

Assessment for a Statewide Rabies Vaccination Requirement for
Dogs and Cats in Kansas

MPH Practicum Experience

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By

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Abstract

Background

Rabies is a highly fatal viral zoonosis that contributes to at least 55,000 human deaths annually throughout the world. Any mammal is susceptible to the rabies virus, but there are only a few species that are reservoirs for rabies; in the U.S., wildlife serves as the source of rabies infection. Domestic animals, such as dogs and cats, contract rabies from these reservoirs; therefore, animal vaccination is key in preventing rabies transmission to humans. Vaccination programs have eliminated canine rabies in the U.S., and Kansas currently does not have a statewide rabies vaccination requirement for dogs and cats. This study analyzes the effectiveness of countywide rabies vaccination laws in Kansas to prevent cases of rabies among dogs and cats.

Methods

An Animal Rabies Vaccination Survey was created using Survey Monkey and sent to all local health departments in Kansas to determine which counties have a rabies vaccination law. Other county agencies were contacted to determine this information if needed. Rabies test data was obtained for all dogs, cats, and ferrets submitted to the Kansas State University Rabies Laboratory for rabies testing from 2006-2010. The address of residence for the animal was geocoded to determine if it resided inside or outside of city limits. Descriptive analyses were performed on the rabies test data and the difference between two independent proportions was calculated. A hypothesis test and 95% confidence interval was used to determine the significance of each comparison.

Results

From 2006 through 2010, 75% of dogs and 25% of cats that were submitted for rabies testing were vaccinated against rabies in Kansas. In counties that have a rabies vaccination law for dogs, 53.9% of dogs submitted were vaccinated against rabies and 0.5% of dogs tested positive for rabies. In counties that do not have a vaccination law for dogs, 35.2% of submitted dogs were vaccinated and 0.3% of dogs tested positive for rabies. In counties that have a rabies vaccination law for cats, 21.8% of cats submitted were vaccinated against rabies and 1% of cats tested positive for rabies. In counties that do not have a vaccination law for cats, 11.9% of submitted cats were vaccinated and 2.4% of cats tested positive. The geocoded rabies data revealed that 50.8% of submitted dogs and 15.2% of submitted cats that resided within city limits were vaccinated against rabies compared to 24.8% of submitted dogs and 11.5% of submitted cats that resided outside of city limits were vaccinated against rabies. Furthermore, 0.5% of submitted dogs and 1.8% of submitted cats that resided inside city limits tested positive for rabies compared to 2.1% of submitted dogs and 6.5% of submitted cats that resided outside of city limits tested positive for rabies.

Conclusions

This study shows that among samples submitted to the KSU Rabies Lab, vaccination rates are much higher in dogs than in cats in Kansas. It shows that there are more dogs submitted for rabies testing that are vaccinated against rabies and more rabies-positive dogs in counties with a rabies vaccination law for dogs than in counties with no dog vaccination law. In addition, there are more cats submitted for rabies testing that are vaccinated against rabies and fewer rabies-positive cats in counties with a rabies vaccination law for cats than in counties with no cat vaccination law. The results also show that there are more vaccinated dogs and cats and fewer rabies-positive dogs and cats submitted for rabies testing residing inside city limits when compared to living outside of city limits. A rabies vaccination requirement of all dogs and cats in Kansas would be beneficial in increasing the number of vaccinated animals and reducing the number of rabies-positive domestic animals.

Background

Rabies

Rabies is an ancient disease that dates back to the 23rd century B.C. when people in Babylon were heavily fined for deaths caused by their dogs biting people. The first large rabies outbreak was reported in 1271 when rabid wolves invaded villages in Franconia, Germany and killed 30 people. The disease continued to spread and it was reported for the first time in the Americas in 1703 by a priest in Mexico. Rabies became common in North America by 1785.¹

Rabies is a highly fatal viral disease that affects the central nervous system. It is present on all continents except for Antarctica.² Rabies is considered zoonotic and can infect all species of mammals.³ This disease contributes to at least 55,000 human deaths annually with more than 95% of them taking place in Asia and Africa. Rabid dogs are responsible for 99% of human deaths and children under 15-years-old make up 40% of people bitten by suspect rabid animals.² Rabies is 100% fatal once symptoms occur, but it is 100% preventable. Wildlife is the primary source of rabies infection in the United States, but domestic animals can contract rabies from wildlife and pass this infection to humans; therefore, vaccination of domestic carnivores is key to the prevention of rabies transmission to humans.⁴

The Virus

The rabies virus is a non-segmented, negative strand of RNA genome that belongs to the family *Rhabdoviridae*, genus *Lyssavirus*.⁵ The genus *Lyssavirus* has seven virus genotypes; rabies virus (genotype 1), Lagos bat virus (genotype 2), Mokola virus (genotype 3), Duvenhage virus (genotype 4), European Bat Lyssaviruses 1 and 2 (genotypes 5 and 6), and Australian Lyssavirus (genotype 7). From an epidemiological standpoint, the rabies virus is the most important; however, the other 6 genotypes are capable of causing encephalomyelitis. The rabies virus is bullet-shaped

and it contains a helical ribonucleoprotein core (RNP) and a surrounding envelope. It encodes five proteins; nucleoprotein (N), phosphoprotein (P), matrix protein (M), glycoprotein (G) and polymerase (L). The N, P, and L proteins are components of the RNP core and M and G proteins surround this core. The N protein protects the genomic RNA from any enzymatic damage and the P and L proteins form important complexes during virus replication. The M protein lines the inner wall of the envelope as well as works as a bridge between the cell membrane and the virus's core, and the G protein forms spikes on the surface of the virus and plays a role in attaching the virus to a host cell.⁶ Infection is initiated when the envelope of the virus fuses to the host cell membrane.⁵ The rabies virus is highly neurotropic. It travels quickly to the peripheral nerves and then to the central nervous system by way of retrograde axonal transport. After the virus multiplies in the brain, it moves to innervated organs, including the salivary glands where it is excreted.⁷ This virus does not survive long in the environment and is easily destroyed by soap and water, bleach, ultraviolet light, heat, and common household disinfectants. Once the material containing the virus is dry, the virus is considered noninfectious. Live rabies virus will not survive longer than 24 hours in a dead animal when temperatures reach 70°F, but it can survive in freezing temperatures for an extended period of time.⁸

Reservoirs

Although all mammals are susceptible to the rabies virus, only a few species are reservoirs for rabies. The principal rabies reservoir in developing countries is the domestic dog.⁴ In the United States, the maintenance and circulation of rabies exists in wildlife, primarily raccoons, skunks, bats, and foxes. With the exception of chiropteran hosts, these reservoir species and their distinct rabies virus variants are distributed mainly according to geography (Figure 1).⁹ Raccoons are the sole terrestrial carnivore reservoir for the entire eastern U.S. Rabid skunks are widespread in the U.S. and can be found in four main geographic regions; the eastern U.S., north central U.S.,

south central U.S., and California. Fox rabies is present in Texas, New Mexico, Arizona, and Alaska⁹ and include the arctic fox variant, red fox variant, and gray fox variant.¹⁰ More than 30 bat species have been reported with rabies in the U.S., but due to their greater mobility, geographic distribution of bat rabies virus variants are unknown.⁹

