., 2011).

When we consider that there is a relationship between potential human rabies exposures, and human and companion animal health outcomes we must acknowledge that the rabies management system is incomplete when we solely focus on human health outcomes. The implication is that human health is not adequately protected unless we also consider the health of companion animals (Rock & Degeling, 2015). This is especially significant as the majority of the local Public Health Unit's investigation are due to incidents involving

companion animals. This points to a systemic flaw within the rabies management system where veterinarians, who are the natural link between companion animals and public health, are not leveraged to their full capacity due to their conflicting public and private responsibilities. That is, because veterinarians operate in a fee-for-service model it may conflict with their ability to fully protect the public from companion animal zoonotic disease. This suggests that veterinarians' conflicting public and private responsibilities contribute to variation in veterinarians' private practice as well as variation in their involvement with other agencies contributing to rabies management, such as the local Public Health Unit. The rabies management system relies on veterinarians to interact with owners, which is arguably the best opportunity for the rabies prevention or zoonotic disease prevention, but if there is variation in practice the opportunity could be missed. This is especially pertinent as veterinarians perceive the influence from the anti-vaccination movement in the human health system moving into veterinary medicine. The flaw in the system is that private veterinarians, and by extension the majority of pet owners, are not entirely engaged with the local Public Health Unit in rabies prevention or exposure response strategies.

6.2.1 Implications for public health

6.2.1.1 Differences in companion animal species

Overall, incidents involving companion animals appear to have decreased between 2010 and 2014, however, when separated by species, incidents involving cats decreased but incidents involving dogs appear to have increased. This may be related to an increase in media attention regarding the translocation of two rabid puppies from Nunavut to Calgary (2013) and to Saskatchewan (2014) (Curry et al., 2016). I found cats were involved in approximately 30% of incidents while dogs represented the majority of animal species involved in potential human rabies exposure in approximately 70% of cases. These proportions nearly match those seen in potential human rabies incidents investigated by the Wellington-Dufferin Public Health Unit (Bottoms et al., 2014). Of interest, however, are the differences in incident companion animal and exposure characteristics between cats and

dogs. The differences between cats and dogs with respect to exposure incidents (e.g. exposure provoked, type of exposure) are more understandable as the two species have distinct behavioural characteristics. What is concerning are the differences between cats and dogs related to pet ownership practices. More dogs than cats were considered household pets and were also vaccinated against rabies prior to the potential human exposure incident. This is consistent with the Ottawa-Carleton survey conducted in 2000 where fewer cats were immunized than dogs (Goodwin et al., 2002). These findings also align with the Bayer Veterinary Care Usage Study in the United States that found pet owners provide different levels of care and access to veterinary medicine depending on whether the companion animal is a cat or dog; dogs are more likely to be seen by a veterinarian and have access to veterinary care than cats (Volk et al., 2011).

Further, the four logistic regression models explored which incident companion animal and exposure characteristics were putatively associated with the occurrence of human or companion animal health outcomes and revealed two major findings. First, the models indicated that the companion animal species modified the effect of incident animal and exposure characteristics in three of the health outcomes: human post-exposure prophylaxis recommendation, companion animal receiving a rabies vaccine after the incident, and the companion animal being placed under observation. Companion animal species did not appear to affect associations related to companion animal euthanasia for rabies testing but that may be related to the low sample size observed. Second, my findings explicitly connect human and companion animal health outcomes in rabies management. There is an association between the human health outcome, human post-exposure prophylaxis recommendation, and two companion health outcomes: the companion animal being euthanized for rabies testing as well as the companion animal being placed under observation. The companion animal receiving a rabies vaccination after the incident was not associated with the other health outcomes. This may be because approximately 47% of the data on whether the companion animal was vaccinated against rabies after an incident was missing. It is ultimately up to the owner to proceed with the rabies vaccination while the local Public Health Unit has more human resource capacity to deal with human post-exposure prophylaxis recommendation, arranging companion animal euthanasia, and

ensuring observation periods are followed compared to ensuring rabies vaccinations are completed. Thus, when approaching rabies management, differences in companion animal species and species-specific pet ownership must be acknowledged as related to influence human and companion animal health outcomes.

6.2.1.2 Human post-exposure prophylaxis

In the municipality under investigation, rabies post-exposure prophylaxis was recommended to an exposed individual in 8% of incidents involving cats and 15% involving dogs. These rates are lower than the Ontario rabies post-exposure prophylaxis recommendations rates that were examined in 2013 which found that 20% were due to cats while 39% were due to dogs (Middleton et al., 2018). After applying exclusion criteria, this 2013 study determined the majority of incidents requiring post-exposure prophylaxis involved cats and dogs that were unknown to the exposed person or had escaped (Middleton et al., 2018). Further, several exposure characteristics were assessed and indicated that more cats than dogs were provoked in incident and that the exposure occurred through a scratch or saliva (Middleton et al., 2018). These exposure characteristics did not appear to be significantly associated with rabies post-exposure prophylaxis recommendations in the cat or dog models. In the model with the cat species there were reduced odds of an exposed individual receiving a post-exposure prophylaxis recommendation when a cat involved in the incident was euthanized for rabies testing, placed under observation, was alive, available and found, and was a household pet. There were reduced odds of an exposed individual receiving a post-exposure prophylaxis recommendation when a dog involved in the incident was euthanized for rabies testing, was alive, available and found, placed under observation, was vaccinated prior to the incident and was a household pet. There is a difference between cats and dogs regarding the significance of the rabies vaccine prior to the incident which may imply that rabies vaccinations may be considered as more important for dogs than cats by the Public Health Unit when recommending rabies post-exposure prophylaxis.

