Prophylactic Animal Rabies Vaccination Requirements in Ohio and Involvement of Local Health Departments in Low Cost Rabies Vaccination Clinics

THESIS

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Abstract

In order to protect public health, the majority of states have laws mandating the prophylactic vaccination of dogs and cats against rabies. Of the 21 states that have endemic raccoon rabies variant, Ohio was the only one that did not have a statewide requirement for vaccination of dogs, and was one of only two that did not require vaccination of cats. This study had three major objectives; the first was to determine the post-epizootic incidence of rabies in US dogs, cats, and ferrets and identify trends by comparing states with and without raccoon rabies variant activity. Analyzing surveillance data from 2000 to 2010 found that the proportion of total dog cases diagnosed in endemic states has been increasing over the last several years. Cats remained the most common rabid domestic animal in the US, and the vast majority (79%) of cases occurred in states endemic for raccoon rabies. In Ohio, local governments have been granted the authority to regulate rabies vaccination of animals. The second objective of this study focused on identifying the presence, distribution, and determinants of local animal rabies vaccination requirements. To accomplish this Environmental Health Directors in Ohio’s 128 local health jurisdictions were surveyed about their vaccination regulations, and responses to these questions were validated. Additional survey data were collected from local health jurisdictions for the third objective of this study: to identify the presence of at least one
low cost rabies vaccination clinic per year and assess the level of public health involvement in rabies clinics. This study found that the majority of the state did not have compulsory rabies vaccination requirements. Mapping them across all 88 counties revealed that for dogs 57 (65%), for cats 65 (74%) and for ferrets 73 (83%) had no requirements in all or part of the county. Logistic regression determined that health jurisdictions in close proximity to raccoon rabies activity were not more likely to have vaccination requirements, but they were more likely to report the presence of rabies clinics as well as public health involvement in rabies clinics. Raccoon rabies activity in a county was associated with cat and ferret vaccination requirements; but not with dog vaccination requirements, the presence of rabies clinics, or public health involvement in rabies clinics. Increasing population size was a positive predictor for the presence and public health involvement in rabies clinics. Health jurisdictions with more residents were also more likely to have dog, cat, and ferret vaccination requirements compared to those that were less densely populated. Given that rabies in animals is more common in rural compared to urban communities and in regions near raccoon rabies activity compared to those that are farther removed; this study concluded that the regions of Ohio at greatest risk for this fatal disease were least likely to require rabies vaccination of companion animals. This study contributes new information that can be utilized by legislators and health officials to make informed decisions and guide public health policy for rabies prevention and control.
Dedication

This document is dedicated to my husband Ken;
our three children Keith, Megan, and Emily;
and our cat Pixie who begrudgingly shared my attention with a laptop computer.
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Chapter 1: Introduction

Rabies is neurologic disease responsible for the death of thousands of people each year. It is caused by a virus that is transmitted through saliva, typically via a bite that penetrates the skin, and is capable of infecting all mammals including wild and domestic animal species. Described as a medical condition by Democritus around 500 B.C. and Aristotle in the 4th century B.C.4, rabies is one of the oldest infectious diseases known to man. Written accounts of reputed cases have been found dating back thousands of years in Mesopotamia and Egypt. In the 23rd century B.C. the Babylonian City of Eshnunna imposed fines to the owners of dogs who went mad and bit a man resulting in his death.5

In 1885, Louis Pasteur administered the first rabies vaccine to a boy who had been bitten by a rabid dog, thereby saving his life.6 Though still based on Pasteur’s discoveries, ongoing research and refinement have led to the production of a vaccine that is both safe and efficacious. In animals and humans pre-exposure vaccination will reliably prevent infection from known and unrecognized rabies exposures; and in humans, vaccination administered soon after a rabies exposure is nearly 100% effective at preventing disease.7-14

Despite many medical advances, rabies is still recognized as having the highest case fatality rate. To date, no successful treatment protocols have been developed.15 Worldwide there are only a handful of people known to have survived rabies once
clinical signs developed, and only three were documented to have survived without receiving some form of post-exposure vaccination.\textsuperscript{16,17} Rabies is highly preventable yet remains essentially incurable.

**Rabies Ecology and Epidemiology**

While transmission between infected humans is possible, rabies is maintained in animal populations. There are several variants or strains of rabies that are typically named for the primary mammalian host species, also referred to as the reservoir. Rabies reservoirs are generally grouped into terrestrial (land-dwelling) species, and bat species. Rabies that is transmitted from a reservoir to a non-reservoir species is said to “spillover”. Though non-reservoir species can and do spread infection, sustained transmission in the new host species is unlikely to occur. Occasionally, host-virus adaptation can occur and a maintenance cycle becomes established resulting in a new reservoir species, as seen with Texas coyotes infected with a canine variant from Mexico in 1988.\textsuperscript{18,19} Animal species that are known to become infected and present a risk of rabies transmission to humans or other animal species are called vectors. For example, in much of the world dogs can be infected with canine rabies variant (dog rabies) and serve as both a reservoir and a vector of transmission. In the US and some other developed countries where canine rabies has been controlled, dogs no longer serve as reservoirs, but they can acquire rabies from wildlife reservoirs (dog with rabies) and serve as a vector of transmission to humans and other animal species.

Rabies in animal populations can occur sporadically in individuals or can exist in an enzootic or epizootic state. Enzootic rabies is native to a reservoir species in a specific
geographic region and occurs with a relatively stable incidence rate. An epizootic occurs when the incidence of disease increases markedly in a reservoir species, typically following the introduction of rabies to a naïve population. Disease that is transmitted from a reservoir to non-reservoir species is said to spillover; this can occur sporadically but the risk is dramatically increased during an epizootic. Though rabies viruses have a preferred reservoir species, all variants can infect and kill any mammal, including humans.

Rabies is maintained in two distinct epidemiological cycles. In the urban cycle, dogs are the main host serving as both the reservoir and the primary vector of transmission to humans. This cycle predominates in much of the world including Africa, Asia, Central America, and South America. Conditions are most severe in developing countries where the costs associated with animal control programs are prohibitive. Worldwide, rabid dogs are responsible for more than 90% of human exposures to rabies and 99% of human cases.

The sylvatic, or wildlife cycle is widely distributed throughout the world. In many countries it exists alongside the urban cycle, but in Europe and North America where domestic animal rabies has largely been controlled it is the predominant maintenance cycle. Rabies variants, especially terrestrial ones such as raccoon and fox, are typically found in specific geographic regions. Several variants of rabies can co-exist in the same region, each within a separate primary reservoir species. The ranges of rabies variants change over time, and epizootics have resulted from the introduction of rabies into naïve populations as they expand. Sylvatic maintenance cycles can be complex.
depending in large part on host ecology and environmental factors. Human exposures to 
rabies can come from the primary reservoir species or from other animals, including pets, 
which serve as bridge vectors.

**Global Rabies Distribution**

Based on research released in 2005, it has been commonly reported that more than 
55,000 people die of rabies each year, mostly in Africa and Asia where access to medical 
care is limited and animal control programs are insufficient to contain the spread of 
rabies.\(^{26,30,31}\) Because the resources needed for disease control are not generally available 
in the areas most severely impacted by this disease, rabies has been classified by the 
World Health Organisation (WHO) as a Neglected Zoonotic Disease. Developing 
countries often have a poorly developed or non-existent veterinary public health 
infrastructure. Effective response is further compromised when the responsibility for 
rabies control falls into the gap between animal and human health disciplines.\(^{32}\) 
International organizations are working together to utilize a “one health” approach in 
order to develop effective control and prevention measures and assist in their 
implementation throughout the world.\(^{33}\)

New research presented in September, 2011 at the World Organisation for Animal 
Health (OIE) Global Conference on Eliminating Rabies indicated that the worldwide 
incidence of rabies is increasing.\(^{34}\) Despite having the knowledge and technology needed 
to successfully control rabies, some areas of the world are seeing rabies in epidemic 
proportions. Human fatalities are highest in areas where access to healthcare is poor, 
awareness of rabies prevention is lacking, and rabies transmission in dogs is
uncontrolled.\textsuperscript{35} Killing more people each year than SARS, H5N1, and Dengue Fever combined, an estimated 70,000 people worldwide die from rabies according to new data released by investigators with the OIE in September, 2011.\textsuperscript{34} The majority of those affected are children under the age of 15.\textsuperscript{26,36}

Rabies is present on all continents with only a few countries, mostly islands, considered free of this disease. The primary reservoir species are carnivores and bats. Some countries considered historically free of classical rabies include New Zealand, Australia, Japan, Iceland, and the South Pacific Islands among others.\textsuperscript{37,38} Following successful eradication, a country can also be classified by WHO as rabies free when there have been no indigenously acquired human or animal cases during the previous two years. Some countries classified as rabies free have rabies in bats at a low level that is not considered to be a significant risk to humans. Following extensive rabies control programs targeting domestic and wild animal species, several European countries have developed a rabies free status: Switzerland in 1999, France in 2000, Belgium in 2001, and the Czech Republic in 2004.\textsuperscript{39}

Global Rabies Prevention and Control

Socioeconomic Burden

Unlike most viral diseases, rabies can be prevented in humans if an appropriate vaccination series is provided soon after exposure. Recognition and proper management of rabies exposures therefore becomes critical to the prevention of human fatalities. There are two main strategies that can be employed to prevent human cases of rabies: 1. detection and appropriate treatment of human rabies exposure events and 2. reduction or
elimination of rabies exposure events. While effective at reducing human fatalities, the former is very costly. Human rabies biologicals are more expensive than animal vaccines and without source reduction in the animal populations, human exposures will continue to occur and may actually increase.4,40

Ideally, both strategies should be implemented concurrently. Though the costs to provide both may initially be higher, the long term decrease in the need for human post-exposure treatment results in substantial savings overall.41-46 In a study modeling canine rabies control in Chad, Zinsstag reported that the cumulative costs of human post-exposure treatment coupled with a mass dog vaccination campaign when compared to human post-exposure treatment alone broke even in less than five years and realized a cost savings in seven years.47

Rabies prevention and control efforts are a continuous drain on resources that are already stretched thin by competing priorities. Recent estimates of the global financial burden attributable to rabies exceeds 4 billion dollars.34 It is estimated that more than 15 million people receive post-exposure treatment to prevent rabies each year26. The World Health Organisation (WHO) reports that the highest financial expenditure related to this disease in any country is the cost of rabies post-exposure prophylaxis.25 As reported by the OIE, researchers have estimated that just 10% of the financial resources currently expended to treat those bitten by potentially rabid dogs could fund the worldwide eradication of canine rabies variant, thereby preventing almost all human cases.35
Public Health Planning

Rabies in animals is a serious public health concern; and many local, state, federal, and international agencies charged with protecting public health have appropriately taken a leadership role in coordinating rabies control efforts. As with many zoonotic diseases, the key to effective prevention of rabies in humans centers on controlling the disease in animal populations. Specific strategies are based largely on the ecology of the animal species involved as well as known patterns of transmission. Based on successfully implemented programs, several national\textsuperscript{48-52} and international\textsuperscript{7,21,25,33,41} model rabies control plans and guidelines have been published.

A major contribution to the development of effective rabies control guidelines in recent years has been the creation of an interdisciplinary, public-private partnership that formed in an effort to coordinate research, share available resources, and facilitate education towards a common goal of eradicating rabies. The Partners for Rabies Prevention (PRP) is comprised of members from animal welfare organizations, academic institutions, and international health organizations (WHO/Pan American Health Organization (PAHO), Food and Agriculture Organization (FAO), World Organization for Animal Health (OIE), European Commission (EC)), and nongovernmental organizations including the Global Alliance for Rabies Control (GARC)\textsuperscript{41}. Based on models used to eradicate smallpox in 1980, this group of global rabies experts developed a \textit{Blueprint for Rabies Prevention and Control} to serve as a guide for countries working to prevent human rabies through the elimination of canine rabies.\textsuperscript{33} Additional blueprints for the control of rabies variants circulating in wildlife populations will be added with the
ultimate goal of eradicating rabies entirely. This integrated approach to developing policy guidelines also facilitates an integrated approach to rabies management at the community level, thereby improving the chance of successful implementation.

*Prevention and Control Strategies in Canine Rabies in Endemic Areas*

For the management of rabies in dogs, which are the primary vector of rabies transmission to humans,26,32,53 all model plans have at their core three essential components: stray dog population control; high-volume vaccination of dogs, and education. Controlling stray dogs can take many forms and may include licensing requirements, restriction of movements so that owned animals are not roaming freely, and/or targeted removal or sterilization of unowned animals in the community. Education should not be overlooked as it is critical to raise awareness of appropriate disease control methods among community officials and policy makers, as well as to better inform the public about personal risk and prevention. Several case studies in high risk areas have demonstrated that comprehensive dog vaccination programs in conjunction with educational awareness and improved availability of human vaccines can reduce human deaths to zero.33,54,55

*Strategies to Prevent the Introduction of Canine Rabies to Non-endemic Areas*

Once rabies has been controlled, ongoing vigilance is required to prevent reintroduction of the virus. Some countries that are free of rabies do not have vaccination requirements for the animals residing there. In these countries strictly enforced import requirements to prevent the introduction of rabies infected animals is essential.56,57
lacking, the introduction of rabies can result in severe epizootics in animal populations that result in human fatalities.

The island of Bali, Indonesia had long been rabies free when a dog incubating the disease was imported from a nearby island in 2008. With an estimated 540,000 dogs, mostly free roaming, an outbreak swept across the country resulting in more than 130 human deaths.\textsuperscript{58} At the time of the outbreak it was illegal to vaccinate an animal or person against rabies unless they were known to have the disease, so access to necessary biologicals was lacking.

Many tourists who were bitten by potentially rabid dogs in Bali had to cut their vacations short and return to their home countries where life saving treatment could be provided.\textsuperscript{59} Initial response to the outbreak was based on indiscriminant culling of dogs to reduce the source population. Several less than humane methods were used, including the distribution of meat laced with strychnine. Despite killing over 200,000 dogs the number of dog-bites surged resulting in an increase in human and animal cases.\textsuperscript{60} In 2010 Bali began extensive campaigns focused on the education of residents and the vaccination of dogs both owned and stray. This has dramatically reduced human exposures and fatalities, and officials are predicting that the disease will be eradicated from their dog populations by the end of 2012.