The spatial boundaries of these definable geographic regions are temporally dynamic and may expand or contract gradually due to virus transmission, animal population interactions, and geographic barriers. Unusual animal dispersal patterns and human-mediated translocation of infected animals can result in rapid and unexpected introduction of rabies into new areas.⁹

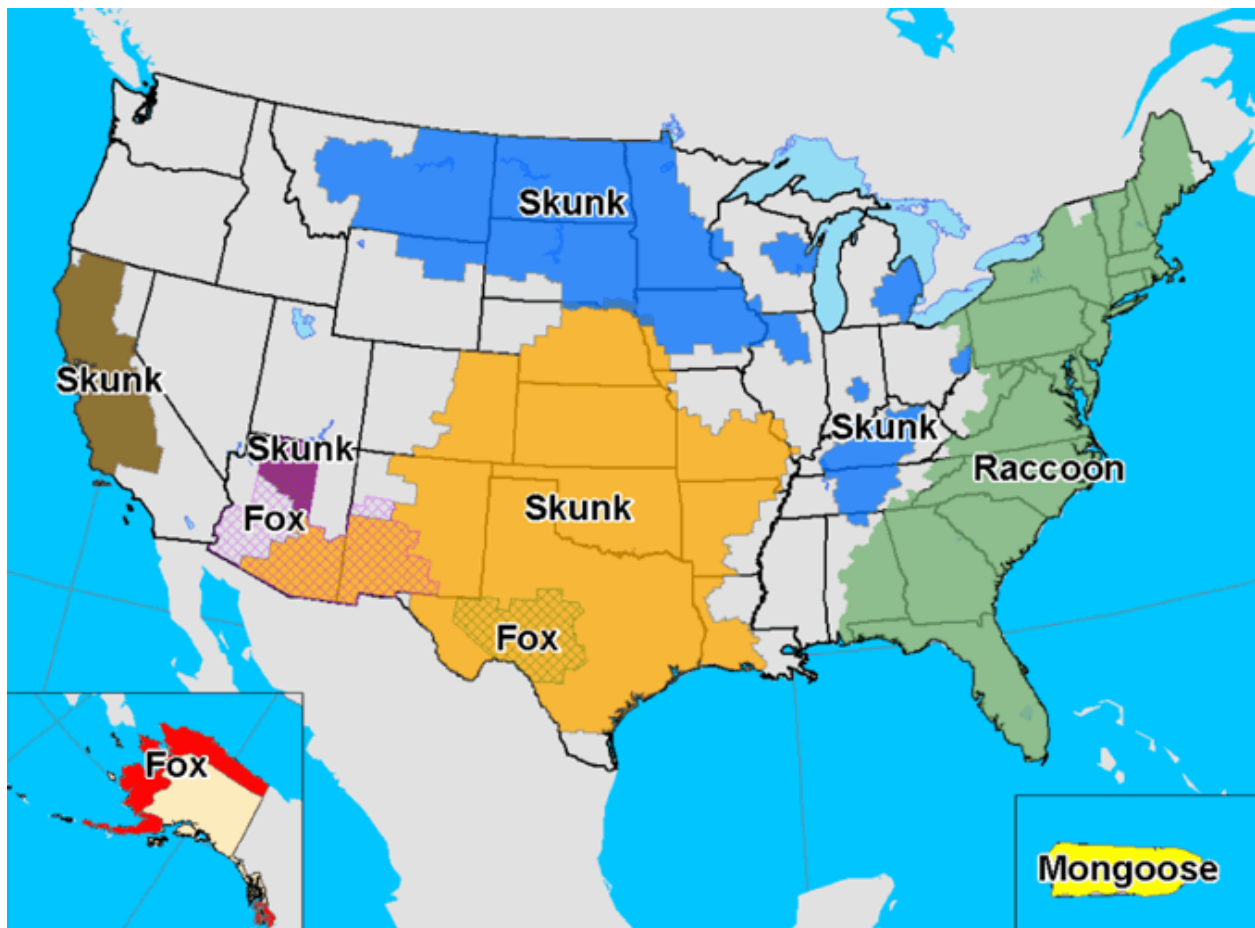


Figure 1: Distribution of terrestrial rabies reservoirs in United States, 2009.

Source: www.cdc.gov/rabies/exposure/animals/wildlife_reservoirs.html

Transmission

The rabies virus is found in the saliva and neural tissue of an infected animal. The common mode of transmission is through a bite of a rabid animal, but rabies transmission can occur through non-bite exposures. Open wounds and mucous membranes contaminated with saliva or neural tissue from a rabid animal constitute such exposures. Also, the rabies virus can be transmitted through corneal and organ transplants from an infected human.¹¹ The incubation period of rabies is variable, ranging from weeks to months in animals and the individual is not symptomatic during this time.⁴ Once the virus reaches the brain, it multiplies, which causes inflammation and the human or animal shows signs of rabies.¹² Rabies causes acute progressive encephalomyelitis⁷ and ultimately results in death.¹³

As shown above in Figure 1, rabies virus variants are typically maintained in their specific hosts, partially because of differential species sensitivity to the virus strains. For example, foxes are more susceptible than skunks to a virus of fox origin. In areas where fox rabies is enzootic, rabid foxes shed sufficient virus to infect other foxes, but not skunks. In addition, skunks are more susceptible than raccoons to a lower dosage of skunk virus. This host specific variant maintenance may also be contributed to lack of interspecies contact because of behavioral or ecological isolation, and failure of small animals to survive the transmission wound of larger animals. However, specie-specific strains can and do infect other animals. For example, raccoons usually survive infection of a skunk rabies virus, but the same cannot be said when infected with a fox rabies virus.¹⁴

Diagnosis

Direct fluorescent antibody testing (DFA) is the method for laboratory diagnosis of rabies in animals. It tests for the presence of rabies virus antigens in brain tissue. This test requires that the animal be euthanized because tissue is needed from at least two areas of the brain in order to rule

out rabies, preferably from the brain stem and cerebellum. The DFA test takes approximately two hours to complete and results are usually available within 24-72 hours.¹⁵

The Kansas State University Rabies Laboratory is the primary diagnostic laboratory for the states of Kansas and Nebraska. It tests between 1,800 and 2,500 animal specimens annually by use of the DFA test and it characterizes all positive specimens to determine what rabies virus variant infected the animal. In addition, the Rabies Laboratory is one of the highest volume serology centers in the world as it handles over 60,000 human and animal samples annually. It measures rabies antibodies by the Fluorescent Antibody Virus Neutralization (FAVN) test, Rapid Fluorescent Focus Inhibition Test (RFFIT) and the Enzyme-linked immunosorbent assay (ELISA).¹⁶

Rabies is a nationally notifiable disease in both humans and animals. Cases of laboratory-confirmed animal rabies are reported to health or agricultural departments in all states and these departments notify the Centers for Disease Control and Prevention (CDC) on a regular basis.⁹ In Kansas, suspect rabies in a human or animal is required to be reported to the Kansas Department of Health and Environment (KDHE) within four hours. The KSU Rabies Lab coordinates closely with KDHE as the results of all animals tested in Kansas are submitted the same day.¹⁷

Rabies detection in humans requires several laboratory diagnostic tests, which are performed ante-mortem. Samples of saliva, serum, spinal fluid, and nuchal skin biopsies are tested. Virus isolation or reverse transcription followed by polymerase chain reaction (RT-PCR) is used to test saliva. Serum and spinal fluid are tested for antibodies to rabies virus, and skin biopsy specimens are examined for rabies antigen.¹⁵