6.2.1.3 Companion animal euthanasia for rabies testing

In instances where the companion animal was alive, available and found it was rare for the companion animal to be euthanized for rabies testing with this occurring in 7% of cases involving cats, and 3% involving dogs. There were reduced odds of a cat or dog being euthanized for rabies testing when the companion animal was placed under observation and when the animal was vaccinated prior to the incident. The difference in euthanasia rates for rabies testing between cats and dogs could be related to a higher prevalence of cats that are free-roaming. It is more common for owned cats to be outdoors unsupervised than it is for dogs and this is concerning as it does put cats a higher risk of encountering a wild rabid animal (Middleton et al., 2018). As well, there is additional risk given that cats observed in this thesis had a lower vaccination rate than dogs. Perhaps this related to historical messaging that canine rabies is more of a threat and people are less concerned about cats acquiring the rabies virus. In fact, a trend reported in the United States has now detected the opposite: rabies in cats has been observed in disproportionately higher rates than rabies in dogs (Gerhold & Jessup, 2013). Further, more people are exposed to rabies due to free-roaming cats than any other companion animal (Gerhold & Jessup, 2013). It has also been reported that 66% of Canadian expert stakeholders believed there was a cat overpopulation problem in their municipality, but the severity of the problem is unknown (Canadian Federation of Humane Societies, 2017). The attitudes of the residents in the municipality surrounding cat husbandry practices in general is not well understood but in Southern Ontario it was found that the treatment of free-roaming cats varies geographically, from the removal of all cats to the management of cat populations but there has yet to be consensus on a management strategy (Hall et al., 2016; Van Patter & Hovorka, 2018). My findings suggest that a greater focus needs to be given to understanding local cat ownership practices, cat demography as well as how the veterinary community and local Public Health can work together to address overall cat welfare and cat related public health concerns.

6.2.1.4 Companion animal observation periods

In this municipality, instances where the companion animal was alive, available and found, cat and dogs were placed under observation in 89% and 88% of cases respectively. This is in

contrast to a study in Ontario in 2013 that stated only 5% of records indicated that a cat was placed under observation (Middleton et al., 2018). This is perhaps due to differences in reporting across all health regions in Ontario. There were reduced odds of a cat being placed under observation when human post-exposure prophylaxis was recommended as well as when the cat was a household pet. There were no significant characteristics related to a dog being placed under observation. This thesis was not able to ascertain the precise reason for this result, and future inquiry into this area is recommended. Although it appears that the majority of cats and dogs are placed under an observation period, there is a gap in research into the effects of at home observation periods on companion animals and their owners. It was perceived by veterinarians interviewed in this thesis that observations are very difficult for some owners and may not be easy or stress-free. Veterinarians were also concerned that the risk and seriousness of rabies were undermined when a potentially rabid animal was sent home with owners who could then expose more people. For this reason, owners may not comply with the observation period. As well, in cases where a veterinarian did not think an animal should be placed under observation, such as if it was aggressive or if it was an older animal that was nearing end of life and the owners decided to euthanize in both instances, it put the veterinarian in a conflicted and difficult position where they may decide to act against the local Public Health Unit for the sake of animal welfare or the animal owners. It has been observed that veterinarians have reported feeling a strong loyalty to their pet owning clients (Volk et al., 2011).

6.2.1.5 Companion animal rabies vaccination after a potential human rabies exposure incident

In incidents where the companion animal was alive, available and found after an incident, only 27% of cats and 50% of dogs were reported to have received a rabies vaccine following the incident. This could be of significance given there is a greater cat population than dog population in Canada, more cats are free-roaming outdoors and fewer cats are vaccinated than dogs which is consistent with the result found in this thesis (Canadian Animal Health Institute, 2015; Canadian Federation of Humane Societies, 2017) In fact, I found the rabies vaccinations rates of alive, available and found of cats prior to an incident to be only 28%.

There were reduced odds of a cat receiving a rabies vaccine after an incident when the exposed person's skin was broken but the reason for this result is unknown. Intuitively, there were increased odds of a cat receiving a rabies vaccine after an incident when the cat was a household pet. Dogs did have a higher rabies vaccination rate prior to an incident at 71%. This was consistent with veterinarians interviewed that perceived a difference in acceptance of the rabies vaccine between the cat owners compared to dog owners, with cat owners being more hesitant. I found reduced odds of a dog receiving a rabies vaccine after an incident when the dog was vaccinated prior to the incident, which is perhaps because the vaccination status of the animal was up-to-date and therefore another vaccine was unnecessary. I did however find there to be increased odds of a dog receiving a rabies vaccine after an incident when the dog was a household pet.

6.2.2 Implications for the veterinary profession

Veterinarians are aware they have public responsibilities and private responsibilities related to rabies management. At times, however, these responsibilities may conflict with one another which propagates further conflicts within their rabies management roles in administering rabies vaccines, reporting potential rabies exposures, communicating with clients and mitigating occupational risks. Berry (2014) writes that it is difficult to navigate the dynamic role of a veterinarian as “our obligation to our patients may conflict with the expectations of our peers, clients and society in general” (Berry, 2014). He continues that even through published protocols, such as vaccine protocols, help veterinarians make decisions, given the geographic variations of diseases it can be difficult for veterinarians to determine a protocol's applicability in their area (Berry, 2014). Thus, the individual veterinarian is required to prioritize relevant local information to inform their decision-making which may lead to variation in their clinical practice (Berry, 2014). My findings are similar in that I postulate the way in which veterinarians approach their public and private responsibilities in rabies management is dictated by how the individual veterinarian prioritizes the seriousness of rabies compared to the risk of rabies. This leads to variation in a veterinarian's clinical practice as well as involvement with other agencies contributing to rabies management. There is a gap in this knowledge area and thus, the lived experiences of

veterinarians need to be further explored as it pertains to companion animal zoonotic disease management and interaction with local Public Health Units as well as pet owners.

6.2.2.1 Veterinarian-Public health interaction

One of the main roles veterinarians have with respect to companion animal rabies management is to report animal bites and suspect rabid animals. However, Bottoms et al., (2014) found that only 6% of potential human rabies incidents were reported to the Wellington-Dufferin Public Health Unit by a veterinarian. While it was not possible to infer this statistic from my data, I found that veterinarians did not always have a clear understanding of reporting requirements, especially when an animal required a euthanasia but had been involved in an exposure incident. Said another way, there is a clear barrier in the rabies management system where veterinarians are unable to access the public health officials in a timely manner. While there is research into the contribution and role of veterinary medicine to the field of public health there is a limited understanding of the barriers in veterinary-public health interaction at the local level (Cipolla, Bonizzi, & Zecconi, 2015). My findings suggest that veterinarians know the local Public Health Unit was the point of contact if there was a clear need to report but experienced difficulty in trying to connect with the correct individual either because they did not know who that person was or because of time delays. Further, veterinarians felt out of the loop with the local Public Health Unit after they did report and were not asked to further engage. Further, in instances where the local Public Health Unit received a report from a non-veterinarian there is a missed opportunity to connect pet owners with veterinarians if the pet owner had not previously accessed veterinary care.

