Analyzing the impact of stray cat and dog populations on the prevalence of human murine typhus cases in Nueces county and Harris county in Texas

Serene Yu
Masters of Public Health
P_HLTH-8971 Veterinary Public Health Capstone
University of Missouri - Columbia
Fall 2025
Nov 2, 2025

Acknowledgements

Special thanks to Dr. Brendan Sullivan at the Texas Department of State Health Services Region 6/5S for his assistance with data compilation, feedback, advice, and resources for estimating stray cat/dog populations and human Murine typhus cases. Additionally, thank you to classmate Dr. Sue Neal for lending her expertise on resources for estimating stray populations as well.

Table of Contents

Abstract

PURPOSE: Within the past 15 years, flea-borne Murine typhus has become a re-emerging zoonotic disease with a significant increase of human cases in urban areas of Texas. The cause of this epidemiological change is unknown, but stray dogs and cats are suspected to play a role in urban transmission dynamics. The purpose of this study was to determine the presence and strength of any statistical relationship between stray dog and stray cat populations and human Murine typhus cases.

METHODS: This was a time-trend ecological research study using data from Nueces and Harris counties from 2011 to 2023. Stray dog and cat populations were estimated using municipal animal shelter animal intake data. Human Murine typhus case data was obtained from the Texas Department of State Health Services. Pearson's correlation coefficient was calculated to identify any linear relationships between stray animal and human data.

KEY FINDINGS: In Nueces county, there was no linear relationship between stray dog or stray cat populations and human Murine typhus cases. In Harris county, there was a moderate negative linear relationship between both stray dog and stray cat populations and human cases. Major limitations in using shelter stray animal intake counts to estimate total stray animal populations restrict the level of accuracy of the findings.

CONCLUSIONS: Despite study limitations, the differences in stray animal populations and Pearson's correlation coefficient between Nueces and Harris county indicate that stray animals play a more significant role in Harris county disease ecology. This study supports further investigation into the role of dogs and cats in Murine typhus transmission in urban regions.

Introduction

Context and Significance

Murine typhus is a bacterial flea borne zoonotic disease caused by *Rickettsia typhi* and in the United States, the highest number of human cases occurs annually in Texas (Texas Department of State Health Services, 2024b). In the 1940's to 1950's, rat and flea eradication efforts rendered Murine typhus virtually extinct in most of Texas except for a focal area of endemicity in the southern parts of the state (Anstead, 2021). However, the 21st century has seen a resurgence of cases, most notably in regions outside southern Texas, making Murine typhus a re-emerging disease.

Humans are infected by *R. typhi* through contamination of skin wounds by infected flea feces, either through a direct flea bite wound or from scratching the bitten area (Texas Department of State Health Services, 2024a). Most people experience non-specific and flu-like symptoms such as rash, headache, chills, fever, nausea, and body aches which interfere with rapid diagnosis and treatment due to lack of pathognomonic signs (Texas Department of State Health Services, 2024a). Untreated cases can lead to chronic disease with increased complications and poorer outcomes, such as multi-organ damage, severe illness, and even death in <1% of cases (CDC, 2025b; Pieracci et al., 2017; Texas Department of State Health Services, 2024a). Nevertheless, the majority of cases will be cured with antibiotic therapy (Texas Department of State Health Services, 2024a).

Counties along the southern Texas-Mexico border typically have the highest prevalence. From 2008-2023, there were 514 cases in Cameron, 1383 in Hidalgo, and 885 in Nueces county (Texas Department of State Health Services, 2024a). However, in the past 15 years urban counties several hundred miles away from the border have emerged with the second highest case rates in the state. These urban counties include Bexar (797 cases from 2008-2023), Dallas (248), Tarrant (256), Travis (402), and Harris (477) county where the large cities of San Antonio, Dallas, Fort Worth, Austin, and Houston, respectively, are located (Texas Department of State Health Services, 2024a). Almost 43.6% of the entire Texas state population (12.7 million out of 29.1 million people) reside in these five counties alone (United States Census Bureau, 2021).

Therefore, the rising rates of Murine typhus in these urban areas have the potential of impacting millions of people in very concentrated areas. While rats are the traditional *R. typhi* reservoir, it has been proposed that urban wildlife (i.e. opossums) and stray cats and dogs may play a significant role in the urban transmission cycle. However, the impact of stray dog and cat populations on the prevalence of Murine typhus in urban Texas counties is not well defined.

Problem statement, Purpose, and Objectives

This research seeks to determine, quantify, and compare the relationship between stray dog and cat populations and human cases of Murine typhus between two counties in Texas, one urban (Harris) and one in the traditional endemic southern region (Nueces). The findings of this study are intended to bolster knowledge of urban transmission cycles and serve as foundational knowledge for designing Murine typhus prevention programs within Texas. Potential results will be aimed at refining animal control and vector control strategies to decrease human Murine typhus cases.

Research Questions

- Is there a statistical correlation between stray cat populations and human Murine typhus cases in the counties of study? If so, what is the correlation type and strength?
- Is there a statistical correlation between stray dog populations and human Murine typhus cases in the counties of study? If so, what is the correlation type and strength?
- How have stray cat and dog populations changed in the past decade in both counties?
- What differences exist between the two counties in terms of stray animal populations, human Murine typhus case counts, and changes in these dynamics over the past decade?

Scope and Delimitations

This study seeks to determine and quantify if there is any type of relationship between stray cat/dog populations and human Murine typhus cases but is not intended to determine how or why any potential relationships exist. Additionally, the study seeks to quantify and determine trends in stray cat/dog populations over time but does not intend on determining why those trends exist. The scope of this study is to act as preliminary data for further interrogation on how stray animal dynamics are related to human Murine typhus disease transmission dynamics.

Competencies addressed by this capstone project:

- CEPH Foundational Competencies
    - Apply epidemiological methods to settings and situations in public health practice
    - Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming, and software, as appropriate
- VPH Concentration Competencies
    - Describe how animal welfare, food safety, animal control and animal sheltering impact public health

Background - Literature Review

Historical Disease Trends

Murine typhus was essentially eliminated from the United States in the middle of the 20th century due to widespread, government coordinated pest control programs (Anstead, 2021, 2025). From 1930 to 1950, at least 42,000 cases were reported in the United States and likely the actual case count was much higher. After World War II ended, “synthetic insecticides and novel rodenticides” were deployed through “a vigorous program for the control of [murine typhus]...conducted by the US Public Health Service from 1945 to 1952” (Anstead, 2021). In addition to robust government programs, the overall rise in economic status of the average American improved housing conditions. Environmental and housing innovations reduced or fully eliminated

conditions for rodent proliferation, decreasing rodent populations. These programs and socio-economic improvements were so effective that “by 1956, the number of cases…in the United States had dropped dramatically to only 98 [annually]” (Anstead, 2021). However, Murine typhus was unable to be eliminated fully. This is likely due to the ubiquitous nature of the vector species (rats and fleas) which are difficult to completely eradicate. As a result, endemic regions have persisted since the 1950’s, namely South Texas, the Los Angeles area in California, and Hawaii (Anstead, 2021).