Effective surveillance, an organized reporting structure, and a response plan were lacking in Bali at the time of the outbreak. These measures are important for early detection and intervention, especially in rabies free countries. Equally important are the
enactment and enforcement of animal import requirements that verify the health and rabies vaccination status of incoming animals that could serve as rabies vectors.\textsuperscript{33,41}

**Canine Rabies Vaccination**

*Success of Vaccination in US Canine Rabies Control*

Vaccination has long been recognized as the cornerstone of rabies prevention.\textsuperscript{25,53,61,62} Successful canine rabies control programs, typically founded on compulsory rabies vaccination, have resulted in the eradication of canine rabies variant from the US, with the last reported indigenous case occurring in 2004.\textsuperscript{22} The US was officially declared free of canine rabies in 2007\textsuperscript{63}; however, in the first half of the 20\textsuperscript{th} century, canine rabies was responsible for many human and animal deaths. Korns and Zesseg reported in a 1948 issue of the *American Journal of Public Health* that active canine vaccination campaigns contributed to the reduction of rabies cases in dogs from 503 in 1945, to 377 in 1946, to only 70 reported in the first nine months of 1947 when the paper was published.\textsuperscript{64} In 1953 Fredrickson and Willet et al. reported similarly dramatic reductions in rabies cases in the city of St. Louis following the introduction of mandatory vaccination requirements and the provision of rabies vaccination clinics to the community. They further noted that other animal control measures implemented without vaccination in the previous few years had not significantly impacted the epizootic, and that “the results are clear for all but the willfully blind to see”.\textsuperscript{65}

In 1950, US public health officials identified 4,979 cases of rabies in dogs. By 1955, vaccination of dogs had become compulsory throughout most of the United
Five years later, in 1960, cases had dropped to less than 700, and in the 1970’s they averaged less than 200 per year.\textsuperscript{67}

In regions where canine rabies is adequately controlled, vaccination of pets reduces the risk that they will contract rabies from local wildlife reservoirs or from animals in neighboring canine endemic areas.\textsuperscript{68} This maintenance of an immunized population, even when disease prevalence is low, protects people from rabies exposure and prevents the re-establishment of rabies in the animal population through migration or importation from outside the controlled area.\textsuperscript{21,30,51}

\textit{Success of Vaccination in Canine Rabies Control outside the US}

Similar results have been reported in other countries implementing vaccination based control efforts for rabies in dogs. Following a 1960 outbreak in Mexico that extended into California, the government of Mexicali, Mexico instituted a rabies control program. The American border city of Calexico, California described dogs freely crossing the border through human check-point stations. They further reported that 29 of 48 (60\%) stray dogs removed by animal control during the peak of the outbreak were confirmed to be rabid and over 600 people were bitten and potentially exposed to rabies.\textsuperscript{69}

Calexico reinforced their existing rabies control measures by enforcement of quarantines and the completion of a door to door check to verify compliance with current rabies vaccination requirements for dogs. Mexicali, Mexico, the source of the rabies outbreak, implemented an animal control program and offered several free vaccination clinics to city residents. This effectively ended the outbreak, and active rabies control
efforts were continued to prevent recurrence. The last case of rabies in a Mexicali dog was reported in 1982, despite a high incidence of rabies in dogs and wildlife in neighboring areas.\textsuperscript{70} In 2004, Flores-Ibarra reported that the canine ecology structure was the same in Mexicali as it was in other regions of Mexico where canine vaccination programs were not widely implemented and canine rabies was still a major problem.\textsuperscript{70} This provides further support for the effectiveness of rabies interventions based on vaccination efforts, and demonstrates that maintaining a high level of vaccination can provide protection even in regions surrounded by uncontrolled canine rabies activity.

Similar results have been demonstrated in South America. In the 1980’s Lima, Peru vaccinated 270,000 dogs in one month, an estimated 65\% of the dog population, which resulted in a large reduction in the rabies incidence of animals and humans.\textsuperscript{71} Dog vaccination efforts in Brazil between 1980 and 1985 reduced the number of dog rabies cases from 4,570 to 496, and the number of human cases from 168 to 52.\textsuperscript{72}

Based on an analysis of response to four rabies outbreaks in urban and rural areas of the US, Mexico, Malaysia and Indonesia, Coleman and Dye reported that vaccination of 70\% of the dog population would be sufficient to interrupt transmission at least 96.5\% of the time in areas experiencing high levels of endemicity.\textsuperscript{73} Countless examples of successful vaccination campaigns can be found in the literature, as can descriptions of outbreaks associated with the re-emergence of rabies when vaccination levels fall below the level needed to provide herd immunity in areas whose geopolitical boundaries are continually threatened by disease incursion.
Rabies Distribution in the United States

Rabies in Humans

According to CDC, the number of rabies-related human deaths in the US has declined from more than 100 annually at the turn of the 20th century to the current average of two to three per year. Effective strategies to reduce the source of exposures and to provide post-exposure treatment when needed have minimized, but not eliminated, the risk of rabies to humans. In the US, bats are responsible for most indigenous human cases of rabies. Between 1995 and August, 2010, the CDC reported 45 human rabies cases; 34 (76%) were infected by bats. The majority of non-bat related human cases were associated with foreign travel; however a Virginia resident was infected by a rabid raccoon in 2003 and a young girl in California acquired rabies from a stray cat near her school in 2011.

Figure 1.1, published by CDC, portrays surveillance data of human and dog rabies cases between 1958 and 2008. This clearly illustrates the public health impact of reducing disease in the primary reservoir species, namely through canine animal control and rabies vaccination.
efforts. However, there is still a significant risk associated with dog and cat bites which warrants ongoing public health response. Mammal bites from both domestic and wild animals are required to be reported to local health officials for exposure risk assessment in all states.

Rabies in Dogs and Cats

Following the dramatic decline in dog rabies in the 1950’s and 1960’s, cases in dogs continued to decrease and are now primarily due to spillover from wildlife reservoirs. Rabies cases in cats, however, have been increasing since the mid 1980’s (Figure 1.2). This trend continues into 2010. The number of rabies cases in cats is consistently three to four times higher than is reported for dogs, and has been largely attributed to spillover from raccoons in the Eastern US. While not fully understood, it has been suggested that the higher incidence may be related to fewer cat vaccination laws, fewer leash laws, and the roaming habits of cats.

Figure 1.2 Rabies Fatalities in US Dogs, Cats and Cattle, 2008-2009 (CDC)
The American Veterinary Medical Association (AVMA) reported that more than 36% of cat-owning households did not visit a veterinarian in 2006.\textsuperscript{2,82} This is more than twice the percentage of dog-owning households that did not visit a veterinarian.

\textit{Rabies in Wildlife}

All states except Hawaii are considered enzootic for rabies, and an average of 7,000 animals are confirmed positive each year. More than 90% of these cases occur in wildlife.\textsuperscript{2,76,85,86} Since these numbers are based on passive surveillance data collected by state and federal laboratories, they do not reflect the actual number of rabies cases in animals. It is unknown how many additional cases occur but are never diagnosed. Bat rabies variants are found throughout the continental states where cases occur sporadically. Raccoon rabies variant is present in the Eastern states, skunk rabies variant is found in the Central states and California, and fox rabies variant is found in Texas, New Mexico, Arizona, and Alaska (Figure 1.3).\textsuperscript{3}

Though less than 1% of bats are found to be positive for rabies in randomly sampled population studies,\textsuperscript{87,88} between 4% and 10% of those submitted to state public health laboratories are confirmed rabid.\textsuperscript{88-90} The public health surveillance system does not test a representative sample, rather those that are found sick or injured and those that have potentially exposed people or their pets are submitted. The CDC reports a 6% national rabies prevalence in bats that were found in close proximity or had direct contact with humans.\textsuperscript{91} Rabies incidence in wildlife populations fluctuates widely, but has risen overall since the mid 1960’s. (Figure 1.4)\textsuperscript{92} The emergence of terrestrial wildlife rabies was detected through surveillance systems already in place to track the source of
infection for residual domestic animal outbreaks. Skunk variant peaked in the 1980’s, but was supplanted by a dramatic increase in raccoon variant in the 1990’s. In 2009, raccoons were again the most frequently reported rabid wildlife species (34.8% of all animal cases), followed by bats 4.3%), skunks (23.9%), foxes (7.5%), and other wild animals, including rodents and lagomorphs (1.9%). Rabies infections can spillover from reservoir species to other mammal species. Most commonly skunk and raccoon variants spillover to other carnivorans such as coyote, dogs, and cats, but also to livestock and large rodents including beaver and groundhogs.

The ascension of rabies in wildlife reservoirs over the last 60 years has brought new public health challenges. As the primary reservoir species changed, so too did the
measures necessary for rabies prevention and control. Oral rabies vaccination programs were successful in eliminating the canine variant from coyote populations in Texas, and similar programs along the Appalachian Mountains have stalled the westward expansion of raccoon variant.\textsuperscript{27,44,46,96} Research continues to seek more effective vaccination delivery systems and the potential inclusion of sterilants for terrestrial reservoir populations in areas where there is high animal density or close proximity to cities and towns.\textsuperscript{97,98}

\textit{Human Rabies Exposure Events}

While the majority of animal rabies cases occur in wildlife, most people are exposed to rabies due to close contact with domestic animals.\textsuperscript{99,100} Between 1993 and 2002, only 2.7\% of rabid terrestrial animals in New York were cats, but they accounted for one third of the state’s human post-exposure prophylaxis.\textsuperscript{101} Four counties in upstate New York reported that cats accounted for 523 (24\%) of 2,216 animal rabies exposures requiring post-exposure prophylaxis between 1995 and 2000.\textsuperscript{99} A study in South Carolina between 1995 and 2003 found that dogs and cats contributed the majority (66.7\% and 26.4\%, respectively) of all reported rabies exposure incidents.\textsuperscript{23}

Additionally, companion animals in some settings have the capacity to interact with large numbers of people. In 1994, a rabid kitten was purchased from a pet store in New Hampshire where the kittens were allowed to wander around the store to mingle with people and other animals. Following extensive investigations, 665 people received post-exposure treatment at an estimated cost of 1.5 million dollars for medical care expenses.\textsuperscript{102} A young kitten found near a softball tournament in 2007 had contact with
players and their families from several states before being diagnosed with rabies. A multistate investigation found that, out of the 60 softball teams present 38 people from 4 states had direct contact with this kitten.\textsuperscript{103} It was also learned that 2 other kittens had been seen in the area and may have been littermates of the rabid kitten, but the public health investigation was not able to determine the whereabouts of those kittens. In 2010, a rabid dog diagnosed in a North Dakota animal shelter led to an investigation involving two states. Several dogs were euthanized and 21 human contacts were referred for post-exposure prophylaxis.\textsuperscript{104}

\textit{Socioeconomic Burden}

The low human mortality attributed to rabies does not accurately reflect its public health significance in this country. Due in part to the necessity of ongoing animal disease surveillance and timely medical response to human exposures, rabies remains an important health risk with considerable economic and emotional impact. The CDC estimates that more than 40,000 people receive post-exposure treatment for rabies exposures in the US each year.\textsuperscript{2}

Preventing rabies in domestic animals, especially dogs and cats, through vaccination and responsible pet ownership practices continues to be essential for the reduction of human rabies exposures.\textsuperscript{15,51,105} Rabies surveillance in animal populations is also important as a method for evaluating the efficacy of control programs and as an indicator of human risk. The CDC estimates that the annual financial burden attributable to rabies in the US exceeds 300 million dollars.\textsuperscript{2}
State Level Prophylactic Rabies Vaccination

Compulsory Statewide Vaccination Requirements

Preventive rabies vaccination of dogs and cats is recommended by the CDC and the National Association of State Public Health Veterinarians (NASPHV), as well as other health organizations.21,51,106 The Compendium of Animal Rabies Prevention and Control states that “governments should initiate and maintain effective programs to ensure the vaccination of all dogs, cats, and ferrets and to remove strays and unwanted animals.”, adding further in the same paragraph, “Because more cases are reported annually involving cats than dogs, vaccination of cats should be required.” 51

Compulsory rabies vaccination has been credited with eliminating the threat of canine rabies in the US; it was also been acknowledged that the risk of rabies to US residents remains small because of mandatory rabies vaccination for household pets.107 The entire country, however, is not covered by such mandates. In states like Ohio, with no rabies vaccination requirements, the county and municipal governments are granted authority by the state to enact vaccination requirements at their discretion.

In order to determine which states had compulsory vaccination requirements for dogs and cats, state public health officials in each state were contacted by this author in 2008. The data were compiled and shared with the participating states and other interested parties. After an annual update in 2009 to ensure that the data remained current, it was published with permission by CDC in Rabies surveillance in the United States during 2009.86
Of the 49 states plus the District of Columbia that have endemic rabies, 39 (78%) required vaccination of dogs while 11 (22%) did not (Figure 1.5). For cats, 31 (62%) required vaccination while 19 (38%) did not. Despite the increasing risk of rabies from cats, fewer states required the vaccination of cats compared than those that required the vaccination of dogs.

The introduction of raccoon rabies variant has been associated with increases in both domestic animal rabies and human rabies exposures. Of the states currently enzootic for this variant, Ohio is the only one that does not have a statewide requirement for the prophylactic vaccination of dogs (Figure 1.6). Ohio and New Jersey are the only two that do not have a statewide requirement for the vaccination of cats.
In 2008, Ohio legislators were considering a bill to make rabies vaccination of dogs, cats, and ferrets mandatory in the state. When the National Rifle Association announced their opposition because hunters would be required to have their dogs vaccinated by a veterinarian, the senate voted to indefinitely postpone the bill. Following publication of the state summary data, in 2010, several of the 11 states with no compulsory vaccination requirements began working to enact legislation. The state of Washington recently passed a bill requiring the vaccination of dogs, cats, and ferrets that will become effective on January 1, 2012. The Minnesota Board of Animal Health announced in 2011 that they were writing a new statewide rule to require the vaccination of all dogs. There is currently an effort underway by stakeholders in Colorado to propose legislation for 2011 that would require the prophylactic vaccination of dogs and cats, in response to increases in skunk rabies.

Compliance with Statewide Vaccination Requirements

While much is discussed and written in support of compulsory rabies vaccination, no recent studies were found that compared the vaccination rates in areas with and without regulations. Only one study, from 1926, reviewed the impact of mandatory vaccination requirements on communities beleaguered with canine rabies concluded that antirabies vaccination could reduce the number of cases, but that systematic enforcement of vaccination laws could eradicate the disease entirely.

There is some information available on the rabies vaccination rates of animal in the US, but data collection methods are not consistent, making comparisons difficult. In Maryland a review of records for animals that had been exposed to rabies between 1981
and 1987 showed that 70% of the dogs and 28% of the cats had been vaccinated against rabies prior to their exposure.\textsuperscript{20} In 1993, following the introduction of raccoon rabies variant, a random survey of Connecticut households was conducted by adding specific rabies questions to their standardized Behavior Risk Factor Surveillance System. This study found that 90% of respondents had heard about rabies in the past year, 84% thought that rabies was a problem in Connecticut, 93% of dogs were currently vaccinated and 80% of cats were currently vaccinated.\textsuperscript{116} Texas requires vaccination and does not have raccoon variant, though other terrestrial variants are active. They reviewed their records of animal bite investigations from 1999 to 2002 and found a vaccination rate of 46% for dogs and 18% for cats.\textsuperscript{117} Researchers in South Carolina analyzed data gathered on dog and cats involved in human and animal rabies exposure incidents between 1995 and 2003. They reported vaccination rates of 40.2% for dogs and 13.8% for cats, far below the WHO recommended levels of 70%.\textsuperscript{23} Though all of these states required vaccination of cats and dogs, vaccination rates varied widely. Several of these studies used convenience samples and may not be representative of the general population; however, they do illustrate that the presence of a law alone is not an adequate rabies control measure.

Several vaccination strategies presented in the literature discussed the importance of community education in raising vaccination rates.\textsuperscript{21,51,64,118} Though settings and circumstances varied widely, convenience and cost were also reported to influence vaccination rates.\textsuperscript{119,120} In 2003, Texas changed its vaccination requirements from an annual vaccine to a triennial schedule despite concerns that compliance would decrease.
Rogers performed an analysis of the animal bite investigation records for the four years prior to the change (1999-2002) and the three years following it (2004-2007) and found that dog vaccination rates increased from 46% to 56% and cat vaccination rates increased from 18% to 36% \( (P<0.001) \). Among other reasons, he suggested that the increase in rabies vaccine compliance was due to the new vaccine schedule being less expensive and more convenient, requiring fewer visits to the veterinarian or vaccination clinic. In 1998 Metzer and Rupprecht reported that the average cost to the owner for a canine rabies vaccination ranged for $16.00 to $24.00. Adjusting for inflation using the US Bureau of Labor Statistics Consumer Price Index Inflation Calculator would estimate the 2011 cost range as $22.24 to $33.36 for the vaccine.\(^a\) The cost of vaccination plus additional fees for an office call and physical examination could create a financial burden for some owners, and this expense is frequently presented as an argument against compulsory vaccination requirements.