6.2.2.2 Veterinarian-owner interaction

The veterinarian-owner interaction is a catalyst for companion animal health and as a result, effective veterinarian-owner communication is imperative. Not surprisingly, ineffective communication has been found to negatively affect the animal health outcomes and compromises the occupational risk of veterinarians and the veterinary team (Hamood, Chur-

Hansen, & McArthur, 2014) There has, however, been a growing body of research delving into the competencies necessary for effective veterinary-owner communication and has been incorporated into veterinary school curricula (Hamood et al., 2014). Factors that contribute to breakdowns in communication include poor communication skills of the veterinarian, difference in motivations between the owner and the veterinarian, the owner's perception about the veterinarian, and the client's understanding of the information (Hamood et al., 2014). While these factors are common to all aspects of veterinary medicine, a study conducted in Australia found that there were specific communication issues related to emerging zoonotic diseases (Mendez, Büttner, Kelly, Nowak, & Speare, 2016). Specifically, veterinarians attributed their varied ability to communicate about Hendra virus due to its low prevalence and slow emergence and as a result, owners were largely uninformed and resisted clinical recommendations because they were worried that veterinarians were focused on the costs (Mendez et al., 2016). This is consistent with another report that over 40% of veterinarians worried that "pet owners believed they were recommending wellness examinations to make money" (Volk et al., 2011) which was comparable in this thesis with concern expressed regarding maintaining trust while working within the fee-for-service model. Other low prevalence but high consequence zoonotic diseases, such as rabies, face similar specific communication issues and veterinarians need to refine their ability to communicate about rabies vaccination and explain the risks to animal health and human health as well as the economic concerns (Mendez et al., 2016; Volk et al., 2011).

In this thesis, the rabies vaccination rates of cats and dogs prior to their involvement in an incident were found to be 21% for cats and 57% for dogs. These rates were different, however, when the companion animal was alive, available and found. Cats were vaccinated against rabies in 28% of cases and dogs were vaccinated in 71% of cases. Comparatively, the rabies vaccination rates of cats and dogs prior to their involvement in a rabies exposure incident in Wellington–Dufferin–Guelph Public Health were 40% for cats and 59% for dogs (Bottoms et al., 2014). The Bayer Veterinary Care Usage Study in the United States (2014) also found lower vaccination rates for cats than dogs (Volk et al., 2014). Given the varying rates of rabies vaccinations both before and after a potential human rabies exposure between species and geographic areas, I question whether current rabies vaccine enforcement

methods are effective. Particularly as veterinarians did not perceive enforcement a part of their role and some owners, as with human medicine, will not vaccinate, will hesitate because they do not see the need, or fear vaccine reactions. Veterinarians were of the opinion that rabies vaccination enforcement only occurred when there was a public health issue with the companion animal, such as an animal bite incident, or when proof is required to access a service, such as grooming, or for cross border travel. This suggests the translation of legislation, by-laws and policies into veterinary practice ultimately puts the health of society at odds with the health of animals because of the underlying public-private divide. A better understanding of factors that influence an owner's decision to incur in the costs of veterinary care and subsequent compliance regarding rabies vaccinations may provide insight into the nuances of these results.

Although veterinarians interviewed in this thesis did not perceive the cost of the actual rabies vaccine to be problematic for owners, but rather the cost associated with the veterinary exam, it is not possible to discern which cost is more prohibitive without current research on owner experiences in this municipality. One study from 2000 reported that the cost of the vaccine was an issue for residents with non-immunized pets in the Ottawa region (Goodwin et al., 2002). This is an important differentiation as only veterinarians are able to administer the rabies vaccine in Ontario but owners ultimately making the decision to access and accept veterinary care and incur the associated costs. Given the majority of veterinarians did not believe that owners they saw knew about the requirement I question what percentage of the pet owning but non-veterinary accessing population are aware of the requirement. It would be necessary to ask owners of their knowledge as the most current estimates are from 2000 and state that 65% of owners are aware of the legislation. This signifies a gap in the rabies management system as no authority is aware of current owners' knowledge, attitudes and perceptions on rabies and thus, it is possible that owners may not be aware of the significant part they represent in the rabies management system. Further, even if owners are aware, they also may not be able to engage due to cost or access barriers.

6.2.2.3 Occupational Risks

All veterinarians in this thesis reported having had a prophylactic rabies vaccine as one measure to mitigate their own occupational risks, but there was uncertainty as to whether other members of the veterinary team had also been vaccinated. This is an unnecessary risk given inherent nature of the veterinary profession puts veterinarians, and presumably other members of the veterinary team, at higher risk of acquiring zoonotic infections (Jackson & Villarroel, 2012). Regardless of the prevalence of rabies in an area it is recommended by the Public Health Agency of Canada that all members of the veterinary team are vaccinated against rabies (Public Health Agency of Canada, 2018a). Little is known, however, about the rabies vaccination rates in veterinary teams in the municipal context, but a study in the United States found that nearly 14% of veterinary respondents had not been vaccinated against rabies (Jackson & Villarroel, 2012). What is concerning is that 21% of veterinary respondents reported having been exposed to a rabid animal, and domestic animals (horse, dog, cattle, cats, and sheep) were the most common exposure species (Jackson & Villarroel, 2012).

6.3 Recommendations for the rabies management system

With the recognition that human and animal health are connected there is a call for a new “paradigm of health management” at the local level where both human and veterinary medicine collaborate (Rock et al., 2009) I deem “public health” to be a term that encompasses both human and animal health, and in order to promote or maintain healthy living environments both must be considered (Rock & Degeling, 2015; Rock et al., 2017). With respect to rabies, I recommend that public health modifications are made to the management of the system. Of importance is the recognition by both public health and the veterinary community that pet owners are instigators of the rabies management system, yet they may not know they are a part of system or may not have the means to engage in the system if access to veterinary medicine is unattainable. Uniform and specific public health messaging and communication about rabies prevention and responsible pet ownership,

including animal acquisition, is needed. Differences in pet ownership practices and access to veterinary care between cats and dogs also needs to be addressed.