Contemporary Disease Trends

As stated briefly in previous sections, Murine typhus was previously controlled but in the 21st century, has become a re-emerging disease especially in Texas. Murine typhus is a state notifiable condition within the state of Texas but not a nationally notifiable disease. According to historical data from the Texas Department of State Health Services (Texas DSHS), annual case counts in endemic counties like Nueces county ranged from 34 in 2010 to 83 in 2018 (Texas Department of State Health Services, 2024b). In contrast, the rise in urban case counts can be demonstrated by examining Harris county, where one of the largest U.S. cities (Houston, TX, population ~2.3 million) is located (City of Houston, 2024). In Harris county, <20 cases annually occurred from 2008 to 2015. However, from 2016 to 2023, annual case counts were 32, 71, 48, 45, 67, 40, 39, 79, respectively.

Anstead (2025) published a comprehensive review article examining One Health factors that may influence these modern trends. Specifically, the article highlights the rapid growth in human populations in Texas urban regions, the resulting effects on increasing stray and owned domesticated species (cats/dogs) and opossum numbers, and overall climate change favoring increased flea reproduction. While Anstead hypothesizes that increased urbanization favors the proliferation of and contact with animals that are likely to be flea vectors, no statistical correlation testing was performed. As a result, the strength of association between stray cat and dog populations and human cases was not evaluated in the Anstead (2025) paper. Regardless, it must be noted that Murine typhus is a disease heavily influenced by environmental factors.

Therefore, stray animal populations constitute only one factor for determining why urban Texas counties have become the new hot spot zones.

Transmission Cycles - Contemporary shifts

It is well understood that rats are the reservoirs for *R. typhi* and also hosts for the flea species which become vectors (Snellgrove & Goddard, 2025). However, contemporary research implicates opossums, and possibly outdoor cats, in disease ecology cycles, especially in Texas (Anstead, 2021; CDC, 2025a). The shift from a rat driven reservoir and transmission system to opossum focused is hypothesized as a plausible cause of Murine typhus re-emergence in the United States (Anstead, 2025). Opposums are an ubiquitous wildlife species in urban areas and frequently can be found roaming in areas where direct and indirect contact with humans and pets is common (yards, parks, etc).

In addition to a shift in the mammal reservoir species dynamics, there has been a modern shift in the flea species that act as *R. typhi* vectors. Previous research confirmed that the Oriental rat flea (*Xenopsylla cheopis*) was the predominant vector, which primarily feeds on rats but easily feeds on humans too (Snellgrove & Goddard, 2025). However, since the 2000's, outbreaks of Murine typhus in Texas have identified the cat flea (*Ctenocephalides felis*) as the primary vector (Blanton et al., 2015). *C. felis* is known to be an indiscriminate feeder, targeting cats, dogs, opossums, other wildlife, and humans as needed (Anstead, 2025). This opportunistic style of feeding increases the theoretical risk of *R. typhi* transmission as it blurs the borders between wildlife/urban and animals/humans. As a result, the role of stray domestic animals (cats and dogs) as reservoirs in urban/suburban transmission cycles in Texas emerges as a potential driver of disease re-emergence.

Epidemiology of Texas Outbreaks

In 2008, an outbreak of Murine typhus occurred in the city of Austin and Travis county, where Austin is situated. A total of 33 confirmed cases were reported and 23 cases required hospitalization (Adjemian et al., 2010). This was a novel outbreak because only 4 reported cases had occurred in the 25 years preceding. A large

incidence of cases occurred from May to July (19/33) with a smaller incidence from August to October (10/33). 26/33 of the cases owned a dog or cat but only 14/33 reported regular flea prevention use for their pets. Robust environmental investigation of 21/33 cases was performed, including sampling of owned cats and dogs from case households and sampling of stray cats, wildlife, and ectoparasites from outbreak areas. A total of 56 animals (cats, dogs, opossums, raccoon, rats) were sampled and 70.6% of opossums, 44.4% of dogs (all sampled dogs were owned), and 17.7% of cats (mix of feral and owned, but all positive cats were feral) were seropositive for *R. typhi*. Fleas were also collected from all serologically sampled animals. The majority of fleas were *C. felis* species but none of the fleas were positive for *R. typhi* during PCR assays. All sampled opossums were infested with *C. felis.* This study provided a very comprehensive epidemiological investigation of exposures and emphasized the role of opossums and *C. felis* in the urban transmission cycle. However, the exposure of humans and their pets to stray and feral dogs/cats as a risk factor was not fully assessed. The seropositivity in sampled feral cats and identification of *C. felis* as the predominant flea species across all sampled mammals supports the theory that feral cats play a not insignificant role in *R. typhi* disease ecology.

In 2018, an outbreak occurred in Galveston county (located just south of the city of Houston and Harris county) (Ruiz et al., 2020). A total of 40 confirmed/probable cases were reported, which was also unprecedented as previous annual case counts were 17 in 2017, 2 in 2016, 8 in 2015, and 1 in 2014. Notably, 30 of the 40 reported cases required hospitalization. There was a temporal bias with 45% of cases occurring in June and July. The majority of remaining cases occurred April-November. Exposure to fleas, opossums, stray dogs and cats, raccoons, rodents, and dog and cat ownership were compared between the confirmed and probable case groups. There were no statistically significant differences in exposures between the groups. However, it would have been more useful if the study had compared rates of exposure between a control group of healthy adults from the same geographic areas (e.g. neighbors or coworkers) to the case patients. The statistical analysis in this study only provides insight that there were no specific exposure differences between groups of symptomatic individuals.

Therefore, exposure to stray dogs and cats as a risk factor for disease transmission cannot be excluded.

Characterizing the role of domestic animals in Murine typhus transmission

A human serological prevalence study by Wiggers & Stewart (2002) found that ownership of cats and dogs did not increase exposure to *R. typhi*, as determined by presence of antibodies against *R. typhi*. However, this study had a small sample size and the study population was not sampled from patients with probable or confirmed cases of Murine typhus. As a result, the preliminary nature of the findings limits the strength of its conclusion. Despite these tentative findings, the lack of support for owned animals as an exposure route may support that stray/feral dog and cat populations may actually have more of an influence instead.

A retrospective case series article from 1985-2015 of Texas Murine typhus cases with fatality due to infection found 4 of 11 cases had exposure to cats or dogs but not opossums (Pieracci et al., 2017). While this retrospective exposure information is interesting, it is hard to understand the significance as there was no statistical significance calculated to compare this rate of exposure to another group. As a result, the role of owned or stray and feral dog/cat exposure is undetermined based on this study.