Rabies in Animals

Animal rabies is distributed in every state of the United States except for Hawaii. There are approximately 7,000-10,000 cases of animal rabies each year in the U.S.⁷ Initial clinical signs of rabies in animals include restlessness and gastrointestinal symptoms such as vomiting, diarrhea, and

loss of appetite. There are two forms of rabies, encephalitic and paralytic. Animals with encephalitic rabies become aggressive and tend to bite other animals and humans. Animals with paralytic rabies develop a progressive paralysis and it usually begins in the jaw, which leads to excessive salivation.⁴ There is no cure for an infected animal once these clinical signs develop and it eventually leads to death.¹²

Up until the mid 1900's, the primary source of rabies in the United States was the domestic dog; however, since 1975, more than 80% of the rabid animals reported are wildlife. In 2009, wild animals accounted for 92.5% of all reported rabid animals. The majority of cases were raccoons with 2,327 cases, bats followed with 1,625 cases, then skunks with 1,603 cases, and foxes with 504 cases.⁹ Even though circulation and maintenance of rabies primarily lies within wildlife populations, companion animals can still contract rabies from these wild animals.⁴ In 2009, domestic animals accounted for 7.5% of all reported rabid animals. Cats were reported the most with 300 cases, dogs followed with 81 cases, cattle with 74 cases, and then horses and mules with 41 cases.⁹

Rabies is endemic in Kansas, with approximately 78 animals testing positive for rabies each year over the last five years (2006-2010). The majority of rabid animals are skunks as it is the primary reservoir for our state, but spillover does occur to domestic animals, including nearly 50 dogs and cats since 2006.¹⁸ From 2006-2010, wildlife accounted for 78.5% of all reported rabid animals. Skunks were reported the most with 268 cases, bats followed with 35 cases, then raccoons and foxes with 1 positive case each. Domestic animals accounted for 21.5% of all reported rabid animals. Cats were reported the most with 39 rabid cases, cows followed with 25 cases, then horses with 10 cases, and dogs with 9 cases. A map of the most current data can be found in Figure 2.¹⁹

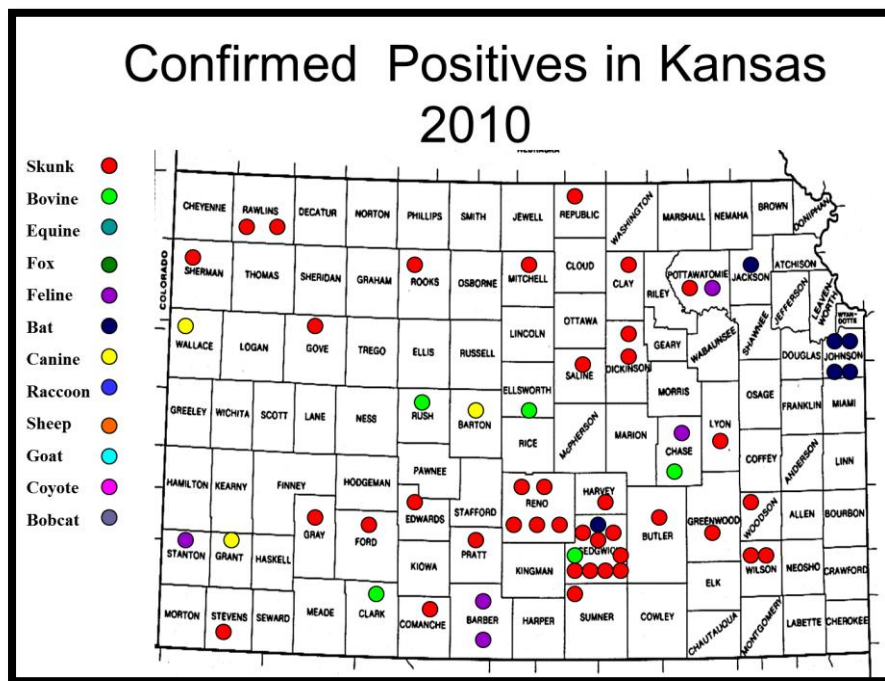


Figure 2: Positive domestic rabies animal cases by county, 2010.

Source: <http://www.vet.k-state.edu/depts/dmp/service/rabies/results.htm>

Rabies in Humans

In the United States from 2000-2010, 31 cases of human rabies was reported, an average of 3 cases per year. Most of these cases were exposed to a bat rabies virus variant. Some were infected with the canine virus variant, but they had all been exposed abroad.²⁰ The last reported human case of rabies in Kansas was in 1968.⁴ Initial clinical signs of rabies in humans are similar to a flu-like illness including fever and headache. Another symptom may include an itching sensation at the site of bite exposure. Both encephalitic and paralytic rabies can occur in humans as it does in animals. Humans with encephalitic rabies exhibit hyperactivity, excited behavior, and have difficulty swallowing. Humans with paralytic rabies develop progressive paralysis, followed by a coma.² Death is the result once these clinical signs develop.¹²

Rabies Post-exposure Prophylaxis (PEP)

Treatment for humans exposed to a rabid animal is post-exposure prophylaxis (PEP). Although human rabies deaths are rare in the United States, there are at least 40,000 people who receive PEP every year²¹ and the cost of this treatment typically exceeds \$3,000 per person.¹⁸

Administration of PEP varies depending on a person's vaccination status. For an unvaccinated, healthy person, a combination of human rabies immunoglobulin (HRIG) and human diploid cell vaccine (HDCV) or purified chick embryo cell vaccine (PCECV) is given. HRIG is administered into and around any wounds. A 4-dose regimen of the vaccine is given intramuscularly on day 0, 3, 7, and 14. An unvaccinated individual who is immunocompromised receives the combination of HRIG and the vaccine, but a 5-dose regimen is given on day 0, 3, 7, 14, and 28.⁴ A previously vaccinated person receives only the vaccine. A 2-dose regimen is given on day 0 and 3. HRIG should not be administered to a previously vaccinated person because it could inhibit the strength or rapidness of a response.²²

Animal Vaccination

Licensed rabies vaccines are available for dogs, cats, ferrets, horses, cattle, and sheep. According to the National Association of State Public Health Veterinarians' Compendium of Animal Rabies Prevention and Control, there are 21 different vaccines available. Each one has a different label regarding animal and age requirements, dosage, route of inoculation, and duration of immunity so all vaccines must be given by a veterinarian and according to label.²³

Animal vaccination is the cornerstone of rabies prevention. Two separate studies have shown that approximately 40% of dogs and fewer than 20% of cats are currently vaccinated against rabies in the United States.¹⁸ Vaccination programs have eliminated domestic dogs as a rabies reservoir in our country and it has significantly decreased the number of confirmed cases in dogs in the U.S. from 6,949 in 1947 to 93 in 2009.²³ Currently, 38 states have a rabies vaccination law, but Kansas is not one of them.²⁴ However, many counties and municipalities have adopted their own ordinances pertaining to domestic animal vaccination requirements. Approximately 350 of the 627 cities in Kansas have a municipal court. Those cities are likely to have a rabies vaccination requirement, but the ordinances do not apply to animals that live outside of city limits.¹⁸ County

laws apply to those cities without an ordinance as well as animals that live outside city limits; however, we currently do not know the number of counties with rabies vaccination laws.