I offer that this may be achieved through a public-private partnership which aligns with the public-private divide in rabies management. Public-private partnerships on a global scale in canine rabies management have been shown to be an effective strategy when multiple stakeholders are involved (Taylor, 2013). In this municipality, I recommend that a public-private partnership be created in the form of a Public Health-Veterinary partnership that also includes relevant community groups, such as animal rescue groups. Community Veterinary Outreach, and community educators. This will provide the mechanisms for public health officials, private veterinarians, and other relevant stakeholders, such as physicians, to communicate, prioritize issues, develop uniform strategies and begin surveillance for a variety of public health issues that require collaborative action to adequately protect human as well as companion animal health. Further, it is through this mechanism that policies on pets can be developed or reformed to better reflect the health of both humans and companion animals at the local level (Rock, Adams, Degeling, Massolo, & McCormack, 2015). It is recommended that the local Public Health Unit is the lead, however, in recognition of potential capacity issues a committed veterinary group or community organization could take a leadership role.

6.4 Limitations

There are limitations with respect to the quantitative and qualitative methodology that may influence the conclusions drawn from the mixed methods findings. As such, the generalization of the findings to other municipalities should be done so after careful consideration even if similar rabies policies and the prevalence of rabies is comparable. In this case, there was a time delay between the quantitative data collection and the qualitative data collection. It is possible that there were differences in the behaviour of the rabies management system during those two periods of time that were missed especially as there was a shift in provincial guidelines in 2013 as well as federal and provincial responsibilities in 2014. It is unknown if the geographical setting of this thesis research is unique or distinctive from other municipalities within Ontario. It would be interesting to reanalyze the

system at various time points to see if there shift in the responsibilities or update in guidelines that had an impact on the health outcomes or the incident companion animal or exposure characteristics.

6.4.1 Limitations: Quantitative

The secondary analysis on potential human rabies exposures had several limitations. Even though the data was cleaned prior to analysis, it was not possible to verify the data quality and accuracy. Systematic variation in the way individuals enter the incident data is possible. Further, the incident data was extracted in such a way that it is not possible to determine if one animal was responsible for exposing more than one individual. The age of companion animal involved in incidents also was not captured. This is relevant as only companion animals that are over 12 weeks of age are required to have a rabies vaccination, and indeed participants in this thesis stated that it is common to wait until 16 weeks of age to vaccinate against rabies. It was also not possible to include some of the desired risk factors as this information was either not captured in the data set or could not be extracted: location of wound, history of aggressive behaviour, exposure to a wild animal or other potentially rabid animal. One or more of these variables could have a significant influence on human or companion animal health outcomes that was not accounted for. Sample size was a central limitation regarding some of the health outcomes and predictors. Although associations were found, it could be an artifact of the sample size and this does not imply associations are causal. Additionally, in the data preparation process, several variables removed from the analysis because the information was missing or ambiguous while other variables were combined or dichotomized leading to a possible loss of information and thus, bias.

6.4.2 Limitations: Qualitative

Veterinarians volunteered to participate in this thesis research, so are likely to be more invested in public health and may even recognize or subscribe to the One Health concept. Further, some veterinarians (n=8) are known to volunteer with a charitable organization, Community Veterinary Outreach, which advocates for One Health. Further, many of the veterinarians that participated were more familiar with the urban areas of the municipality

rather than the rural areas. Due to this selection bias, generalizing the findings to other veterinarians should be done so with a degree of caution. It is not inconceivable, however, that other veterinarians that practice within similar municipalities may share similar perceptions as in the Veterinarian Oath, established by the Canadian Veterinarian Medical Association, is the inclusion of the promotion of animal health along with the protection of the health of the public (Canadian Veterinary Medical Association, 2018).

The findings are limited to veterinarian's perception of their approach and role in rabies management. As the questions asked were exploratory in nature, it would be interesting to ask more nuanced questions regarding their approach and role in companion animal rabies management and zoonotic diseases in general. As well, the findings are limited to veterinarian's perception of companion animal owners, and not of owners themselves. The findings are not a direct observation of how decisions are made or how interactions between veterinarians and owners, OMAFRA or the local Public Health Unit actually occur. Direct observation would be necessary to fully contextualize the interactions characterized. To get a more complete visualization of the rabies management system it would also be imperative to explore the perceptions of other actors in the systems including pet owners, OMAFRA and the Public Health Unit. I did speak to individuals at the OMAFRA and the local Public Health Unit to gather general information about the interactions and processes within the rabies management system but was unable to conduct a formal interview.

7. Conclusion

This thesis makes a contribution to the application of the One Health concept. The systems approach used in this thesis to apply the One Health concept strengthens the value of the findings by identifying systemic failures within the rabies management system. The mixed methods analysis contributes to existing literature on human and companion animal health outcomes in rabies management within a municipality. The human health outcome of interest is the recommendation of human rabies post-exposure prophylaxis after a potential rabies exposure by a cat or dog. The companion animal health outcomes include a cat or dog involved in a potential human rabies exposure receiving a rabies vaccine after the incident, being euthanized for rabies testing, or being placed under observation. Specifically, this thesis adds to the knowledge on the explicit connection between human and companion animal health outcomes related to rabies, companion animal health outcomes in rabies, and veterinarians' perceived role in rabies management; all of which had yet to be studied in the municipal context where rabies prevalence is low. However, the experiences of the individuals within the local Public Health Unit and pet owners do need to be included to complete the rabies management system reconceptualization.

