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ORIGINAL RESEARCH ARTICLE

A Retrospective Review of Morbidity and Mortality in 'Good Samaritan' Animals Admitted to a Tertiary Referral Veterinary Health Center From 2014 to 2022: Postmortem Examination

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Abstract

***Introduction*:** Good Samaritan animals are frequently encountered at veterinary teaching hospitals and provide a useful indirect surveillance tool for monitoring major morbidity and mortality in unattended animals.

***Methods*:** Retrospective study. Good Samaritan animals' medical and postmortem examination records were searched from the OSU VMC medical record database and the OSU CVM Anatomic pathology database and identified 100 cases from 2014 to 2022.

***Results*:** One hundred Good Samaritan animals that underwent postmortem examination were identified. These included 59 cats, 36 dogs, 2 raccoons, 1 squirrel, 1 bat, and 1 opossum with mean and median ages of 2.61 years and 1 year, respectively. The most predominant cause of death or major morbidity requiring euthanasia was euthanasia for rabies test (n = 19) in cats and vehicular trauma (n = 16) in dogs. Other mortality and significant morbidities include trauma (n = 15) followed by infectious disease (n = 5) in cats and infectious disease (n = 12) and neoplasia (n = 2) in dogs. Brain tissue from 51 animals was submitted to the Ohio Department of Health for rabies tests, and all had negative results. In 17 canines and felines with infectious diseases, dogs had viral (n = 6), parasitic (n = 5), and bacterial (n = 1) etiologies, while cats had bacterial (n = 2) and viral (n = 1), fungal (n = 1), and mixed (n = 1) etiologies.

***Conclusion*:** Epidemiological review of morbidity and mortality in Good Samaritan animals submitted for postmortem examination helps to characterize the types and severity of vehicular trauma and infectious diseases in stray animals. Young and intact animals were important demographic factors in Good Samaritan dogs and cats. The rabies test results tightly correlate with a trend of rabies test results in dogs and cats in Franklin County.

Keywords: *Good Samaritan animals*; *trauma*; *infectious disease*; *stray animals*

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Supplementary material
Supplementary material for this article can be accessed here.

'Good Samaritan animals' typically refer to animals found injured, sick, or distressed by individuals who provide assistance or bring them to a veterinary facility for care. It is a unique patient population that exists only in veterinary medicine and seeks immediate medical care without identifiable owners. The American Animal Hospital Association recommends the practice of a Uniform Good Samaritan Law such as the following: 'Any veterinarian or veterinary technician who, in good faith, renders emergency care, without remuneration or expectation of remuneration, to a sick or injured animal shall not be liable for any civil damages resulting from his or her acts or omission, except for such damages as may result from acts of gross negligence or wanton acts or omissions'.[1] Only a few states have laws promoting animal emergency care, such as Ohio Maryland, and Colorado.[2] The statute in the state of Ohio (Ohio § 4765.52 (2023)) states, 'In the course of an emergency medical response, fire response, or a first responder, emergency medical may provide any of the following emergency medical services to a dog or cat prior to the dog or cat being transferred to a veterinarian for further treatment'.[3]

As such, the Ohio State University Veterinary Medical Center (OSU VMC) has Good Samaritan animal funds and a standard operating procedure to provide immediate medical care to animals whose owners cannot be readily

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identified. These cases are distinct from instances in which the animal owners relinquish ownership to the veterinary hospital to seek medical care; the animals must be registered and triaged as Good Samaritan animals upon admittance to the hospital. In addition to medical care and adoption policies, the OSU VMC Good Samaritan animal policy states that all Good Samaritan canines that died in the hospital are to be submitted for autopsy, whereas it is optional for felines.

Although these Good Samaritan animals are encountered regularly in a teaching hospital setting and provide an indirect epidemiological survey of morbidities and deaths in unattended animals, there has been a gap in knowledge on the major mortality and morbidity of Good Samaritan animals. Here, we describe the major morbidity and mortality in all Good Samaritan animals admitted to the OSU VMC and subsequently submitted for postmortem examination from 2014 to 2022.

