Master of Public Health

Integrative Learning Experience Report

RABIES SURVEILLANCE PRACTICES IN KANSAS

by

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MASTER OF PUBLIC HEALTH

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Abstract

Rabies is a deadly but preventable zoonotic disease. Through routine vaccination, canine rabies has been eliminated from the United States; however, spillover from wild animals continues to pose a risk to domestic species. Vaccinating companion animals protects their health and serves as a barrier between wildlife and humans, ultimately reducing human rabies exposures. The project objectives were to quantify the outcomes of animal contacts exposed to rabies and to validate post-exposure prophylaxis as an option for unvaccinated contact animals to avoid euthanasia. To achieve this, the project utilized rabies surveillance data collected by the Kansas Department of Health and Environment to analyze the outcomes of animals exposed to confirmed rabid animals from 2018 to 2024. Exposed animals were classified by exposure level, rabies vaccination status at the time of exposure, and outcome. Additionally, a statewide survey was sent to Kansas local health departments to evaluate rabies vaccination ordinances and bite reporting procedures. Findings indicated that animals categorized with a high-risk level of exposure to rabid animals were significantly more likely to face euthanasia recommendations if they were not previously vaccinated for rabies, compared to animals that were up to date on rabies vaccination. However, the analysis validated the effectiveness of post-exposure prophylaxis (PEP) protocols, as unvaccinated animals that received PEP promptly and completed the required observation period did not develop clinical rabies. Furthermore, the survey revealed a lack of uniformity in local rabies ordinances, specifically regarding bite reporting requirements and the adoption of a standardized procedure. By highlighting current trends, these findings provide a framework to guide future statewide rabies prevention efforts and strengthen local responses.

Keywords: rabies, surveillance, exposure, prophylaxis, PEP

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Chapter 1 - Literature Review

Rabies Background

Rabies is a unique One Health topic that links the health of humans, animals, and the environment. The transmission cycle involves wildlife reservoirs (such as bats, raccoons, skunks, and foxes in the United States), domestic animals that may interact with wildlife and humans, and human populations at risk of exposure (CDC, 2024). Effective prevention, surveillance, and control strategies are crucial to a collaborative approach among public health, veterinary, and environmental agencies. Rabies is a preventable viral zoonosis with vaccines, but it is still an important public health issue in developing countries. Over 60,000 people die, while approximately 15 million people receive rabies post-exposure prophylaxis annually (Hampson et al., 2015). Despite vast attempts at rabies control and management measures, Asia and Africa still account for over 95% of worldwide human rabies mortality. This disproportionate burden is due to canine rabies remaining enzootic in these regions, where limited access to post-exposure prophylaxis and inconsistent dog vaccination programs persist (Changalucha et al., 2021). Dog slaughterhouses are considered a vital risk factor in some Asian and African countries (Loeb, 2021). More specifically, India is one of the countries with the largest rabies burden (Thangaraj et al., 2025). In many developing countries, official human rabies mortality rates remain low due to under-reporting, limited public awareness regarding post-exposure prophylaxis protocols, and traditional cultural beliefs that lead patients to seek alternative healers rather than medical care (Taylor et al., 2017).

Although human rabies cases are rare in the United States, typically resulting from spillover from wildlife, the disease remains a significant concern because of its near 100% fatality rate once symptoms occur and the absence of specific antiviral treatment (CDC, 2025;

Hampson et al., 2015). Worldwide, rabies is endemic, and the global cost of rabies is estimated at around US $8.6 billion per year, including costs of life, medical care, and psychological trauma (WHO, 2024). Rabies affects all warm-blooded animals and is prevalent worldwide, except on islands such as Australia and Antarctica (WHO, 2024; Singh et al., 2017). Rabies prevalence in domestic species has been documented at 20% to 50%, with susceptibility determined by factors such as genetic makeup, age, and viral strain (Singh et al., 2017).

The word rabies, or 'rabere' in Latin, means 'to be mad' (Singh et al., 2017). The disease has been recognized since the dawn of civilization, with the earliest documentation of rabies appearing in the pre-Mosaic Eshnunna Code of Babylon dating back to the twenty-third century BC (Baer, 2007). Despite its long history, the infectious nature of saliva from infected dogs was not scientifically described until 1804 by Zinke (Singh et al., 2017). A pivotal moment in medical history occurred in 1885, when Louis Pasteur identified the viral etiology of rabies and developed the first effective vaccine treatment, which was administered to Joseph Meister after a severe canine attack (Pasteur, 1885, as cited in Singh et al., 2017). Subsequent milestones include the identification of the rabies virus by Remlinger and Riffat-Bay in 1903. In the mid-20th century, the epidemiological landscape shifted as RABV emerged in red foxes, leading to a widespread outbreak across Europe in the 1940s; this eventually led to the implementation of the first rabies oral vaccination campaign (WHO, 2018; Singh et al., 2017). According to the World Health Organization (2018), a country that has no record of an indigenously acquired case of human or animal rabies within two years, due to surveillance and import regulations, can claim rabies-free status. A landmark example of this achievement is Mexico, which in 2019 became the first country in the world validated by the WHO for eliminating dog-mediated human rabies as a public health problem (WHO, 2019). However, achieving this milestone does not signal the end of intervention; there remains a concern for susceptibility to reintroduction. Consequently, a country considered rabies-free requires strict, continuous monitoring, mandatory quarantine of imported animals, and legal regulations to prevent the entry of the virus from endemic regions.

Rabies is fatal in mammals due to central nervous system (CNS) involvement. After viral transmission, the Rhabdovirus enters the peripheral nervous system and progresses to the CNS, where it targets the encephalon and induces encephalomyelitis (Khairullah et al., 2023; Fooks et al., 2017). The rabies virion is a bullet-shaped, enveloped infectious particle belonging to the Lyssavirus genus of the Rhabdoviridae family and the Mononegavirales order.

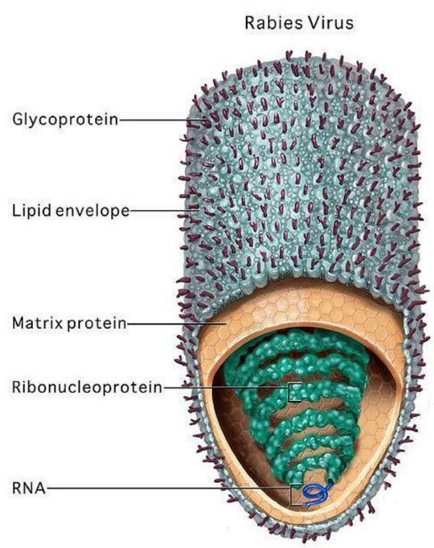

Figure 1.1: Diagram of rabies virus structure showing glycoprotein, lipid envelope, matrix protein, ribonucleoprotein, and RNA. From Flickr (n.d.).

According to Singh et al. (2017), the Lyssavirus genus comprises several distinct species, including the rabies virus (RABV). The RABV genome encodes five structural proteins, namely nucleoprotein (N), phosphoprotein (P), matrix protein (M), glycoprotein (G), and RNA-dependent RNA polymerase (L). The N, P, and L proteins form a ribonucleoprotein complex that facilitates viral replication within the host cell cytoplasm. The RABV glycoprotein is responsible for viral pathogenicity and the induction of protective immunity, while the phosphoprotein promotes viral replication in muscle cells by blocking the host interferon system, thereby facilitating infection of the peripheral nervous system (Singh et al., 2017). Furthermore, RABV is not viable outside the host and can be inactivated by sunlight and heat. While primarily affecting carnivores and bats, RABV circulating in dogs is responsible for more than 99% of human cases worldwide (WHO, 2018). Geographically, rabies-related lyssaviruses, such as Lagos bat virus, Mokola virus, and Duvenhage virus, are widely distributed in Africa, whereas the European bat Lyssavirus (EBLV-1 and EBLV-2) is restricted to Europe (Fooks et al., 2017; Singh et al., 2017).