The primary objective of this study was to determine the effectiveness of countywide rabies vaccination laws to prevent cases of rabies among dogs and cats. This entailed determining which counties have a rabies vaccination law and performing a descriptive analysis of dogs, cats, and ferrets submitted to the Kansas State University Rabies Laboratory for testing.

Methods

Animal Rabies Vaccination Survey

A survey was created using Survey Monkey, an online survey tool. The objective of this survey was to determine which Kansas counties have a rabies vaccination law. The survey consisted of 27 questions regarding county-level information on rabies vaccination laws, tracking of animal vaccination status, licensing of animals, notification of suspect rabid animals, animal bite reporting, etc. Most of the questions were multiple choice, but there was a free text portion response for 6 of the questions. It was sent to all 105 county health department administrators in Kansas via e-mail. The administrators were asked to send the survey to the appropriate person within the health department to complete if they were not able to do so. If the survey was not completed within the three week deadline, administrators were sent a reminder e-mail and then called if needed. If the survey was still not completed, other county agencies including County Clerks, Sheriff Departments, Extension Offices, and County Attorneys were contacted to determine if a particular county had a rabies vaccination law.

Rabies Test Data

Rabies test data was obtained for all dogs, cats, and ferrets submitted to the Kansas State University Rabies Laboratory, from January 1, 2006 to December 31, 2010. In Kansas, data is collected through a submission form that is filled out by the person submitting the animal for

testing. Information collected includes type and breed of animal; town, county, and specific address of where the animal resides; vaccination status of animal; contact information for the animal's owner or complainant; and exposure history of the animal. Data was obtained in the form of an Excel file and cleaned by means of making the categories consistent. A descriptive analysis was performed on all dog, cat, and ferrets submitted to the KSU Rabies Lab from 2006-2010.

This data was further cleaned by means of separating out animals that were submitted from counties with a known rabies vaccination requirement from animals that were submitted from counties that did not know whether or not a law existed. A descriptive analysis was performed on all dogs and cats that were submitted from counties with a known rabies vaccination law status.

Finally, data was geocoded to determine if the animals resided inside or outside of city limits. Geocoding is a process of assigning a latitude and longitude to geographic data so that it can be positioned on a map; therefore, only animals with physical addresses listed were used. Cases were excluded if they listed a veterinarian's office or animal shelter as the physical address or if the physical address listed was outside of the state of Kansas. Cases with a physical address that did not have a zip code were manually searched for using Google Maps. The data was geocoded using ESRI ArcMap 9.3.1 Service Pack 3. For the addresses that were ruled invalid by the ESRI ArcMap 9.3.1 Service Pack, ESRI ArcGIS Desktop 9.3.1 Service Pack 1 and Google Maps were used to re-check and manually match geographic coordinates to those addresses. A descriptive analysis was performed on all dogs and cats that had a valid physical address, a positive or negative test result, and were submitted from a county with a known vaccination law status.

The difference between two independent proportions was calculated for the rabies test data. A hypothesis test and 95% confidence interval was used to determine the significance of each comparison.

Results

Descriptive Analysis of Animal Rabies Vaccination Survey

Of the 105 departments, 101 (96.2%) completed the survey. According to the survey responses, 23 (22.8%) counties have a rabies vaccination law, 56 (55.4%) counties do not have a rabies vaccination law, and 22 (21.8%) counties do not know. Those counties that reported an unknown response to the vaccination law were contacted to determine if there was a law. Phone calls were placed to the County Clerks, Sheriff Departments, Extension Offices, and County Attorneys. These county employees were also contacted if survey responses pertained to the city the health department is located and not the county itself, which was evident through the free text portion answers of the survey. Of the 23 counties that reported they had a law through the survey, 2 did not. Of the 22 counties that did not know, 1 has a law, 18 do not have a law, and 3 were unknown. Of the 4 counties that did not complete the survey, all 4 do not have a law. After follow-up it was determined that there are 22 (21%) counties in Kansas that have a rabies vaccination law, 80 (76.2%) that do not have a law and 3 (2.8%) are unknown. Of the 22 counties that have a rabies vaccination law, 10 (45.5%) require vaccination of dogs only, 8 (36.4%) require vaccination of dogs and cats, 3 (13.6%) require vaccination of dogs, cats and ferrets, and 1 (4.5%) county law requires vaccination of dogs, cats, ferrets, and horses (Figure 3). Responses to additional survey questions, relevant to this study, can be found in Table 1.

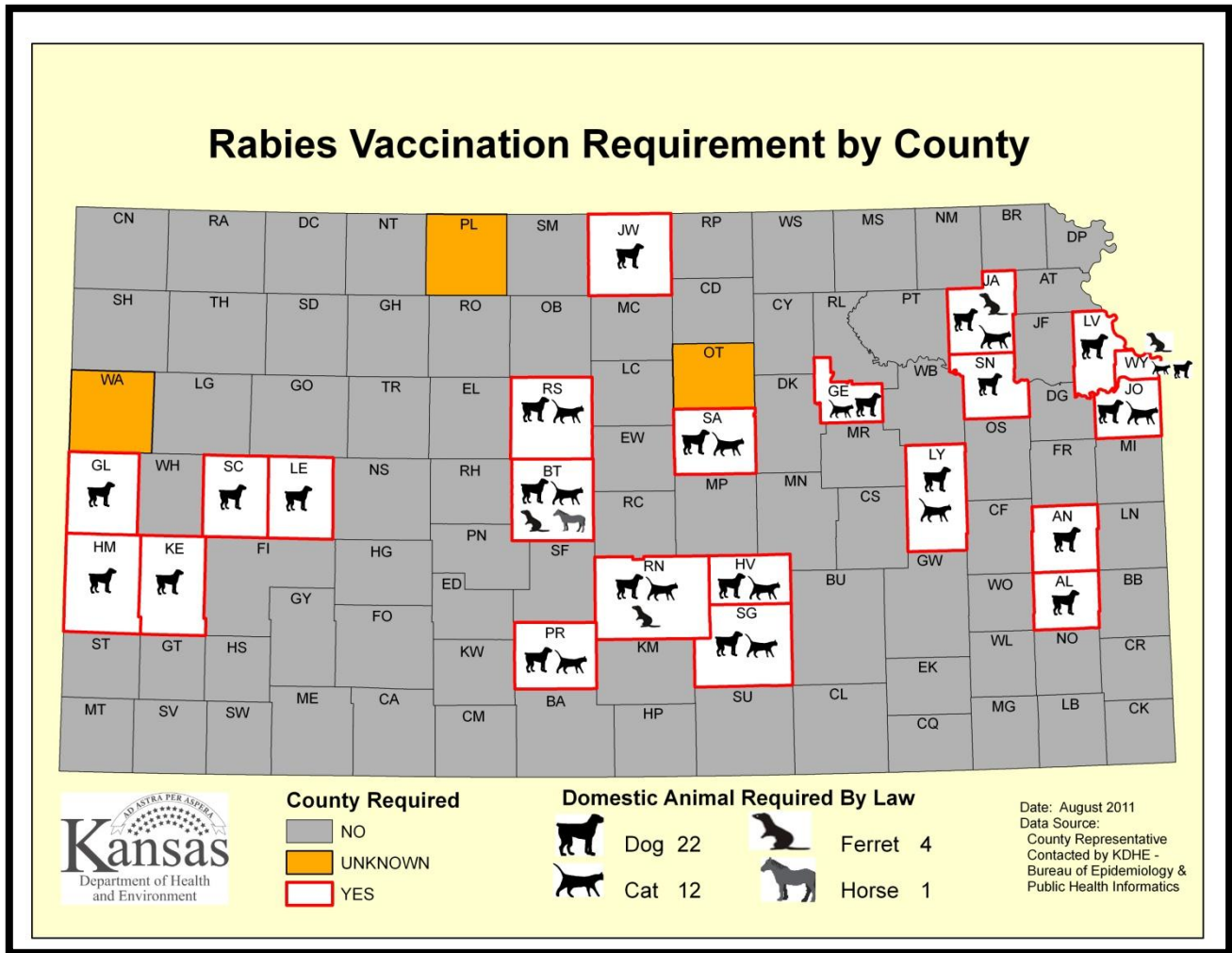


Figure 3: Rabies vaccination requirements for domestic animals in Kansas by county, 2011.