Material and methods

Case identification

For this retrospective study, a cross-reference search of the OSU VMC medical records and the OSU CVM's Anatomic Pathology Services archive yielded postmortem examination reports, and associated medical records of 100 most recent Good Samaritan animals submitted for postmortem examination from 2014 to 2022. Keywords such as 'Good Sam' and 'Good Samaritan' were used to identify Good Samaritan animals. Of note, the patient cohort was limited to animals that either died or were euthanized at the OSU VMC and did not include other patients who were discharged, adopted, or relocated to local shelters.

Review of gross and histopathologic findings

Two pathologists reviewed one hundred postmortem examination reports and hematoxylin and eosin (H&E) slides from 59 cases. Causes of death were compiled as described in the original gross and histopathologic diagnosis, and other morbidities were confirmed by histopathology. Histopathology slides from 59 cases were reviewed blindly and compared to the initial diagnosis.

Review of medical records

Medical records of Good Samaritan animals were additionally reviewed to acquire missing clinical information such as presumed age, sex, and antemortem clinical signs.

Histopathology and imaging

H&E slides were processed following routine histology procedures. In brief, tissues from all samples were routinely processed for histopathology on a Leica Peloris 3 Tissue Processor (Leica Biosystems, Buffalo Grove, IL), embedded in paraffin, sectioned at an approximate thickness of 4–5 micrometers and batch stained with H&E on a Leica ST5020 automatic slide stainer (Leica Biosystems, Buffalo Grove, IL) using a routine and quality-controlled protocol overseen by a veterinary pathologist board certified by the American College of Veterinary Pathologists (ACVP) and the Comparative Pathology and Digital Imaging Shared Resources (CPDISR) Histology Laboratory Manager. Histopathology images were captured using the Olympus BX43 microscope, Olympus SC180 camera, and Olympus cellSens Entry software (version 2.1).

Rabies fluorescent antibody test

The rabies fluorescent antibody test (FA) was performed following the routine FA procedure. In brief, complete cross-sections of the cerebellum and brainstem were obtained and submitted to the Ohio Department of Health. Multiple 15 mm long impression smears of the cerebellum and brainstem were made on a slide, and the slides were dried at room temperature for 15–30 min, followed by acetone fixation for a minimum of 1 h to overnight fixation at 20°C. After the fixation, the slides were air dried at room temperature, and anti-rabies conjugate (Fujirubio Diagnostics, Inc. #800-090) was added by dispensing through a syringe fitted with a 0.45 um low protein-binding filter. Then, the slides were incubated at 37°C in a high-humidity chamber for 30 min. After staining, excess conjugates were removed with absorbent paper, and slides were briefly rinsed with phosphate-buffered saline (PBS) and immersed in PBS for 3 to 5 min twice. After removing excess liquid on the slide, the slides were mounted with a drop of 20% glycerol-Tris-buffered saline pH 9.0 onto coverslips. For test results, 40 fields at 200X magnification were visualized with fluorescent microscopy with positive and negative controls.

Descriptive statistics

Sex and age groups were compared in canine and feline patients using the Fisher's exact and chi-square tests in R studio (ver.4.3). A P-value less than .05 was considered statistically significant. Visual graphics were generated using ggplot2 and cowplot packages on R studio (ver. 4.3).

Results

Good Samaritan animal demographics

The cohort consisted of 100 animals, including 59 cats, 36 dogs, two raccoons, one squirrel, one bat, and one opossum. Among these, 85 animals were humanely euthanized, 11 had natural deaths, and four had unknown deaths. The sex was reported in 85 animals, including 44 males and 41 females (including seven female-spayed and five male-castrated animals). In 77 animals whose age was reported, the mean and median age were 2.61 years and 1 year, respectively (Table 1), with statistically significant enrichment in patients under the age of 2 (*P*-value: 7.97E-31, chi-square test). The feline cohort predominantly consisted of 55 domestic shorthair cats followed by two domestic medium hair cats and two domestic longhair cats. The canine cohort included 28 mixed breed dogs, five Pitbull terriers, one Chihuahua, one Dachshund, and one Rottweiler. The mean and median body condition scores recorded upon gross examination in 83 animals were 2.56/5 and 3/5. Most animals were identified and rescued in the Columbus Metropolitan area, within a 15-mile radius of the OSU VMC. One case was an exception; the animal was rescued in Dayton, OH, and was brought to the OSU VMC. The types of postmortem examinations performed were complete gross and histopathologic examinations (n = 59), gross examinations only (n = 24), and brain collection tests only for rabies (n = 17). In particular, gross examination-only cases were limited to patients in which gross findings provided sufficient clinical information to identify the major mortality and morbidity (i.e. trauma, hemoabdomen, and organ fractures), and these decisions were made on a case-by-case basis at the attending pathologists' discretion.