Kennedy, et al examined the risk of rabies in cats based on several county socioeconomic and demographic characteristics. The authors reported that the main risk factors for a cat contracting rabies included the presence of raccoon rabies and the absence of state mandated rabies vaccination requirements for cats.\(^b\) The authors also concluded that the incidence of rabies in cats can be decreased by the adoption of mandated vaccination requirements for cats in all states. They further suggested that socioeconomic factors identified in the study as being associated with poor vaccination

\[^a\] http://www.bls.gov/data/inflation_calculator.htm
compliance could be used to target areas for vaccination clinics and educational campaigns.

**Raccoon Rabies Epizootic**

*Introduction and Expansion of Raccoon Rabies*

For decades, raccoon rabies variant was isolated in and around Florida.\textsuperscript{121} This changed when sportsmen captured raccoons in Florida and released them along the Virginia and West Virginia border to replenish hunting stock.\textsuperscript{122} At least one of those translocated raccoons was incubating rabies, which caused an outbreak in the local raccoon population. Virus isolated from the new foci of raccoon rabies was found to be identical to the virus circulating in Florida raccoons.\textsuperscript{109} The resulting epizootic of raccoon rabies has had a profound and lasting impact.

During the 1980’s and 1990’s raccoon rabies spread in all directions from the site of introduction; across the Mid-Atlantic and Northeastern states, South towards Florida, and west into Ohio.\textsuperscript{20,93,108,123} From 1991 to 1992, the number of reported cases of rabies in raccoons increased 40% ,from 3,079 to 4,311, making them the most commonly reported rabid animal in the country.\textsuperscript{124} Of the 8,644 animals reported rabid during 1992, a total of 3,759 (43%) were raccoons in the mid-Atlantic and northeastern states.\textsuperscript{26,96}

The first case of raccoon rabies variant in Ohio was identified in Northeastern Ohio in 1996.\textsuperscript{29,125} In response to this disease incursion, a program to distribute oral rabies vaccines to raccoons along a 14 county corridor between Ohio and Pennsylvania was implemented in the spring of 1997.\textsuperscript{29,124} This induced immunity in a percentage of the local raccoon populations thereby suppressing the transmission of rabies. Soon
thereafter the program expanded to become a multi-agency collaboration with local, state, and federal departments of health and wildlife working together to distribute oral rabies vaccine along the Appalachian corridor. These efforts have thus far successfully halted the westward expansion of this epizootic.

Raccoon rabies continued to spread through the northeastern states entering Canada in 1999. Through the year 2000, advancement of the fronts had progressed at approximately 18 to 24 miles each year. Expansion occurred more quickly in habitats that raccoons prefer while physical barriers such as rivers and mountain ranges tended to slow the advance. However, large geographic barriers alone cannot be relied upon to contain the epizootic as evidenced by the fact that it has already crossed the St. Lawrence River into Canada and the Appalachian Mountains across West Virginia and Pennsylvania. The Ohio River may delay the natural introduction of raccoon rabies to parts of eastern and southern Ohio, but should raccoon variant rabies become established in Ohio, there will be few geographic barriers to slow its spread throughout the Midwestern states.

*Spillover to Pet Species*

In addition to the studies above, numerous publications demonstrate that the number of terrestrial mammals infected with rabies increases when raccoon rabies is introduced, as do the number of species infected. Not only are companion animals and other wild carnivores affected, but also some species that rarely develop rabies like deer, squirrel, and chipmunks. Eidson and Matthews et al published a case report
describing the unusual diagnosis of rabies in 1 pet guinea pig and 7 pet rabbits in New York; all were attributed to the raccoon rabies variant.\textsuperscript{134}

Fischman and Gregor et al reviewed rabies surveillance data in Maryland and reported that raccoon rabies spillover persisted in all health jurisdictions even after raccoon variant became enzootic, and that increases in domestic animal cases occurred every 4 to 5 years as raccoon populations replenished.\textsuperscript{20} Gordon and Curns et al reviewed all cases of animal rabies in the northeastern states between 1992 and 2000. They also showed an increase in secondary cases during periods of epizootic activity followed by decreases during what they identified as inter-epizootic periods.\textsuperscript{135} In their study cats were second only to raccoons as the most commonly infected species. In fact, cats were found to be 12 times more likely to contract rabies during the initial raccoon rabies epizootic compared to the time prior to the introduction of raccoon rabies. The risk for cats remained elevated at 6 to 7 times the pre-epizootic level even after raccoon rabies had become enzootic.\textsuperscript{135}

\textit{Public Health Impact of Raccoon Rabies Epizootic}

The impact on public health in the affected states is well represented in the literature. An MMWR documented the results of a Connecticut survey of pharmacies and health care providers to determine the usage of post-exposure prophylaxis in the state between 1990 and 1994 during the time that raccoon rabies was spreading across the state. They found that the number of persons treated increased from 41 in 1990 to 887 during the first 9 months of 1994, at an estimated cost of $1,500 per person (1994 dollars).\textsuperscript{136}
A study in Maryland by Fogelman and Fischman et al reported that 129 cats and 12 dogs were diagnosed with rabies between 1983 and 1992 as a result of a widespread outbreak of raccoon rabies in the state. The researchers examined the medical records for the 31 cats confirmed rabid between 1983 and 1986, finding that the majority had no vaccination history and approximately 40% were unowned. Fourteen (14) of the 31 cats were presented to a veterinarian early in their illness, but only 3 were initially suspected to have rabies. Exposure to these 31 rabid cats resulted in 194 persons receiving post-exposure treatment, including 63 veterinarians. Several other studies have also concluded that the presence of raccoon rabies increases the risk to domestic animals, and that rabid cats generally expose more people than do other rabid species.

A 2001 study by Bretsky and Wilson analyzed data collected from all rabies positive terrestrial animals in Connecticut between 1985 and 1994. No human exposures to rabid terrestrial mammals occurred between 1985 and 1990, prior to the 1991 introduction of raccoon variant to the state. Sixty-six (66) persons were exposed to rabid terrestrial mammals in 1991 and exposures increased to an average of 291 per year between 1992 and 1994. The average annual incidence rate of exposure to rabid terrestrial mammals following the introduction of raccoon rabies rose from 0 to 7.2 per 100,000 people years. Bretsky and Wilson also reported that the majority of exposures occurred near home, involved contact with a rabid raccoon, and were mediated through a domestic animal. Logistic regression modeling found that rabid dogs and cats with raccoon rabies variant posed nearly 7 times the risk of potential rabies exposure to humans as compared with infected wildlife.
Increases in human rabies exposures occurred in New York following the introduction of raccoon rabies variant to the state as documented by Blanton and Bowden et al in 2005. Four counties in upstate New York reported an exposure incidence rate of 27 per 100,000 person years between 1995 and 2000; the majority of these exposures were associated with dog and cat bites. Blanton and Bowden et al also found that exposure to cats infected with raccoon rabies variant accounted for 24% of 2,216 exposures requiring post-exposure prophylaxis in upstate New York during that same time period.

**Rabies Distribution in Ohio**

*Rabies in Humans*

The last human case of rabies in Ohio occurred in 1970, and was associated with a bat rabies variant. Local health departments annually investigate nearly 21,000 rabies exposure events and report that more than 400 persons receive post exposure prophylaxis to prevent rabies each year. These numbers underestimate the actual incidence of human rabies exposures because many bites are not reported and post-exposure prophylaxis in Ohio is not required to be reported to the state.

Bats, raccoons, fox, skunk, and coyote are considered rabies vector species in Ohio, and human or animal contact with these species should be carefully evaluated for possible rabies exposure. In 2009, similar to past years, 93% of rabies exposure events investigated by local health departments involved contact with domestic animals.
**Rabies in Animals**

Between 2000 and 2010 an average of 60 animals (range 47 to 86) each year were confirmed as rabid in Ohio.\textsuperscript{141,142} Bat rabies variant is endemic and occurs sporadically across the state (Figure 1.7). Historically, a skunk rabies variant circulated in parts of Ohio; however, there have been no confirmed cases associated with this strain in the last 5 years,\textsuperscript{142} prompting CDC to remove Ohio from the skunk variant range on their 2010 distribution map of terrestrial rabies variants (Figure 1.7). Raccoon rabies variant is now endemic in Ohio, but remains clustered in a geographically discrete area of Northeastern Ohio.

Though bats and raccoons are the primary reservoir species in Ohio, rabies can infect all mammals. Between 1980 and 2010, 1,311 Ohio animals have tested positive for rabies. The majority have been bats (814), followed by skunks (212), and raccoons (201). Other rabid wild and domestic animals included: fox (22), cows (22), horses (16), dogs (13), cats (10), groundhogs (3), coyote (2), opossum (2), deer (1), and chipmunks (1).\textsuperscript{142}

Forty-four (44) animals were confirmed by the Ohio Department of Health Laboratory to have rabies in 2011 between January 1\textsuperscript{st} and October 31\textsuperscript{st}. Thirty-three (33)
were bats, 5 were raccoons, 5 were skunks with raccoon rabies variant, and 1 was a dog with raccoon rabies variant. This was the first report of a dog with raccoon rabies variant in Ohio, and raccoon rabies variant in Summit County. The dog, 13 months past due for rabies vaccination, was a pet living on a farm with frequent contact with wildlife. The Summit County Health Department informed the public of the risk through press releases and media interviews. They are also offering several low cost rabies vaccination clinics throughout the county.

**Raccoon Rabies Variant and Oral Rabies Vaccination Programs**

In 1997, 62 rabid animals, including 59 raccoons were identified in northeastern Ohio. The Ohio Department of Health (ODH) in cooperation with other local, state and federal partners initiated the first raccoon oral rabies vaccination program (ORV) along the eastern Pennsylvania border. Nearly 1.5 million vaccine packets sealed in edible fishmeal polymer bait were distributed in 14 Ohio counties. When the bait is eaten the packet ruptures and the vaccine is ingested. If a sufficient number of raccoons develop immunity to rabies then transmission is interrupted creating an immune barrier between infected and susceptible animals. Following this intervention, the number of rabid raccoons in Ohio decreased by more than 50% in 1998, and no cases were detected in 2000 (Figure 1.8). Following Ohio’s success, other states joined the program and now 15 states along an Appalachian corridor distribute ORV baits.

In 2004, rabies positive raccoons were found west of Ohio’s immune barrier resulting in an increase in raccoon cases (Figure 1.8). Molecular epidemiology determined that transmission occurred through the barrier demonstrating that passive
surveillance may not have been sensitive enough to detect low incidence levels circulating in the raccoon populations. As a result surveillance was enhanced to better assess public risk and guide prevention efforts. Additional ORV operations were conducted in the area and USDA Wildlife Services began a trap-vaccinate-return program for raccoons surrounding the clusters of positive cases in order to further increase herd immunity in these at-risk populations. As seen with the initial response to ORV, this intervention quickly and effectively reduced the number of cases (Figure 1.8), preventing further spread of disease into susceptible raccoon populations.

All rabies cases in Ohio skunks during the last five years were attributed to raccoon rabies, and there is concern that this variant may become established in northeastern skunk populations. Other areas of the country have reported similar increases in skunks infected with the raccoon variant; this trend is highlighted in Figure 1.4 as the lines depicting rabies in skunks and skunk rabies variant diverge. This is of special concern because the only ORV bait approved for use in the US has not demonstrated significant efficacy in skunks.
With a few cases confirmed each year, raccoon rabies has not yet been eradicated from Ohio. However, raccoon vaccination efforts have successfully halted the westward advancement of the raccoon rabies variant for the last 14 years. Spatial dynamics modeling predicted that, without intervention, the spread of raccoon rabies across Ohio would take less than 3 years.

Local, state, and federal budget cuts have forced governments to make difficult decisions during the recent fiscal recession. ODH reduced support for ORV in 2009 reducing the number of distributed baits, stopped purchasing vaccine baits altogether in 2010, and eliminated all funding of raccoon rabies control efforts in 2011.

Because maintenance of the immune barrier is critical to the protection of public health in Ohio as well as other Midwestern states, USDA Wildlife Services provided baits and coordinated their distribution in 2010 and 2011 but at a reduced density compared to prior years. In 2008, 1,352,422 vaccine-laden baits were distributed in Ohio; 874,301 were distributed in 2009; 774,714 in 2010; and 761,789 (projected) in 2011. Compared to 2008, this represents a 35% reduction in 2010 and 44% reduction in 2011. The minimum raccoon immunization rate necessary to prevent an outbreak in the face of ongoing challenge has not been determined, and it is not known what impact these reductions will have on the sustainability of the immune barrier. The fiscal forecast remains unstable and there are no assurances that the federal government will continue to fund Ohio’s raccoon rabies control efforts.
Risk of Migration and Importation

Natural Migration

Biological migration of rabid animals from Pennsylvania and other neighboring states remains a threat to Ohio despite the Ohio River and other natural barriers.\(^{131-133,149}\) While Ohio’s animal rabies incidence has remained comparatively low, our border state of Pennsylvania reported 409 cases in 2009.\(^8\) Cats, dogs, and livestock accounted for 65 (16\%) of those cases; providing Pennsylvania once again with the distinction of being the state with the highest number of rabid domestic animals. Fifty-seven (88\%) of Pennsylvania’s domestic animal cases in 2009 were cats.

Even areas that participate in the ORV program may not acquire a level of herd immunity sufficient to prevent clusters of rabies in local populations. In early 2011, an outbreak of rabies in raccoons was investigated on a small Ashtabula County farm near the Pennsylvania border. The raccoons were living in a horse barn with 6 horses, 1 dog, and more than 14 cats; none of them had been vaccinated and were quarantined for 6 months as a result of their rabies exposures.\(^{150}\) Active surveillance of the surrounding raccoon populations is being conducted by the USDA Wildlife Services, and additional baiting in the area is planned to ensure that rabies does not become established in this population.

Translocation

Humans are also responsible for the movement of vast numbers of animals both domestic and wild. This can be intentional as seen with the translocation of raccoons for hunting purposes in the 1970’s or animals can occur unknowingly on various types of transportation vehicles. The frequency and speed with which we travel between states
and countries vastly increases the risk of disease transmission. Livestock are regularly purchased and sold, with many residing in more than one state during their lifespan. In 2010, a calf purchased in Pennsylvania was moved to a farm in Guernsey County where it was housed in a closed feeder-calf operation with 700 other calves. The calf later died of rabies which was confirmed to have been a raccoon rabies variant (Figure 1.7). Guernsey County does not border the ORV zone and raccoon rabies variant had never before been reported in that part of Ohio. As a precaution 62 calves that had potential contact with the rabid calf were destroyed and USDA Wildlife Services began conducting active surveillance in the wildlife populations surrounding the farm.

Companion animals frequently accompany their owners when they relocate to live in new communities. Homeless pets are also moved, sometimes great distances, during animal rescue transport for adoption or during disaster response efforts. For example, Operation Baghdad Pups, a program of the Society for the Prevention of Cruelty to Animals (SPCA) International, transports dogs and cats befriended by US troops working in Iraq and Afghanistan back to the states to be cared for by the soldier’s family. In June 2008 a mixed-breed puppy, which had been transported to New Jersey by the SPCA International along with 24 other dogs and cats, was found to be rabid.