Finally, a Murine typhus review article through a One Health perspective by Anstead (2025) compiles estimations of owned and stray/feral dogs and cats and human populations in Texas, specifically, Bexar, Cameron, Harris, Hidalgo, Nueces, and Travis counties. The estimates compare numbers from 1994/1995 to numbers from 2014/2015, but do not include data from the years in between. Human Murine typhus cases in Texas are also included up to 2019. While this article is a comprehensive overview of many different factors that may impact Murine typhus incidence in Texas, it poses a further research question it was unable to answer: “How do the numbers of opossums, dogs, and cats and strays relate to increases in human cases in individual counties?” Anstead likely posed this question because annual estimates of dog and cat populations were not calculated (only 1994/1995 and 2014/2015) so a granular level of animal population data was not presented. In addition to this gap it explicitly stated, the

article does not mention how the COVID-19 pandemic may have affected the dynamics of human and dog/cat populations, because all data in the article is prior to 2020. While COVID-19 may not have impacted Murine typhus dynamics within Texas, it is still a major external factor that necessitates reassessment of data past 2019-2020.

Methodology and Approach

Study Design

This project is a time-trend ecological research study focusing on analysis of secondary data to compare the trends in stray dog and cat populations to human cases of Murine typhus in Harris and Nueces counties in Texas. Correlation statistical testing was employed for data analysis to assess for the presence and strength of any relationships between human case counts and animal populations. Harris and Nueces counties were chosen based on urban (Harris) and endemic south Texas (Nueces) classifications, high case counts, and easily accessible municipal animal shelter intake data.

Data Collection

Secondary data was collected and compiled from municipal animal shelters and Texas Department of State Health Services data (Texas DSHS). Data from 2011 to 2023 was collected and analyzed. This timeframe was chosen based on several reasons. First, the publicly available Texas DSHS data on human Murine typhus cases by county is only available for 2008 to 2023. Ideally, data prior to 2008 would have been incorporated into analysis but availability of such historical data was extremely limited, both at the level of Texas DSHS and municipal animal shelters. Second, the resurgence of Murine typhus in Harris county first occurred in 2015-2016; therefore, analysis of the few years prior to 2015 was included. Third, publicly available municipal animal shelter data was less robust prior to 2011 (explained in more detail below).

The Texas DSHS website was accessed for publicly available data on human cases of Murine typhus with case counts by county and year (Texas Department of

State Health Services, 2024b). Case counts for Harris and Nueces counties from 2011 to 2023 were compiled and organized with Google Sheets.

For stray cat and dog population counts, which are notoriously difficult to calculate, the stray animal intake numbers for municipal animal shelters in each county were used as a proxy for estimating total stray cat and dog populations. Data was limited to municipal animal shelters and did not include private animal shelters (explained on page 14). Shelter stray intake numbers were chosen as proxy because definitive or at least closely approximate numbers could be obtained. There is currently no census data for stray animal populations nor any studies that counted stray animal populations at the county level for the purpose of this study. The alternative would be utilizing stray cat population calculators that compute stray cat numbers as a proportion of the human population, which may overestimate cat populations (e.g. University of California Davis Koret Shelter Medicine: https://www.sheltermedicine.com/library/resources/shelter-and-oucalculatortdoor-cat-population-). However, this calculator is not validated by any peer-reviewed studies and is instead a compilation of experiential data and predicted dynamics. Additionally, there are no commonly used or validated stray dog population calculators at all. Due to these factors, shelter stray intake numbers were chosen, even though the intake numbers may underestimate real stray populations in each county.

The total stray intake numbers for cats and dogs (separately) were calculated by calendar year, from 2011 to 2023 for Harris and Nueces county. When shelter data only listed total intake numbers (i.e. stray + owner surrender + lost but owned animals), the stray animal count was calculated by multiplying the total intake number by 0.6. This equation comes from the ASPCA, which calculated that on average, 60% of shelter intake were stray animals (ASPCA, 2025).

For Harris county, the two municipal animal shelters are Harris County Pets (run by Harris county government) and BARC (run by City of Houston government). Both shelters have publicly available shelter data on their websites which include total cat intake numbers and total dog intake numbers, but not stray specific. Therefore, for both institutions, stray numbers were calculated as stated above for each calendar year and then added together to calculate the Harris county total from 2011 to 2023. To obtain

data from calendar years not already present on the shelter websites, Texas Public Information Act (PIA) requests were submitted through online appeals to both municipal governments. As a result of the PIA requests, PDF compilations of existing shelter data were emailed for the desired timeframe, after paying a nominal cost (<$5/request). Unfortunately, data from BARC for 2013 and 2014 was absent even with the PIA request. As a result, Harris county stray cat and dog populations were excluded for these years.

For Nueces county, the main municipal animal shelter is Corpus Christi Animal Care Services (run by the City of Corpus Christi government). While Nueces county government has an Animal Services division, it was unclear whether they maintained an active animal shelter that took in stray animals and there was limited contact and facility information available. As a result, only data from the City of Corpus Christi was included in data analysis. There was no publicly available data, thus a PIA request was submitted to the City of Corpus Christi for animal shelter data by calendar year. The data that was received did delineate between stray intake animals and non-stray animals. Therefore, exact stray cat and dog numbers were used for Nueces county counts.

While both Harris and Nueces counties have many other animal shelters that take in stray animals, the study was limited to the shelters listed above for several reasons. The primary reason was the time limitation of the capstone project. Due to the short timeframe (<4 weeks) of data collection and analysis, restricting the number of shelters that data would need to be requested from increased the feasibility of the project. Additionally, in the state of Texas, all municipal governments are required by the Public Information Act (PIA) to respond and comply with requests for data within ten business days. Data obtained through PIA requests were integral to this project. However, privately run animal shelters (predominately non-profit organizations) are not legally bound to provide data that is not already publicly available. As a result, even though several private animal shelters in both Nueces and Harris county were contacted through email, there were no responses and thus were not included in the study. Furthermore, private animal shelters are not obligated to take in stray animals, unlike municipal shelters. While using only municipal animal shelter data inherently

under-reports stray animal populations, the assumption in this study was that the trends in stray animal intake over time could be representative and proportional to actual stray population trends overall.

Data Analysis Methods

Google Sheets was used for data compilation, organization, and generation of graphics. Tables were generated for human Murine typhus case counts and stray cat and dog populations from 2011-2023 for Harris and Nueces counties. After data was tabulated, line graphs were generated to identify trends within the specific counties. The ratio of stray animals to county geographical size was also calculated by calendar year to assess if the concentration of stray animals differed between the counties. Nueces county is 839.3 square miles while Harris county is 1707.3 square miles (United States Census Bureau, 2021). Pearson's correlation coefficient testing was used to investigate any linear relationship between human Murine typhus cases and stray cat/stray dog populations for Harris and Nueces county from 2011 to 2023. Prior to Pearson's correlation coefficient testing, preliminary scatterplots of human Murine typhus cases and animal populations were made to ensure that the data was not distributed in a non-linear pattern.

Results and Analysis

Summary of Trends

From 2011 to 2023, the average annual human Murine typhus case count in Nueces county was 58 and in Harris county was 36. However, in Harris county, there were significant temporal differences in average annual counts. The average case count from 2011 to 2015 was 10 cases/year but from 2016 to 2023, increased to 52 cases/year. In comparison, the Nueces county average annual counts remained relatively stable throughout the same time period with an average of 56 cases/year from 2011 to 2015 and 60 cases/year from 2016 to 2023. Table 1 summarizes the annual case count data for both counties.