Cause of death and significant morbidities

In 59 cats, the most predominant cause of death or major morbidity requiring euthanasia was euthanasia for rabies test (n = 19, 32%), followed by trauma (n = 15, 25%) and unknown etiology (n = 9, 15%) (Fig. 1). Other less common diseases contributing to the clinical decline were infectious (n = 5, 8%), gastrointestinal (n = 2, 3%), and endocrine diseases (n = 2, 3%), and one case each of cardiac, renal, metabolic, vascular, toxic, neoplastic, and respiratory diseases. Among the 36 canine patients, trauma (n = 16, 44%) was the most common cause of death or clinical decline, followed by infectious diseases (n = 12, 33%) (Fig. 1). Other morbidities include neoplasia (n = 2, 6%), renal (n = 2, 6%), unknown (n = 2, 6%), metabolic (n = 1, 3%), and gastrointestinal (n = 1, 3%) etiologies. Two raccoons, a squirrel, and a bat were all humanely euthanized for rabies tests. The cause of death in an opossum was trauma.

Trauma

There were 16 dogs, 15 cats, and one opossum whose major morbidity and mortality were trauma; 16 dogs included three female, one female-spayed, 11 male, and one male-neutered animal, while 15 cats included seven female, one female-spayed, five male, and one male-neutered animal. The mean age in dogs and cats was 3.6 and 2.6 years, respectively. The opossum was male, and the age was not reported.

Among the 32 animals, 30 had acute blunt force trauma, and two had acute penetrating trauma; 28 cases had reported history (24 motor vehicle accidents, two dog bites, two penetrating trauma), and four had an unknown history. Intriguingly, most dogs (15/16) had motor vehicle accidents, and the other dog was also suspected of having had vehicular impacts. On the other hand, cats had various sources of trauma: motor vehicle accidents (8/15), unknown traumas (3/15), dog bites (2/15), and penetrating injuries (2/15). The opossum had had motor vehicle accident trauma.

Table 1. Reported sex and age of canine and feline patients

Groups	Canine	Feline	*P*
Sex			0.516
Male, intact	20	23	
Male, neutered	1	4	
Female, intact	16	25	
Female, spayed	1	6	
Age (year), (median, interquartile range)			
Male	2 (0.3–3)	2 (0.4–5)	
Female	0.8 (0.4–3)	3 (1–2)	
Age (year) group			< 0.0001
0–2, *n* (%)	18 (23.6)	31 (40.7)	
3–5, *n* (%)	7 (9.2)	9 (11.8)	
6–8, *n* (%)	2 (2.6)	2 (2.6)	
9–11, *n* (%)	1 (1.3)	3 (3.9)	
12–14, *n* (%)	0 (0)	2 (2.6)	
>15, *n* (%)	0 (0)	1 (1.3)	

Sex: Fisher's exact test / Age group: Chi-squared test. *P*-value of < 0.05 was considered significant.

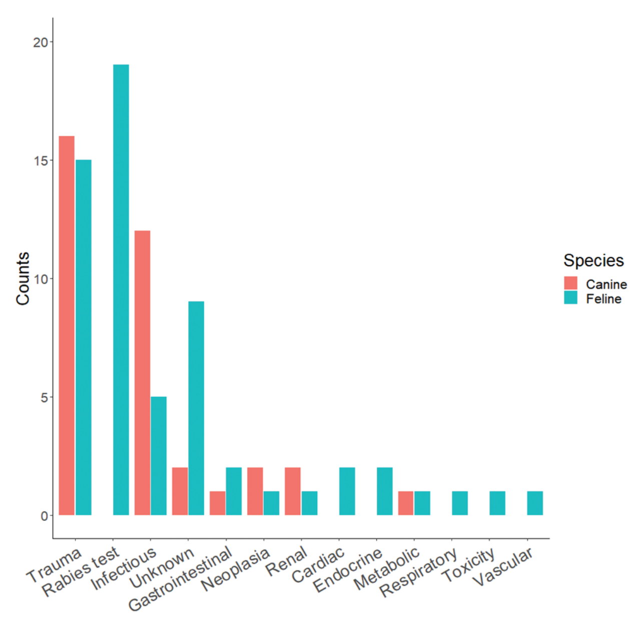

Fig. 1. Major mortality and morbidity in dogs and cats.