By the time the public health laboratory had confirmed the diagnosis the other animals had been sent to homes in 16 states, including Ohio. All of them were located by state and local public health authorities and placed on six month quarantine. None of the dogs had met the CDC import requirements for rabies vaccination, and cats are not required to be vaccinated prior to import into the US. Thirteen people were determined to
have been exposed to the rabid dog during his infectious period and were recommended to seek post-exposure prophylaxis; no secondary rabies cases in humans or animals were identified.¹⁵⁵ This incident and others like it prompted the US Government Accountability Office to investigate the risk of disease introduction through live animal imports. Their report identified gaps in oversight and encouraged interagency collaboration to address shortfalls that could otherwise compromise public health and safety.¹⁵⁶

**Rabies Vaccination Laws in Ohio**

Human rabies is a “Class A disease of major public health concern” and suspect or confirmed cases must be reported to ODH within 24 hours.¹⁵⁷ Animal rabies is classified as a “dangerously contagious or infectious disease” and suspect or confirmed cases must be reported to both ODH and the Ohio Department of Agriculture (ODA).¹⁵⁸

Ohio does not have a state-wide mandate requiring the prophylactic vaccination of resident dogs, cats, or ferrets against rabies; however, several state laws require vaccination in specific circumstances. For example, the state legislated that no dog, cat, or ferret shall be released from the required quarantine after biting someone until and unless it has been properly vaccinated against rabies by a licensed doctor of veterinary medicine.¹⁵⁹ Additionally, a rabies quarantine has been declared in four northeastern counties (Ashtabula, Trumbull, Mahoning, and Columbiana) where raccoon rabies is active. This gave the Director of Health the authority to require vaccination of all dogs and cats residing in those counties through a Director’s Journal Entry which is currently still in effect.¹⁶⁰
Ohio law requires that all dogs and cats being imported to or transported through Ohio be accompanied by a certificate of veterinary inspection indicating freedom from disease and be currently vaccinated against rabies in accordance with NASPHV Compendium of Animal Rabies Control guidelines\textsuperscript{161}. Ohio law also requires that dogs and cats staying in Division of Parks and Recreation and Division of Forestry campgrounds must be currently vaccinated and display proof of rabies vaccination\textsuperscript{162,163}. Similarly, state parks with designated dog exercise areas require dogs to wear a tag as proof of current rabies vaccination\textsuperscript{164}.

**Study Objectives**

*Objective 1: Determine the incidence of rabies in US dogs, cats, and ferrets between 2000 and 2010 and identify trends by comparing states with and without raccoon rabies variant activity*

It has been well documented that RRV increased costs associated with rabies prevention for individuals exposed and communities attempting to reduce exposures\textsuperscript{44,46,93,108,120,136,165}. The literature also established the increase in animal cases and animal species involved\textsuperscript{95,124,135,166}. Cats in particular were noted to be at a higher risk for infection and at a higher likelihood of exposing humans\textsuperscript{100,116,137,138}. Studies examined the national rabies trends by species, and several compared the state incidence rates for a particular species pre- and post-epizootic\textsuperscript{2,83,84,124,135,137,138,167,168}. It was frequently noted that the risk of rabies in domestic animals, and specifically cats, was higher in RRV-states, but no studies were found that examined these difference on a national level. Additionally, most papers reviewed data collected during the height of the raccoon rabies epizootic in the 1990’s.
To fill this gap, one goal of this study was to describe the 2000 to 2010 surveillance data for dog, cat, and ferret rabies by state with attention to the classification of states by raccoon rabies activity. This will aid in the identification of epidemiological trends and provide insight into the risk to domestic animals now that advancement of the raccoon rabies epizootic has been halted while raccoon rabies in affected states has become enzootic.

**Objective 2: Determine the distribution of local rabies vaccination requirements for dogs, cats, and ferrets in Ohio and analyze potential determinants for the presence of regulations**

Ohio law does grant local governments the authority to enact rabies vaccination regulations at their discretion. There are 128 local health districts in 88 Ohio counties. Some of them require rabies vaccination, some of them do not, and requirements may vary within a single county. The general public, government officials, and even those involved in providing human and animal healthcare services do not have a centralized, referenceable resource describing vaccination requirements by location. Since local regulations have not been compiled at the state level, state policy makers must make assumptions when establishing policies that impact rabies prevention and control. One of the objectives of this study was to ascertain the distribution of rabies vaccination requirements for dogs, cats, and ferrets by local health jurisdiction. Determinants reflective of rabies risk and available local health department resources were analyzed to identify potential associations with the presence or absence of rabies vaccination requirements.
Objective 3: Determine the availability and public health involvement in low cost rabies clinics and analyze potential determinants representing rabies risk, presence of vaccination requirements, and the availability of local resources

Since cost was known to be a limiting factor for the rabies vaccination of some pets, survey data were collected on the availability of low cost rabies vaccination clinics (rabies clinics) and the level of public health involvement in the operation rabies clinics. Another objective of this study was to examine the relationships between the presence of rabies clinics, public health involvement in rabies clinics, the presence of raccoon rabies variant, the presence of an ORV program and various indicators of the resources available to local health departments.
Chapter 2: Methods and Materials

Survey of Ohio Environmental Health Directors

Subjects

In Ohio, rabies control is defined in the Ohio Revised Code as an environmental health science\textsuperscript{28}, and the primary responsibility for protecting the public from rabies has been given to the local health departments. In order to meet the objectives of this study, a web-based survey was developed for administration to the Environmental Health Director of each local health department in Ohio. The research protocol was submitted to the Ohio Department of Health Human Subjects Institutional Review Board, and was approved following a full board review. An Ohio Department of Health database was used to identify the 129 Directors and obtain their contact information. Two of the local health departments merged after the contact list was generated but before the survey was deployed, leaving 128 active at the time of the study. When an email was returned undelivered the local health department was contacted by phone to obtain the name and current contact information for their Environmental Health Director. To ensure that someone knowledgeable about the local rabies ordinances and the availability of low cost rabies vaccination clinics completed the survey, the Environmental Health Directors were asked to complete the survey themselves or delegate the responsibility to a staff member who regularly worked in rabies control as part of their assigned duties.
Survey Development

The Ohio Department of Health Zoonotic Disease Program collaborated with the Ohio State University Colleges of Public Health and Veterinary Medicine to conduct a cross-sectional survey of local health departments to determine their local regulations concerning the prophylactic rabies vaccination of animals (Appendix B.1). The survey also explored the availability of low cost rabies vaccination clinics (rabies clinics), public health involvement in providing rabies clinics to the community, and public health support for state mandated rabies vaccination requirements.

Those health jurisdictions that indicated direct involvement in rabies clinics between 2008 and 2010 were also asked a series of questions requesting information based on their experiences in this area. The data collected from this section of the survey were intended to be used by the Ohio Department of Health (ODH) to compile a resource manual for those running rabies clinics, and will not be addressed further in this thesis. Information for ODH was gathered on best practices and lessons learned with respect to administrative issues such as location, advertising, staffing, record keeping, and budgeting; as well as operational issues such as staff training, animal handling protocols, and adverse events involving illness or injuries to those involved.

The survey tool was developed using the online Qualtrics Survey Research Suite (Qualtrics, Utah). It was then administered to four Environmental Health Directors and two veterinary public health professionals in order to identify any important issues that may have been overlooked, ensure that the wording and objectives were clear, and
estimate the time needed to complete the survey. As a result of this pilot, some wording was changed in the final survey, but the overall content and structure remained the same.

Survey Administration

An email was sent to the Environmental Health Directors near the end of November, 2010 to introduce the purpose of the survey and notify them that it would be sent the following week. A link to the survey with a cover letter was emailed in early December, 2010. Two weeks later a reminder containing the survey link was sent, and a letter of support encouraging completion of the survey was also emailed to the Environmental Health Directors from the president of their professional organization, the Ohio Environmental Health Association. Due to the holiday season, a second reminder email to non-responders was delayed until the second week of January. A third attempt to collect surveys was made by calling those who had not yet responded, and the survey was closed in February, 2011.

The survey link was opened 139 times; 13 of those attempts were not completed or submitted. Of the 127 completed surveys, five were duplicates. In one case, I was contacted and asked to discard the first submission. Three were submitted by the same person, with only one of them actually including responses to the majority of questions. There were no conflicts among the three surveys with regard to responses so the two that were least complete were discarded. In one case, two individuals from the same agency each completed a survey. They were contacted and asked to submit a single completed survey. The total number of fully completed surveys was 122.
Verification of Local Rabies Vaccination Requirements

A major objective of this survey was to identify the presence or absence of local requirements for prophylactic rabies vaccination of animals for each health jurisdiction. In order to validate the survey responses to those questions, all local health departments were contacted individually to verify the accuracy of their response. In March, 2011 each Environmental Health Director was sent the answers provided to the first question on their survey which pertained to the presence or absence of local vaccination requirements for dogs, cats, and ferrets. The email further explained that the data would be published and requested that the information be verified by a notification that it was correct as written or with a notification of correction. Those who had not participated in the original survey were also contacted and asked to provide this information order to complete the data set. A reminder to verify the information was emailed to both the Environmental Health Director and the Health Commissioner of health jurisdictions that did not respond to the initial request. Finally, a phone call was made to those still not verified, resulting in 102 health jurisdictions verifying and correcting the information originally provided in the survey. Several of the health jurisdictions choose to send a copy of their local ordinances to provide additional corroboration.

An internet search of local health department agency websites and publicly accessible websites that publish municipal codified ordinances was conducted.²⁶⁹-²⁷¹ Twenty-two (22) health jurisdiction codes were found and reviewed to verify the rabies vaccination requirements provided in the survey. Because online resources may not always reflect current records, the Environmental Health Director’s confirmation was
selected if it conflicted with the information available from internet published codes. For 8 health jurisdictions no verification was available. In all 8 of these cases the responses on the original survey were consistent with an informal telephone survey conducted by the Ohio Department of Health Zoonotic Disease Program in 2008. Thus data verification completed and confirmed responses for 128 (100%) of Ohio local health jurisdictions. Except where noted, these verified results were used in all analyses involving vaccination requirements.

**Additional Data Collection and Descriptive Analysis**

*National Rabies Surveillance Data*

The range of terrestrial rabies variants by reservoir and state were acquired through publically available resources. The CDC National Center for Emerging and Zoonotic Infectious Diseases was contacted in order to request rabies surveillance data for dogs, cats, and ferrets in the United States for the years 2000 through 2010. A line list of positive cases by state and species was provided. Though rabies variant type was not able to be determined for a few of the animals, studies have demonstrated that nearly all cases of rabies in dogs, cats, and wild carnivores in the US were the result of the terrestrial variant circulating in their county of origin. These data were imported into Microsoft Office Excel® 2007 (Microsoft Corporation, Washington), and a descriptive analysis was performed by state and year to study the epidemiology of rabies in these three domestic animal species.

Graphs were then created to compare the incidence of laboratory confirmed positive rabies cases between states with endemic raccoon rabies variant and those
without endemic raccoon rabies variant to examine any trends. This analysis was also repeated after removing states that were endemic for fox rabies variant, a terrestrial variant that is responsible for numerous cases of rabies in domestic animals. Fox rabies variant is found in Alaska and in a limited geographic region in and around Texas; there is no overlap with the range of raccoon rabies variant. Direct comparisons between other rabies variants by state were not possible due to overlapping variant activity.

**Local Health Department Demographics**

Key local health department demographics for calendar year 2010 were obtained from the Ohio Department of Health (ODH), including the number of employees (full time, part time, and total) and the annual budget (total revenues and total expenditures). This information was not available for one of the local health departments. Given the economic downturn during 2009 and 2010, it was decided that data from calendar year 2009 could be substituted for the purpose of these analyses without adjustment for inflation. The population of each health jurisdiction was also obtained from ODH. Since 2010 US Census Data were not yet available, population estimates were based on 2000 US Census Data. These variables were imported along with the survey results into Microsoft Office Excel® 2007 (Microsoft Corporation, Washington), and descriptive analysis was performed.

**Risk of Raccoon Rabies Variant Activity in Ohio Counties**

Publically available resources were used to identify Ohio counties that are currently endemic for raccoon rabies variant and those that are involved in the oral rabies vaccination program. Counties that have endemic raccoon rabies variant are at
highest risk for the associated cases of rabies. All counties that have raccoon rabies variant as well as counties that border endemic areas including the Ohio Pennsylvania border participate in the oral rabies vaccination program. As each township becomes infected, the probability of infection in neighboring township increases, so participation in the oral rabies vaccination program serves as an indicator of increased rabies risk. These variables were imported along with the survey results into Microsoft Office Excel® 2007 (Microsoft Corporation, Washington), and descriptive analysis was performed.

Statistical Analysis

Based on thesis objectives, five binomial outcomes of interest were identified: the presence or absence of dog vaccination requirements, cat vaccination requirements, ferret vaccination requirements, low cost rabies vaccination clinics (rabies clinics), and public health involvement in community rabies clinics. Potential relationships among these variables and between these variables and selected indicators of elevated rabies risk and local health department demographics were examined.

Statistical analysis was performed using JMP® Pro 9.0.0 (SAS Institute, North Carolina). Crude odds ratios, 95% confidence intervals, and $P$-values for each outcome were calculated against binomial variables such as the presence of vaccination requirements, the presence raccoon rabies variant and the presence of an oral rabies vaccination program in the county. A Pearson’s $\chi^2$-test was used to determine statistical significance. When an expected cell value was less than five a Fisher’s exact test was substituted. For each outcome, continuous variables including the number of local health
department employees (full time, part time, and total), the annual budget (total revenue and total expenditures), and population, were evaluated using a Mann-Whitney-Wilcoxon test to calculate $P$-values from comparison of the group means.

Following this initial screening, the previously identified five outcomes of interest were designated as dependant variables and logistic regression was performed for each. Independent variables included all relevant data collected including presence of vaccination requirements, presence of raccoon rabies variant, involvement in oral rabies vaccination program, presence of rabies clinics, public health involvement in rabies clinics, and local health department demographics such as employees (full time, part time, and total), annual budget (total revenue and total expenditures), and population. Univariate logistic regression and multivariable logistic regression were performed using JMP® Pro 9.0.0 (SAS Institute, North Carolina). Adjusted odds ratios, 95% confidence intervals, and $P$-values were calculated and reported.

A forward selection process was chosen for the multivariable analysis due to the relatively small number of cases (128) and the infrequency of some events as revealed in the contingency table. These categories were not collapsible, but the data were considered stable because the number of cases represented nearly the entire population and no cell counts were near zero. All covariates in the final model were statistically significant based on the likelihood-ratio $\chi^2$ test. To allay potential concerns about the forward selection method a hybrid selection process was also performed using $<0.05$ statistical significance and a selection cutoff of $<0.25$. The final models using both methods were identical for all 5 outcomes, increasing confidence in their fitness.
Chapter 3: Results

Descriptive analysis of the incidence of rabies in US dogs, cats, and ferrets between 2000 and 2010 and identification of trends related to raccoon rabies variant activity

The US incidence of confirmed rabies in dogs, cats, and ferrets was obtained from CDC for the years 2000 through 2010. Additional data were compiled on rabies variant range by state so that comparisons could be made between states with raccoon rabies variant (RRV) and those without. Stretching from Maine to Florida between the Eastern Seaboard and the Appalachian Ridge, raccoon rabies is now considered endemic in 21 states and the District of Columbia. Several of these states, like Ohio, have relatively small regions of raccoon rabies activity; while the majority of the state remains free but at risk of more widespread outbreaks.

Between 2000 and 2010, 882 rabid dogs were reported to CDC. Of those, 355 (40%) came from states with RRV activity; an area that geographically comprises less than ¼ of the country (Table 3.1). During these 11 years, non-RRV states were responsible for the majority of rabid dogs. However, starting in 2005 the margin has narrowed, and 2006 actually reported more rabid dogs in RRV states than in non-RRV states (Figure 3.1).