The primary transmission route for the rabies virus is inoculation of infected saliva or neural tissue via bite wounds (occurring in approximately 90% of cases) or pre-existing open skin cuts (find source). Fook et al. (2017) noted that the risk of rabies infection varies significantly by exposure type: bites carry a 5%-80% risk, roughly 50 times higher than licks and scratches, which carry a 0.1%-1% risk. Non-bite exposures, though rare, include inhalation of aerosolized rabies virus (primarily in bat caves), organ transplantation, or contamination of mucous membranes with infectious brain tissue (Singh et al., 2017). Following entry, the virus uses rapid retrograde fast axonal transport to travel along peripheral nerves toward the blood-brain barrier. Upon entry into the brain, it induces acute encephalitis, which ultimately leads to death (Fooks et al., 2017). While human-to-human transmission is possible, it is clinically exceptional; there is only one documented case of an encephalitic rabies patient biting another human, reported in South Africa in 1996 (Vaughan et al., 1998). Furthermore, there are no reports of rabies transmission through blood transfusion or viremia during RABV infection in both animals and humans (Singh et al., 2017). The incubation period is highly variable, typically ranging from two weeks to six years (average two to three months), depending on the viral dose, inoculation site, and innervation density. Exposures on the head, face, or neck pose the greatest risk and are generally associated with shorter incubation periods due to the high density of neurons and proximity to the limbic system. Clinical symptoms include fever, agitation, hallucinations, paralysis, and coma. The disease presents in two clinical forms: encephalitic (furious) or paralytic (dumb) rabies (Ashwini et al., 2024). No immune response is detectable in most human cases at seven to ten days after the onset of clinical signs (Singh et al., 2017).

The definitive diagnosis of rabies is primarily based on the Direct Fluorescent Antibody (DFA) test, which is recognized by both the World Health Organization (2018) and the CDC (2026) as the gold standard for detecting rabies virus antigens in brain tissue. The diagnostic procedure involves the application of a specific anti-rabies antiserum or globulin conjugated with fluorescein isothiocyanate (FITC) to a tissue smear. When viewed under a specialized fluorescence microscope, the viral nucleoprotein antigens appear as distinct apple-green, fluorescent aggregates. The DFA test is highly sensitive and specific, enabling rapid diagnosis of rabies (CDC, 2026). However, the test requires that the animal be euthanized, as a valid diagnosis requires fresh brain tissue, specifically a transverse section of the brainstem (pons and medulla) and the cerebellum (WOAH, 2024; CDC, 2026). While the laboratory process is brief, final diagnostic reporting usually occurs within 72 hours to allow for logistics and confirmation. Although the DFA test remains the global standard, newer molecular methods such as Reverse Transcription Polymerase Chain Reaction (RT-PCR) and the Direct Rapid Immunochemistry Test (dRIT) are utilized in resource-limited settings or for confirmatory testing (Singh et al., 2017). Kansas State University is the primary diagnostic laboratory for Kansas, Nebraska, and other Midwestern states. All test results must be reported and coordinated with the Kansas

Department of Health and Environment. The Kansas State Veterinary Diagnostic Rabies Laboratory (n.d) tests between 1,800 and 2,500 animal specimens annually by the direct fluorescent antibody method. The rabies laboratory processes over 100,00 samples each year and meets all quality monitoring standards. Titer tests performed within the laboratory include the Fluorescent Antibody Virus Neutralization (FAVN) test and Rapid Fluorescent Focus Inhibition Test (RFITT). Detection of rabies in humans requires various laboratory diagnostic tests performed antemortem. Clinical samples collected from saliva, cerebrospinal fluid, nasal mucosa, and corneal smears are tested.

There have been approximately 213 confirmed cases of rabies over the past six years (2018 – 2024). The majority of rabid animals come from skunks as the primary reservoir, followed by bats. A map of the most current data can be found in Figure two.

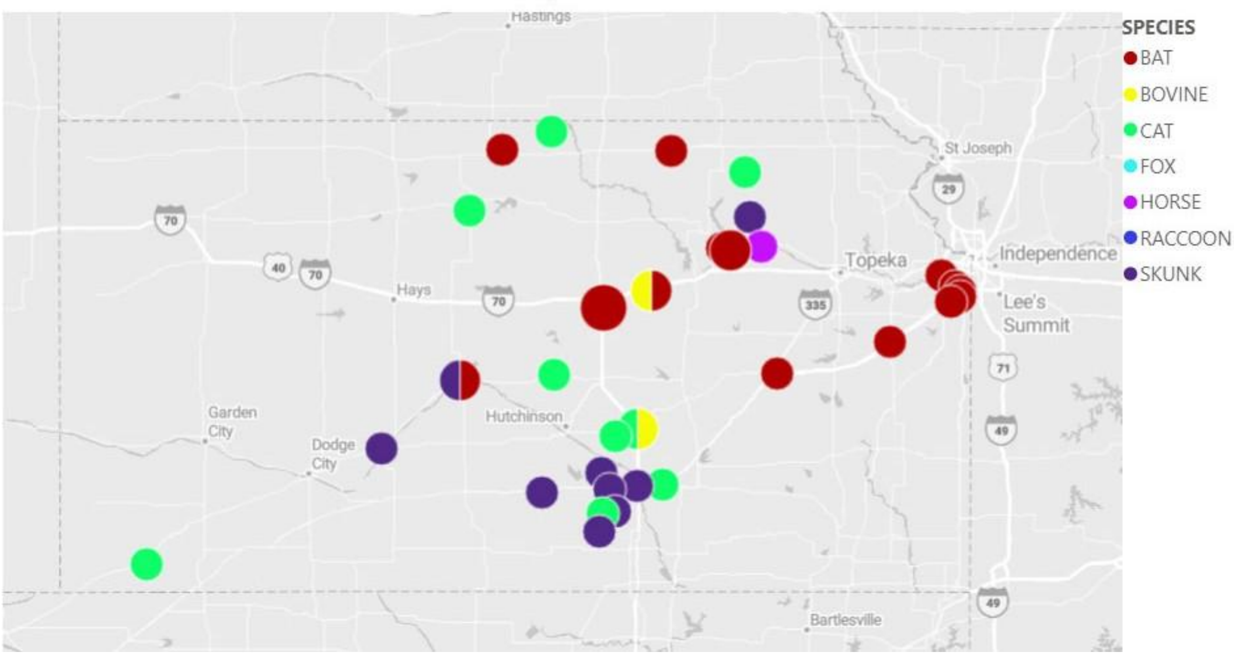

Figure 1.2: Positive domestic rabies animal cases by county, 2025.

Fortunately, rabies can be prevented if post-exposure prophylaxis (PEP) is administered promptly. Even though rabies is rare within the United States, more than 6 million Americans report animal bites, 1.6 million seek medical attention, and approximately 60,000 to 100,000 receive PEP annually following confirmed or suspected rabies exposure (Holzbauer et al., 2021; CDC, 2025). Rabies vaccines are complex and expensive, with limited supply. Treatment for PEP costs range from $3,000 to $8,000 per person. Fewer than 10 people die each year in the United States. The administration of PEP varies depending on a person's vaccination status. The Advisory Committee on Immunization Practices (ACIP) rabies PEP recommendations for unvaccinated people involve immediate wound cleaning, a dose of human rabies immune globulin (HRIG), and a four-dose rabies vaccine series over 14 days (CDC, 2025). For those who have been previously vaccinated, PEP consists of two doses of the vaccine three days apart. The effectiveness of this regimen is nearly 100% when administered promptly following exposure and performed correctly (Hampson et al., 2015). Following initial inoculation, RABV can persist within the muscle for a prolonged period. This provides a critical window of opportunity for the administration of PEP treatment, allowing the host's immune system to clear the virus before it achieves neuroinvasion (Fooks et al., 2017; WHO, 2018). Singh et al. (2017) further noted that once the virus undergoes primary replication in the myocytes and enters the peripheral nerve endings, the efficacy of treatment significantly decreases.

In the United States, rabies vaccines are licensed for use in dogs, cats, cattle, horses, and ferrets. According to the National Association of State Public Health Veterinarians (NASPHV, 2024), these biologics should only be administered by a veterinarian or under direct veterinary supervision of a licensed veterinarian to ensure compliance with local laws. The Compendium of Animal Rabies Prevention and Control provides a comprehensive list of these licensed vaccines, each categorized by species-specific requirements, including age of initial inoculation, dosage, and the duration of immunity (either 1-year or 3-year labels). An animal is legally considered “immunized” after 28 days from their initial vaccination. Animal vaccinations provide a safety net for exposure and rabies prevention. These vaccination programs have been instrumental in eliminating the canine rabies virus variant (CRVV) in the United States. However, legal requirements vary by jurisdiction; currently, 39 states mandate rabies vaccination, while 11 states—including Kansas—lack a statewide mandate (NASPHV, 2016). In states without a central ordinance, rabies management is deferred to local authorities. Consequently, individual counties and cities within Kansas have adopted their own rabies ordinances to manage domestic animal vaccinations and bite reporting protocols (KDHE, n.d).