This thesis has demonstrated that rabies management is more complicated than a linear concept of interactions and processes that occur to protect human health. This is evident as the human health outcome under investigation is explicitly connected to companion animal health outcomes in the rabies management system. For example, there is an association between human rabies post-exposure prophylaxis recommendations and two companion health outcomes: the companion animal being euthanized for rabies testing as well as the companion animal being placed under observation. Of potential public health importance are the observed differences between cat and dog characteristics, such as rabies vaccination rates prior to an incident, and their relation to the human and companion animal health outcomes. This suggests that pet ownership practices differ based on the species of companion animal and thus, there is a knowledge gap on local pet ownership practices. The public health implication is that veterinarians are being under-leveraged with respect to companion animal zoonotic disease management. This may be because how veterinarians approach their public

and private responsibilities, and subsequently their role in rabies management is dictated by how the individual veterinarian prioritizes the seriousness of rabies compared to the risk of rabies. This is in addition to other push-pull factors that dictate how they approach their role. Veterinarians also perceived that pet owners experienced push-pull factors that influence their decision to access veterinary care. This not only leads to variation within the veterinarian's clinical practice and interactions with pet owners but also to variation in involvement with other agencies contributing to rabies management. The findings suggest that the push-pull factors experienced by veterinarians and pet owners can be modified. In turn, they can influence human and companion animal health outcomes in rabies management. Thus, there is a plain need for further inquiry into the lived experiences and approach of veterinarians managing companion animal zoonosis and associated barriers and opportunities to leverage their link between pet owners and the local Public Health Unit.

In conclusion, this thesis ultimately highlights the multiple salient stakeholder interactions and health outcome processes that aggregate to form the rabies management system. There is no apparent overarching authority which may be attributed to the public-private divide that occurs between rabies prevention and reporting. At the local level, however, there is an opportunity to marry this divide through a collaborative partnership between the local Public Health Unit and private veterinarians. The nature of this collaboration would focus on engaging pet owners in health-for-all optimization strategies pertaining to rabies and other zoonotic diseases. Companion animals and their owners are a significant part of our society; it is critical that our public health system reflects this regardless of the public-private divide.

8. References

- Aenishaenslin, C., Simon, A., Forde, T., Ravel, A., Proulx, J.-F., Fehlner-Gardiner, C., ... Bélanger, D. (2014). Characterizing rabies epidemiology in remote Inuit communities in Québec, Canada: a “One Health” approach. *EcoHealth*, 11(3), 343–55. <https://doi.org/10.1007/s10393-014-0923-1>
- Asokan, G. V. (2015). One Health and Zoonoses : The Evolution of One Health and Incorporation of Zoonoses. *Central Asian Journal of Global Health*, 4(1). <https://doi.org/10.5195/cajgh.2015.139>
- Berry, J. (2014). Ethical practice. *The Canadian Veterinary Journal = La Revue Veterinaire Canadienne*, 55(1), 1187–1190.
- Bottoms, K., Trotz-Williams, L., Hutchison, S., MacLeod, J., Dixon, J., Berke, O., & Poljak, Z. (2014). An evaluation of rabies vaccination rates among canines and felines involved in biting incidents within the Wellington-Dufferin-Guelph Public Health Department. *Zoonoses and Public Health*, 61(7), 499–508. <https://doi.org/10.1111/zph.12101>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Canadian Animal Health Institute. (2015). Latest Canadian Pet Population Figures Released. *American Veterinary Medical Association 2012 Pet Ownership & Demographics Sourcebook*, 30.
- Canadian Animal Health Institute. (2017). *Latest Canadian Pet Population Figures Released*. Guelph.
- Canadian Federation of Humane Societies. (2017). *Cats in Canada 2017*. Retrieved from https://d3n8a8pro7vhm.cloudfront.net/cfhs/pages/1782/attachments/original/1524169616/Cats_In_Canada_2017-FINAL-EN-LRs.pdf?1524169616
- Canadian Food Inspection Agency. (2014a). 2011-2013 Positive Rabies in Canada. Retrieved from <http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/rabies/rabies-in-canada/positive-rabies-2011-2013-/eng/1406218460196/1406218461478>
- Canadian Food Inspection Agency. (2014b). Rabies testing at the CFIA: General information and submission guidelines. Retrieved January 11, 2017, from [https://www.canadianveterinarians.net/rabies/en/documents/1_general information and submission guidelines v1 2014.pdf](https://www.canadianveterinarians.net/rabies/en/documents/1_general%20information%20and%20submission%20guidelines%20v1%202014.pdf)
- Canadian Food Inspection Agency. (2018). Rabies in Canada. Retrieved July 17, 2018, from <http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/rabies/rabies-in-canada/eng/1356156989919/1356157139999>
- Canadian Veterinary Medical Association. (2018). The Canadian Veterinary Oath. Retrieved July 17, 2018, from <https://www.canadianveterinarians.net/about/veterinary-oath>
- Cardiff, R. D., Ward, J. M., & Barthold, S. W. (2008). “One medicine---one pathology”: are veterinary and human pathology prepared? *Laboratory Investigation; a Journal of Technical Methods and Pathology*, 88(1), 18–26. <https://doi.org/10.1038/labinvest.3700695>
- Cipolla, M., Bonizzi, L., & Zecconi, A. (2015). From “One Health” to “One Communication”: The Contribution of Communication in Veterinary Medicine to