Fox rabies variant is endemic in 4 states where it contributes to rabies spillover to other animals. States endemic for fox rabies variant accounted for 195 (22%) cases of
rabies in dogs. In order to further examine the impact of raccoon variant on rabies cases in dogs, a second comparison was performed after controlling for this variable. States endemic for RRV contributed 52% (355/687) of the total cases of rabies in dogs reported from the 46 states and the District of Columbia that do not have fox rabies variant. In the majority of years, rabies in dogs from RRV endemic states exceeded the incidence in states that were free of both RRV and fox variants (Figure 3.2), remaining consistently higher between 2005 and 2010. Direct comparisons based on other rabies variants were not possible because bat rabies is endemic across the entire continent and skunk rabies has several regions of activity, including some areas of overlap with raccoon and fox variants.

During this same time period, CDC reported 3,143 cases of rabies in cats. The overwhelming majority of them, 2,475 (79%) occurred in states endemic for RRV (Figure 3.3). Every year, the number of rabid cats in states with RRV far exceeded the number in states without RRV. The four states with fox rabies variant were responsible

<table>
<thead>
<tr>
<th>Species</th>
<th>Total</th>
<th>RRV endemic</th>
<th>Non RRV endemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>882</td>
<td>355 (40%)</td>
<td>527 (60%)</td>
</tr>
<tr>
<td>Cats</td>
<td>3,143</td>
<td>2,475 (79%)</td>
<td>668 (21%)</td>
</tr>
<tr>
<td>Ferrets</td>
<td>6</td>
<td>6 (100%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Table 3.1 Rabies Incidence for Dogs, Cats, and Ferrets between 2000 and 2010 by Raccoon Rabies Variant Activity in the State
Figure 3.1 US Incidence of Rabies in Dogs, 2000-2010

Figure 3.2 US Incidence of Rabies in Dogs in States without Fox Rabies Variant, 2000-2010
for 193 (6%) of the total rabies cases in cats during this study period. Controlling for the
effect of fox variant (Figure 3.4) reveals similar trends and an even more dramatic
difference. States endemic for RRV contributed 84% (2,475/2,950) of the total feline
rabies cases from the 46 states and the District of Columbia that do not have fox rabies
variant. In states with RRV activity rabies in cats occurred 7 times more often than rabies
in dogs, compared to 1.3 times as often in states without RRV activity.

Rabies incidence in states endemic for RRV appears to rise and fall for both cats
and dogs with a periodicity of approximately 4 to 5 years. This is the same pattern
reported in raccoon populations with disease incidence decreasing as populations decline
during outbreaks and rising again as the number of naïve animals born or migrating into
the population increases.20,129 This periodicity is not seen in the feline or canine cases
from non-RRV states. A longer time period would need to be analyzed to determine if
this was real or an artifact. Evaluation of the data by state may also provide more insight.

The incidence of rabies in ferrets was also examined. CDC documented 6 cases of
rabies in ferrets between 2000 and 2010. Though very low numbers, when compared with
dogs and cats, all 6 (100%) rabid ferrets originated from states that were endemic for
RRV.

**Review of Acquired Data and Survey Responders**

Information regarding the presence of RRV and involvement in the cooperative
oral rabies vaccination program (ORV) were acquired for each Ohio county as an
indicator of rabies risk. Of the 128 local health departments, 18 (14%) had a confirmed
Figure 3.3 US Incidence of Rabies in Cats, 2000-2010

Figure 3.4 US Incidence of Rabies in Cats in States without Fox Rabies Variant, 2000-2010
animal case of RRV in their county and 32 (25%) were located in counties that had participated in ORV.\textsuperscript{29,96,128}

Surveys were completed by 95% (122/128) of local health departments. Of the 18 operating in counties with RRV, 17 (94%) responded to the survey and one did not. Of the 32 operating in counties with ORV, 30 (94%) responded to the survey and two did not.

Demographics were collected from the Ohio Department of Health (ODH) for each local health department in order to evaluate available resources for local rabies prevention efforts in 2010. These included the number of employees (full time, part time, and total employees), annual budget (total revenue and total expenditures), and the population based on the 2000 US Census (Table 3.2). There was notable variation in the data as indicated by the standard deviations. A few agencies had vast resources in comparison to the others, elevating the mean. The median is a better measure of central tendency in these data.

A comparison of survey responders (n=122) and non-responders (n=6) is summarized in Table 3.3 which shows the mean and median for both groups with respect to each demographic variable. In general the non-responders were smaller health departments having fewer staff and monetary resources as well as representing smaller populations. Because the response rate was very high (95%) and local health departments of similar size to the non-responders were well represented among the responders, it is unlikely that these differences reflect a non-response bias.
Table 3.2 Descriptive Statistics for Local Health Department Resource Variables (FY 2010)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Range</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full time Employees</td>
<td>36</td>
<td>64</td>
<td>481</td>
<td>20</td>
</tr>
<tr>
<td>Part time Employees</td>
<td>10</td>
<td>14</td>
<td>113</td>
<td>6</td>
</tr>
<tr>
<td>Total Employees</td>
<td>46</td>
<td>71</td>
<td>478</td>
<td>26</td>
</tr>
<tr>
<td>Total Expenditures</td>
<td>$4,593,182</td>
<td>$7,374,124</td>
<td>$49,074,368</td>
<td>$2,323,017</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>$3,546,476</td>
<td>$6,617,268</td>
<td>$44,560,349</td>
<td>$1,543,068</td>
</tr>
<tr>
<td>Population</td>
<td>89,852</td>
<td>138,372</td>
<td>881,257</td>
<td>41,053</td>
</tr>
</tbody>
</table>

†2010 data were unavailable for one health department, 2009 statistics were substituted.

Table 3.3 Central Tendency of Local Health Department Resource Variables (FY 2010) for Survey Responders and Non-responders

<table>
<thead>
<tr>
<th>Resource</th>
<th>Responders (n=122)</th>
<th>Non-responders (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>Full time Employees</td>
<td>37</td>
<td>21</td>
</tr>
<tr>
<td>Part time Employees</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Total Employees</td>
<td>47</td>
<td>26</td>
</tr>
<tr>
<td>Total Expenditures</td>
<td>$4,773,966</td>
<td>$2,424,977</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>$3,688,326</td>
<td>$1,674,803</td>
</tr>
<tr>
<td>Population</td>
<td>$92,657</td>
<td>$41,053</td>
</tr>
</tbody>
</table>

†2010 data were unavailable for one health department, 2009 statistics were substituted.
Comparison of Survey-provided and Validated Local Animal Vaccination Requirements

As described in Chapter 2: Materials and Methods, local health department responses to a question regarding the presence or absence of local animal vaccination requirements were validated to ensure accuracy. When the original responses were compared to the corrected and verified responses several discrepancies were noted. Of the 120 respondents who answered this question, 20 (17%) did not accurately report the vaccination requirements for dogs in their local health jurisdictions, for cats 22 (18%), and for ferrets 23 (19%). While some respondents incorrectly reported all three species, it was more common that one or two were incorrectly reported. Thirty-two (27%) did not accurately report their vaccination requirements for one or more of dogs, cats, and ferrets. Most indicated that they did have vaccination requirements when they did not, but some reported that they did not have vaccination requirements when in fact they did (Table 3.4).

Table 3.4 Comparison of 2011 Survey Responses for the Presence of Local Animal Rabies Vaccination Requirements with Post-survey Validation (n=122)

<table>
<thead>
<tr>
<th>Species</th>
<th>Survey Response was Validated</th>
<th>Survey Response was Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs</td>
<td>100 (83%)</td>
<td>20 (17%)</td>
</tr>
<tr>
<td>Cats</td>
<td>98 (82%)</td>
<td>22 (18%)</td>
</tr>
<tr>
<td>Ferrets</td>
<td>97 (81%)</td>
<td>23 (19%)</td>
</tr>
<tr>
<td>One or more of dogs, cats,</td>
<td>88 (73%)</td>
<td>32 (27%)</td>
</tr>
<tr>
<td>ferrets</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Validated Local Animal Rabies Vaccination Requirements in Ohio

Of the 128 health departments operating at the time of the study; 62 (48%) required vaccination of dogs, 49 (38%) required vaccination of cats, and 32 (25%) required vaccination of ferrets (Figure 3.5). No Ohio health departments required the vaccination of other animal species. In comparison to those with vaccination requirements for dogs, fewer health jurisdictions had requirements for cats and ferrets, and none required vaccination of cats or ferrets unless they also required vaccination of dogs. Therefore, the data presented for dog requirements also represents the distribution of health jurisdictions that have a mandatory vaccination requirement for any species.

Many of Ohio’s 88 counties encompass more than one health jurisdiction. Compiling the vaccination requirements by county shows that the distribution of Ohio
counties with vaccination requirements for any species is far less than half of the state, as could otherwise be implied from reviewing the results by health jurisdiction. Vaccination is required for dogs in 31 (35%) counties, for cats in 23 counties (26%), and for ferrets in 15 (17%) counties (Figure 3.6). The rest of the counties either have vaccination requirements for a portion of the county or no vaccination requirements at all.

To examine the geographic distribution of rabies vaccination requirements in Ohio, the validated responses were mapped for dogs (Figure 3.7), cats (Figure 3.8), and ferrets (Figure 3.9) which display counties with mandatory vaccination, those without, and those with requirements that vary within the county based on the health jurisdiction. In response to the incursion of raccoon rabies in 1997 the Ohio Director of Health signed a Journal Entry requiring rabies vaccination of all dogs and cats in affected counties (Ashtabula, Trumbull, Mahoning, and Columbiana)\textsuperscript{160}. This Journal Entry is still in effect. Counties under the Director’s Journal Entry are delineated by a red outline.

![Figure 3.7 Local Dog Vaccination Requirements by Ohio County, 2011](image-url)
Figure 3.8 Local Cat Vaccination Requirements by Ohio County, 2011

Figure 3.9 Local Ferret Vaccination Requirements by Ohio County, 2011
**Crude Analysis of Local Dog, Cat, and Ferret Rabies Vaccination Requirements**

The presence of endemic RRV in the county demonstrated a significant relationship with the presence of vaccination requirements in all three species (Table 3.5). Examining the odds ratios showed that local health jurisdictions with RRV activity in their county were 3.2 times more likely to have requirements for dog vaccination \( (P=0.029) \), 5.3 times more likely to have requirements for cat vaccination \( (P=0.001) \), and 3.8 times more likely to have requirements for ferret vaccination \( (P=0.016) \) than counties without RRV. However, the presence of ORV in the county did not yield a significant difference for dog, cat, or ferret vaccination requirements when compared to health jurisdictions that did not have ORV in their county.

Mann-Whitney-Wilcoxon tests were performed to exam the possible relationships between the presence of local requirements for dog, cat, and ferret vaccination and several continuous variables representative of local health department resources. For these outcomes, all of the demographics except the number of part time employees demonstrated a statistically significant difference in their group means. Population was consistently the most strongly associated factor in these analyses with \( P \)-values of 0.001, <0.001, and <0.001 for dog, cat, and ferret vaccination requirements respectively (Table 3.6).

Breakdowns showed that no jurisdiction had cat vaccination requirements that did not also have dog vaccination requirements; and no jurisdiction had ferret vaccination requirements unless they also had both dog and cat vaccination requirements. Both group
Table 3.5 Unadjusted Effect of the Presence of Raccoon Rabies Variant and Oral Rabies Vaccination Program in a County on the Presence of Local Dog, Cat, or Ferret Rabies Vaccination Requirements

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>N</th>
<th>%</th>
<th>OR</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog Vaccination Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRV in County</td>
<td>128</td>
<td>3.2</td>
<td>1.08</td>
<td>9.70</td>
<td>0.029*</td>
</tr>
<tr>
<td>Present</td>
<td>18</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>110</td>
<td>86%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORV in County</td>
<td>128</td>
<td>1.5</td>
<td>0.68</td>
<td>3.40</td>
<td>0.307</td>
</tr>
<tr>
<td>Present</td>
<td>32</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>96</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat Vaccination Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRV in County</td>
<td>128</td>
<td>5.3</td>
<td>1.77</td>
<td>16.15</td>
<td>0.001*</td>
</tr>
<tr>
<td>Present</td>
<td>18</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>110</td>
<td>86%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORV in County</td>
<td>128</td>
<td>1.9</td>
<td>0.85</td>
<td>4.30</td>
<td>0.115</td>
</tr>
<tr>
<td>Present</td>
<td>32</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>96</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferret Vaccination Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRV in County</td>
<td>128</td>
<td>3.8</td>
<td>1.35</td>
<td>10.62</td>
<td>0.016*†</td>
</tr>
<tr>
<td>Present</td>
<td>18</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>110</td>
<td>86%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORV in County</td>
<td>128</td>
<td>1.5</td>
<td>0.63</td>
<td>3.71</td>
<td>0.346</td>
</tr>
<tr>
<td>Present</td>
<td>32</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>96</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant P<0.05, †Fisher’s Exact Test
Table 3.6 Unadjusted Effect of Local Health Department Resource Variables on the Presence of Local Rabies Vaccination Requirements for Dogs, Cats, and Ferrets

<table>
<thead>
<tr>
<th>Model Variable</th>
<th>Dog Vaccination Required, n=62</th>
<th>Not Required, n=66</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog Vaccination Full time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees †</td>
<td>54 (87)</td>
<td>19 (16)</td>
<td>0.005*</td>
</tr>
<tr>
<td>Part time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees ‡</td>
<td>12 (19)</td>
<td>8 (8)</td>
<td>0.575</td>
</tr>
<tr>
<td>Total Employees †</td>
<td>66 (96)</td>
<td>27 (22)</td>
<td>0.008*</td>
</tr>
<tr>
<td>Total Expenditures †</td>
<td>$6,938,982</td>
<td>$2,389,551</td>
<td>0.006*</td>
</tr>
<tr>
<td>Total Revenue ‡</td>
<td>($9,853,699)</td>
<td>($2,223,937)</td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>140,786 (184,076)</td>
<td>42,006 (28,501)</td>
<td>0.001*</td>
</tr>
<tr>
<td>Cat Vaccination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees †</td>
<td>53 (73)</td>
<td>25 (55)</td>
<td>0.002*</td>
</tr>
<tr>
<td>Part time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees ‡</td>
<td>12 (21)</td>
<td>8 (8)</td>
<td>0.795</td>
</tr>
<tr>
<td>Total Employees †</td>
<td>66 (88)</td>
<td>33 (56)</td>
<td>0.005*</td>
</tr>
<tr>
<td>Total Expenditures †</td>
<td>$6,941,490</td>
<td>$3,136,636</td>
<td>0.004*</td>
</tr>
<tr>
<td>Total Revenue ‡</td>
<td>($8,913,819)</td>
<td>($5,833,434)</td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>158,677 (198,401)</td>
<td>47,163 (46,154)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Ferret Vaccination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees †</td>
<td>57 (81)</td>
<td>29 (56)</td>
<td>0.007*</td>
</tr>
<tr>
<td>Part time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employees ‡</td>
<td>15 (24)</td>
<td>8 (9)</td>
<td>0.196</td>
</tr>
<tr>
<td>Total Employees †</td>
<td>72 (98)</td>
<td>37 (58)</td>
<td>0.011*</td>
</tr>
<tr>
<td>Total Expenditures †</td>
<td>$7,867,251</td>
<td>$3,501,825</td>
<td>0.009*</td>
</tr>
<tr>
<td>Total Revenue ‡</td>
<td>($10,085,164)</td>
<td>($5,889,844)</td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>165,564 (211,950)</td>
<td>64,615 (91,449)</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

† 2010 data were unavailable for one health department, 2009 statistics were substituted. * significant P<0.05
population means for ferret vaccination requirements were higher (165, 564 with and 64,615 without) in comparison to dogs (140,786 with and 42,006 without), with cats falling in between. A similar trend was evident with all financial and staff resource variables indicating that those with ferret vaccination requirements overall had more available resources than those with cat vaccination requirements, and both had more available resources than those with dog vaccination requirements.