The primary goal of this study was to measure the outcomes of animal contacts exposed to rabies and to validate rabies post-exposure prophylaxis as an option for unvaccinated contact animals to prevent euthanasia. This involved reviewing seven years of data for analysis and developing a statewide survey to identify which counties have rabies vaccination laws. The project mainly focuses on the follow-up actions taken for unvaccinated animals and the outcomes of quarantine when applicable. The findings will help expand and promote the use of post-exposure prophylaxis in animals. The previous study was conducted in 2011, making this an updated analysis of progress in rabies surveillance and prevention. This research was carried out in partnership with the Kansas Department of Health and Environment (KDHE), led by Dr. Erin Petro, a Public Health Veterinarian in the Epidemiology and Public Health Informatics division in Topeka, Kansas.

Chapter 2 - Learning Objectives, Project Description, Methods

Objectives

- **Objective 1.** Learn to use an electronic disease surveillance system to access and export epidemiological data.
- **Objective 2.** Gain experience cleaning and analyzing messy data.
- **Objective 3.** Apply statistical analyses to understand how the inclusion of multiple datasets can contribute to our understanding of disease prevention and effective interventions.
- **Objective 4.** Be able to explain concepts related to rabies epidemiology to public health professionals, veterinarians, and lay people.
- **Objective 5.** Understand where to find information regarding rabies epidemiology and disease prevention measures in humans and animals.
- **Objective 6.** Apply a systems thinking tool to illustrate the process of zoonotic disease prevention.

Methods & Activities

Rabies surveillance data were obtained through EpiTrax, the Kansas Department of Health and Environment's (KDHE) electronic disease reporting system, for the period January 1, 2018, to December 31, 2024. This system compiles rabies testing results from multiple sources, including the Kansas State Veterinary Diagnostic Laboratory (KSVDL), the Southeastern Cooperative Wildlife Disease Study (SCWDS), and other reporting laboratories. The dataset included animals submitted for rabies testing, representing both domestic and wildlife species, which served as potential rabies cases. In Kansas, animals submitted for rabies testing are accompanied by a standardized submission form completed by the submitting party, typically a veterinary clinic, that captures the species, breed, geographic location (town, county, and address), vaccination status, and exposure history. Under the supervision of a State Public Health Veterinarian, rabies surveillance data were accessed and extracted from EpiTrax, which includes the documentation of animal contacts and exposure events. Animal contacts associated with rabid animals were identified, and the analytic population for this study was limited to domestic animals. A critical component of the initial data gathering involved identifying the exposure category, which is documented on a scale of one to four based on the severity and contact type. These categories included:

1. Category One: Direct exposure – e.g., bitten by a rabid animal, killed a rabid animal, fight with a rabid animal, exposed animal found chewing on or playing with carcass of rabid animal, exposed animal has injuries indicative of an attack and rabid animal found nearby, exposed animal nursing from a rabid animal, exposed animal was nursed by a rabid animal
2. Category Two: Probable exposure – e.g., rabid animal found dead in a pen, stall, small lot, room, or other enclosure with the exposed animal(s); rabid animal found near a litter of exposed animals; exposed animal rolled on the carcass of the rabid animal; sprayed by a rabid skunk
3. Category Three: Low probability exposure, but recommended PEP as precaution: the owner expresses uncertainty that there were contacts of an exposed animal with a rabid animal, a bat found in the same room as an animal, but no direct exposure was witnessed, and the bat was unable to be tested
4. Category Four: No exposure

I conducted all data cleaning procedures, which involved reviewing submission forms to ensure completeness and removing records with insufficient or unusable information. I utilized identifiers within EpiTrax to ensure no duplicate entries were present across the seven-year study period. Human exposure forms were excluded from the analysis to focus specifically on animal-to-animal exposure events. Rabies test results were categorized based on the laboratory classifications documented in EpiTrax. Animals were classified as “confirmed” rabies cases if laboratory testing yielded a positive result. Compared to “probable” rabies cases, in which rabies infection was suspected but could not be confirmed by laboratory testing. Confirmed and probable rabies cases were separated by data management to allow for classification-specific review. Only rabid animals with at least one identified animal contact were included in the final analysis.

To evaluate the factors influencing animal outcomes, I conducted a descriptive analysis of all domestic and wildlife species submitted during the study period. This process involved close collaboration with a KDHE Epidemiologist to translate my research goals into a formal statistical model. After identifying the necessary variables and outcomes for the final analysis, the Epidemiologist performed the statistical analysis and additional data processing. I was then provided with the resulting output tables and guided through the underlying SAS code and analytic approach used to generate the results. This collaborative effort ensured the analysis was statistically rigorous while directly addressing the specific public health concerns developed for this project.

Animals exposed to rabid animals were included if they resided in Kansas at the time of exposure and had documented contact. Exposures were stratified by exposure category, including bite exposures and non-bite exposures such as contamination of open wounds or mucous membranes. Indirect exposures without evidence of direct contact were excluded from the analysis, as were animals with missing outcome information or those unavailable for follow-up observation. Vaccination status of exposed animals was categorized as vaccinated and up-to-date, previously vaccinated, never vaccinated, or unknown. Outcomes of exposed animals were assessed and included euthanasia, rabies vaccination with survival, rabies vaccination with death, and no rabies vaccination with death. Analyses were further stratified by county rabies vaccination ordinance status to evaluate the differences in outcomes between counties with and without a rabies vaccination law. This approach allowed for consistent characterization of rabies exposures and outcomes using routine public health surveillance data.

In addition to surveillance data analysis, I developed a survey to collect information from local health departments (LHDs) in Kansas regarding county-level rabies vaccination ordinances and bite reporting management. The purpose of this survey was to provide an updated understanding of local policies and practices that had not been formally assessed in a decade. Survey questions were designed using a mix of binary, multiple-choice, and open-ended formats to identify the presence of requirements, enforcement practices, and species-specific coverage. The survey instrument was approved by a State Public Health Veterinarian and reviewed by other team members within KDHE for clarity and the prevention of leading questions. I conducted the survey through the Qualtrics platform, using branching logic to tailor questions to each LHD's specific situation. The survey was initially distributed in October 2025 to 110 contacts representing 100 local health departments. Contact information from Salesforce was used to send the initial email invitation to participate in the survey. To maximize the response rate, follow-up invitations to participate in the survey were sent to non-responders and distributed through local public health nurses. In November 2025, the State Public Health

Veterinarian conducted final outreach to finalize responses before the survey officially closed in December 2025. This survey complemented the surveillance analysis and supported the interpretation of county-level differences.

Chapter 3 - Products and Results

From January 1, 2018, through December 31, 2024, rabies surveillance data for animals tested in Kansas and reported through EpiTrax, the electronic disease reporting system used by KDHE, were analyzed. Over the seven years, a total of 376 animals met the inclusion criteria for the rabies surveillance analysis. Laboratory results identified 213 (56.6%) confirmed cases and 163 (43.4%) probable cases. Annual case counts fluctuated over the study period, with higher counts in 2018 and 2024 and a decline in 2020. Surveillance activity peaked in 2019 (n = 74) and reached a study-period low in 2022 (n = 39), all shown in the table below.

Table 3.1: Number of Confirmed (positive) and Probable (unsuitable and indeterminate) animals from 2018 - 2024

Table of rabid_mmwr_year by state_case_status			
rabid_mmwr_year	state_case_status		
Frequency	Confirmed	Probable	Total
2018	30	24	54
2019	55	19	74
2020	30	19	49
2021	25	27	52
2022	17	22	39
2023	25	30	55
2024	31	22	53
Total	213	163	376

Wildlife species accounted for 72.6% of the total surveillance population, with bats (n = 156) and skunks (n = 117) being the most frequent. The classification of these cases differed significantly by species: 94.99% of skunks were laboratory-confirmed, whereas only 37.8% of bats were laboratory-confirmed, with the remainder classified as probable. Confirmed rabies was most prevalent in skunks (111 out of 117), whereas bats represented the highest number of probable cases (97 out of 156). Domestic species included in the surveillance data were 32 cats, 21 bovines, and 14 dogs, with sporadic reports of horses, sheep, and goats. The table below breaks down animal species by confirmed and probable cases, highlighting bats and skunks as the most common.