Table 1: Responses of county health departments to additional questions from the Animal Rabies Vaccination Survey.

Question	Response
At what age is the initial vaccine required?	12 weeks: 8 (34.8%) 16 weeks: 2 (8.7%) Unknown: 5 (21.7%) Other: 8 (34.8%)
What type of rabies vaccine is to be administered to animals?	1 year vaccine: 3 (13%) 3 year vaccine: 4 (17.4%) Either can be used: 15 (65.2%) Unknown: 1 (4.3%)
Does your county track the vaccination status of animals?	Yes, owners are required to present rabies vaccination certificate when licensing animals: 5 (21.7%) Yes, owners are required to present rabies

	vaccination certificate when animal has bitten another animal or person: 8 (34.8%) No: 5 (21.7%) Unknown: 4 (17.4%) Other: 1 (4.3%)
Is the local health department notified by either the designated animal control officer or veterinarians regarding suspect rabid animals?	Yes: 83 (82.2%) No: 16 (15.8%) Unknown: 2 (2%)
Is there a contract with a veterinarian(s) to euthanize and decapitate animals to submit for rabies testing in your county?	Yes: 19 (18.8%) No: 62 (61.4%) Unknown: 20 (19.8%)
In your opinion, how important do you think it is to have a countywide rabies vaccination law?	Very important: 64 (63.4%) Somewhat important: 22 (21.8%) Neither: 9 (8.9%) Somewhat unimportant: 3 (3%) Very unimportant: 3 (3%)
In your opinion, how important do you think it is to have a statewide rabies vaccination law?	Very important: 72 (71.3%) Somewhat important: 21 (20.8%) Neither: 3 (3%) Somewhat unimportant: 2 (2%) Very unimportant: 3 (3%)
Are animals required to be licensed in your county?	Yes: 33 (32.7%) No: 56 (55.4%) Unknown: 12 (11.9%)
What animal(s) are required to be licensed?	Dogs only: 12 (36.4%) Dogs and cats: 18 (54.5%) Dogs, cats, and ferrets: 1 (3%) Dogs and unknown: 1 (3%) Dogs, cats, and unknown: 1 (3%)
Are animal bites required to be reported to the local health department?	Yes: 53 (52.5%) No: 31 (30.7%) Unknown: 17 (16.8%)

Descriptive Analysis of Rabies Test Data

All Animals Submitted for Rabies Testing

There were a total of 3,785 dogs, cats, and ferrets that were submitted for rabies testing between the years of 2006 and 2010 to the Kansas State University Rabies Laboratory. Of those tested, 27 cases were of animals that resided outside the state of Kansas so they excluded from this study. This left 3,758 in-state cases to analyze. The test results of these animals can be found in

Table 2. It displays that 2,057 (54.7%) submissions were from cats and 1.8% of cats submitted were positive for rabies while 0.5% of dogs submitted were positive for rabies.

Table 2: Test results of dogs, cats, and ferrets from 2006-2010.

	Dogs	Cats	Ferrets	Total
Negative	1,654 (97.6%)	1,997 (97.1%)	6 (100%)	3,657
Positive	8 (0.5%)	37 (1.8%)	0 (0%)	45
Unsuitable	33 (1.9%)	23 (1.1%)	0 (0%)	56
Total	1,695	2,057	6	N=3,758

Of the 3,758 dogs, cats, and ferrets submitted for rabies testing, 1,942 (51.7%) had information regarding vaccination status. This data is shown below in Table 3, which displays that 75% of dogs submitted were vaccinated against rabies and 25% of cats submitted were vaccinated against rabies.

Table 3: Vaccination status of dogs, cats, and ferrets from 2006-2010.

	Current Vaccination	Out-of-Date Vaccination	Not Vaccinated	Total
Dogs	446 (75%)	262 (59.3%)	288 (31.8%)	996
Cats	149 (25%)	180 (40.7%)	614 (67.8%)	943
Ferrets	0 (0%)	0 (0%)	3 (0.3%)	3
Total	595	442	905	N=1,942

There is a seasonality associated with animals submitted for rabies testing; the frequency increased during the summer months of June, July, and August. There were 465 (12.4%) animals tested in both June and July, and 371 (9.9%) animals tested in August. A complete chart of seasonality for animals tested for rabies from 2006-2010 in Kansas can be found below in Figure 4.

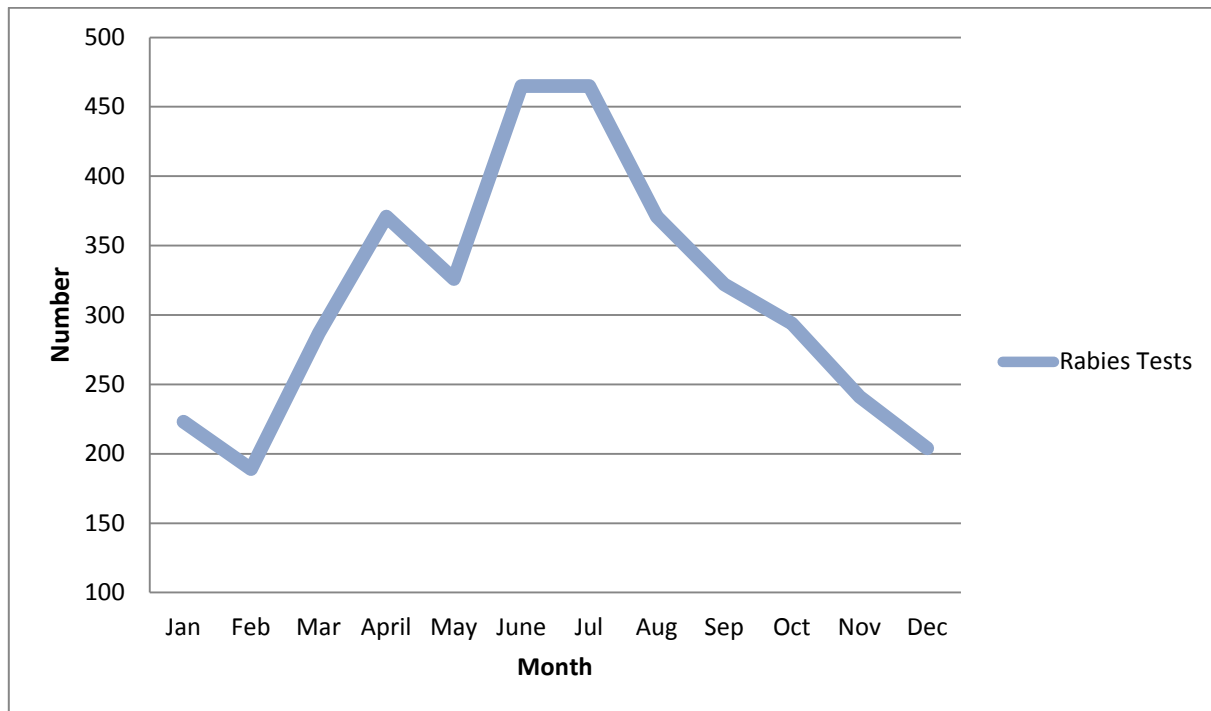


Figure 4: Seasonality of rabies tests of dogs, cats, and ferrets from 2006-2010.