Presence of Low Cost Rabies Vaccination Clinics (Rabies Clinics) and Public Health Involvement in Rabies Clinics

For the purposes of this survey a rabies clinic was defined as “an event held at a specific time for the primary purpose of administering rabies vaccination. Fees are generally below the average normally charged by local veterinarians and no separate fee is charged for an office visit or examination.” The survey asked Environmental Health Directors whether or not there were typically one or more rabies clinics in their health jurisdiction each year. Of 122 respondents 53 (43%) answered yes, 56 (46%) answered no, and 13 (11%) answered not sure. Those answering no and not sure were taken to the end of the survey.

The 53 respondents continuing with the survey were asked to select from a list all organizations and businesses that were involved in offering or collaborating to offer rabies clinics in their health jurisdiction between 2008 and 2010. The most frequently selected response was “Humane societies/animal control agencies” with 27 (59%), followed by “Veterinary hospitals” with 18 (40%), “neighboring health departments”, with 11 (27%) respondents, “veterinary medical associations” with 8 (20%) respondents, “pet stores” with 7 (16%), “public service agencies (e.g. fire department, county
extension)” with 4 (10%), and “agriculture/feed stores” with 3 (7%). Several organizations were written in the text box, but all of them fell within one of the categories already available as response options suggesting that those listed above were responsible for offering the majority of the reported rabies clinics in this study.

Respondents were then asked if their local health department was involved in offering or collaborating to offer a rabies clinic between 2008 and 2010; 36 (68%) answered yes while 17 (32%) answered no. Those answering no were taken to the end of the survey.

Of the 36 responding that they had been involved in offering a rabies clinic between 2008 and 2010, 16 (44%) indicated that they had been the lead organizing agency, 10 (28%) were a collaborating agency, and 8 (22%) were both an organizing and a collaborating agency at different rabies clinics during that time span. Two (6%) agencies indicated that they had no involvement in rabies clinics during those years despite answering that they had offered or collaborated to offer rabies clinics in the previous question. One of those responding “no involvement” in this question added that they had recently ended their involvement in rabies clinics due to budget cuts. Nearly half reported that their local health department had either organized or collaborated to offer at least 1 clinic in 2008, 2009 and 2010 (Figure 3.10). The number of local health departments offering 0 clinics in 2008 and 2009 was 2 (6%); this increased to 5 (14%) in 2010. Though 2010 showed a slight increase in the 3 or more categories, there appeared to be a general decline in the total number of rabies clinics with local health department involvement between 2008 and 2010.
Of the responders (35/36) providing the fee charged to the public during their most recent rabies clinic, none indicated that rabies vaccines were free and none reported charging over $16.00. Fees ranged from $1.00 and $5.00 (54%), $6.00 and $10.00 (43%), $11.00 and $15.00 (3%).

Ninety-two (75%) respondents reported they had no involvement in rabies clinics or had ended their prior involvement in rabies clinics by 2010. They were asked to select all reasons that applied to explain their lack of involvement. Of the 84 local health departments answering this question, 55 (65%) selected “budget constraints”, 48 (57%) selected “staffing constraints”, 22 (26%) selected “other”, 17 (20%) selected “can’t find veterinarians willing to assist”, 9 (11%) selected “no need for rabies clinics because low cost rabies vaccination are available in my jurisdiction through other means” (e.g. vaccination vouchers, low-cost veterinary practices), 7 (8%) selected “pet animal rabies vaccination is not a priority concern for public health”, 5 (6%) indicated “poor clinic attendance in the past”, and 2 (2%) selected that “rabies clinics were already available in their jurisdiction” (Figure 3.11).
Some respondents noted in the text box, that there was a shortage of veterinarians in the community or a lack of cooperation between vets and humane agencies. A few wrote that owners should be responsible for taking their own pets to a veterinarian and should pay for their animals needs, one further indicated that rabies vaccination was animal health NOT public health. Others shared concerns that they wouldn’t reach the target population of owners who could not otherwise vaccinate their pets or that there seemed to be no demand in their jurisdiction.

**Crude Analysis of the Presence of Rabies Clinics and Public Health Involvement in Rabies Clinics**

As seen with the analysis of vaccination requirements, the presence of RRV was strongly associated with both of these outcomes. Local health departments with endemic
RRV were 10.7 times more likely to indicate the presence of a rabies clinic in their jurisdiction ($P<0.001$) and 3.3 times more likely to be involved in offering rabies clinics ($P=0.022$) than those without RRV in their county (Table 3.7). The presence of ORV was also significant for both with odds ratios of 5.9 for the presence of a rabies clinic in the health jurisdiction ($P<0.001$) and 2.8 for local health department involvement in rabies clinics ($P=0.018$) compared to health jurisdictions that do not have ORV programs in their county.

The presence of dog vaccination requirements did not impact local health department involvement in rabies clinics, and having vaccination requirements for ferrets was not significantly associated with either outcome. Local health departments with cat vaccination requirements, on the other hand, were 3.6 times more likely to indicate the presence of a rabies clinic in their health jurisdiction ($P=0.002$), and 2.3 times more likely to be involved in offering a rabies vaccination clinic ($P=0.036$) than those without cat vaccination requirements.

Since rabies clinics may be offered by several organizations within a community their presence was not dependent on local health department specific resources so population was the only variable included in the analyses for this outcome. Once again population was found to have a highly significant relationship with higher populations increasing the likelihood that a rabies clinic would be present in the health jurisdiction ($P=0.017$).

Public health involvement in rabies clinics was analyzed against all available variables representing local health department resources in this study. Interestingly, the
unadjusted odds for this outcome were not significantly associated with population, annual revenue, or annual expenditures. The number of full time employees ($P=0.035$) and the total number of employees ($P=0.042$), however, did demonstrate a significant difference in the group means comparing those that were involved with those that were not (Table 3.8).

Table 3.7 Unadjusted Effect of the Presence of Raccoon Rabies Variant, Oral Rabies Vaccination Program, and Local Vaccination Requirements of Dogs, Cats, and Ferrets on the Presence of Rabies Clinics and Public Health Involvement in Rabies Clinics

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>N</th>
<th>%</th>
<th>OR</th>
<th>95% CI</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHD Involved in Rabies Clinic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRV in County</td>
<td>122</td>
<td>3.3</td>
<td>1.14, 9.27</td>
<td>0.022*</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>17</td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>105</td>
<td>86%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORV in County</td>
<td>122</td>
<td>2.8</td>
<td>1.18, 6.60</td>
<td>0.018*</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>30</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>92</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHD Involved in Rabies Clinic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog Vaccination</td>
<td>122</td>
<td>1.5</td>
<td>0.69, 3.29</td>
<td>0.304</td>
<td></td>
</tr>
<tr>
<td>Required</td>
<td>59</td>
<td>48%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Required</td>
<td>63</td>
<td>52%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat Vaccination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.036*</td>
</tr>
<tr>
<td>Required</td>
<td>47</td>
<td>39%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Required</td>
<td>75</td>
<td>61%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferret Vaccination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.147</td>
</tr>
<tr>
<td>Required</td>
<td>30</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Required</td>
<td>92</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.7 Continued

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>N</th>
<th>%</th>
<th>OR</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabies Clinic in Health Jurisdiction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRV in County</td>
<td>109</td>
<td>10.7</td>
<td>2.30, 49.35</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>17</td>
<td>16%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>92</td>
<td>84%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORV in County</td>
<td>109</td>
<td>5.9</td>
<td>2.16, 16.20</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>28</td>
<td>26%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>81</td>
<td>74%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog Vaccination</td>
<td>109</td>
<td>2.5</td>
<td>1.17, 5.50</td>
<td>0.017*</td>
<td></td>
</tr>
<tr>
<td>Required</td>
<td>53</td>
<td>49%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Required</td>
<td>56</td>
<td>53%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat Vaccination</td>
<td>109</td>
<td>3.6</td>
<td>1.61, 8.16</td>
<td>0.002*</td>
<td></td>
</tr>
<tr>
<td>Required</td>
<td>43</td>
<td>35%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Required</td>
<td>66</td>
<td>65%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferret Vaccination</td>
<td>109</td>
<td>1.9</td>
<td>0.81, 4.64</td>
<td>0.138</td>
<td></td>
</tr>
<tr>
<td>Required</td>
<td>28</td>
<td>26%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Required</td>
<td>81</td>
<td>74%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant P<0.05

Table 3.8 Unadjusted Effect of Local Health Department Resource Variables on the Presence of Rabies Clinics and Public Health Involvement in Rabies Clinics

<table>
<thead>
<tr>
<th>Model Variable</th>
<th>Mean (Standard Deviation)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabies Clinic present</td>
<td>Present, n=53</td>
<td>Not Present, n=56</td>
</tr>
<tr>
<td>Population</td>
<td>139,944 (188,210)</td>
<td>57,271 (76,516)</td>
</tr>
<tr>
<td>LHD Involved in rabies clinic</td>
<td>Involved, n=36</td>
<td>Not Involved, n=86</td>
</tr>
<tr>
<td>Full time Employees†</td>
<td>46 (59)</td>
<td>33 (67)</td>
</tr>
<tr>
<td>Part time Employees†</td>
<td>15 (24)</td>
<td>8 (8)</td>
</tr>
<tr>
<td>Total Employees†</td>
<td>61 (79)</td>
<td>42 (70)</td>
</tr>
<tr>
<td>Total Expenditures†</td>
<td>$6,398,108 ($8,557,323)</td>
<td>$4,094,093 ($6,962,855)</td>
</tr>
<tr>
<td>Total Revenue†</td>
<td>$5,106,693 ($7,807,196)</td>
<td>$3,094,591 ($6,203,861)</td>
</tr>
<tr>
<td>Population</td>
<td>144,181 (202,066)</td>
<td>71,088 (99,682)</td>
</tr>
</tbody>
</table>

†2010 data were unavailable for one health department, 2009 statistics were substituted. *significant P<0.05
Multivariable Analysis

The Presence of Rabies Vaccination Requirements

Population was found to be the most strongly associated factor for dog vaccination requirements \((P<0.001)\), cat vaccination requirements \((P<0.001)\), and ferret vaccination requirements \((P=0.002)\). As population increased, the probability that rabies vaccination would be required increased for all three species evaluated (Table 3.9). Comparing thematic population density maps of Ohio to the maps showing the distribution of vaccination requirements further supports this finding (Figure 3.12).

The presence of RRV was also a strong indicator that rabies vaccination requirements would be present in a local health jurisdiction. Those in counties with endemic RRV were 5.5 times more likely to require vaccination of cats \((P=0.004)\), and 1.6 times more likely to require vaccination of ferrets \((P=0.028)\). The presence of RRV appears to be associated, though not statistically significant at \(\alpha<0.05\), with the presence of dog vaccination requirements. Health jurisdictions operating in a county with raccoon rabies activity were 3.0 times more likely to require vaccination of dogs \((P=0.061)\) than those operating in counties free of RRV.

All counties with endemic RRV are involved in the ORV program along with counties that border those areas with raccoon rabies activity. Though these areas are at highest risk of disease introduction from neighboring counties, the presence of ORV was not significantly associated with the presence of local rabies vaccination requirements. With population and the presence of RRV in the model, multivariable analysis also showed no significant connection with the number of employees (full time, part time and
total), annual budget (revenue and expenditures), the presence of rabies clinics, or public health involvement in rabies clinics.

*Presence of Rabies Clinics in Local Health Jurisdiction and Public Health Involvement in Rabies Clinics*

Local health departments with ORV programs in the county were 6.1 times more likely to have a rabies clinic in their jurisdiction ($P<0.001$) and 2.7 times more likely to participate in offering rabies clinics ($P=0.033$) than those operating in counties without ORV programs. However, RRV was not associated with either of these outcomes.

Population was once again found to be a major contributing factor. As population increased so did the likelihood that rabies clinics would be present (1.9, $P=0.002$) and the likelihood that local health departments would be involved in offering rabies clinics (1.4, $P=0.019$). Local vaccination requirements, the number of employees (full time, part time, and total), and the annual budget (revenue and expenditures) had no impact on the presence of rabies clinics in the community or public health involvement in rabies clinics.

Figure 3.12 Population Density by Ohio Census Tract, 2000 US Census (Left) and Local Dog Vaccination Requirements by Ohio County, 2011 (Right)
Table 3.9 Multivariable Logistic Regression Model to Estimate Adjusted OR's for Factors Associated with the Vaccination Requirements of Dogs, Cats, and Ferrets; the Presence of Rabies Clinics, and the Involvement of Public Health in Rabies Clinics

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>OR</th>
<th>95% CI (OR)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog Vaccination</td>
<td>Population /100,000</td>
<td>4.6</td>
<td>2.10, 12.29</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td></td>
<td>RRV Present</td>
<td></td>
<td></td>
<td>0.061</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.0</td>
<td>0.95, 10.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Cat Vaccination</td>
<td>Population /100,000</td>
<td>3.2</td>
<td>1.78, 7.14</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td></td>
<td>RRV Present</td>
<td></td>
<td></td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>5.5</td>
<td>1.73, 19.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Ferret Vaccination</td>
<td>Population /100,000</td>
<td>1.6</td>
<td>1.19, 2.36</td>
<td>0.002*</td>
</tr>
<tr>
<td></td>
<td>RRV Present</td>
<td></td>
<td></td>
<td>0.028*</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.5</td>
<td>1.15, 10.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Rabies Clinic in Health Jurisdiction</td>
<td>Population /100,000</td>
<td>1.87</td>
<td>1.22, 3.42</td>
<td>0.002*</td>
</tr>
<tr>
<td></td>
<td>ORV in County</td>
<td></td>
<td></td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>6.1</td>
<td>2.27, 18.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.0</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>LHD Involved in Rabies Clinics</td>
<td>Population /100,000</td>
<td>1.4</td>
<td>1.06, 1.96</td>
<td>0.019*</td>
</tr>
<tr>
<td></td>
<td>ORV in County</td>
<td></td>
<td></td>
<td>0.033*</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>2.7</td>
<td>1.08, 6.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.0</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

*significant P<0.05
Local Health Department Support for State Mandated Rabies Vaccination Laws

Of 119 survey respondents 109 (92%) indicated that they were in favor of state mandated vaccination requirements for dogs, 5 (4%) selected no, and 5 (4%) selected not sure. Of the 5 respondents that were not in favor a state mandated rabies vaccination law for dogs, none have a local vaccination requirement for dogs. For cats, 101 out of 120 respondents (84%) indicated that they were in favor of state mandated vaccination requirements; 9 (8%) selected no, and 10 (8%) selected not sure. Of the 9 respondents that were not in favor a state mandated rabies vaccination law none have a local vaccination requirement for cats. For ferrets, 77 out of 120 respondents (64%) indicated that they were in favor of state mandated vaccination requirements, 21 (18%) selected no, and 22 (18%) selected not sure. Of the 22 respondents that were not in favor a state mandated rabies vaccination law for ferrets 2 (9%) have a local vaccination requirement. Respondents were also asked if they thought the state should require rabies vaccination for other (e.g. horses, livestock) species. Of 118 respondents 20 (17%) indicated that they were in favor of state mandated vaccination requirements for other species besides dogs, cats, or ferrets; 47 (40%) selected no and 51 (43%) selected not sure. A few respondents commented that domestic livestock and exotics animal species should have vaccination requirements. Overall, there appears to be strong support from local health departments for the enactment of state mandated animal vaccination laws.
Chapter 4: Discussion

Descriptive Analysis of the incidence of rabies in US dogs, cats, and ferrets between 2000 and 2010 and identification of trends related to raccoon rabies variant activity

A review of national rabies surveillance data was performed for this study. Between 2000 and 2010, there were 882 rabid dogs, 3,143 rabid cats, and 6 rabid ferrets reported from 50 United States and the District of Columbia. Feline cases were persistently three to four times more common than rabies cases in dogs, which is consistent with annual reports published by the CDC.63,94,168,173,174 Though rabies cases in cats first surpassed those of dogs in 1981,123 canine rabies has remained the primary focus of domestic rabies prevention efforts in the US. Numerous laws exist for dog control including licensing, leash laws and stray removal. At the same time most states have inadequate or nonexistent animal control programs for cats, and fewer states require vaccination of cats (62%) compared to dogs (78%).