Table 3.2: Number of Confirmed (positive) and Probable (unsuitable and indeterminate) animals from 2018 - 2024 by species

Table of animal_species by state_case_status			
animal_species	**state_case_status**		
Frequency	**Confirmed**	**Probable**	**Total**
BADGER	0	1	1
BAT	59	97	156
BOVINE	11	10	21
CAT	18	14	32
COYOTE	0	2	2
DOG	3	11	14
FOX	6	0	6
GOAT	1	0	1
HORSE	2	4	6
MUSKRAT	0	1	1
OPOSSUM	0	2	2
RACCOON	1	14	15
SHEEP	1	0	1
SKUNK	111	6	117
SQUIRREL	0	1	1
Total	213	163	376

There were 260 unique animal-to-animal exposure events during the study period. Among the 197 confirmed rabid animals, domestic exposure investigations were identified and met the inclusion criteria for analysis. Dogs accounted for the largest proportion of exposed animals (n = 117), followed by cats (n = 68), horses (n = 8), cattle (n = 3), and pigs (n = 1), as shown in the table below.

Table 3.3: Number of Animal Contacts to Confirmed (positive) and Probable (unsuitable or indeterminate) animals by year

Table of rabid_mmwr_year by state_case_status			
rabid_mmwr_year	**state_case_status**		
Frequency	**Confirmed**	**Probable**	**Total**
2018	47	11	58
2019	47	6	53
2020	15	7	22
2021	22	6	28
2022	16	10	26
2023	21	15	36
2024	29	8	37
Total	197	63	260

Vaccination status, highlighted in table four, among exposed animals indicated that 82 animals were up to date on rabies vaccination, 67 were not vaccinated, 41 were previously vaccinated but not up to date, and 7 had unknown vaccination status. When combined, 123 animals had documentation of prior rabies vaccination (current or previous), whereas 67 were confirmed unvaccinated at the time of exposure. This lack of current vaccination directly influenced clinical outcomes; 74% of unvaccinated animals were euthanized post-exposure, whereas 96.3% of up-to-date animals survived through a 45-day observation period.

Table 3.4: Vaccination Status of Animal Contacts to Confirmed Rabid Animals, 2018 - 2024

vacc_status	Frequency	Cumulative Frequency
Not vaccinated	67	67
Previously vaccinated for rabies, but not up-to-date	41	108
Unknown	7	115
Up-to-date on rabies vaccination	82	197

species2	Frequency	Cumulative Frequency
Cat	68	68
Cow	3	71
Dog	117	188
Horse	8	196
Pig	1	197

Disposition outcomes following rabies exposure were documented for the majority of animals, as shown in Table five. Observation was the most common outcome (n = 97), followed by euthanasia (n = 53), quarantine (n = 29), cases where observation or quarantine was not indicated (n = 11), and unknown (n = 7).

Table 3.5: Disposition of Animal Contacts to Confirmed Rabid Animals, 2018 - 2024

cont_animal_disp	Frequency	Cumulative Frequency
Euthanized	53	53
O/Q not indicated	11	64
Observation	97	161
Quarantined	29	190
Unknown	7	197

The analysis of the surveillance data reveals a critical correlation between rabies vaccination status and the resulting rate of euthanasia following an exposure event. Animals that were up to date on their rabies vaccinations maintained a low euthanasia rate of only 4.88%. Compared to the euthanasia rate for unvaccinated animals, which was substantially higher, reaching 65.67% shown in Table six. These findings show a strong association between vaccination status and animal outcome, demonstrating that current immunization reduces the likelihood of euthanasia as a management outcome after exposure.

Table 3.6: Rate of Euthanasia Among Animal Contacts that were Previously Vaccinated Compared to those that were Never Vaccinated

Euthanasia Rate of Animals Up-to Date on Vaccinations	Euthanasia Rate of Animals that are Unvaccinated
4.88%	65.67%

Out of a total of 53 euthanasia outcomes, 44 involved animals that had never been vaccinated, while an additional 5 cases involved animals with lapsed vaccinations that were not up to date, as shown in Table 7. In contrast, animals with current, up-to-date rabies vaccinations accounted for only a single case within this group. These frequency distributions reinforce the protective role of the rabies vaccination and suggest that maintaining current vaccination status is a primary factor in avoiding euthanasia as a management outcome.

Table 3.7: Vaccination Status Animals Euthanized After Contact with a Confirmed Rabid Animal

Vaccination Status	Frequency
Not vaccinated	44
Previously vaccinated for rabies, but not up-to-date	5
Unknown	3
Up-to-date on rabies vaccination	1
Total	53

Euthanasia outcomes varied by vaccination status, with euthanasia occurring more frequently among unvaccinated animals compared with vaccinated animals. To assess the association between vaccination status and euthanasia outcome, a 2x2 contingency table was constructed, excluding animals with unknown vaccination status. As shown in Table eight, 44 of 66 unvaccinated animals were euthanized compared with 6 of 118 vaccinated animals. The odds of euthanasia among unvaccinated animals were 37.3 times the odds among vaccinated animals. This association was statistically significant ($\chi^2 = 81.11$, $p < 0.0001$), as shown in Table nine.

Table 3.8: Odds of Euthanasia by Vaccination Status Among Animal Contacts to Confirmed Rabid Animals

Table of vacc_status2 by euth			
vacc_status2	euth		
Frequency Percent Row Pct Col Pct	Euthanized	Not euthanized	Total
Not vaccinated	44 23.91 66.67 88.00	22 11.96 33.33 16.42	66 35.87
Vaccinated	6 3.26 5.08 12.00	112 60.87 94.92 83.58	118 64.13
Total	50 27.17	134 72.83	184 100.00
Frequency Missing = 13			

Table 3.9: Statistical Results of Odds Ratio and Relative Risks

Odds Ratio and Relative Risks			
Statistic	Value	95% Confidence Limits	
Odds Ratio	37.3333	14.1849	98.2578
Relative Risk (Column 1)	13.1111	5.9030	29.1208
Relative Risk (Column 2)	0.3512	0.2490	0.4952

Sample Size = 184
Frequency Missing = 13

A logistic regression model was constructed to evaluate the association between species and outcome. The dependent variable was coded as not euthanized, consistent with the SAS output specification. Dogs were designated as the reference category. Maximum likelihood estimates are presented in Table 10. Species was significantly associated with outcome (Wald χ^2 = 28.01, $p < 0.0001$). Compared with dogs, cats had significantly lower odds of not being euthanized (OR = 0.15, 95% CI: 0.07-0.30), indicating a higher likelihood of euthanasia among cats following rabies exposure. Estimates for other species were unstable due to small sample sizes and evidence of quasi-complete separation, resulting in wide confidence intervals and limited interpretability.

Table 3.10: Maximum Likelihood Estimates for Logistic Regression Model Assessing Odds of Vaccination by Species (Reference: Dog)

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	1.3218	0.2297	33.1018	<.0001
species2	Cat	1	-1.3843	0.3396	16.6138	<.0001
species2	Cow	1	-15.7132	770.0	0.0004	0.9837
species2	Horse	1	-2.4204	0.8482	8.1426	0.0043
species2	Pig	1	-15.7132	1333.7	0.0001	0.9906

In addition to the surveillance data analysis, a survey was developed and distributed to 110 contacts representing 100 local health departments to assess rabies vaccination ordinances and animal bite reporting practices. There were 77 responses received, and 76 responses that agreed to participate in the survey. Sixty-three distinct local health departments were represented, and 62 surveys included information beyond the county name. In total, 51 fully completed surveys were further analyzed. Responses were received from counties representing all population density classifications in Kansas: 18 frontier, 17 rural, 13 densely settled rural, 8 semi-urban, and 6 urban jurisdictions. County population representation is shown in figure three.