In animals with motor vehicle trauma, 15 dogs had 175 lesions, and eight cats had 51 lesions (average per animal: 11.6 lesions in dogs and 6.3 in cats). The most frequent trauma-associated lesion was skin laceration/contusion in cats and dogs (Fig. 2). Intramuscular hemorrhage and pelvic bone fractures were the second and third most frequent trauma-associated lesions in both species. Interestingly, appendicular bone fracture was common in dogs (n = 10) but rare in cats (n = 1). Overall, dogs tended to have more skin lacerations than cats (average per animal: 4.3 in dogs and 2.5 in cats). However, the average in other lesions per animal was similar in both species.

Two cats had acute penetrating trauma with a foreign object passing through the left globe and C7-T1 vertebra, respectively. The only opossum in this cohort had vehicular trauma resulting in a frontal bone and pelvic bone fracture and an inguinal hernia.

Rabies tests

Brain tissue from 51 animals (38 cats, 9 dogs, 2 raccoons, 1 bat, and 1 squirrel) was submitted to the Ohio Department of Health (ODH) for fluorescence antibody tests. 23 and 56% of canine and feline Good Samaritan animals were tested for rabies. From 2014 to 2022, the number of rabies test requests for Good Samaritan animals from the OSU accounted for 0 to 1.21% and 0 to 8.86% of annual rabies tests performed on dogs and cats in Franklin County, OH, respectively (Fig. 3).

Among the 51 tested animals, 23 animals, including 19 cats, two raccoons, one squirrel, and one bat, were euthanized specifically for rabies test submission (Fig. 3). The rationale for euthanasia and rabies test was as the following: history of biting caretakers (n = 9), precaution (n = 8), reported antemortem neurological signs (n = 3), vehicular trauma and possible neurological signs predisposing to such trauma (n = 2), and history of attack by dogs (n = 1) (Fig. 3). Importantly, all 51 animals had negative rabies results, and there have been zero positive rabies cases in dogs and cats in Franklin County, OH, within this period.

Infectious diseases

Seventeen animals, including 12 dogs and five cats, had infectious diseases as the leading cause of morbidity and

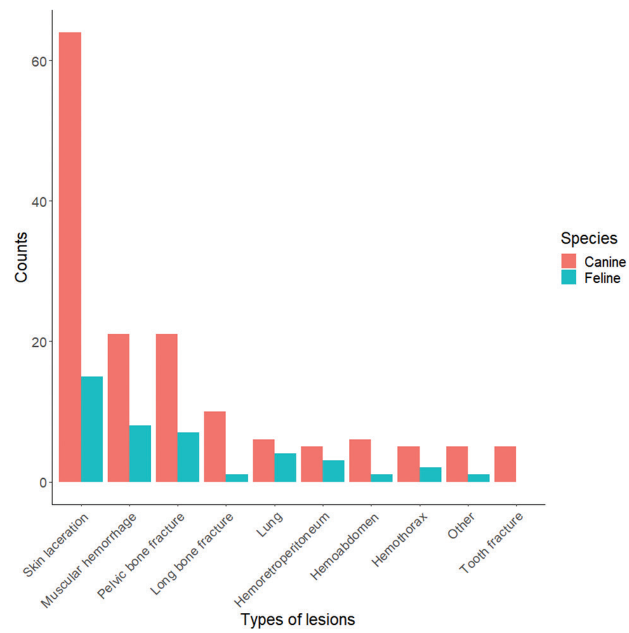

Fig. 2. Top 10 trauma lesions in dogs and cats.