In Table 2 - 5, the stray dog and cat intake numbers for both Nueces and Harris county from 2011 to 2023 are summarized, along with the concentration of dogs/cats per square mile of each county. In general, the overall stray dog intake numbers decreased in both counties for the study time period. The average annual dog intake counts for 2011 to 2015 were 3350 and 18,512 and then decreased to 2029 and 13,767 for Nueces and Harris county, respectively. In Harris county, there was a precipitous decline in stray dog intakes from 2019 (16,754 dogs) to 2021 (9,220 dogs), coinciding with the onset of the COVID-19 pandemic. A similar but less pronounced decline was seen in the same time period in Nueces county (2019: 2367 dogs to 2021: 1316 dogs). In both counties, there was a gradual increase in stray dog intake numbers following 2021 but numbers in Harris county did not return to pre-2020 levels. When comparing the ratio of stray dog intakes to county size (i.e concentration of stray dogs per square mile), the trends in each county followed the stray dog intake count trends. The concentration of stray dogs throughout the study time period remained consistently higher in Harris county than Nueces county.

When analyzing the stray cat intake counts, the temporal trends are dissimilar to stray dog intake trends. In Harris county, despite outlier years where counts increased in 2012 and 2019, the overall trend from 2011 to 2023 was a steady decrease in annual stray cat intake (2011: 9,283 to 2023: 4,842). In Nueces county, there was a sharp decline in stray cat intake from 2011 (2,555 cats) to 2014 (1,209 cats) and then overall stable intake counts from 2016 to 2022 (average 982 cats/year) before a slight increase up to 1,659 cats in 2023. The ratio of stray cat intake to county size decreased from 2011 to 2023 in Harris county, such that the 2023 ratio (2.8) was almost convergent with the Nueces county 2023 ratio (2.0). Overall, the Harris county ratio range was 4.1, showing a larger change in ratio count from 2011 to 2023 when compared to the range of ratios in Nueces county (2.7).

Pearson’s correlation coefficient was calculated for each county to determine if there was a linear relationship between county specific annual human Murine typhus counts and county specific annual stray dog/stray cat intake counts from 2011 to 2023 (Table 6). When performing the statistical testing, stray dog/stray cat intake counts were considered the independent variable and the human Murine typhus case counts were

considered the dependent variable. For Nueces county, both stray dog and stray cat counts had weak, positive correlations with human case counts (0.105 and 0.124, respectively). For Harris county, both stray dog and stray cat counts had moderate, negative correlations with human case counts (-0.549 and -0.625, respectively).

Table 1: Human Murine typhus cases Nueces and Harris county, Texas, 2011 to 2023

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Nueces	73	66	38	55	50	44	72	83	65	33	69	54	62
Harris	5	5	14	14	16	32	71	48	45	67	40	39	79

Table 2: Stray dog intake counts in Nueces and Harris county, Texas, 2011 to 2023

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Nueces	4100	3318	3018	3155	3163	3227	*	2392	2367	1446	1316	1419	2036
Harris	18,115	18623	*	*	18799	18094	16610	15641	16574	11953	9220	10346	11698

**Incomplete or absent data, thus excluded from analysis*

Table 3: Stray cat intake counts in Nueces and Harris county, Texas, 2011 to 2023

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Nueces	2555	3106	2448	1209	1402	1029	*	916	983	851	1176	942	1659
Harris	9,283	11835	*	*	10387	9450	9099	8726	10087	7579	7210	5417	4842

**Incomplete or absent data, thus excluded from analysis*

Table 4: Ratio of stray dog intake counts to county size (in square miles) in Nueces and Harris county, Texas, 2011 to 2023

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Nueces	4.9	4.0	3.6	3.8	3.8	3.8	*	2.8	2.8	1.7	1.6	1.7	2.4
Harris	10.6	10.9	*	*	11.0	10.6	9.7	9.2	9.7	7.0	5.4	6.1	6.9

**Incomplete or absent data, thus excluded from analysis*

Table 5: Ratio of stray cat intake counts to county size (in square miles) in Nueces and Harris county, Texas, 2011 to 2023

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Nueces	3.0	3.7	2.9	1.4	1.7	1.2	*	1.1	1.2	1.0	1.4	1.1	2.0
Harris	5.4	6.9	*	*	6.1	5.5	5.3	5.1	5.9	4.4	4.2	3.2	2.8

**Incomplete or absent data, thus excluded from analysis*

Table 6: Pearson's correlation coefficients for county specific stray dog and cat intake counts and county specific human Murine typhus case counts from 2011 to 2023

		Pearson's Correlation Coefficient
Nueces County	Stray dog intake and Human Murine typhus cases	**0.105**
	Stray cat intake and Human Murine typhus cases	**0.124**
Harris County	Stray dog intake and Human Murine typhus cases	**-0.549**
	Stray cat intake and Human Murine typhus cases	**-0.625**

Figure 1: Trend analysis in human Murine typhus annual case counts from 2011 to 2023 in Nueces and Harris county, Texas

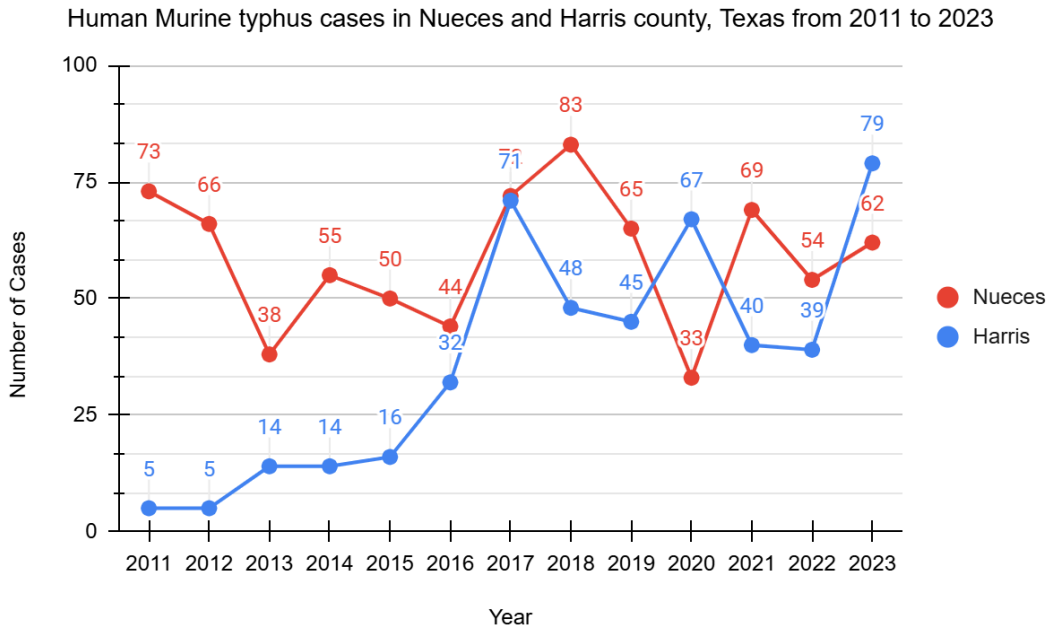


Figure 2: Trend analysis in annual stray dog intake counts from 2011 to 2023 in Nueces and Harris county, Texas