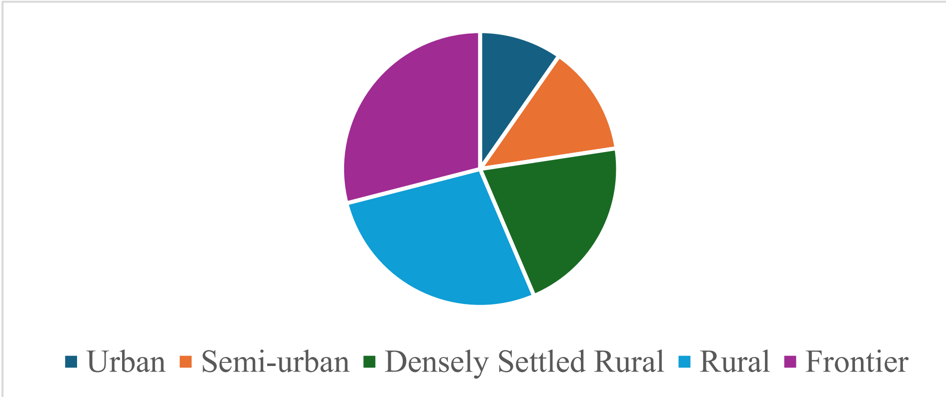

Figure 3.1: County Population Representation gathered from the survey results

Of the 62 responding counties (59%), 22 reported having a county-level rabies vaccination ordinance, while 40 reported no ordinance.

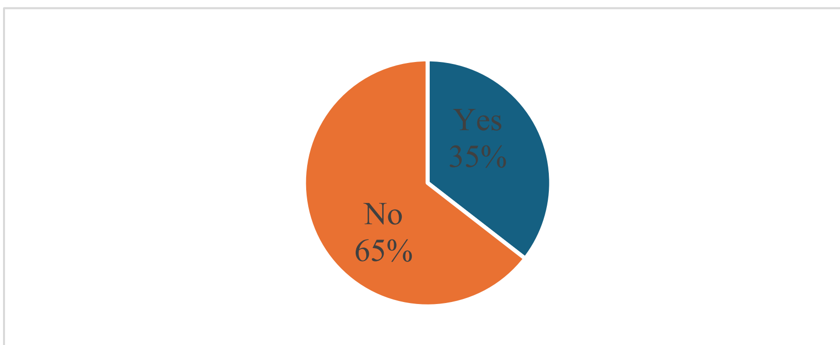

Figure 3.2: This figure shows the results of the question asked, "Does your county have a rabies vaccination ordinance?"

Sixty-three percent of respondents indicated that cities within their jurisdiction had rabies vaccination ordinances that differed from county-level requirements.

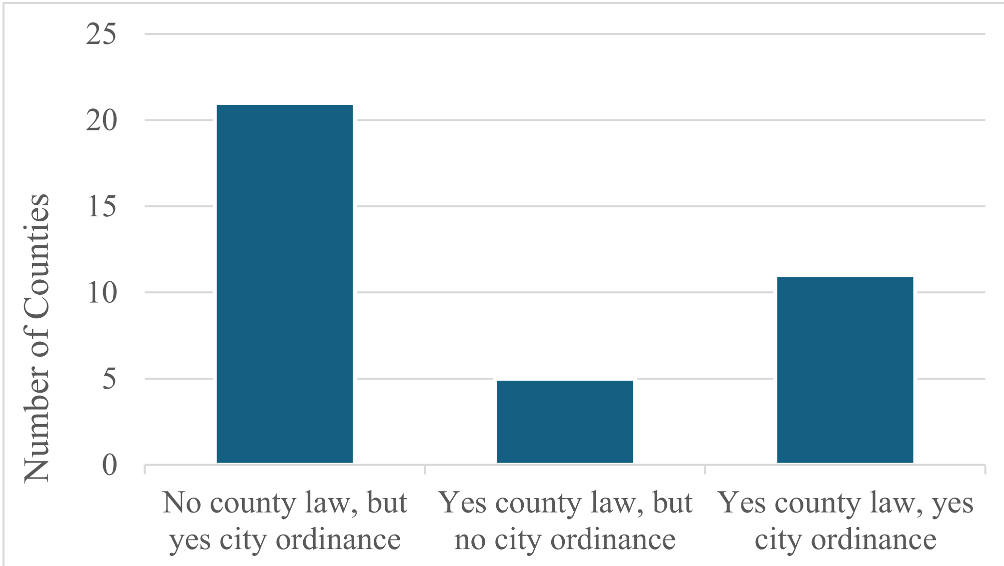

Figure 3.3: Chart Showing the responses to the question if cities within a county jurisdiction had a rabies vaccination ordinance that differed from the county

Further, while only 19 out of 50 counties require animal registration or licensing, 26 local health departments reported that rabies vaccination is a mandatory prerequisite for licensing where it exists.

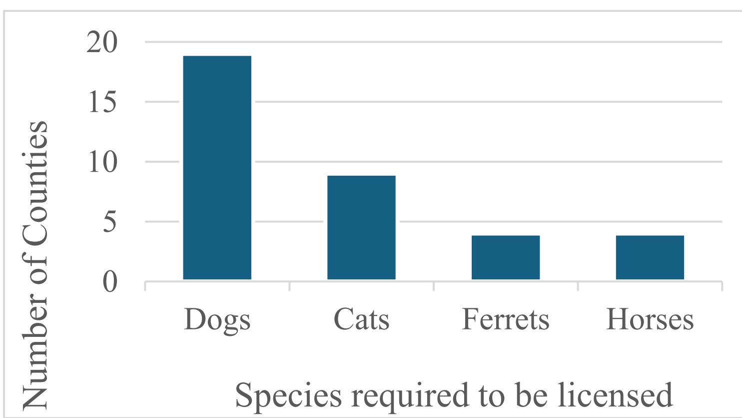

Figure 3.4: This chart presents the number of counties where animal licensing is required

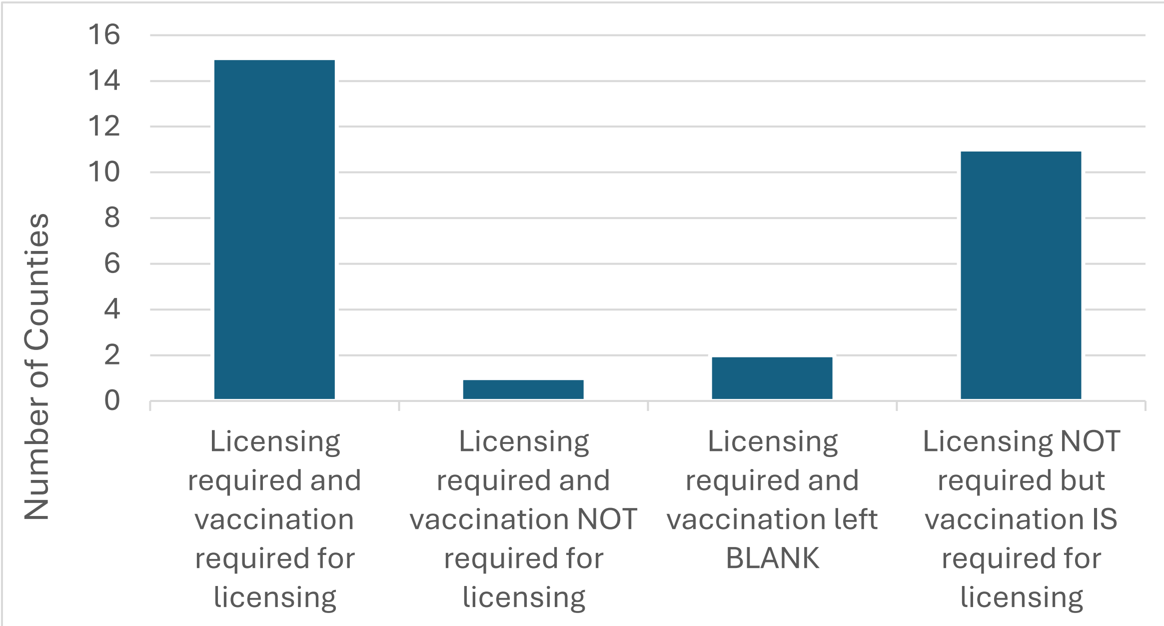

Figure 3.5: Results from the question asked in the survey, "Is rabies vaccination required for licensing?"

Despite the lack of mandates, 82% percent of counties reported that animal bites are legally reportable under local health officer authority (K.S.A. 65-118). Counties reported that animal bites were legally reportable, and 65% indicated support for a statewide rabies vaccination law.