- Public Health. *Veterinary Sciences*, 2(3), 135–149.
<https://doi.org/10.3390/vetsci2030135>
- City of Ottawa. (2016). Animal Care and Control By-law No. 2003-77. Retrieved January 11, 2017, from
http://documents.ottawa.ca/sites/documents.ottawa.ca/files/2003_77_en.pdf
- Cleaveland, S., Lankester, F., Townsend, S., Lembo, T., & Hampson, K. (2014). Rabies control and elimination: a test case for One Health. *The Veterinary Record*, 175(8), 188–193. <https://doi.org/10.1136/vr.g4996>
- Coe, J. B., Adams, C. L., & Bonnett, B. N. (2008). A focus group study of veterinarians' and pet owners' perceptions of veterinarian-client communication in companion animal practice. *Journal of the American Veterinary Medical Association*, 233(7), 1072–1080. <https://doi.org/10.2460/javma.233.7.1072>
- College of Veterinarians of Ontario. (n.d.). Legislative Overview. Retrieved January 11, 2017, from [http://cvo.org/CVO/media/College-of-Veterinarians-of-Ontario/Resources and Publications/Professional Practice Standards/LORabies.pdf](http://cvo.org/CVO/media/College-of-Veterinarians-of-Ontario/Resources%20and%20Publications/Professional%20Practice%20Standards/LORabies.pdf)
- Copeland, A. J., & Agosto, D. E. (2012). Diagrams and Relational Maps : The Use of Graphic Elicitation Techniques with Interviewing for Data Collection, Analysis, and Display. *International Journal of Qualitative Methods*, 11(5), 513–533.
- Creswell, J. (2014). *Research design: qualitative, quantitative, and mixed methods approach* (4th ed.). Thousand Oaks: Sage Publications.
- Creswell, J., Klassen, A. ., Plano Clark, V., & Smith, K. . (2011). *Best Practices for Mixed Methods Research in the Health Sciences*. Retrieved from
https://www2.jabsom.hawaii.edu/native/docs/tsudocs/Best_Practices_for_Mixed_Methods_Research_Aug2011.pdf
- Cumming, D., & Cumming, G. (2015). One Health: A ecological and conservation perspective. In J. Zinsstag, E. Schelling, D. Waltner-Toews, M. Whittaker, & M. Tanner (Eds.), *One Health: The theory of integrated health approaches* (pp. 38–52). Boston: C.A.B. International.
- Curry, P., Kostiuk, D., Werker, D., Baikie, M., Ntiamoah, W., Atherton, F., ... Mema, S. (2016). Translocated dogs from Nunavut and the spread of rabies. *Canada Communicable Disease Report*, 42, 121–124.
- Filejski, C. (2016). The changing face of rabies in Canada. *Canada Communicable Disease Report*, 42(6), 118–119. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/16vol42/dr-rm42-6/assets/pdf/16vol42_6-ar-01-eng.pdf
- Frank, D. (2008, November). One world, one health, one medicine. *The Canadian Veterinary Journal = La Revue Veterinaire Canadienne*. Canada.
- Gehrig, A.-C., Hartmann, K., Gunther, F., Klima, A., Habacher, G., & Bergmann, M. (2018). A survey of vaccine history in German cats and owners' attitudes to vaccination. *Journal of Feline Medicine and Surgery*, 1098612X18759838. <https://doi.org/10.1177/1098612X18759838>
- Gerhold, R. W., & Jessup, D. A. (2013). Zoonotic diseases associated with free-roaming cats. *Zoonoses and Public Health*, 60(3), 189–195. <https://doi.org/10.1111/j.1863-2378.2012.01522.x>
- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal*, 204(6), 291–295. <https://doi.org/10.1038/bdj.2008.192>

- Given, L. . (Ed.). (2008). *Sage Encyclopedia of Qualitative Research Methods*. London: Sage Publications.
- Goodwin, R., Werker, D., Hockin, J., Ellis, E., & Roche, A. (2002). A survey of knowledge, attitudes, and practices of dog and cat owners with respect to vaccinating their pets against rabies, Ottawa-Carleton, Ontario, July 2000. *Canada Communicable Disease Report*, 28(1). Retrieved from <http://www.collectionscanada.gc.ca/webarchives/20071218015646/http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/02vol28/dr2801ea.html>
- Graham, H. (2010). Where is the future in public health? *The Milbank Quarterly*, 88(2), 149–168. <https://doi.org/10.1111/j.1468-0009.2010.00594.x>
- Habacher, G., Gruffydd-Jones, T., & Murray, J. (2010). Use of a web-based questionnaire to explore cat owners' attitudes towards vaccination in cats. *The Veterinary Record*, 167(4), 122–127. <https://doi.org/10.1136/vr.b4857>
- Hall, C. M., Adams, N. A., Bradley, J. S., Bryant, K. A., Davis, A. A., Dickman, C. R., ... Calver, M. C. (2016). Community Attitudes and Practices of Urban Residents Regarding Predation by Pet Cats on Wildlife: An International Comparison. *PloS One*, 11(4), e0151962. <https://doi.org/10.1371/journal.pone.0151962>
- Hamood, W. J., Chur-Hansen, A., & McArthur, M. L. (2014). A qualitative study to explore communication skills in veterinary medical education. *International Journal of Medical Education*, 5, 193–198. <https://doi.org/10.5116/ijme.542a.975d>
- Hartig, C. (n.d.). Personal communication.
- Jackson, J., & Villarreal, A. (2012). A survey of the risk of zoonoses for veterinarians. *Zoonoses and Public Health*, 59(3), 193–201. <https://doi.org/10.1111/j.1863-2378.2011.01432.x>
- Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. *Nature*, 451(February). <https://doi.org/10.1038/nature06536>
- Lechenne, M., Miranda, M. E., & Zinsstag, J. (2015). Integrated Rabies Control. In J. Zinsstag, E. Schelling, D. Waltner-Toews, M. Whittaker, & M. Tanner (Eds.), *One Health: The theory of integrated health approaches* (pp. 176–189). Boston: C.A.B. International.
- Leung, Z., Middleton, D., & Morrison, K. (2012). One Health and EcoHealth in Ontario: A qualitative study exploring how holistic and integrative approaches are shaping public health practice in Ontario. *BMC Public Health*, 12(1), 358. <https://doi.org/10.1186/1471-2458-12-358>
- McGinnis, M., & Ostrom, E. (2014). Social-ecological system framework : initial changes and continuing. *Ecology and Society*, 19(2).
- Mendez, D. H., Büttner, P., Kelly, J., Nowak, M., & Speare (posthumously), R. (2016). Difficulties experienced by veterinarians when communicating about emerging zoonotic risks with animal owners: the case of Hendra virus. *BMC Veterinary Research*, 13, 56. <https://doi.org/10.1186/s12917-017-0970-2>
- Middleton, D., Edwin, J. J., Johnson, K. O., & Warshawsky, B. F. (2018). A descriptive analysis of rabies post-exposure prophylaxis data: 2013, Ontario, Canada. *Zoonoses and Public Health*, 65(1), e66–e78. <https://doi.org/10.1111/zph.12410>
- Middleton, D., Johnson, K. O., Rosatte, R. C., Hobbs, J. L., Moore, S. R., Rosella, L., & Crowcroft, N. S. (2014). Human Rabies Post-Exposure Prophylaxis and Animal Rabies