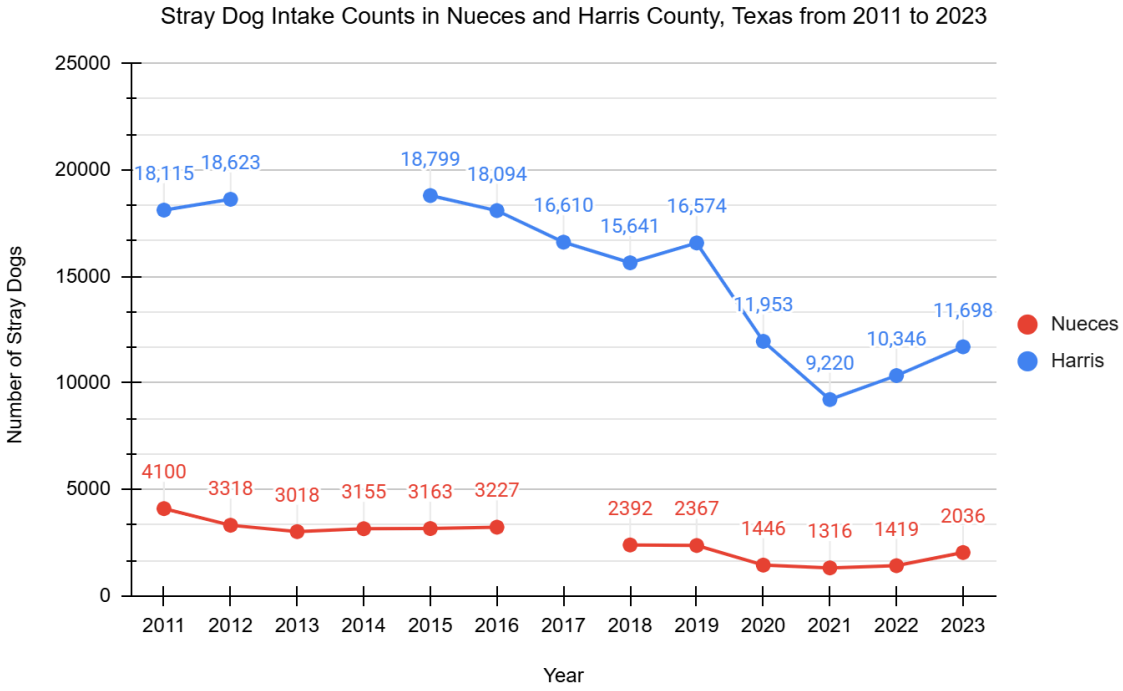


Figure 3: Trend analysis in annual stray cat intake counts from 2011 to 2023 in Nueces and Harris county, Texas

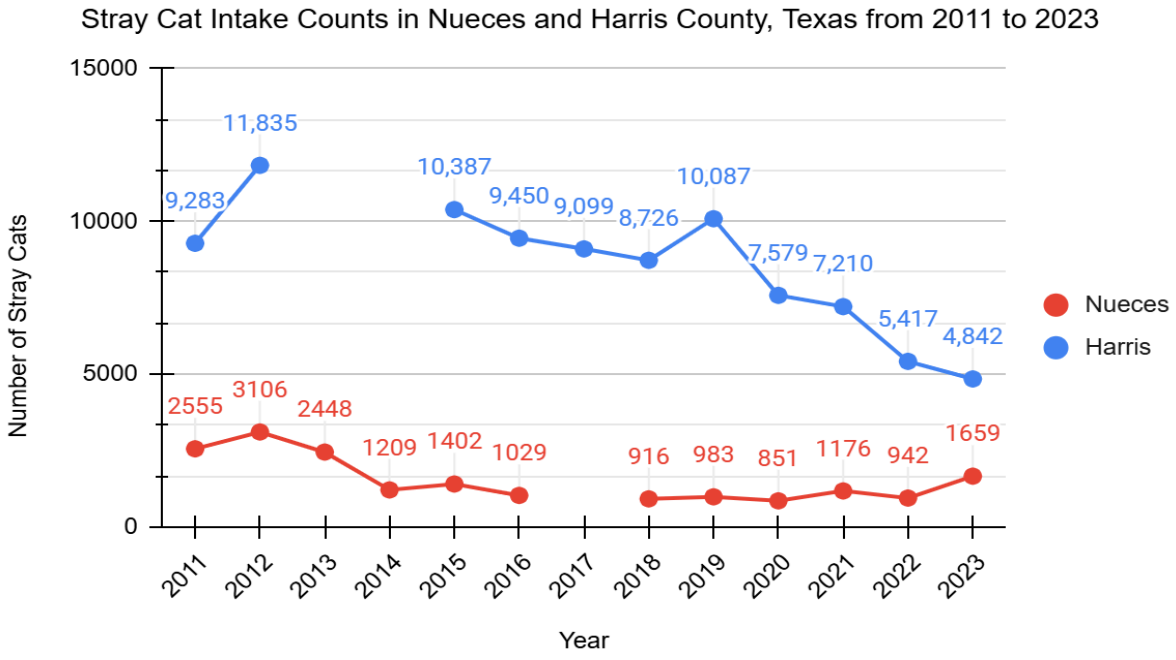


Figure 4: Trend analysis in concentration of stray dogs (based on shelter intake counts) per square mile in Nueces and Harris county, Texas from 2011 to 2023