Several constraints were identified that may limit the effectiveness of rabies management and animal bite prevention efforts at the local level. As part of the survey, respondents were asked what resources could be improved to support local rabies control within their jurisdictions. Common themes included the need for increased funding, additional staffing, and enhanced educational resources for both public health professionals and the general public. Respondents also highlighted the importance of expanding community vaccination opportunities, such as vaccine clinics and community vaccination events, as well as increasing outreach and public education programs related to rabies prevention. Other suggestions included improving access to grant funding, strengthening county-level policies, specifically in unincorporated areas, and addressing accessibility barriers that may limit residents' ability to obtain rabies vaccinations for their animals. Additionally, respondents noted the potential added benefit for increased visits from the Kansas State University mobile veterinary clinic and expanded mobile vaccination services to improve access to rabies vaccination in underserved communities.

Chapter 4 - Discussion

The primary objective of this project was to characterize rabies exposure outcomes among domestic animals in Kansas and to assess differences in animal outcomes within the context of rabies vaccination practices. Using statewide rabies surveillance data from 2018 to 2024, this study provides an updated evaluation of animal rabies prevention and control, offering insight into how vaccination status, species, and local public health practices influence animal outcomes following rabies exposure.

Consistent with the analysis, dogs represented the largest proportion of domestic animals exposed to rabid animals (n = 117), followed by cats (n = 68). Vaccination coverage differed by species, with dogs substantially more likely to be vaccinated against rabies than cats; specifically, as the logistic regression model demonstrated that cats had significantly lower point estimates for vaccination compared to dogs. This disparity remains a critical public health issue, as cats continue to experience a higher likelihood of euthanasia following rabies exposure compared to dogs (Ma et al., 2023). The logistic regression analysis demonstrated that cats had significantly lower odds of survival (not being euthanized) than dogs. This finding aligns with established rabies prevention guidance provided by the National Association of State Public Health Veterinarians, which emphasizes the importance of vaccination status in determining animal management following exposure.

Vaccination status emerged as the strongest predictor of animal outcome following rabies exposure. In the regression model, the association between vaccination and survival was highly significant ($\chi^2 = 81.11$, $p < 0.0001$), with an odds ratio of 37.33 (95% CI: 14.18 – 98.26). This indicates that unvaccinated animals were over 37 times more likely to be euthanized than vaccinated animals, reinforcing the protective effect of routine vaccination in reducing public health burden.

Survey results from local health departments provided important context for interpreting the surveillance findings. While some counties reported having rabies vaccination ordinances, a majority of 64.5% (n = 40/62) did not. Notably, many local health departments' staff reported uncertainty regarding local ordinances, with some relying on a perceived state law despite the absence of a statewide mandate. This lack of clarity highlights a structural gap in rabies prevention efforts and may contribute to inconsistent vaccination coverage and animal management practices. It is particularly noteworthy that Kansas lacks a statewide rabies vaccination ordinance, given that the state is a central hub for the KC Animal Health Corridor, which represents the largest concentration of animal health interests in the United States. This geographic and economic distinction suggests a significant legislative disconnect; while Kansas leads in animal health innovation and vaccine production, it has yet to implement a uniform preventative mandate at the state level to protect the domestic animal population.

Despite this variability, 65% of local health departments expressed support for statewide rabies vaccination laws to standardize reporting and ease administrative burdens on rural counties. However, we cannot rely solely on a statewide vaccination ordinance to improve vaccination coverage rates among companion animals. Success requires a multidimensional approach that includes access to affordable care, community education, and sustainable funding. To address concerns about veterinary access, KDHE should initiate community vaccination clinics in rural and frontier areas or partner more frequently with the K-State Veterinary Mobile Clinic. A significant opportunity for growth lies in "One Health" clinics, where local health departments provide influenza or COVID-19 vaccines alongside veterinary partners who provide rabies vaccines. This “pet and person” model has proven successful in other states for building community trust and improving compliance.

Furthermore, we must address the gap in education on animal bite management. Strengthening coordination through initiatives like the “Rabies Rodeo” is essential. Still, we need more than a single touchpoint to educate local health departments and the public on bite management and vaccination. A critical area for improvement is the education of veterinarians themselves. Many practitioners look to national NASPHV guidelines, which often recommend euthanasia as the first choice for unvaccinated exposed animals, and are unaware that Kansas state regulations offer post-exposure prophylaxis for animals as an option. Veterinarians need a clear, reliable source of information and must understand the critical role public health plays in bite management, rather than relying solely on diagnostic labs or animal health authorities.

There are some limitations that should be considered when interpreting these findings. Rabies surveillance data relies on submission-based reporting, which may underestimate true exposure events and vaccination coverage. Some species-specific estimates in the regression analysis were unstable due to small sample sizes, particularly for species like badgers and foxes, which resulted in quasi-complete separation of data points in the SAS output, limiting inference for less commonly exposed animals. Additionally, rabies ordinance data were self-reported by local health departments and may be subject to reporting errors or incomplete knowledge of local regulations. A primary limitation of the survey data is the 59% response rate (n = 62); because the findings are based only on the counties that responded, they may be subject to non-response bias. It is possible that counties with more robust rabies management programs were more likely to participate, which could lead to an overestimation of local oversight or support for new mandates across the state as a whole. To fill these gaps, the survey should be reopened to capture information from the remaining counties and improve our data reporting rates.

Finally, county-level demographic and socioeconomic factors were not included in this analysis and may influence both vaccination practices and rabies exposure risks. Future analyses should incorporate geospatial and county-level variables, including rurality, socioeconomic indicators, estimated animal populations, and wildlife rabies reservoirs, to better understand structural drivers of rabies risk. More advanced modeling approaches, such as multivariable logistic regression or hierarchical models, could further clarify how policy, geography, and vaccination practices interact to influence rabies outcomes. Expanded evaluation of statewide rabies vaccination policies across jurisdictions may also help inform evidence-based legislative action.

Overall, the findings from the study support the continued promotion of rabies vaccination among domestic animals and suggest that more standardized vaccination policies may reduce euthanasia and improve rabies prevention outcomes in Kansas. Strengthening communication, education, and coordination among local health departments may further enhance rabies control efforts and support more consistent public health practices statewide.

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Appendix 1 - Synthesis and/or Integration of Competencies

Competency 3 – In my Introduction to Biostatistics (MPH 701) and Introduction to Epidemiology (MPH 754), I worked with datasets that had already been cleaned and were ready for use. prepared for analysis. During my APE, I built and applied these foundational skills by managing real-world surveillance data. Under the guidance of a State Epidemiologist, I used SAS programming to analyze and organize a seven-year surveillance dataset of 376 rabies cases. I evaluated and improved data quality by verifying species classifications, identifying duplicate entries in EpiTrax, and excluding human-exposure cases to focus on animal-to-animal contact events. This experience allowed me to connect classroom concepts to applied epidemiological work.

Additionally, I utilized Qualtrics to design and carry out a survey distributed to 110 contacts across 100 local health departments to collect qualitative data on rabies ordinance and bite-reporting practices, which have not been updated in 10 years. I combined and interpreted both quantitative and qualitative data to develop a more complete understanding of the current rabies landscape in Kansas. Through this process, I identified patterns and compared findings across data sources, such as a high percentage of confirmed cases among skunks and inconsistent reporting in certain counties. These findings allowed me to draw conclusions and highlight areas needing improvement in current surveillance practices.

Competency 19 – A major priority of this project was ensuring that seven years of rabies surveillance data were actionable for a variety of stakeholders. I adapted and presented the same set of findings in multiple formats based on the intended audience. I developed PowerPoint for the KDHE Epidemiology team to present and explain statistical analysis results, including species-specific confirmation rates and the likelihood of euthanasia for unvaccinated animals. I also created a GIS-style map that organized and displayed county-level rabies laws, supporting KDHE's internal tracking. This allows public health state officials to see at a glance how local ordinances vary across 105 counties. In addition, I designed a research poster that combined and summarized surveillance trends survey results through visualizations for research forums and conferences. Across these products, I kept the findings consistent while adjusting how they were communicated based on the audience background and needs. I also strengthened this skill in the Multidisciplinary Thought and Presentation (DMP 815) course, where I developed a technical report on rabies surveillance practices in Kansas, and explained complex information in clear, accessible language.

My APE and MPH program experiences allowed me to adjust my communication approach depending on the audience, whether to provide statistical findings, develop tools for KDHE leadership, or present research to an academic environment. This improved my ability to clearly communicate public health data in different formats.