In 2011, a young girl in California contracted rabies from a stray cat near her school.16 The growing population of feral and free-roaming cats across the country provides a large source of unowned, and likely unvaccinated, animals living in close association with wildlife and human communities. An outbreak of rabies in these cat populations would present an increased risk for human exposure. Though rare, it is possible for a rabies variant to become established in a new reservoir species.135,175,176
If this were to happen in stray cats as it did with stray dogs the public health consequences would be severe. Public health officials should include contingencies for cats in their rabies outbreak response plans. Additionally, governments are strongly encouraged to examine options for humane control strategies to reduce unwanted cat populations, ideally involving community partners in an active population control program.

Given the higher incidence of rabies in cats and particularly in those living outdoors, it is also recommended that organizations involved in trap-neuter-return (TNR) activities vaccinate cats against rabies before returning them to the location where they were found. The inability to effectively provide booster vaccination to these cats should not preclude administration of an initial vaccine. A study in Florida reported that only 3% of feral cats demonstrated titers against rabies virus, and 98% of them seroconverted within 10 weeks of rabies vaccination at the time of neutering. Though booster vaccinations are ideal and necessary in pet populations to ensure maintenance of the highest level of immunity, a single vaccine should afford immunity for at least a year and likely for some time thereafter. State or local governments that are regulating TNR programs should consider rabies vaccination as a requirement prior to release.

Raccoon rabies variant (RRV) is now considered endemic in 21 US states. Numerous studies have demonstrated that rabies cases in domestic animals increase significantly beyond the levels attributed to bat rabies, following the introduction of raccoon rabies variant to a state. Those comparing state surveillance data prior to and during the raccoon rabies epizootic identified a large number of spillover
cases which translated into more opportunities for rabies transmission to humans.\textsuperscript{20,108,124,130,136,139} The most recent study of this type reviewed surveillance data from the northeastern US between 1992 and 2000. This multi-state study showed increases in domestic animal cases, and reported that the odds of diagnosing a rabid cat early in the epizootic were 12 times greater than prior to the epizootic.\textsuperscript{135} The costs associated with rabies prevention and the risk to domestic animals remained significantly elevated even after the initial outbreak.\textsuperscript{165}

To further characterize the post-epizootic epidemiology of rabies in dogs and cats, national incidence data between 2000 and 2010 were analyzed with respect to terrestrial rabies variants. The overwhelming majority of rabid cats (79\%) occurred in states with raccoon rabies activity. Though the disparity between RRV-endemic and non-endemic states is not as dramatic in dogs as it is in cats, a multi-year trend demonstrated that a growing proportion of all rabid dogs can be attributed to states with raccoon rabies activity. The overall incidence of rabies in raccoons during this time has declined;\textsuperscript{168} however, the risk to domestic animals and public health clearly remains elevated even though the epizootic period has ended.

Though not reaching levels associated with previous epizootic outbreaks, spillover of raccoon rabies to domestic animals has persisted for years in enzootic regions, and appears to have stabilized. Predictions made from these data can aid in targeting specific rabies interventions including the delivery of public health messages aimed at reducing human exposures.
Distribution of Local Rabies Vaccination Requirements for Dogs, Cats, and Ferrets in Ohio

Though mandatory vaccination of dogs, cats, and ferrets is recommended by rabies experts and national public health officials, some states have not enacted such legislation. A previous study by this author found that 11 (22%) of US states did not require prophylactic rabies vaccination of dogs and 19 (38%) did not require vaccination of cats. Of the 21 (42%) states with raccoon rabies variant (RRV) circulating in the wildlife population, Ohio was the only one that did not require vaccination of dogs and was one of only two that did not require vaccination of cats.

In Ohio, authority is granted by the state to the local health departments who may enact regulations at their discretion. Rabies control programs in Ohio are managed by the environmental health sections of local health departments and vaccination requirements, when present, are typically found in the municipal health codes. To determine the presence and distribution of rabies vaccination requirements in Ohio’s 128 local health jurisdictions, a survey was administered to each department’s Environmental Health Director. The survey responses to this question were then confirmed by direct contact with the administration of each health district and through publically available external sources. It appears that this study is the first to collect, validate, and compile the distribution of local animal vaccination requirements in Ohio.

The results demonstrated that a large proportion of the state does not have vaccination requirements for dogs, cats, or ferrets. Though approximately half of the 128 local health jurisdictions (48%) required vaccination of dogs, mapping these results by county illustrated that only 35% of counties required vaccination of dogs and 8% of
counties required vaccination of dogs in part of the county. Compared to dogs, there were fewer requiring vaccination for cats (26%), and only a small percentage requiring vaccination of ferrets (17%). The remaining counties either did not have vaccination requirements or their presence varied within the county based on the local health jurisdiction.

Based on the multivariable regression, population was strongly associated with the presence of local rabies vaccination requirements. For every increase of 100,000 people, local health jurisdictions had 4.6 ($P<0.001$), 3.4 ($P<0.001$), and 1.6 ($P=0.002$) greater likelihood of having vaccination requirements for dogs, cats, and ferrets respectively. After accounting for population, the other resource variables did not make a significant difference in the odds of having vaccination requirements in any of these species. A comparison of a population density map of Ohio to the distribution maps for vaccination requirements (Figure 3.12) further supports the significance of this factor.

The relationship with population density may be related to a larger governmental infrastructure in areas with higher numbers of residents who are both requiring services and contributing to the tax base. Several studies report that the majority of rabies cases, including those in domestic animals, occur in rural, less populated areas.\textsuperscript{84,99,100} This disparity means that the areas at highest risk are the least likely to require vaccination of companion animals.

Averaging 60 cases per year, Ohio has enjoyed a relatively low incidence of animal rabies despite the 1997 incursion of RRV into the northeastern counties. A local, state, and federal partnership to distribute oral rabies vaccinations (ORV) to raccoons
began that same year in an effort to interrupt rabies transmission. Vaccines are distributed in 14 eastern Ohio counties, creating a barrier of immune raccoons that is intended to prevent further spread of raccoon rabies. Predicted to cross Ohio by the year 2000, westward expansion of the raccoon rabies epizootic was effectively stalled. Enhanced rabies surveillance continues, and almost every year Ohio reports a few cases of raccoon rabies within the ORV bait zone. On our eastern border, Pennsylvania consistently reports one of the nation’s highest rates of rabies in raccoons and in domestic animals.

Like population, the presence of raccoon rabies was a strong indicator that vaccination would be required for cats and ferrets, but interestingly not for dogs. Local health departments with RRV in their county were 5.5 times more likely to require vaccination of cats \((P=0.004)\) and 1.6 times more likely to require vaccination of ferrets \((P=0.028)\) than those that were operating in counties free of RRV. Though not quite statistically significant, the odds that health jurisdictions in counties with RRV would have dog vaccination requirements were 3.5 times greater than counties without RRV \((P=0.061)\). There are more local health jurisdictions that require vaccination of dogs than require them for cats or ferrets, which may have diluted the significance of this relationship. Overall, these results indicate that those currently dealing with raccoon rabies are more likely to have rabies control programs that require vaccination of companion animals.

Despite the increased risk associated with the close proximity to raccoon rabies activity and the resulting public health involvement in wildlife rabies control efforts; local health departments with ORV programs in their county were not more likely than
those without to have vaccination requirements for dogs, cats, or ferrets. One can predict that companion animal vaccination requirements would follow if raccoon rabies were to enter their health jurisdiction. However, waiting until the disease is present seems very short-sighted. This represents a reactive approach to public health intervention, and it may well lead to increased costs and human rabies exposures that could have been prevented.

This study was the first to examine the distribution of local rabies vaccination requirements and the availability of low cost rabies vaccination clinics in Ohio. It was established that Ohio’s current system is inadequate and has not resulted in rabies vaccination requirements over the majority of the state. Further analysis reveals that sparsely populated communities and those within counties participating in the oral rabies vaccination program are significantly less likely to have local rabies vaccination requirements than more densely populated areas. This means that the areas least likely to require vaccination are the same areas that are most likely to diagnose rabies in their animal populations. Collectively, these data can be used by legislators and health officials to make informed decisions and guide public health policy for rabies prevention and control.

Validation of Survey Data

An unexpected finding from this study was the number of respondents that incorrectly reported their local vaccination requirements on the initial survey. Once collected, the responses to this question were verified through individual contact with the Environmental Health Director and/or Health Commissioner in each jurisdiction. The
relevant health codes, when available online or provided by the local health department, were also reviewed to ensure accuracy. A comparison of the survey responses to the validated data found discrepancies in the reporting of vaccination requirements for dogs 20 (17%), cats 22 (18%), and ferrets 23 (19%). Overall, 32 (27%) local health departments did not accurately report their vaccination requirements for one or more of dogs, cats, and ferrets.

The majority of these discrepancies resulted from respondents selecting “yes” or “not sure” when they actually did not have local rabies vaccination requirements. Two agencies reported that they did not require vaccination when in fact, they did. This is alarming given the important role local public health agencies play in rabies prevention and control, and the potential ramifications of misinforming the public.

It is not clear why those responsible for the regulations were not fully aware of them. Some of the surveys may have been completed by persons who do not regularly respond to rabies exposure events. However, this did not account for all of the discrepancies. During the verification process, several environmental health directors reported reviewing their health codes and finding their original response in error. In one agency the environmental health director verified that their survey indicating the presence of vaccination requirements for dogs, cats, and ferrets was correct, while the health commissioner accurately responded that they did not have local rabies vaccination requirements for any species.

Chronic under staffing and in some cases high employee turnover are frequently reported by local health departments. These factors may contribute to this lack of
awareness by placing additional responsibilities on staff with less training and experience. Environmental health, which is responsible for rabies prevention in Ohio health districts, is a complex and varied discipline. Public health agencies should strongly consider advanced education in a relevant field as a prerequisite for employment. To ensure a proficient workforce, it is important to also provide site and task specific training opportunities at the onset of employment and prior to assuming new duties.

**Availability and Public Health Involvement in Low Cost Rabies Vaccination Clinics (Rabies Clinics)**

For some, the expense of veterinary care could present a barrier to immunizing pets. Rabies clinics are one method of providing reduced fee vaccinations to the public. Nearly half of responding health departments (53, 43%) indicated that they were aware of at least one rabies clinic held annually in their health jurisdiction, of which 36 (30%) reported that their agency was involved in planning or collaborating to offer at least one rabies clinic between 2008 and 2010. A public fee of $10.00 or less was charged per vaccine by 97% of rabies clinics with public health involvement.

Because rabies clinics are offered by numerous organizations without the involvement or awareness of local public health agencies, this data likely under represents the actual availability of rabies clinics in Ohio. The 53 respondents that indicated awareness of a rabies clinic in their health jurisdiction were asked about other organizations that offered or collaborated to offer rabies clinics. “Humane societies/animal control agencies” (27, 59%) were most commonly selected followed by veterinary hospitals (18, 40%), and neighboring health departments (11, 27%). Additionally, other reduced cost options for rabies vaccination are typically available
through low-cost wellness clinics, spay neuter clinics, and general vaccination clinics that offer other immunizations in addition to rabies.

Of 92 (75%) of survey respondents that indicated they were not involved or had recently ended their involvement in rabies clinics, 84 provided reasons for their lack of involvement. Not surprisingly resource limitations were the most common responses: “budget constraints” (65%) and “staffing constraints” (57%). Twenty percent (20%) indicated they had difficulty finding veterinarians who were willing to assist with the clinics, while 13% said there was no need for them to be involved because other low-cost options were already available in their health jurisdiction. A small but notable 8% expressed opinions that pet animal rabies vaccination was not a priority concern for public health. These sentiments were further detailed in the comments section where 2 respondents wrote that animal vaccination was the responsibility of the pet owner who shouldn’t have pets if they couldn’t afford them, and 1 wrote that they worked in “public health” not “animal health”. A few shared concerns that they wouldn’t reach the target population of owners who could not otherwise afford to vaccinate their pets.

As seen with the rabies vaccination requirement models, population was a highly significant predictor for the presence and public health involvement in rabies clinics. Each incremental increase of 100,000 persons resulted in a 1.9 times greater likelihood of having rabies clinics ($P=0.002$) and a 1.4 times greater likelihood of public health involvement in rabies clinics ($P=0.002$). Population was highly correlated with annual budgets and the number of employees, so likely serves as a collective indicator of available resources in these regression models. This conclusion is also supported by the
the high percentage of local health departments that selected resource limitations as reasons for not being involved in offering rabies clinics. These findings indicate that less populated areas are least unlikely to have rabies clinics which is a problem given that the majority of animal rabies cases occur in rural areas.

Raccoon rabies activity in the county is an indicator of an elevated rabies risk; however it was not found to impact the presence of rabies clinics or public health involvement in them. Participation in the oral rabies vaccination program, on the other hand, did have a substantial impact, especially on the presence of rabies clinics. Counties in the ORV program are at high risk of rabies due to the presence of RRV or their proximity to RRV-endemic areas. After adjusting for population, local health jurisdictions operating in counties with ORV programs are 6.1 times more likely to have rabies clinics \( (P=0.002) \) and 1.4 times more likely to be involved in rabies clinics \( (P=0.109) \) than those in counties that do not participate in this program.

**Conclusions**

Counts that are in close proximity to raccoon rabies activity, as evidenced by the presence of ORV programs, did not have an increased likelihood for vaccination requirements. However, they did exhibit tremendously high odds of having a rabies clinic which could indicate a greater awareness of the risks associated with rabies. This is encouraging, and could indicate that a lack of vaccination requirements may not equate to low vaccination rates within a community. On the other hand, the presence of rabies clinics may not necessarily equate to higher vaccination rates. Additional studies are needed to evaluate the impact of the presence of vaccination requirements, the
availability of rabies clinics, and awareness of rabies risk, on community vaccination rates. These issues were not addressed in this study and no pertinent research was found in the literature. An outcomes assessment of rabies clinics would also be valuable to determine whether or not they reach the target population and increase the overall vaccination rate in the community as intended.

Another limitation of the study involved the use of self-reported data collected via a survey instrument to evaluate the availability of rabies clinics and public health involvement in rabies clinics. Individual respondents may not have been aware of nearby rabies clinics and newer employees may not have had knowledge of prior involvement of public health in offering rabies clinics. Also, no data were collected on other options for rabies vaccination that may have been available. It is likely then that the findings in this study under-represent the actual availability of low cost rabies vaccination options in Ohio communities.