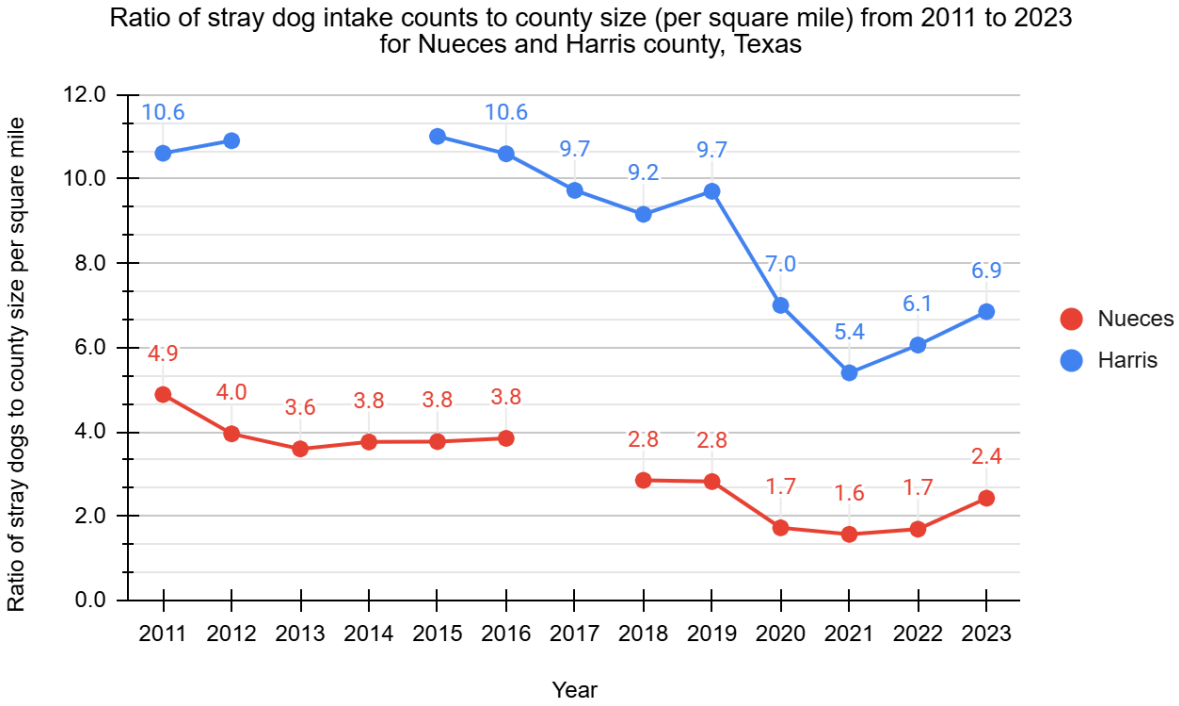
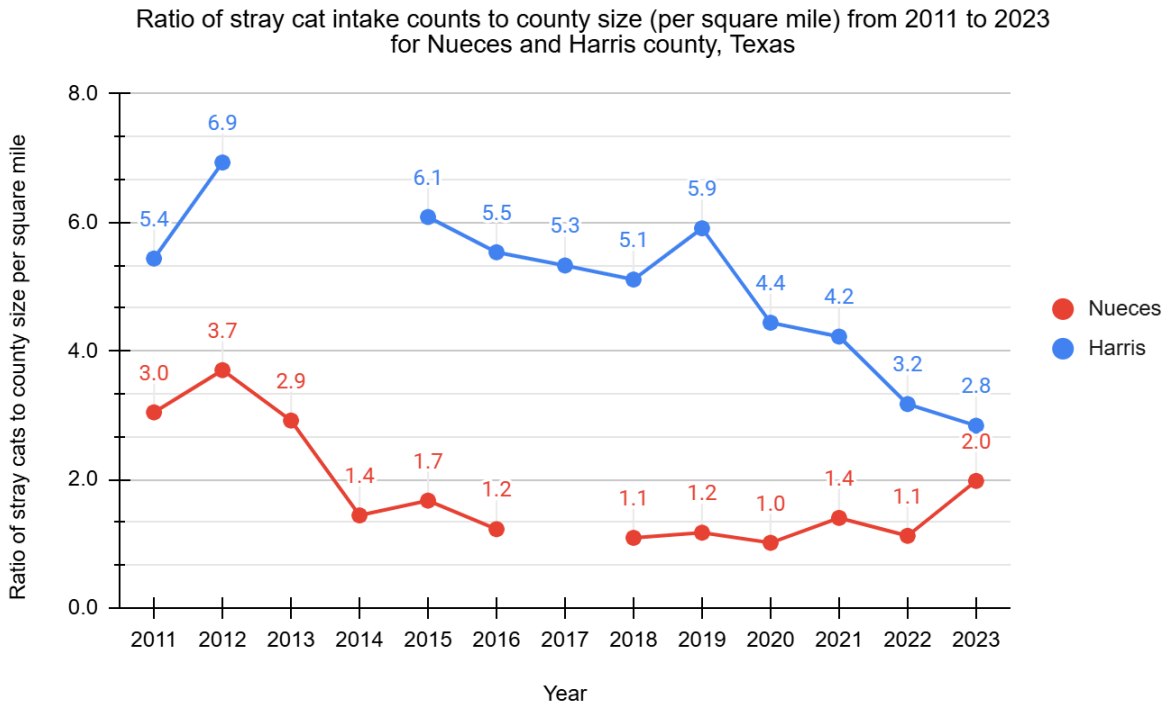


Figure 5: Trend analysis in concentration of stray cats (based on shelter intake counts) per square mile in Nueces and Harris county, Texas from 2011 to 2023



Discussion

The purpose of this study was to quantify and compare the relationship between stray dog and cat populations and human cases of Murine typhus to identify potential transmission dynamics that are contributing to the re-emergence of Murine typhus in previously non-endemic regions of Texas. Trends from an urban county with emergence of high case counts in the last decade (Harris) were compared with a county from the traditionally endemic region of Texas (Nueces) to further delineate if stray dog and cat dynamics differ between these two settings. Overall, the findings from this study indicate a weakly positive to absent linear relationship between both stray dog and stray cat populations and human Murine typhus cases in Nueces county. In contrast, there was a moderate negative linear relationship in Harris county. In the section that follows, limitations, further analysis of the specific trends, and significance will be explored.

Limitations of the study

The discussion of this study's results must start with acknowledging the data limitations due to the inherent difficulty of accurately estimating stray animal populations. The extent of the limitations significantly affect how the data is interpreted and to what degree this study's findings are considered representative of real world dynamics.

The first major limitation is that using stray dog and cat intake counts at animal shelters to approximate overall stray populations vastly under-estimates the true population numbers. This under-reporting is two-fold: municipal shelters are not the only animal facilities that will intake strays and not all stray animals will be turned into shelters. As mentioned earlier in the methodology section, only municipal animal shelter data was used because they are legally compelled by Texas state law to provide data upon request. Private animal shelters, such as the the Gulf Coast Humane Society in Nueces county and the Houston SPCA in Harris county, intake significant amounts of stray animals but are not legally compelled to share data or to make data publicly available. As such, private shelters were excluded from the study. The number of private shelters in Harris county also made it unfeasible for the timeline of this study because contacting each one individually would have been extremely time consuming. Additionally, stray intake numbers at shelters likely represent only a fraction of the true stray animal population. There are no estimates for how shelter stray intake counts approximate true stray populations but it is highly unlikely to be close to 100%. Unfortunately, at the time of this study, there were also no reliable mathematical or validated models to predict stray animal counts.

The second major limitation is that each shelter had a different animal record database and classification system. For some shelters, exact stray intake counts were listed but for others, the stray intake count had to be calculated based on gross intake numbers. This inconsistency introduces a layer of doubt into the accuracy of exact numbers. Different shelters also have different animal control capabilities and stray animal impoundment policies. These differences would affect the rate at which shelters intake stray animals, independent from shelter space for animals, and would affect what proportion of the stray population is being documented. As a result, the

representativeness of each shelter's stray animal proportion likely has high variability between shelters.

Finally, the third major limitation is that findings of this study speculate on correlation but not causation. This study's objective was not to prove a causative relationship, but to expand on whether stray animal populations were related to human Murine typhus cases at all. Vector-borne disease transmission dynamics are inherently more complex than directly communicable diseases. Therefore, these findings are to increase understanding of disease transmission in emerging urban hot spots.

Despite the limitations listed above, this study presents the first known approximation of stray dog and cat populations in Nueces and Harris counties at the level of annual populations. Therefore, while the limitations of the study restrict the level of confidence in the accuracy of the findings, it presents a broad preliminary understanding of dynamics in both counties over a significant time period.