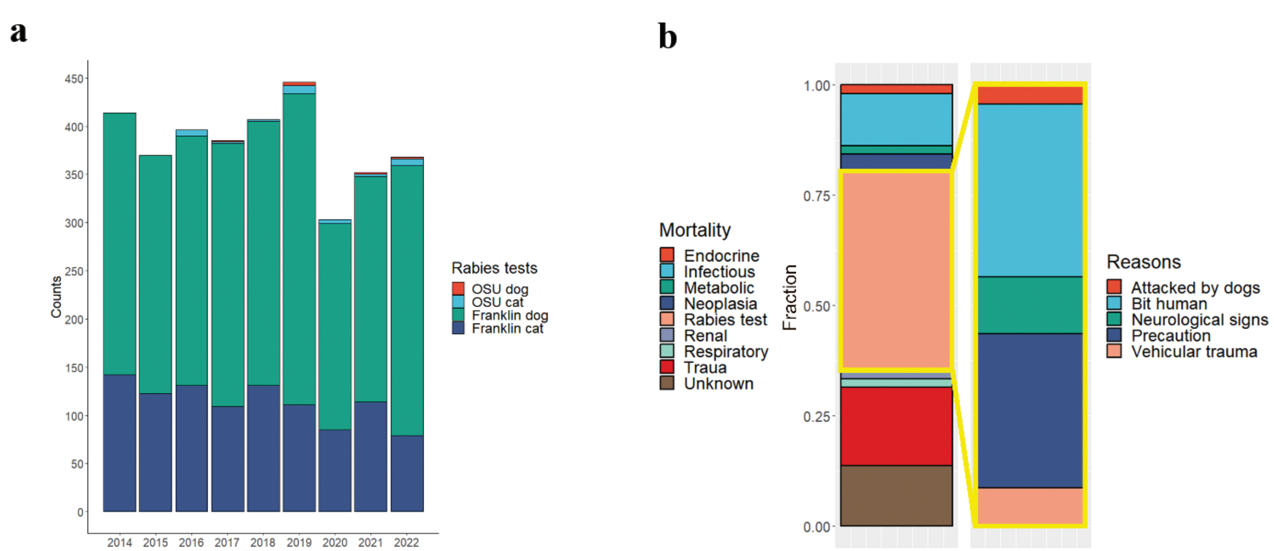

Fig. 3. Rabies test performed in Franklin County, Ohio. (a) Numbers of rabies tests performed in Franklin County and counts of Ohio submissions from 2014 to 2022. (b) Causes of rabies test submission in Good Samaritan animals (n = 51).

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mortality. A wide array of infectious agents was confirmed by histopathology, which includes viruses, parasites, bacteria, fungi, and mixed infections (parasite or virus and bacteria) (Supplemental Table 1).

In 12 dogs, the most prevalent infectious disease was parvoviral enteritis ($n = 6$) (Fig. 4, Supplemental Table 1). Additionally, gross and histopathologic examinations confirmed parasitic infestations such as fleas (*Ctenocephalides canis*), *Toxocara canis*, *Trichuris* spp., and an unspecified nematode. One canine patient had necrotizing and suppurative dermatitis and cellulitis of the right forelimb with intralesional coccobacilli, but the bacterial populations were not cultured to further characterize.

Only five cats had infectious diseases, which is significantly lower than in dogs (8.5% in cats vs. 33.3% in dogs). Two cats had bacterial infections: pyothorax with microscopically confirmed filamentous bacteria and septic meningoencephalomyelitis due to presumed *Staphylococcus* or *Streptococcus* spp. infection. Moreover, one case each of *Blastomyces dermatitidis* pneumonia (Fig. 4), Feline infectious peritonitis (Fig. 4), and non-suppurative encephalitis, presumably due to parasitic or viral infection, was confirmed on histopathology.

Other diseases

Seventeen animals, including six dogs and 11 cats, had other various causes of mortality and morbidities, including neoplasia ($n = 3$), gastrointestinal ($n = 3$), renal ($n = 3$), and endocrine diseases ($n = 2$) (Supplemental Table 2). A case of feline asthma with pathognomonic histopathologic lesions illustrates an excellent example of a histopathologic diagnosis that indicates the cause of clinical decline (Fig. 4, Supplemental Table 2).