Dog and Cats Submitted for Rabies Testing from Counties with a Known Law Status

We analyzed the relationship between counties with a rabies vaccination law and those without laws. Cases were excluded from the analysis if they did not list a county of residence (n=29) or were submitted from a county with an unknown rabies vaccination status (n=37). Cases were also excluded if they involved ferrets (n=6). This left 3,686 valid cases used in this analysis; 1,669 (45.3%) dogs and 2,017 (54.7%) cats. The test results of dogs and cats can be found below in Tables 4 and 5. Table 4 shows that 0.5% of dogs submitted from counties with a rabies vaccination law for dogs were positive for rabies compared to 0.3% of dogs submitted from counties with no rabies vaccination law for dogs that were positive for rabies. Table 5 shows that 1% of cats submitted from counties with a rabies vaccination law for cats were positive for rabies compared to 2.4% of cats submitted from counties with no rabies vaccination law for cats that were positive for rabies.

Table 4: Test results of dogs submitted from counties with a known vaccination law status from 2006-2010.

	Counties with Dog Vaccination Law	Counties with No Dog Vaccination Law	Difference in Proportions	95% CI
Negative	937 (97.5%)	692 (97.7%)		
Positive	5 (0.5%)	2 (0.3%)	0.002	-0.004, 0.008
Unsuitable	19 (2%)	14 (2%)		
Total	961	708		

Difference in proportions of positive test results is not statistically significant at a 95% level.

Table 5: Test results of cats submitted from counties with a known vaccination law status from 2006-2010.

	Counties with Cat Vaccination Law	Counties with No Cat Vaccination Law	Difference in Proportions	95% CI*
Negative	932 (97.7%)	1,028 (96.7%)		
Positive	10 (1%)	25 (2.4%)	0.014	0.002, 0.026
Unsuitable	12 (1.3%)	10 (0.9%)		
Total	954	1,063		

*Difference in proportions of positive test results is statistically significant at a 95% level.

From the 3,686 dogs and cats, 1,901 (51.6%) had information regarding vaccination status; 980 (51.6%) were dogs and 921 (48.4%) were cats. This data is shown below in Tables 6 and 7. Table 6 displays that 53.9% of dogs submitted from counties with a rabies vaccination law for dogs were vaccinated against rabies compared to 35.2% of dogs submitted from counties with no rabies vaccination law for dogs that were vaccinated against rabies. Table 7 shows that 21.8% of cats submitted from counties with a rabies vaccination law for cats were vaccinated against rabies compared to 11.9% of cats submitted from counties with no rabies vaccination law for cats that were vaccinated against rabies.

Table 6: Vaccination status of dogs submitted from counties with a known vaccination law status from 2006-2010.

	Counties with Dog Vaccination Law	Counties with No Dog Vaccination Law	Difference in Proportions	95% CI*
Current Vaccination	271 (53.9%)	168 (35.2%)	0.187	0.126, 0.248
Out-of-Date Vaccination	116 (23.1%)	143 (30%)		
Not Vaccinated	116 (23.1%)	166 (34.8%)		
Total	503	477		

*Difference in proportions of current vaccination is statistically significant at a 95% level.

Table 7: Vaccination status of cats submitted from counties with a known vaccination law status from 2006-2010.

	Counties with Cat Vaccination Law	Counties with No Cat Vaccination Law	Difference in Proportions	95% CI*
Current Vaccination	76 (21.8%)	68 (11.9%)	0.099	0.048, 0.150
Out-of-Date Vaccination	82 (23.5%)	96 (16.8%)		
Not Vaccinated	191 (54.7%)	408 (71.3%)		
Total	349	572		

*Difference in proportions of current vaccination is statistically significant at a 95% level.

Geocoded Rabies Data

Next, we analyzed the relationship between animals that resided inside city limits and those that resided outside of city limits. This descriptive analysis includes all dogs and cats that had a valid physical address, a positive or negative test result, and submitted from a county with a known vaccination law status. From a total of 3,758 records, only 1,692 (45%) cases included a physical address where the animal resided at the time of the test. There were 25 cases that did not have a physical address, but were all positive for rabies; their addresses were manually searched for using the Kansas Electronic Disease Surveillance System database and by contacting the local health departments. This resulted in an additional 20 records with an address for a total of 1,712 (45.5%) valid records. The number of records excluded from this analysis included 1,767 (47%) cases that did not have an address listed and 279 (7.4%) cases that listed a veterinarian’s office or shelter as place of residence. The cases that had a veterinarian’s office or shelter listed as the animal’s physical address were excluded because it was assumed they were strays. Of the 1,712 cases, 1,589 (92.8%) animals were used in this analysis; 83 records had an invalid address, 17 animals were submitted from counties with an unknown rabies vaccination law status, 19 animals yielded unsuitable test results, and 4 cases involved ferrets and were all excluded from this analysis.

Of the 1,589 animals, 734 (46.2%) were dogs and 855 (53.8%) were cats. The test results of these animals can be found below in Tables 8 and 9. Table 8 shows that 0.5% of dogs that resided inside city limits tested positive for rabies compared to 2.1% of dogs that resided outside of city limits tested positive for rabies. Table 9 shows that 1.8% of cats that resided inside city limits tested positive for rabies compared to 6.5% of cats that resided outside of city limits tested positive for rabies.

Table 8: Test results and area of residence for dogs from 2006-2010.

	Resided inside City Limits	Resided outside City Limits	Difference in Proportions	95% CI
Positive	3 (0.5%)	4 (2.1%)	0.016	-0.006, 0.038
Negative	543 (99.5%)	184 (97.9%)		
Total	546	188		

Difference in proportions of positive test results is not statistically significant at a 95% level.

Table 9: Test results and area of residence for cats from 2006-2010.

	Resided inside City Limits	Resided outside of City Limits	Difference in Proportions	95% CI*
Positive	10 (1.8%)	19 (6.5%)	0.047	0.018, 0.076
Negative	551 (98.2%)	275 (93.5%)		
Total	561	294		

*Difference in proportions of positive test results is statistically significant at a 95% level.

Of the 1,589 animals, 838 (52.7%) had information regarding vaccination status; 440 (52.5%) were dogs and 398 (47.5%) were cats. This data is shown in Tables 10 and 11. Table 10 displays that 50.8% of dogs that resided inside city limits were vaccinated against rabies compared to 24.8% of dogs that resided outside of city limits were vaccinated against rabies. Table 11 shows that 15.2% of cats that resided inside city limits were vaccinated against rabies compared to 11.5% of cats that resided outside of city limits were vaccinated against rabies.