Emphasis Area Competency 4: Disease Surveillance – During my APE experience at KDHE, I analyzed and interpreted 376 rabies cases to identify species-specific risk patterns and surveillance trends. I used these findings to assess how well current rabies monitoring systems are working and to consider how a statewide mandate could improve the accuracy of disease reporting. Throughout my APE and MPH program experiences, I have used and connected multiple data sources to better understand disease surveillance. This included EpiTrax data to identify high-risk animal populations, using Qualtrics survey results to identify reporting gaps, and selecting appropriate measures to describe surveillance trends. These experiences strengthened my ability to interpret data, recognize gaps, and apply findings to real public health challenges. This supports more effective disease prevention and control efforts.

Table A.0.1 Synthesis and Integration of Competencies

Competency	**Description of Synthesis and Integration**
3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming, and software, as appropriate.	I interpreted a seven-year dataset of 376 cases from EpiTrax using SAS programming to manage and analyze the surveillance data. I also evaluated local rabies ordinances by designing and distributing a Qualtrics survey to 100 local health departments. I integrated these quantitative and qualitative sources to construct a more complete understanding of rabies trends and reporting practices across Kansas.
4. Analyze disease risk factors and select appropriate surveillance.	I evaluated surveillance trends through a descriptive analysis in collaboration performed in collaboration with a State Public Health Veterinarian and Epidemiologist. I validated these findings to identify current monitoring gaps and determined how improvements, such as a statewide mandate, could strengthen the accuracy of future disease reporting.
19. Communicate audience-appropriate public health content, both in writing and through oral presentation, to a non-academic, non-peer audience with attention to factors such as literacy and health literacy.	I translated rabies surveillance findings for different audiences by delivering an oral presentation to public health professionals and developing a research poster for a broader audience. I reconstructed how the information was organized and explained to ensure clarity and accessibility, while accurately conveying key findings.

Appendix 2 - Demonstration of Competency Attainment

Competency 3 – For product one (PowerPoint), I showed I could handle professional public health data by using SAS software to look at seven years of rabies cases in Kansas. Since working closely with a state epidemiologist, I learned how to take the SAS codes she gave me, plug them in correctly, and run the analysis myself for the results. This helped me understand how to work with a large dataset of 376 animals. For product two (Map/Survey), I used Qualtrics to collect and organize both numerical data and open-ended feedback from 62 local health departments. This approach allowed me to identify a significant gap in state-level prevention, specifically finding that 64.5% of responding counties lack a uniform rabies ordinance.

Competency 4 – In product one, my role went beyond running a code, and I had to interpret the statistical outputs meant for public health practice. For example, I interpreted the logistic regression results to show that unvaccinated animals faced a 37-fold increase in the likelihood of euthanasia following exposure. For product two, I interpreted survey responses to show a "fragmented" legal landscape, where cities and counties have different rules, which can create confusion for public health officials. Finally, for product three (Poster), I interpreted these findings for a general audience, translating evidence-based materials into messaging about the value of domestic animals receiving the rabies vaccine.

Competency 18 – I demonstrated this competency by choosing two very different communication strategies based on the target audience. For product one, I selected a presentation for the KDHE epidemiology team, focusing on data validity and statistical significance. Compared to product three, I created a poster for educational use for the general public. Instead of focusing heavily on the math, this strategy used visuals and "call-to-action" messaging to encourage better vaccination habits among pet owners. This showed I can adapt my approach to meet the various needs of different public health sectors.

Competency 19 – Tailoring content was a main focus across all deliverables. In product one, I used professional terminology that is typically used for an epidemiology audience. In product two, I utilized data visualization by creating a map of Kansas counties, which allowed stakeholders to see the legislative gaps at a glance. For product three. I simplified the language and use of icons to ensure that the main message was easy to access and appropriate for all audiences.

Competency 22 – In product two, I applied a systems thinking approach to the issue of rabies control in Kansas. Rather than looking at rabies as an isolated event, I looked at the state as a complex system of wildlife, economics, and law. I used the survey data to identify where the lack of a statewide rabies ordinance leads to complex county and city laws. A uniform state law would help standardize how all 105 counties report and manage rabies cases, regardless of local resources.

Table A.0.1 Attainment of Competencies

Practice-based products that demonstrate competency attainment	
Specific products	**Competency**
PowerPoint presentation geared towards public health professionals within the KDHE epidemiology group to present data analysis results	Competencies 3 & 4
A map of rabies vaccination laws/requirements by county in Kansas, through a survey sent to local health departments	Competencies 3, 4, 19, & 22

Poster presentation geared towards the general public to educate on rabies control management and vaccination practices in Kansas.	Competencies 4, 18, & 19

Appendix 3 – KDHE Presentation Slides

Rabies Exposure Outcomes and Vaccination Status in Kansas (2018 – 2024)

Selena Gilyot

KANSAS STATE UNIVERSITY

Data Sources

Rabies Surveillance Data

- Rabies surveillance data were obtained from EpiTrax for all reported rabies-positive animals
  - KSVDL animals
  - SCWDS tested animals
  - Any other reported results from other labs
- Study period: January 1, 2018 – December 31, 2024
- The dataset pulled from EpiTrax included both rabid animals and their associated contacts (exposed animals)

Variables Analyzed

- Animal species
- Vaccination status
- Exposure category
- Outcome (euthanasia, observation, quarantine)
- County of residence

Study Population Overview

Two populations were included in this analysis

- Rabid Animals
  - Animals that had a rabies test performed
  - Has documented animal contacts
  - Source of exposure
- Exposed Animals (Animal Contacts)
  - Domestic animals exposed to rabid animals
  - Included dogs, cats, livestock, and other domestic species (horses and ferrets)
  - Used for outcome analysis

Key Points

- Rabid animals define the exposure event
- Exposed animals define the analytic population

Rabid Animal Criteria

Inclusion Criteria

- Year of analysis: Jan. 1, 2018 – Dec. 31, 2024
  - All animals that have a rabies test performed

Exclusion Criteria

- Animals outside of the state of Kansas
- Animals without a positive or negative result
- Animals with no animal contacts identified
- Animals where only human exposures were identified

Final Population of Rabid Animals = tested +, reside in Kansas, and exposed another animal

Exposed Animal Criteria

Inclusion Criteria

- Animals that resided in Kansas at the time of exposure
- Stratify based on nature of exposure (Category 1-3 included in final analysis)
- Specific species of animal contacts
- Vaccination status of exposed animals

Exclusion Criteria

- Animals with a category 4 exposure (indirect exposure)
- Missing data/key information (observation outcome)
- Animals not available for follow-up

Data Cleaning Hurdles

Data quality issues were identified during dataset preparation

- Missing vaccination status
- Missing exposure classification
- Missing observation outcomes
- Duplicate entries

Data processing steps

- Remove duplicate records
- Excluded records with missing key outcome variables

Limitations

- Rabid animal data
  - Known exposure status
- Overall state of the animal for testing (decomposition/cannot get a proper tissue sample)
  - Accuracy and reliability

KANSAS STATE UNIVERSITY

Rabies Exposure Investigation and PEP

Key consideration during investigations:

- Vaccination status of exposed animals
- Nature of exposure
- Clinical signs during the observation period
- Potential risks

Animal management decisions (quarantine, observation, euthanasia) are important because they can affect recommendations for PEP administration

Animal Exposure Outcomes

cont_animal_disp	Frequency	Cumulative Frequency
Euthanized	53	53
O/Q not indicated	11	64
Observation	97	161
Quarantined	29	190
Unknown	7	197

- A total of 197 confirmed rabid animal contacts were identified during the study period
- Observation was the <u>most common</u> outcome, followed by euthanasia
  - Euthanasia is more commonly used among unvaccinated animals
- Majority of the cases had complete follow-up and documented outcomes

Rate of Euthanasia by Vaccination

euth_rate_utd	euth_rate_unvax
4.88%	65.67%

- The euthanasia rate was substantially higher among unvaccinated animals
- Animals that were up to date on rabies vaccination had a very low euthanasia rate following exposure
- This demonstrates a strong association between vaccination status and exposure outcome

Vaccination Status of Euthanized

- The majority of euthanized animals were unvaccinated
- Vaccinated animals accounted for a small proportion of euthanasia outcomes
- These findings further support the protective role of rabies vaccination

vacc_status	Frequency	Cumulative Frequency
Not vaccinated	44	44
Previously vaccinated for rabies, but not up-to-date	5	49
Unknown	3	52
Up-to-date on rabies vaccination	1	53