Discussion

To the authors' knowledge, this is the first report to describe morbidity and mortality in stray animals admitted to and presented for postmortem examination

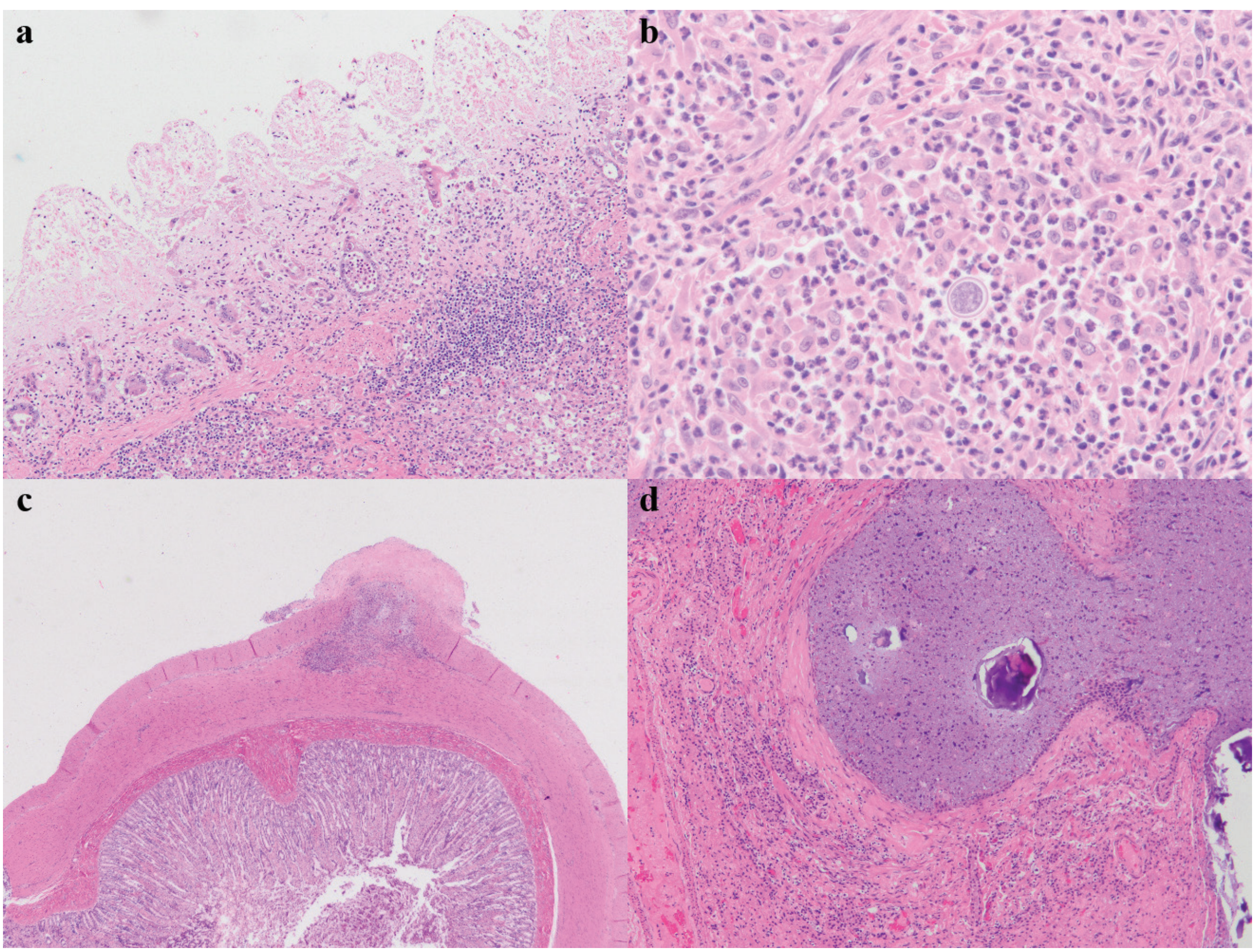

Fig. 4. Examples of pathognomonic histopathologic lesions of select diseases in dogs and cats. (a) Parvoviral enteritis in a dog showing multifocal severe crypt necrosis and crypt abscess (100X). (b) Blastomyces dermatitidis pneumonia with multifocal severe granulomatous and suppurative bronchointerstitial pneumonia with a fungal yeast (200X). (c) Feline infectious peritonitis characterized by multifocal severe granulomatous serositis and necrosis (40X). (d) Feline asthma with multifocal severe peribronchial glandular hyperplasia with smooth muscle hypertrophy and intrabronchial exudates and necrotic debris (100X).

at a single institution. The 100 animals in the Good Samaritan cohort were overrepresented in animals younger than 2 years old, and the majority of animals were cats and dogs.