Table 10: Vaccination status and area of residence of dogs from 2006-2010.

	Resided inside City Limits	Resided outside City Limits	Difference in Proportions	95% CI*
Current Vaccination	156 (50.8%)	33 (24.8%)	0.26	0.168, 0.352
Out-of-date Vaccination	84 (27.4%)	55 (41.4%)		
Not Vaccinated	67 (21.8%)	45 (33.8%)		
Total	307	133		

*Difference in proportions of current vaccination status is statistically significant at a 95% level.

Table 11: Vaccination status and area of residence of cats from 2006-2010.

	Resided inside City Limits	Resided outside City Limits	Difference in Proportions	95% CI
Current Vaccination	34 (15.2%)	20 (11.5%)	0.037	-0.030, 0.104
Out-of-date Vaccination	53 (23.7%)	21 (12.1%)		
Not Vaccinated	137 (61.2%)	133 (76.4%)		
Total	224	174		

Difference in proportions of current vaccination status is not statistically significant at a 95% level.

Discussion

Conclusions

The primary objective of this study was to determine the effectiveness of countywide rabies vaccination laws to prevent cases of rabies among dogs and cats. In this study population, dogs submitted for rabies testing have higher vaccination rates than cats submitted for rabies testing. The results of this study show that among the animals submitted for rabies testing, there are more currently vaccinated dogs and more rabies-positive dogs from counties with a rabies vaccination law for dogs than from counties that do not have a dog vaccination law; however, the latter finding was not statistically significant. The results also show that there are more currently vaccinated cats and fewer rabies-positive cats from counties with a rabies vaccination law for cats than from counties that do not have a cat vaccination law. Furthermore, the results show that among rabies submissions, there are more dogs vaccinated against rabies and fewer rabies-positive dogs residing inside city limits than outside of city limits, but the latter finding is not statistically significant. This study also indicates that among submitted animals, there are more vaccinated cats and fewer rabies-

positive cats residing inside city limits than outside of city limits; however, the vaccination finding was not statistically significant. It was assumed that the dogs and cats residing inside city limits were mandated by law to be vaccinated and that the dogs and cats residing outside of city limits were not required to be vaccinated.

This study shows that among the dogs and cats submitted to the KSU Rabies Lab from 2006-2010, there were only 75% of dogs and 25% of cats vaccinated against rabies in Kansas. Two other studies; one conducted by the American Veterinary Medical Association and another by the Oklahoma Veterinary Medical Association found that approximately 40% of dogs and fewer than 20% of cats are currently vaccinated against rabies in the U.S. It is evident that vaccination rates are much higher in dogs than in cats. A few possible explanations for such low vaccination rates in cats include vaccination law specifications, population of feral cats, and how people define the term 'pet ownership.' Of the 38 states that have a rabies vaccination law in the U.S., only 30 of them pertain to cats and of the 22 counties in Kansas that have a rabies vaccination law, only 12 pertain to cats. Many of these vaccination laws were created when dog rabies was the primary concern and they have yet to be altered to include cats. This is an issue because there is a high feral cat population and a large number of owned cats that roam outside of their homes. The population of feral cats in the United States is suspected to approach the population of owned cats, which was 90.5 million in 2006.²⁵ Many people feed these cats along with stray cats and allow them to seek shelter on their property, but do not claim them as their animals because they do not live with them or spend time with them. Therefore, they do not take the responsibility to vaccinate these cats and even if they did, feral cats are very difficult to catch in order to vaccinate. It is estimated that two-thirds of all owned cats are allowed outdoors at least part of the time;²⁶ thus, there is great opportunity for unvaccinated owned cats to contract rabies directly from rabid feral cats or other

wildlife. Moreover, cats have more of a nature to roam and to hunt than do dogs, which makes them more vulnerable to come into contact with a rabid animal when let outdoors.

The process of analyzing responses from the Animal Rabies Vaccination Survey and directly discussing this issue with county employees has brought to the surface that many people are unaware of the laws regarding vaccination requirements of animals in their city, county, and even the state of Kansas. Several of the local health department employees completed the survey in regards to the city the health department is located and were unaware if domestic animals were required to be vaccinated in their county. In addition, local health department employees and county employees referred me from person to person to answer my question regarding county-level rabies vaccination laws and even then some of the results were unknown. There were some responses where people stated they just follow the state law regarding animal vaccination implying that Kansas has a rabies vaccination law. A possible explanation for this lack of knowledge is that many of the counties do not submit animals or they submit only a few to be tested for rabies. As a result, they do not deal with this issue enough to know as to whether or not a rabies vaccination law exists. Although, many local health departments were not aware of the rabies vaccination laws within their county, our survey results show that approximately 70% of local health departments in Kansas think it is very important to have a statewide rabies vaccination law and more than 60% of local health departments think it is very important to have a countywide rabies vaccination law.

The results from this study suggest that the number of rabies-positive dogs and cats can be decreased in Kansas by enacting a statewide mandatory rabies vaccination law for dogs and cats. Mandated vaccination programs of domestic animals have shown to be effective in rabies prevention. A study conducted by CDC found that rabid cats are less likely to be found in counties with states that have a mandatory rabies vaccination law for cats than counties in states without such a law.²⁷

Further statistical analysis of the geocoded rabies data is needed enable to examine additional risk factors for why people do not vaccinate their animals. One factor we were unable to analyze due to time constraints was county characterization; specifically rural counties in comparison to urban counties. Analyzing the influence of such demographic and socioeconomic features of counties will provide more information on the prevalence of rabies in dogs and cats in Kansas. An events/trials logistic regression model was used in a study conducted by the CDC to examine the influence of socioeconomic and demographic features of counties on the prevalence of rabies in cats. It also examined the influence of the estimated cat population, rurality, the existence of a state cat rabies vaccination law, the use of oral rabies vaccine in a county, the terrestrial rabies reservoir, and the number of other rabid animals.²⁷ This particular model or one similar could be used for further analysis. In addition, no research has been done to compare the prevalence of rabies in dogs and cats in states with a rabies vaccination law to states with no such law. Such a study could help determine whether a statewide rabies vaccination requirement of dogs and cats is effective in increasing the number of currently vaccinated animals and reducing the number of rabies-positive domestic animals.

Limitations

There are at least four limitations of this study. First, the Animal Rabies Vaccination Survey was completed by a local health department administrator or a local health department employee based on who had the most knowledge about rabies for that specific area. Other county agencies were contacted to find which counties have a rabies vaccination requirement for domestic animals when local health departments did not know. Many of the people answering the survey were unsure if such a law existed in their county or answered it in reference to the city the health department resided so the survey responses were not answered with a guarantee; therefore, the validity of the responses is unknown.

The rabies test data was obtained from the KSU Rabies Lab in the form of an Excel spreadsheet and included information on where the animal resided at the time of the test. Many of the fields encompassing this data were incomplete. Several of the physical addresses (46.7%) were left blank along with city, county, and zip code information. This limited our sample size in regards to the geocoded data because in order to determine if the animal was located inside or outside of city limits, a physical address was required. There were 7.4% of animals with a veterinarian's office or shelter listed as the physical address; thus we cannot accurately assess where the animal resided or spent the majority of its time. Even the animals with a valid physical address is not a guarantee that is where the animal spent the majority of its time or was exposed as we were not given any information as to whether the animal was owned or a stray.