Harris county trends

In Nueces county, the stray dog and cat populations remained relatively stable over the study time period despite minor increases/decreases from year to year. In contrast, in Harris county there was a sharp decline in both populations during 2020 which is likely due to the COVID-19 pandemic. Even after the pandemic subsided, stray intake numbers did not rebound to pre-pandemic levels and stray cat intakes actually continued to gradually decrease from 2021 to 2023. This sharp decline in Harris county stray animal intake leads to the negative Pearson's correlation coefficient calculated. Harris county is a large, urban county, so it can be hypothesized that the density and size of the human population is correlated with a higher level of impact from the COVID-19 pandemic. As a result, municipal animal shelters were likely unable to continue normal operations leading to the decrease in stray animal intake numbers starting in 2020.

However, as the pandemic decreased in severity, it is interesting to note that stray cat intake counts did not increase in 2023 like stray dog intakes. The sustained decrease in stray cat intake counts after COVID-19 is likely not due to a true decrease in the Harris county stray cat populations. The reason why this is not suspected is

because there are no obvious environmental events or known feline disease outbreaks that could have led to widespread stray/feral cat mortality. For example, there were no severe natural disasters (e.g. Category 4-5 hurricanes with widespread flooding, such as Hurricane Harvey in 2017), severe and prolonged freezing events, massive stray/feral cat sterilization events, or widespread stray cat eradication programs that occurred in Harris county from 2020-2023. There is also no documentation or alerts that were sent out by BARC or Harris County Pets (the municipal shelters in Harris county) about widespread outbreaks of mortality events in shelter animals or cases reported to animal control departments. While undetected outbreaks of infectious diseases in stray/feral cats leading to large mortality events is possible, it is unlikely that such a large number of cats would have died, leading to a decrease of almost 3000 cats on stray intake from 2020 to 2023, without notice. Therefore, despite the negative Pearson's correlation coefficient between stray cats and human Murine typhus cases in Harris county, this statistic is likely not representative of actual dynamics.

Possible reasons why the stray cat intake numbers for Harris county continued to decline include changes in shelter euthanasia policies, decreases in budgets, changes in shelter record keeping, loss of shelter staff and/or building capacities, animal intake diversion policies, and/or increased recruitment of non-profit partnerships to increase cat fostering. A news article from March 2025 highlights that BARC is underfunded compared to other major city shelters in Texas and has had to drastically increase euthanasia rates to compensate (Walsh, 2025). In comparison, a report from the Harris County Office of County Administration highlights that Harris County Pets has cut intake rates by almost 70% from 2013 to 2023, partially due to a "decrease in…number of animals admitted…and switch to an appointment-based system to restrict intake during the COVID-19 pandemic" and due to prioritizing "admitting animals that are in most need of care or pose a public safety risk" (*Assessment of VPH Structures and Potential Program Expansion*, 2024). As a result, the author does not consider the moderate negative linear relationship between stray cat populations and human Murine typhus cases in Harris county to be fully accurate.

As for stray dog population trends in Harris county, there was a similar decrease in stray dog intake during 2020-2022 and then an increase again in 2023. For 2024, the

stray dog intake count was 11,817 (not listed in figures/tables above due to lack of DSHS human murine case data for 2024). The relatively static stray dog intake counts from 2023 to 2024 may represent a lack of immediate rebound to pre-COVID counts. Similar to stray cat population dynamics, the lack of return to pre-COVID stray dog intake numbers is suspected to be due to reasons other than a true decrease in stray dog populations. A decrease of almost 7000 dogs from 2019 to 2021 without any documented natural disasters or reported widespread mortality or sterilization events is unlikely to be due to true population decreases. It is unclear why stray dog intakes increased slightly after 2021 while stray cat intakes continued to decline. Likely, shelter management and capacity along with animal control protocols affect these intake dynamics more than actual stray dog population changes. Another factor to consider is that there are many large private animal shelters and rescue organizations in Harris county that may have increased stray intake, thus decreasing intake at municipal facilities. As a result, the negative linear population for stray dogs and human Murine typhus cases in Harris county is likely not fully accurate either.

Nueces county trends

Unlike Harris county, the fluctuations in stray cat and dog intake counts were not as pronounced during the study time period. Stray cat intake counts slowly and steadily decreased from 2011 to 2018, reached the lowest counts in 2020, before increasing again until counts almost doubled from 2020 to 2023. COVID likely impacted shelter intake counts as well, but likely not due to the same degree as Harris county because Nueces county is smaller with a lower human population density. Similar fluctuations in stray dog intake counts are seen. It can be speculated that the overall decrease in stray animal intake from 2011-2016 versus 2018-2023 may be due to true population decreases but that is hard to confirm as well. It is also just as likely that shelter intake capabilities were shifted between these two time periods as well. Notably, there was no data for the calendar year of 2017 despite filing a PIA request for data from 2000 to 2024 to Nueces county. 2017 is also when the stray intake counts shift from higher to lower annual cats for both stray dogs and cats. It is hypothesized that the municipal

shelter had a major change in 2017 with stray intake policies and/or record keeping, likely resulting in this data gap and shift in trends.

Despite the major limitation that stray intake counts may not be fully representative of stray animal populations in Nueces county, the overall populations in Nueces county were relatively stable over time. As a result, there was no linear relationship to human Murine typhus cases over the study time period. This result confirms historical findings that stray dogs/cats do not play a pivotal role in Murine typhus transmission in endemic regions. The disease ecology of Murine typhus in south Texas is based on environmental factors more so than animal reservoir dynamics. Studies such as Anstead (2025) and Wang et al. (2024) highlight that the precipitation and temperature levels in south Texas favor robust flea reproduction throughout most of the year. As a result, vector proliferation increases rates of disease transmission independently from animal reservoir populations.

Significance of findings

The findings of this study represent the first approximation of stray dog and cat populations in Nueces and Harris counties across a large time span. Additionally, it is the first study that has directly analyzed the relationship between stray animal populations and human Murine typhus cases, especially in an emerging urban hotspot.

The moderate negative relationship between stray animal populations and human Murine typhus cases in Harris county was surprising. Previous studies had hypothesized that increasing urbanization has enabled increasing stray animal populations, implicating stray cats specifically as a new Murine typhus host species in urban/suburban areas. However, if municipal stray intake counts are actually representative of true stray populations, then the stray dog and stray cat populations in Harris county are not positively correlated with the increase in human Murine typhus cases in the past decade. As a result, it is possible that stray domestic animals are not a significant factor in the urban/suburban transmission cycle at all. This would implicate some other still unconfirmed factor, such as urban wildlife species or even potentially owned but not stray domestic animals instead. Alternatively, it is possible there is a

difference in vector behavior in urban areas, instead of a shift in host species, that has increased recent human Murine typhus infection.