Vaccination rates have been estimated and reported in the literature, varying widely between states as well as between dogs and cats within the same state. A random sample study in Connecticut found that 93% of dogs and 80% of cats were vaccinated against rabies while a convenience sample of animals that had been involved in a rabies exposure event in South Carolina reported that 40% of dogs and 14% of cats were currently vaccinated. Connecticut and South Carolina both have statewide requirements for rabies vaccination of dogs and cats. Clearly, mandated vaccination alone is not enough to ensure compliance.
Vaccination, animal control, and education are all essential to a successful rabies prevention program. Efforts to raise community awareness regarding the importance of pet vaccination and prompt reporting of human rabies exposures will serve to protect public health. As demonstrated in this study by the responses of a small minority of public health professionals, sometimes educating the policy-makers and those charged with managing rabies control efforts is necessary as well. Forming partnerships between governments, public health officials, animal shelters, and veterinarians can facilitate education and awareness efforts to increase vaccination rates, and should also improve response should a rabies outbreak occur.

Though it does not ensure vaccination, the presence of a statewide vaccination law would underscore the important role this simple measure plays in protecting human health. A priority worthy of legislation, especially during a time when overall rabies incidence is low, raises awareness and may persuade some to vaccinate their pets when they otherwise would not. The threat of non-compliance penalties, only possible when a law is in place, may also influence some in favor of vaccination.

National recommendations for state mandated rabies vaccination are largely based on the serious threat to public health, poor associated health outcomes, and the highly preventable nature of this disease. A similar paradigm involves compulsory immunization of human children for diseases such as measles, whooping cough, and polio among others. Human immunization laws have been justified, despite low disease incidence, by a civil responsibility to protect the public. The CDC cites the risk of exposure to background levels of circulating disease and the risk of reintroduction of
disease from outside the country as rationale to support the maintenance of high
immunization rates.\textsuperscript{179,180} The American legal system has addressed the issue of whether
government can compel vaccination, and has repeatedly supported immunizations.\textsuperscript{181}

Ohio does currently have several laws that require rabies vaccination in certain
situations. Existing state laws regarding vaccination of dogs and cats require that they be
current or brought current before they can be released from quarantine if they bite
someone.\textsuperscript{159} Dogs and cats entering or travelling through the state must be properly
vaccinated and must be accompanied by valid proof of rabies vaccination.\textsuperscript{161} Dogs and
cats staying in state park or forest campgrounds and dogs visiting designated dog parks
on state property must be vaccinated and display their rabies tag on their collar.\textsuperscript{162-164}
These regulations do not appear to be uniformly or widely enforced.

This study found that local regulations requiring prophylactic rabies vaccination
in Ohio are absent in the majority of health jurisdictions. Those that are in place vary
with respect to species, minimum age, and requirements for proof of vaccination needed
to obtain a dog license. Even within the same county the regulations may not be vary due
to health district boundaries. The changing requirements in the state based on location
and circumstances can be confusing for pet owners, local veterinarians, and even for the
public health community charged with implementing rabies prevention and control
activities.

The continuous presence of raccoon rabies in parts of Ohio and along the entire
eastern border increases the risk of rabies outbreaks that could spread across the state and
into other Midwestern states. Though ORV efforts are ongoing, state and federal budget
reductions have drastically reduced the amount of vaccine bait that is distributed\textsuperscript{147}. The potential impact of these changes on the immune barrier is not yet known. However, the 2011 increase of RRV in raccoons and skunks in northeastern Ohio as well as the confirmation of a rabid dog in Summit County\textsuperscript{143,144} are cause for concern. The increase in domestic animal rabies and human exposures to rabid animals when raccoon rabies advances through a state is well documented,\textsuperscript{20,124,127,129,130,166} as are the exorbitant costs associated with enhanced rabies prevention efforts.\textsuperscript{65,108,110,136,182} These remain elevated even after the initial epizootic wave has passed.

The current myriad local and state regulations lack uniformity leading to confusion and uncertainty. Local health departments have been empowered by the state to enact rabies vaccination requirements and to enforce state rabies control legislation. This study surveyed the Environmental Health Directors in Ohio’s local health departments and found that a large majority of them were in favor of state mandated vaccination requirements for dogs (92\%) and cats (84\%). If the State were to enact legislation requiring prophylactic rabies vaccination it would replace the current, ineffective system with a single law providing consistent regulation for the entire state.
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Appendix

Environmental Health Director:
This survey is being conducted in collaboration with the Ohio Department of Health Zoonotic Disease Program and the Ohio State University Colleges of Public Health and Veterinary Medicine. The findings from this survey will be summarized and shared with all local health departments and interested parties. Your responses will also assist in the development of a guidance document for planning and conducting successful rabies vaccination clinics. Your participation is voluntary. Individual responders will not be identified in any summaries or publications that result from this survey, though health jurisdictions may be listed when appropriate (e.g. those with regulations requiring rabies vaccination and those without). Subjective responses and comments will not be linked with the identity of the responder or the health jurisdiction, so we hope you will be candid in sharing your experiences, both good and bad. Several questions will be asked about your involvement in Low Cost Rabies Vaccination Clinics (LCRVC). Before beginning please locate information on the clinics your agency has organized or collaborated to offer in 2008, 2009, and 2010. Specifically, we are interested in the planning process, number of clinics, funding sources, clinic staffing, and any complications that occurred. In order to compile a summary of rabies vaccine regulations and availability of LCRVC to Ohio citizens, we are asking for input from all health jurisdictions. Even if you have no involvement in LCRVC, please complete the survey which will skip the questions that are not relevant based on your responses. Any questions or concerns can be addressed to: Dr. Jeanette O'Quin, Public Health Veterinarian, Ohio Department of Health, jeanette.oquin@odh.ohio.gov
Does your local health jurisdiction have regulations requiring rabies vaccination for the following types of animals?

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<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
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<tbody>
<tr>
<td>Dogs</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Cats</td>
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<td>Ferrets</td>
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<tr>
<td>Other (e.g. horses, livestock)</td>
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Should the State of Ohio require rabies vaccination for the following types of animals?

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<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
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<tbody>
<tr>
<td>Dogs</td>
<td>☐</td>
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<td>Cats</td>
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<td>Ferrets</td>
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<td>Other (e.g. horses, livestock)</td>
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For the purposes of this survey, a Low Cost Rabies Vaccination Clinic (LCRVC) is an event held at a specific time for the primary purpose of administering rabies vaccination to animals. Fees are generally below the average normally charged by local veterinarians and no separate fee is charged for an office visit or examination.

Are there typically one or more LCRVC in your health jurisdiction each year? This includes any held by your agency.

☐ Yes
☐ No
☐ Not Sure

Please indicate which of the following agencies (excluding your local health department) have planned or collaborated to offer one or more LCRVC in your health jurisdiction between 2008 and 2010, including those scheduled for later this year.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
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<tbody>
<tr>
<td>Humane Society/Animal Control Agency</td>
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<tr>
<td>Pet Store</td>
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<tr>
<td>Agriculture/Feed Store</td>
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<tr>
<td>Veterinary Hospital</td>
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<tr>
<td>Veterinary Medical Association</td>
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<td>Public Service Agency (e.g. fire department, county extension)</td>
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<td>Neighboring health department</td>
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<tr>
<td>Other</td>
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Has your health department planned or collaborated to offer one or more LCRVC in your health jurisdiction between 2008 and 2010, including those scheduled for later this year.

- Yes
- No
- Not Sure

During the years 2008 through 2010 what has been your agency’s involvement or role with LCRVC in your health jurisdiction?

- Organizing (lead) agency
- Collaborating agency
- Both organizing and collaborating depending on the clinic
- No involvement

How many LCRVC did your agency organize or collaborate to offer in the following years?

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<th>0</th>
<th>1</th>
<th>2</th>
<th>3 or more</th>
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<tbody>
<tr>
<td>2008</td>
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<td>2009</td>
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<td>2010</td>
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How did actual attendance generally relate to expected attendance?

- Higher than expected
- Lower than expected
- As expected
- Varied widely depending on the clinic
- Not sure
In addition to rabies vaccination, the following services are sometimes offered during LCRVC? Please indicate your agreement or disagreement that the addition of these services contribute to the success of your LCRVC.

<table>
<thead>
<tr>
<th>Service</th>
<th>Not Offered</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>Microchipping</td>
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<td>County dog licensing</td>
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<tr>
<td>Vaccinations other than rabies</td>
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<td>Diagnostic tests (e.g. feline leukemia, heartworm disease)</td>
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<td>Parasite control (e.g. flea control, deworming)</td>
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<td>Counseling on local low cost spay/neuter options</td>
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<td>Other wellness services</td>
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<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Of the following, please rank the three (3) you believe to be the most effective methods of advertising LCRVC. (drag responses on left to the box on right, they can also be removed by dragging back to the left)

<table>
<thead>
<tr>
<th>Top three methods of advertising</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
</tr>
<tr>
<td>Television</td>
</tr>
<tr>
<td>Local Newspaper</td>
</tr>
<tr>
<td>Mailing (e.g. letter, postcard)</td>
</tr>
<tr>
<td>Agency Website</td>
</tr>
<tr>
<td>Email/listserv</td>
</tr>
<tr>
<td>Social Media (facebook, myspace, twitter, etc)</td>
</tr>
<tr>
<td>Posters/flyers</td>
</tr>
<tr>
<td>Via local organizations (animal shelters, churches, etc.)</td>
</tr>
<tr>
<td>Word of Mouth</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>
Of the locations commonly utilized, which contributed most to the success of LCRVC? (drag one response from the left to the box on right)

<table>
<thead>
<tr>
<th>Preferred location</th>
</tr>
</thead>
<tbody>
<tr>
<td>______ County fairgrounds</td>
</tr>
<tr>
<td>______ Local park</td>
</tr>
<tr>
<td>______ Firehouse</td>
</tr>
<tr>
<td>______ Health department</td>
</tr>
<tr>
<td>______ Animal shelter</td>
</tr>
<tr>
<td>______ Private veterinary clinic</td>
</tr>
<tr>
<td>______ Location did not affect success of clinic</td>
</tr>
<tr>
<td>______ Not sure</td>
</tr>
<tr>
<td>______ Other</td>
</tr>
</tbody>
</table>

Do the following impact the success of LCRVC? (drag all responses from the right to an appropriate box on the left, selections can also be moved from one box to another)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>______ Month of the year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______ Week of the month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______ Day of the week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______ Proximity to a holiday</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______ Time of the day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______ Length of clinic (hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______ Location/accessibility</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please share information regarding additional services, advertising, location, or timing that you feel have contributed to the success or failure of LCRVC.

Which of the following staffed LCRVC?

| Paid agency employees (organizing or collaborating agency staff on paid time) | Yes | No | Not Sure |
| Paid service providers (not employees of organizing or collaborating agency, but paid by the organizers) | Yes | No | Not Sure |
| Volunteers | Yes | No | Not Sure |

Animals were restrained by (select all that apply)

- Veterinarians
- Licensed veterinary technicians
- Animal care personnel
- Lay staff
- Owners
Rabies vaccines were administered by (select all that apply)

- Veterinarians
- Licensed veterinary technicians
- Animal care personnel
- Lay staff

Which of the following safety-related instruction was provided to non-medical staff and volunteers who would have direct animal contact during the LCRVC?

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Provided verbally or in writing</th>
<th>Only those with previous training were allowed contact</th>
<th>None provided</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal restraint techniques</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Animal bite prevention</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Zoonotic disease prevention</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Needlestick prevention</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Were food or drinks available to staff and volunteers onsite during LCRVC?

- Yes
- No
- Not Sure
What hand washing options were available to staff and volunteers without leaving the LCRVC?

- Hand washing with soap and water
- Hand sanitizers
- Both hand washing and hand sanitizers
- None
- Not Sure

Did veterinarians express concerns about any of the following factors regarding veterinary involvement in LCRVCs?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal legal/liability concerns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief that LCRVC clinics provide a reduced standard of care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No time available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of or insufficient pay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concerned that takes business from local clinics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief that lower cost devalues their services to full paying clients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Just not interested</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opposes concept of public clinics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What fee was charged per vaccine during your most recent LCRVC?

- $0
- $1 to $5
- $6 to $10
- $11 to $15
- $16 to $20
- > $20

Including vaccination fees and outside support (e.g. donations, volunteers), what is the relationship between expenses and income for the LCRVC your agency has organized or collaborated to offer?

- Income has generally exceeded expenses
- Expenses have generally exceeded income
- Income has generally met expenses
- Varies too much to generalize
- Not Sure
Please indicate which of the following have provided funding or in-kind donations.

(select all funding types that apply for each source)

<table>
<thead>
<tr>
<th>Source</th>
<th>Financial support</th>
<th>Donation of vaccine</th>
<th>Donation of supplies</th>
<th>Volunteer staff</th>
<th>Not sure</th>
<th>Nothing provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public health agency</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Corporate sponsorship</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Civic organization</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Veterinary Medical Association</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Animal control/humane society</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Local Business</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Individuals</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Other</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Did you prepare any of the following for your LCRVC?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed budget</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Final budget</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Cost benefit analysis</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Written protocols or operating plan</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Please indicate your willingness to share budget or protocol information with the Ohio Department of Health Zoonotic Disease Program by entering your name and email address below.

Indicate whether each of the following issues affecting people occurred during LCRVC held in your jurisdiction from 2008 to date in 2010.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person bitten by an animal</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Person suffered non-bite injury from an animal (e.g. scratched, knocked down)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Person suffered injury at LCRVC not related to an animal</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Other</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Indicate whether each of the following issues affecting animals occurred in association with LCRVC held in your jurisdiction from 2008 to date in 2010.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal escaped</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Aggression between animals, no injuries</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Aggression between animals, with injuries</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Immediate vaccine reaction (at the clinic)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Delayed vaccine reaction (after leaving the clinic)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Non-vaccine related animal health emergency (e.g. heat stroke)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Animal death</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Were owners provided with written information about the vaccine that included signs of a potential vaccine related reaction?

- Yes
- No
- Not Sure
Were owners provided a phone number to call for concerns about vaccination complications?

- Yes
- No
- Not Sure

Were pre-arranged plans with veterinary care providers (e.g. shelter staff veterinarian, local clinician, emergency clinic) made for handling after-hours vaccine related emergencies?

- Yes, at owners expense
- Yes, at agency’s expense
- No
- Not Sure

Was current licensure verified on dogs attending the LCRVC?

- Yes
- No
- Not Sure
What was the duration of the rabies vaccine on the rabies certificate?
- All 1 year
- All 3 year
- 3 year only with proof of previous vaccination
- 3 year if owner stated the dog had been previously vaccination
- Not Sure

Were records maintained in a manner that would allow proof of vaccination to be provided upon request to the clinic organizers or veterinarian?
- Yes
- No
- Not Sure

Were arrangements made for owners to receive rabies vaccination booster reminders for their pets?
- Yes
- No
- Not Sure

Please share at least one successful strategy or lesson learned that might help others in planning, promoting, or conducting LCRVC.

Has your health department ended its previous involvement in LCRVC?
- Yes
- No
- Not Sure
Please tell us why your health department does not currently organize or collaborate to offer LCRVC? (select all that apply)

☐ Budget constraints
☐ Staffing constraints
☐ Pet animal rabies vaccination is not a priority concern for public health
☐ No need to participate because LCRVC are already available in my jurisdiction
☐ No need for LCRVC because low cost rabies vaccination is available in my jurisdiction through other means (e.g. shelters, pet stores, veterinary general vaccine clinics)
☐ Poor clinic attendance in the past
☐ Can't find veterinarians willing to assist
☐ Other ____________________

Thank you for completing this survey. Before submitting your responses by clicking >> at the bottom of this page please enter your contact information and health jurisdiction. Your name will not be reported out with any data, it will only be used to contact you if we have questions about your responses.

Please enter your name and email address

• Name
• Email address

Please select your county

Please select your health jurisdiction