- in Ontario, Canada, 2001-2012. *Zoonoses and Public Health*, 62(5), n/a-n/a.
<https://doi.org/10.1111/zph.12155>
- Ministry of Health and Long-Term Care. (2018a). *Management of Potential Rabies Exposures Guidelines, 2018*. Retrieved from
http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/protocols_guidelines/Management_of_Potential_Rabies_Exposures_2018_en.pdf
- Ministry of Health and Long-Term Care. (2018b). *Ontario's Rabies Immunization Requirements for Animals*. Retrieved from
https://www.ontarioagsocieties.com/images/2018/FAQs_Rabies_Immunization_-_March_2018.pdf
- Ministry of Health and Long-Term Care. (2018c). Ontario Public Health Standards: Requirements for Programs, Services, and Accountability. Retrieved July 18, 2018, from
http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/protocols_guidelines/Ontario_Public_Health_Standards_2018_en.pdf
- Ministry of Health and Long-Term Care. (2018d). *Rabies Prevention and Control Protocol, 2018*. Retrieved from
http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/protocols_guidelines/Rabies_Prevention_and_Control_Protocol_2018_en.pdf
- Morrison, V. (2013). *Wicked problems and public policy*. National Collaborating Centre for Healthy Public Policy. Retrieved from
https://www.inspq.qc.ca/pdf/publications/1841_Wicked_Problems_Policy.pdf
- Ontario Ministry of Agriculture Food and Rural Affairs. (2018). Rabies in Ontario. Retrieved August 24, 2018, from <https://oahn.ca/news/ontario-rabies-update-for-august-15-5-new-cases/>
- Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, 104(39), 15181–7.
<https://doi.org/10.1073/pnas.0702288104>
- Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science (New York, N.Y.)*, 325(5939), 419–422.
<https://doi.org/10.1126/science.1172133>
- Public Health Agency of Canada. (2018a). For health professionals: Rabies. Retrieved July 17, 2018, from <https://www.canada.ca/en/public-health/services/diseases/rabies/for-health-professionals.html>
- Public Health Agency of Canada. (2018b). Surveillance of rabies.
- Report of the Canadian National Canine Importation Working Group*. (2016). Retrieved from <https://www.canadianveterinarians.net/documents/canadian-canine-importation-working-group-report>
- Rock, M., Buntain, B., Hatfield, J., & Hallgrimsson, B. (2009). Animal-human connections, “one health,” and the syndemic approach to prevention. *Social Science & Medicine* (1982), 68(6), 991–995. <https://doi.org/10.1016/j.socscimed.2008.12.047>
- Rock, M., & Degeling, C. (2015). Public health ethics and more-than-human solidarity. *Social Science & Medicine*, 129, 61–67.
<https://doi.org/10.1016/j.socscimed.2014.05.050>
- Rock, M., Adams, C. L., Degeling, C., Massolo, A., & McCormack, G. R. (2015). Policies on pets for healthy cities: a conceptual framework. *Health Promotion International*,

- 30(4), 976–986. Retrieved from <http://dx.doi.org/10.1093/heapro/dau017>
- Rock, M., Rault, D., & Degeling, C. (2017). Dog-bites, rabies and One Health: Towards improved coordination in research, policy and practice. *Social Science & Medicine (1982)*, 187, 126–133. <https://doi.org/10.1016/j.socscimed.2017.06.036>
- Roger, F., Caron, A., Morand, S., Pedrono, M., Garine-, M., & Chevalier, V. (2016). One Health and EcoHealth: the same wine in different bottles? *Infection Ecology and Epidemiology*, 1, 4–7.
- Rogers, C. L. (2011). Rabies vaccination compliance following introduction of the triennial vaccination interval--the Texas experience. *Zoonoses and Public Health*, 58(4), 229–233. <https://doi.org/10.1111/j.1863-2378.2010.01369.x>
- Stevenson, B., Goltz, J., & Massé, A. (2016). Preparing for and responding to recent incursions of raccoon rabies variant into Canada. *Canada Communicable Disease Report*, 42(3), 125–129.
- Tabel, H., Corner, A. H., Webster, W. A., & Casey, C. A. (1974). History and epizootiology of rabies in Canada. *The Canadian Veterinary Journal = La Revue Veterinaire Canadienne*, 15(10), 271–281.
- Tataryn, J., & Buck, P. (2016). The Canadian Rabies Management Plan : An integrated approach to the coordination of rabies activities in Canada. *Canada Communicable Disease Report*, 42(6), 135–136.
- Taylor, L. (2013). Eliminating canine rabies: the role of public-private partnerships. *Antiviral Research*, 98(2), 314–318. <https://doi.org/10.1016/j.antiviral.2013.03.002>
- Trochim, W., Donnelly, J., & Arora, K. (2014). *Research Methods: The Essential Knowledge Base*. Boston: Cengage Learning.
- Van Patter, L. E., & Hovorka, A. J. (2018). “Of place” or “of people”: exploring the animal spaces and beastly places of feral cats in southern Ontario. *Social & Cultural Geography*, 19(2), 275–295. <https://doi.org/10.1080/14649365.2016.1275754>
- Vercauteren, K., Ellis, C., Chipman, R., DeLiberto, T., & Shwiff, S. (2012). Rabies in North America : A Model of the One Health Approach. *USDA National Wildlife Reserach Center-Staff Publications, Paper 1202*. Retrieved from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2200&context=icwdm_usdanwrc
- Volk, J. O., Felsted, K. E., Thomas, J. G., & Siren, C. W. (2011). Executive summary of the Bayer veterinary care usage study. *Journal of the American Veterinary Medical Association*, 238(10), 1275–1282. <https://doi.org/10.2460/javma.238.10.1275>
- Volk, J. O., Thomas, J. G., Colleran, E. J., & Siren, C. W. (2014). Executive summary of phase 3 of the Bayer veterinary care usage study. *Journal of the American Veterinary Medical Association*, 244(7), 799–802. <https://doi.org/10.2460/javma.244.7.799>
- Zinsstag, J., Mahamat, M. B., & Schelling, E. (2015). Measuring added value from integrated methods. In J. Zinsstag, E. Schelling, D. Waltner-Toews, M. Whittaker, & M. Tanner (Eds.), *One Health: The theory of integrated health approaches* (pp. 53–59). Boston: C.A.B. International.
- Zinsstag, J., Schelling, E., Waltner-Toews, D., & Tanner, M. (2011). From “one medicine” to “one health” and systemic approaches to health and well-being. *Preventive Veterinary Medicine*, 101(3–4), 148–156. <https://doi.org/10.1016/j.prevetmed.2010.07.003>
- Zinsstag, J., Waltner-Toews, D., & Tanner, M. (2015). Theoretical Issues in One Health. In

J. Zinsstag, E. Schelling, D. Waltner-Toews, M. Whittaker, & M. Tanner (Eds.), *One Health: The theory of integrated health approaches* (pp. 16–25). Boston: C.A.B. International.