Among over a thousand animals presented as Good Samaritan, a significant number of dogs and cats were either adopted, transferred to local shelters, or reunited with their owners. These were not included in the study. In line with the hospital's standard-operating procedure, animals that were severely injured or ill and required extensive or expensive therapy, those demonstrating uncontrollable suffering, or those displaying severe chronic illness were euthanized and then submitted for postmortem examination. The decision to euthanize was based on examinations performed by board-certified emergency and critical care specialists to ensure consistency in decision-making. Eventually, only 100 animals in the study cohort that had undergone postmortem examinations over 9 years were included in the present study.

Other than euthanasia for rabies tests, trauma accounted for the most predominant cause of euthanasia in this cohort. Within the trauma group, this cohort overrepresented younger and sexually intact dogs and cats, aligning with findings from previous literature.[4–6] Intriguingly, most dogs in this group had motor vehicle-associated trauma, while cats had different sources of trauma (vehicular vehicle trauma, penetrating trauma, and suspected dog bites).

Skin lacerations/contusions and pelvic bone fractures were most commonly associated with vehicular impacts in dogs and cats. Consistent with previous studies, long bone fractures were common in dogs (10/15) with motor vehicle trauma[7–9] but were less common in cats (1/8), reflecting inherent cross-species differences in the distribution of vehicular trauma.

In this cohort, rib fractures were seen in only three animals with vehicular trauma (2 dogs and one cat) and were less frequent than fractures of other bones nor other thoracic injuries (i.e. hemothorax and lung injuries), contrary to previously reported findings.[9,10] Such contrast may be attributed to the cohorts' enrichment in young adult patients, as previous reports suggest that young animals' ribs are more elastic and difficult to break by blunt force trauma.[11]

Another important aspect of this study is that the negative rabies test results of the cohort tightly correlated to the rabies status of all dogs and cats in Franklin County, with 0 positive cases from 2014 to 2022. As shown in Fig. 3, the rabies tests requested specifically for Good Samaritan animals accounted for as high as 1.2 and 8.9% of all rabies tests performed in dogs and cats annually in Franklin County, OH. Our study cohort represents a sizeable fraction of all tested animals to monitor the rabies epidemiology in this period. As Leung and Davis alluded, monitoring of rabies status in stray animals provides an essential tool for surveillance of herd immunity against rabies for both stray and companion dogs.[12]

From 2017 to 2023, the majority of rabies cases in Ohio have been reported in bats and raccoons and range from 37 to 55 positive cases annually.[13] Notably, there have been two positive cases in cats in 2017 and 2022, a single case in a horse in 2023, and no positive cases in dogs in the same period.[13,14] This low incidence has been primarily due to the Oral Rabies Vaccination (ORV) Campaign conducted by the Ohio Department of Health in conjunction with local agencies and the USDA Animal and Plant Health Inspection Service Wildlife Services.[15–18] Following the spread of the raccoon rabies variant to the northeastern regions of Ohio in 1996,[15,16] most positive cases are still found within the region, including a case in a cat in 2022.[13] The Ohio ORV campaign targeting the wildlife hosts[15–18] is focused in Northeast Ohio and is part of a larger Appalachian Ridge Rabies vaccination zone.[15,17] These efforts have significantly reduced and attained the rabies outbreaks to the Northeastern Ohio and Ohio-Pennsylvania state borders and resulted in low counts of positive cases in central Ohio.[16,17]

In contrast, the feline rabies case in 2017 occurred in Summit County, OH, which was previously a rabies-free area. Detailed public health investigations and molecular phylogenetics analyses revealed that the cat harbored a North Carolina raccoon variant and was infected before the owners moved to Ohio.[14] As of May 2018, following six months of quarantine in all exposed cats, no additional cases were reported regarding this strain.[14] Although only a single incident, this case reiterates the importance of human intervention in the spread of rabies, in addition to its natural expansion.