Table of vacc_status2 by euth			
vacc_status2	euth		
Frequency Percent Row Pct Col Pct	Euthanized	Not euthanized	Total
Not vaccinated	44 23.91 66.67 88.00	22 11.96 33.33 16.42	66 35.87
Vaccinated	6 3.26 5.08 12.00	112 60.87 94.92 83.58	118 64.13
Total	50 27.17	134 72.83	184 100.00
Frequency Missing = 13			

Statistic	DF	Value	Prob
Chi-Square	1	81.1102	<.0001
Likelihood Ratio Chi-Square	1	83.8164	<.0001

Association between Vaccination Status and Euthanasia

This table was used to evaluate the association between vaccination status and euthanasia outcome

Odds Ratio Calculation

Odds ratios were calculated to measure the association between vaccination status and euthanasia

Odds of euthanasia among unvaccinated animals:

44÷2 = 2.0

Odds of euthanasia among vaccinated animals:

6÷112 = 0.0536

Odds Ratio Calculation:

2.0÷0.0536 = 37.3

Interpretation = unvaccinated animals had **approximately 37 times higher odds** of euthanasia following exposure

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	1.3218	0.2297	33.1018	<.0001
species2	Cat	1	-1.3843	0.3396	16.6138	<.0001
species2	Cow	1	-15.7132	770.0	0.0004	0.9837
species2	Horse	1	-2.4204	0.8482	8.1426	0.0043
species2	Pig	1	-15.7132	1333.7	0.0001	0.9906

Logistic Regression Model

A logistic regression model was developed to evaluate the relationship between species being vaccinated

Reference species = dogs

Interpretation of Regression Model

Key Findings:

- Species was significantly associated with the outcome and vaccination status
- Cats had significantly lower odds of surviving exposure management compared with dogs
- Livestock estimates were unstable due to the smaller sample sizes
- Vaccination status remained the strongest protective factor in exposure management decisions

Kansas State University

Public Health Implications

Vaccination remains the most important protective factor in rabies prevention and exposure management

Increasing vaccination coverage could reduce euthanasia in exposed animals

Improved surveillance data quality with enhanced epidemiologic modeling and risk assessment

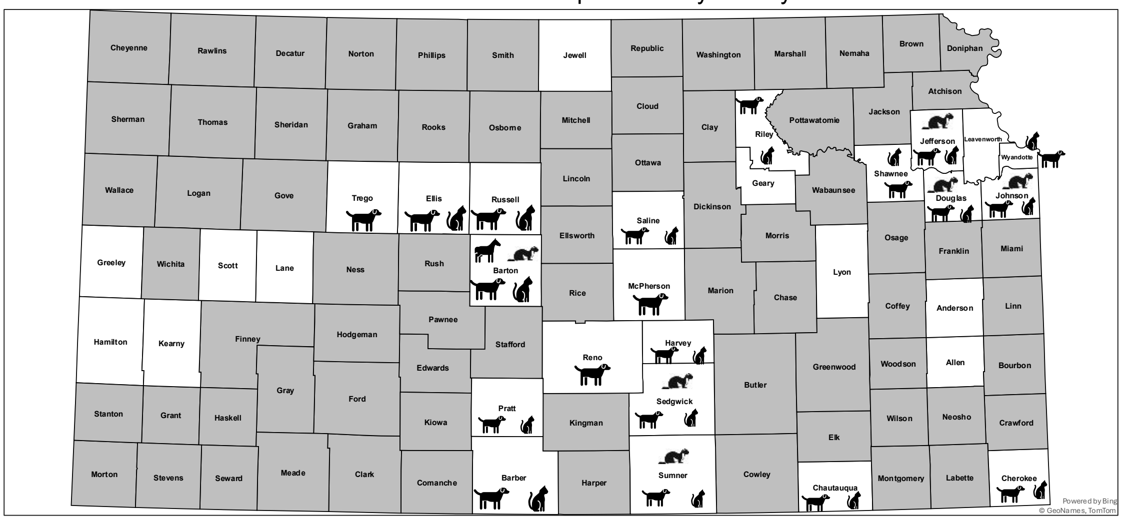
Collaboration between veterinarians, epidemiologists, and the local health department is essential for rabies prevention

Kansas State University

Appendix 4 – Map of Rabies Vaccination Requirement by County

*Still needs to be edited, waiting on responses from local health departments/counties

Rabies Vaccination Requirement by County



Appendix 5 – Poster Presentation

RABIES SURVEILLANCE PRACTICES IN KANSAS

S.M. GILYOT[1], E.M. Petro[2], E.R. Mulcahy[1]. [1]Master of Public Health Program, Kansas State University. [2]Kansas Department of Health and Environment

Introduction

Rabies is a One Health disease linking human, animal, and environmental health, transmitted through wildlife reservoirs (e.g., bats, skunks) and domestic animals. Although preventable with vaccination, rabies causes ~ 60,000 deaths globally each year, with over 95% occurring in Asia and Africa due to limited access to post-exposure prophylaxis (PEP) and inconsistent dog vaccinations. In the United States, human rabies is rare but nearly always fatal once symptoms appear. Wildlife serves as the primary reservoir, and prevention relies on vaccination and timely PEP. Despite low mortality in the U.S., rabies remains costly and a public health concern. This study examines rabies exposures and outcomes in Kansas, focusing on domestic animal contacts, vaccination status, and the role of local rabies vaccination ordinances to inform prevention strategies and reduce unnecessary euthanasia.

Methods

- Rabies surveillance data (2018 – 2024) were obtained from Kansas' state disease surveillance system, EpiTrax, which included domestic and wildlife animals with data on species, location, vaccination status, and exposure history; exposures categorized by severity and limited to rabid animals with identified animal contacts.
- Data records were cleaned and cases classified as confirmed or probable. The analysis focused on domestic animals, evaluating exposure type, vaccination status, outcomes (euthanasia, survival, death), and county rabies vaccination ordinance status.
- Statistical analysis conducted in collaboration with a KDHE epidemiologist using SAS.
- In the Fall of 2025, a Qualtrics survey of 100 Kansas local health departments assessed rabies vaccination ordinances and bite reporting practices to support interpretation of county-level differences.

Results

Chi-Square test of Independence of Vaccination Status and Outcome of Animal (i.e., euthanized or not euthanized)

Odds Ratio and Relative Risks			
Statistic	Value	95% Confidence Limits	
Odds Ratio	37.3333	14.1849	98.2578
Relative Risk (Column 1)	13.1111	5.9030	29.1208
Relative Risk (Column 2)	0.3512	0.2490	0.4952

Sample Size = 184
Frequency Missing = 13

Maximum Likelihood Estimates for Logistic Regression Model Assessing Odds of Vaccination by Species (Reference: Dog)

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	1.3218	0.2297	33.1018	<.0001
species2	Cat	1	-1.3843	0.3396	16.6138	<.0001
species2	Cow	1	-15.7132	770.0	0.0004	0.9837
species2	Horse	1	-2.4204	0.8482	8.1426	0.0043
species2	Pig	1	-15.7132	1333.7	0.0001	0.9906

Disposition of Animal Contacts to Confirmed Rabid Animals, 2018 – 2024

cont_animal_disp	Frequency	Cumulative Frequency
Euthanized	53	53
O/Q not indicated	11	64
Observation	97	161
Quarantined	29	190
Unknown	7	197

Rate of Euthanasia among Animal Contacts that were Previously Vaccinated versus those Never Vaccinated

euth_rate_utd	euth_rate_unvax
4.88%	65.67%

Discussion

The objective of this study was to assess rabies exposure outcomes among domestic animals in Kansas (2018 – 2024) and evaluate the influence of vaccination status and local policies. Dogs were the most exposed animals (n = 117), while cats had lower vaccination coverage and were more likely to be euthanized (n = 68). Vaccination was the strongest predictor of survival, with unvaccinated animals 37 times more likely to be euthanized. Survey results indicated that 64.5% of counties lacked rabies vaccination ordinances, though 65% of local health departments supported a statewide rabies law. Findings emphasize promoting vaccination, standardizing policies, and improving local coordination to strengthen rabies prevention. Limitations include possible underreporting, small sample sizes, a 59% survey response rate, and the exclusion of county-level demographic factors.

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