9. Appendices

A. Literature review search strategy

The following sources were searched for rabies related policies: Government of Canada, Public Health Agency of Canada, Canadian Food Inspection Agency, Government of Ontario, Ontario Ministry of Health and Long-term Care, Public Health Ontario, Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario Ministry of Natural Resources and Forestry, City of Ottawa and Ottawa Public Health.

Titles and abstracts were scanned within the MEDLINE and EMBASE databases, and if relevant to the research questions were included. References of relevant articles were manually searched, and titles of potential relevance were also included. All fields were searched for the following terms:

General

Rabies

Rabies management

Ottawa OR Ontario OR Canada

Human Health Outcome

Rabies management

Human

Post exposure prophylaxis

Human rabies vacc*

Ottawa OR Ontario OR Canada

Companion Animal Health Outcome

Rabies management

Animal rabies OR Companion animal* OR Domestic animal* OR Pet* OR Cat* OR Dog*

Rabies vacc*

Epidemiology

Rabies testing OR fluorescent antibody test

Observation OR Quarantine

Ottawa OR Ontario OR Canada

Veterinarian's Perceived Role in Rabies Management

Rabies management

Ottawa OR Ontario OR Canada

Veterinarian

Veterinary

B. University of Ottawa ethics certificates

File Number: 02-17-13B

Date (mm/dd/yyyy): 02/13/2017



Université d'Ottawa **University of Ottawa**
Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

Ethics Approval Notice **Social Sciences and Humanities REB**

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

<u>First Name</u>	<u>Last Name</u>	<u>Affiliation</u>	<u>Role</u>
Craig	Kuziemyky	School of Management	Supervisor
Raywat	Deonandan	Health Sciences / Others	Co-Supervisor
Morgann	Reid	School of Management	Student Researcher

File Number: 02-17-13B

Type of Project: Master's Thesis – Secondary Use of Data

Title: Applying the Social-Ecological Systems Framework to health outcomes: A case study of rabies management in Ottawa, Ontario

Approval Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
02/13/2017	02/12/2018	Approval

Special Conditions / Comments:

N/A



Ethics Approval Notice
Social Sciences and Humanities REB

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

<u>First Name</u>	<u>Last Name</u>	<u>Affiliation</u>	<u>Role</u>
Craig	Kuziemyky	School of Management	Supervisor
Raywat	Deonandan	Health Sciences / Others	Co-Supervisor
Morgann	Reid	School of Management	Student Researcher

File Number: 02-17-13

Type of Project: Master's Thesis

Title: Applying the Social-Ecological Systems Framework to health outcomes: A case study of rabies management in Ottawa, Ontario

Approval Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
03/13/2017	03/12/2018	Approval

Special Conditions / Comments:
 N/A

C. Veterinarian interview guide

<p>Introduction</p> <p>Thank you for agreeing to this interview. As you know, this is part of my Master's thesis in Health Systems at the University of Ottawa. I am studying rabies management in Ottawa and I am particularly interested in variables that influence human and companion animal health outcomes in rabies management. By health outcomes, I mean human mortality or animal death or euthanasia, post-exposure prophylaxis for both humans and animals, and animal observation periods. I am asking you to participate because I am interested in the veterinary perspective on factors that influence these outcomes. My goal is to identify the various components and interactions within the rabies management system, and determine if there are weaknesses, threats, opportunities or strengths.</p> <ul style="list-style-type: none">○ Explain consent form and have participant sign
<p>Rabies Management Situations</p> <p>1. Have you been involved in a situation where a companion animal has been suspected of having rabies or has had rabies?</p> <p><i>If no, then skip to next section</i></p> <p><i>If yes, then prompt</i></p> <ul style="list-style-type: none">• Tell me about that situation.• Tell me about your role in that situation.• Who did you go to for guidance?• What resources did you use?• Can you describe the follow up?<ul style="list-style-type: none">• Human: Post-exposure prophylaxis• Animal: Observation period, vaccination, euthanasia?• Who else was involved? <p>2. Are there other cases in which you were concerned about rabies?</p>
<p>Rabies Vaccinations</p> <p>3. Tell me about the process of recommending preventative rabies vaccines in your practice.</p> <p><i>Prompt</i></p> <ul style="list-style-type: none">• Tell me about the information you give clients when you recommend rabies vaccines.• Tell me about the clients that refuse preventative rabies vaccines.<ul style="list-style-type: none">• How do you handle these situations?• What reasons do these clients list, if any, for refusing rabies vaccines?• Tell me if clients seem aware that having their pet vaccinated against rabies is a legislated requirement?<ul style="list-style-type: none">• Tell me your thoughts on how these requirements are enforced.• Tell me about cases when you have not recommended a rabies vaccine. <p>4. Tell me about your thoughts on rabies only vaccinations clinics.</p> <p>5. Can you describe if, and how, cost is discussed regarding animal rabies vaccines?</p>
<p>Rabies Management in Ottawa</p> <p>6. What are your thoughts on how rabies is managed in companion animals in Ottawa?</p> <p><i>Prompt</i></p> <ul style="list-style-type: none">• Tell me about barriers that exist in rabies management.• Tell me your thoughts on the role the College of Veterinarians of Ontario plays in rabies management?
<p>Social-Ecological Systems</p> <p>7. Here is a working visualization of the rabies management system. Taking a moment to look at this document, what are some things that come to mind?</p> <p>a) Add anything that is missing, cross of anything you find to be irrelevant</p> <p>b) Circle what you think to be most important aspects or connections of the system</p>
<p>Conclusion</p> <p>That brings us to the end of all the questions I wanted to ask:</p> <p>8. Is there anything else you would like to add?</p>
<p>Other contacts and thank you</p> <p>9. Can you please refer me to other veterinarians who may be interested in participating in this research?</p> <ul style="list-style-type: none">• Can you provide their e-mail address? <p>○ Thank participant</p>

D. Rabies system graphic elicitation