On the other hand, our Good Samaritan animal cohort was mainly identified and rescued within the Columbus metropolitan area, and our cohort represents the stray animal populations in central Ohio. The geographical distance from the ORV and enhanced surveillance zones likely contributed to the overall low incidence of rabies in stray animals in Franklin County, which is also reflected in our cohort.

Although all the rabies tests were negative in the present study, these animals were tested for rabies primarily based on underlying reasons, as illustrated in Fig. 3B. Notably, rabies tests were requested for the following reasons: 1) the presence of neurological symptoms upon presentation, 2) incidents of the patient biting hospital staff or rescuer during handling, coupled with an unknown vaccination history, and 3) suspicion of rabies or other neurological diseases possibly contributing to vehicular injuries, or 4) precaution at clinicians' discretion. In most cases, the decision to request a rabies test was made either by critical care specialists or by board-certified pathologists,

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following the hospital policy, which prioritizes the safety of the hospital staff and trainees and minimizes zoonotic risks. In the future, expanding resources from the community to provide isolated observation for stray animals showing neurological symptoms could potentially reduce the number of rabies tests performed.

The novelty of this study is an unbiased description of infectious epidemiology in stray animals. While most previous literature investigated the prevalence of a single or select infectious etiologies in stray/shelter animals,[19–25] the infectious etiologies described in this cohort encompass viruses, bacteria, ecto/endoparasites, fungi, and co-infections. This unbiased approach helped reveal the prevalence of the most predominant infectious diseases in unattended animal populations. Although this cohort does not show any major zoonotic diseases, infectious epidemiology of stray animals also provides an excellent tool for assessing potential zoonotic threats. These are active research areas in parasitological and protozoal diseases.[26–33] Importantly, the decisions regarding infectious disease tests were made by attending pathologists within the limited scope afforded by the nature of the postmortem examination. Therefore, multiple subclinical co-infections could have occurred in individual animals, remaining undiagnosed among those presented here.

One limitation of this retrospective study is the exclusion of live and discharged patients. Our initial unfiltered search through the medical records has yielded over 1,000 entries from 2014 to 2022. However, as healthy Good Samaritan animals are encouraged to be adopted or transferred to local shelters, their medical records are largely incomplete. Moreover, tracking adopted Good Samaritan animals was especially challenging. While all Good Samaritan animals are named 'Good Sam' on the medical records system, they are given pet names upon adoption and are no longer searchable in the database.

Authors acknowledge that focusing on animals submitted for postmortem examination added an inherent bias toward selecting for more critically ill and life-threatening cases. For example, multiple studies have reported good survival and high discharge rates in penetrating and blunt force traumas in dogs and cats.[34–37] The chances of recovery and discharge can be as high as 89.5% in canine blunt-force trauma patients.[35] Similarly, feline trauma patients showed 99.0 and 73.5% of discharge with and without surgical interventions.[37] Ultimately, animals in this cohort represent a fraction of Good Samaritan animal patients that are presented with severe clinical conditions and tend to carry more severe lesions/diseases.

At the same time, this approach had some added benefits, such as standardized and detailed macroscopic and microscopic descriptions of various lesions on the gross and pathology reports and more in-depth clinical history provided in the postmortem examination request. Therefore, narrowing down to those submitted for postmortem examination enabled a more detailed analysis, including histopathological confirmation of infectious agents.

An important next step will be a prospective study of the epidemiology of Good Samaritan animals. Ideally, in a prospective study, patients will be enrolled with a standardized history taking. For this current cohort, many desirable features of clinical history, such as Acute Triage Trauma Score[38] in trauma patients or Feline leukemia virus and Feline immunodeficiency virus (FeLV/FIV) status in stray cats, were inconsistently recorded. Hence, these features were not included in the analysis. In the future, collaborations with local shelters will provide a more comprehensive overview of the morbidity and mortality of stray animals.

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Author credit statement

Drs. Jeong, Premanandan, and Her were responsible for study conception and design. Dr. Jeong was responsible for data collection. Drs. Jeong, Premanandan, and Her were responsible for analysis and interpretation of the results. Dr. Jeong was responsible for draft manuscript generation. Drs. Jeong, Premanandan, and Her reviewed and approved the manuscript.

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