The third limitation is the source of the data to obtain rabies vaccination rates. These animals were submitted to the KSU Rabies Laboratory because they were suspected to have rabies. Rabies is more likely to be suspected in animals that have never been vaccinated or are not currently vaccinated; therefore the vaccination rates may be lower in this population.

Finally, the rabies surveillance data for Kansas is not uniform across counties because there are some counties that very seldom or never submit animals for testing in any given year. This is apparent in the 2006-2010 rabies data we collected from the KSU Rabies Lab. Reasons for this may be that there is no veterinarian in some counties in Kansas or suspect rabid animals are killed without examination by the person finding the animal.

Recommendations

As stated above, a limitation of this particular study pertained to the uncertainty of existing rabies vaccination laws in counties. For this reason, we encourage employees of local health

departments and other county officials to refresh themselves on rabies vaccination laws to better inform their local communities.

In addition there were incomplete fields in the data we obtained from the Kansas State University Rabies Laboratory. We recommend that veterinarians or the person filling out the rabies submission form be made aware of the importance of completing all sections. Furthermore, if any information is missing from a submission form, we encourage the Rabies Lab to follow-up with the submitter. We also recommend that the Rabies Lab standardize categories within the data because some of it was inconsistent and this resulted in data cleaning that was time-consuming. For example, the vaccination status fields included current, no, none, not current, unknown, and unvaccinated when the rabies submission form only has four options; current, not current, unvaccinated, and unknown.

Lastly, a rabies vaccination law would be beneficial in increasing the number of currently vaccinated domestic animals and reducing the number of rabies-positive animals; therefore, we recommend a statewide rabies vaccination requirement for all dogs and cats in Kansas.

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References

1. Rabies Free World. "A short history of rabies." Retrieved 9/21/2011 from <http://www.rabiesfree.org/page26.htm>.
2. World Health Organization. "Rabies Fact Sheet N°99." Sept 2010. Retrieved 7/6/2011 from <http://www.who.int/mediacentre/factsheets/fs099/en/>.
3. Weinstein, Susan. "White Paper Rabies Control Laws Arkansas." *Arkansas Department of Health*. Dec 2008.
4. Garrison, Ingrid. "Rabies: Investigation Methods for Local Health Departments." *Power Point Presentation conducted at Kansas Department of Health and Environment*. Given May 26, 2011.
5. Centers for Disease Control and Prevention. "The Rabies Virus." Retrieved 9/21/2011 from <http://www.cdc.gov/rabies/transmission/virus.html>.
6. Kumar, P. Dileep. "Rabies." *Biographies of Disease*. Edited by Silver, Julie K. Greenwood Press, 2009.
7. Rupprecht, Charles E. "Rabies: A Neglected, Re-Emerging Zoonosis." Retrieved 9/21/2011 from www.cdc.gov/about/grand-rounds/archives/2011/pdfs/PHGRRabies20Jan201010am.pdf.
8. Briggs, Deborah J., Gerald L. Stokka, and Jeremy Van Boening. "Rabies." Kansas State University Agricultural Experiment Station and Cooperative Extension Service, 2000.
9. Blanton, Jesse D., Dustyn Palmer, and Charles E. Rupprecht. "Rabies Surveillance in the United States during 2009." *Journal of the American Veterinary Medical Association* 237, (6): 646-657, Sept 2010.
10. Hanlon, Cathleen A., Michael Niezgod, and Charles E. Rupprecht. "Rabies in Terrestrial Animals." *Rabies*. Edited by Jackson, Alan C. and William H. Wunner. Academic Press, 2002.
11. Centers for Disease Control and Prevention. "Rabies: How is rabies transmitted?" Retrieved 2/11/11 from <http://www.cdc.gov/rabies/transmission/index.html>.
12. Rupprecht, Charles E. and Cathleen A Hanlon. "Rabies." *Viral Infections of Humans: Epidemiology and Control*. Edited by Evans, Alfred S. and Richard A. Kaslow. Plenum Publishing Corporation: 665-685, 1997.
13. Centers for Disease Control and Prevention. "Rabies." Retrieved 2/11/11 from <http://www.cdc.gov/rabies/>.
14. Kansas City, MO, Health Department. "Wildlife Rabies." *Rabies Manual 2011*. Retrieved 10/7/2011 from www.kcmo.org/idc/groups/health/.../rabiesmanualwildlife-2011.pdf.
15. Centers for Disease Control and Prevention. "Diagnosis in animals and humans." Retrieved 10/7/2011 from <http://www.cdc.gov/rabies/diagnosis/animals-humans.html>.
16. Kansas State University College of Veterinary Medicine. "Kansas State University Rabies Laboratory." Retrieved 9/21/2011 from <http://www.vet.k-state.edu/depts/dmp/service/rabies/index.htm>.
17. Kansas Department of Health and Environment. "Rabies Investigation Guideline (Including Management of Potential Rabies Exposure)." Retrieved 8/3/2011 from www.kdheks.gov.

18. Division of Health Bureau of Surveillance and Epidemiology. "Mandatory Rabies Vaccination of all Dogs, Cats and Ferrets." *Kansas Department of Health and Environment Issue Paper Legislative Session 2011*, 2011.
19. Diagnostic Testing and Results for Animals Suspected of Having Rabies. Kansas State Veterinary Diagnostic Lab, Rabies Lab. Retrieved 1/28/2011 <http://www.vet.k-state.edu/depts/dmp/service/rabies/results.htm>.
20. Texas Department of State Health Services Zoonosis Control Branch. "Rabies in Humans in the USA: 1950-Present." Retrieved 10/10/2011 from www.dshs.state.tx.us/idcu/disease/rabies/cases/statistics/reports/us.pdf.
21. Centers for Disease Control and Prevention. "Cost of Rabies Prevention." Retrieved 9/21/2011 from <http://www.cdc.gov/rabies/location/usa/cost.html>.
22. Centers for Disease Control and Prevention. "Recommendations of the Advisory Committee on Immunization Practices." *Morbidity and Mortality Weekly Report*, no. 59. Retrieved 7/21/2011 from http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5902a1.htm?s_cid=rr5902a1_e.
23. National Association of State Public Health Veterinarians. "Compendium of Animal Rabies Prevention and Control, 2011." Retrieved 7/14/2011 from <http://www.nasphv.org/Documents/RabiesCompendium.pdf>.
24. Centers for Disease Control and Prevention. Rabies Vaccination Laws, By State. Retrieved 7/13/2011 from <http://www.cdc.gov/rabies/resources/publications/2009-surveillance/vaccination-laws.html>.
25. Fischer, Sarah M., et al. "Response of feral cats to vaccination at the time of neutering." *Journal of the American Veterinary Medical Association* 230, (1): 52-58, Jan 2007.
26. Kahlar, Susan C. and Bridget M. Kuehn. "The Cat Debate." *Journal of the American Veterinary Medical Association News*, Jan 2004.
27. Kennedy, E., Blanton, J., and Rupprecht, C. "Epidemiology of Rabies in Cats and County Characteristics Associated with the Risk of a Rabid Cat: USA, 2002-2006." Abstract from Rabies in the Americas Conference in Atlanta, Georgia. 2008.