Future studies

Due to the limitations and correlation testing of this study, there is still much future work that needs to be done to understand the urban/suburban transmission dynamics of Murine typhus in Texas. Below are several research questions that this study further proposes:

- To what degree does stray animal intake counts at shelters represent true stray animal populations?
- If private shelter data was included in the study, how would that change the findings?
- Is there a correlation between urban wildlife prevalence (opossums, raccoons, coyotes) and human Murine typhus cases in urban areas?
- Are there changes in the vector species (*X. cheopis* and *C. felis*) dynamics that contribute more to the urban/suburban cycle than host species changes?

Conclusion and Recommendations

This study confirmed that stray animal populations are not strongly correlated with human Murine typhus cases in endemic areas but was unable to determine the strength of a relationship in emerging hotspots. As discussed previously, there were significant limitations which restrict the accuracy and representativeness of the data. Specifically, the large decrease in stray dog and cat intake numbers in Harris county which started around 2019-2020 is suspected to be due to shelter reporting/intake changes instead of true animal population decreases. Also, the use of shelter intake data to represent true stray populations will inherently underreport actual populations.

Despite these limitations, the contrast in animal population trends and Pearson's correlation coefficient between Nueces and Harris county do show that stray dog and cat dynamics between both counties are different. While stray animal populations in Nueces county may have remained relatively stable over the past decade, the

populations in Harris county may have had significant changes. Therefore, the impact of stray dogs and cats on human Murine typhus cases in Harris county is likely more significant than in Nueces county.

The author encourages a more thorough investigation of stray animal populations in Harris county through contact of the private animal shelters that were excluded from the study, to increase accuracy of stray animal counts for analysis. Additionally, for all confirmed and suspected human Murine typhus cases in Harris county, thorough environmental investigation should be performed which includes: assessment of stray dog and cat presence around home and workplace, flea collection at home and workplace, and assessment of urban wildlife around home and workplace. Finally, a standardized stray and shelter animal data infrastructure would bolster animal population surveillance. Currently, private and municipal animal shelters exist in a fragmented network where data sharing is not common. Record keeping and data analysis varies widely between shelters, both in the extent of data collection and also the quality and consistency of data. However, the Shelter Animals Count organization (https://www.shelteranimalscount.org/) has made attempts to unify and standardize shelter data reporting to enable higher level shelter animal population trend analysis. Shelter Animals Count serves as a central database compiling voluntarily reported data from municipal and private shelters. This author recommends that all states should mandate municipal shelters to comply with Shelter Animals Count reporting standards. To encourage private shelters to voluntarily contribute, additional tax benefits and/or grants should be offered to reward compliance. Ultimately, more data is needed to better understand the roles that dogs and cats play in the re-emergence of Murine typhus in rapidly urbanizing areas.

References

Adjemian, J., Parks, S., McElroy, K., Campbell, J., Eremeeva, M. E., Nicholson, W. L., McQuiston, J., & Taylor, J. (2010). *Murine Typhus in Austin, Texas, USA, 2008—Volume 16, Number 3—March 2010—Emerging Infectious Diseases journal—CDC*. https://doi.org/10.3201/eid1603.091028

Anstead, G. M. (2021). History, Rats, Fleas, and Opossums. II. The Decline and Resurgence of Flea-Borne Typhus in the United States, 1945–2019. *Tropical Medicine and Infectious Disease*, *6*(1), 2. https://doi.org/10.3390/tropicalmed6010002

Anstead, G. M. (2025). A One Health Perspective on the Resurgence of Flea-Borne Typhus in Texas in the 21st Century: Part 1: The Bacteria, the Cat Flea, Urbanization, and Climate Change. *Pathogens*, *14*(2), 154. https://doi.org/10.3390/pathogens14020154

ASPCA. (2025). *U.S. Animal Shelter Statistics | Shelter Intake and Surrender | ASPCA*. https://www.aspca.org/helping-shelters-people-pets/us-animal-shelter-statistics

Assessment of VPH Structures and Potential Program Expansion. (2024, October). Office of County Administration. https://oca.harriscountytx.gov/Media/Blog/assessment-of-veterinary-public-health-structures-and-potential-program-expansion

Blanton, L. S., Vohra, R. F., Bouyer, D. H., & Walker, D. (2015). *Reemergence of Murine Typhus in Galveston, Texas, USA, 2013—Volume 21, Number 3—March 2015—Emerging Infectious Diseases journal—CDC*. https://doi.org/10.3201/eid2103.140716

CDC. (2025a, April 2). *Murine Typhus: A Re-emerging Threat in the United States*. Clinician Outreach and Communication Activity (COCA). https://www.cdc.gov/coca/hcp/trainings/murine-typhus.html

CDC. (2025b, May 23). *About Murine Typhus*. Typhus Fevers. https://www.cdc.gov/typhus/about/murine.html

City of Houston. (2024, July 1). *Planning Department—Demographics*. https://www.houstontx.gov/planning/Demographics/

Pieracci, E. G., Evert, N., Drexler, N. A., Mayes, B., Vilcins, I., Huang, P., Campbell, J., Behravesh, C. B., & Paddock, C. D. (2017). Fatal Flea-Borne Typhus in Texas: A Retrospective Case Series, 1985–2015. *The American Journal of Tropical Medicine and Hygiene*, *96*(5), 1088–1093. https://doi.org/10.4269/ajtmh.16-0465

Robert J. Wiggers & Robert S. Stewart. (2002). Ownership of dogs and cats does not increase risk of murine typhus. *Texas Medicine*, *98*(6), 56–58.

Ruiz, K., Valcin, R., Keiser, P., & Blanton, L. S. (2020). Rise in Murine Typhus in Galveston County, Texas, USA, 2018. *Emerging Infectious Diseases*, *26*(5), 1044–1046. https://doi.org/10.3201/eid2605.191505

Snellgrove, A. N., & Goddard, J. (2025). Murine typhus: A re-emerging rickettsial zoonotic disease. *Journal of Vector Ecology*, *50*(1), 1–13. https://doi.org/10.52707/1081-1710-50.1-1

Texas Department of State Health Services. (2024a). *Flea-borne Typhus*. https://www.dshs.texas.gov/notifiable-conditions/zoonosis-control/zoonosis-control-diseases-and-conditions/flea-borne-typhus

Texas Department of State Health Services. (2024b). *Flea-borne Typhus Cases Reported In Texas, 2008-2023, By County of Residence* [Dataset]. https://www.dshs.texas.gov/sites/default/files/IDCU/disease/typhus/Typhus-2008-2023-cases-by-County.pdf

United States Census Bureau. (2021). *Texas—Census Bureau Search*. https://data.census.gov/all?q=Texas

Walsh, D. A. (2025, March 17). *As BARC speeds up euthanasia process, Houston City Council considers new organizational structure*. Houston Public Media. https://www.houstonpublicmedia.org/articles/news/city-of-houston/2025/03/17/516181/as-barc-speeds-up-euthanasia-process-houston-city-council-considers-new-organizational-structure/

Wang, H., Patricio, O. M., Quintana, F. G., Goonatilake, R., Solis, A., & Mia, R. I. (2024). A Path Analysis to Understanding the Epidemiology of Murine Typhus in South Texas. *Journal of Mathematics and Statistics*, *20*(1), 37–44. https://doi.org/10.3844/jmssp.2024.37.44