REPORTED ANIMAL EXPOSURES AND RABIES TESTING IN ALLEGHENY COUNTY, PENNSYLVANIA 2013-2014

by

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ABSTRACT

Rabies prevention is a local, national, and global public health concern. As rabies is essentially fatal once symptoms develop, the prevention and proper treatment of high-risk animal exposures (e.g. bites, scratches) is of paramount importance. Therefore, healthcare practitioners in Allegheny County are required to report all animal bites within 24 hours to the Allegheny County Health Department (ACHD) Infectious Diseases (ID) Program. Animal exposure information collected on an Animal Bite Report (ABR) form and results from rabies testing at the ACHD Public Health Lab are used to assess the risk of rabies and advise victims on proper care. The objective of this study is to summarize information about animal exposures reported to ID from January 1, 2013 to December 31, 2014 and results from rabies testing conducted during the same time period. Information from ABR forms and rabies testing lab slips for incidents occurring from January 1, 2013 to December 31, 2014 was extracted from a database and analyzed using Microsoft Excel 2010. Records from the ACHD Public Health Lab were reviewed for rabies testing information. During the study period, 3,693 animal exposures were reported to ID. The highest number of exposures occurred during the summer months. Over half (58.4%) of all incidents involved female victims. All age groups were affected but most victims (89.5%) were younger than 65: 20.0% of victims were 0-14 years old, 32.4% were 15-34 years old, and 24.5% were 35-54 years old. The majority of incidents involved pets (76.4%) with

68.3% of incidents involving dogs and 24.4% of incidents involving cats. The ACHD Public Health Lab tested 1,553 animals during the study period; 34 from Allegheny County tested positive for rabies. The majority of rabies positive animals were bats (50.0%) and raccoons (29.4%). This information can be used in the development of public health messages specific to Allegheny County, which supports the public health significance of this study. Several potential messages and interventions are described as well as suggested improvements for the reporting system.

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PREFACE

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1.0 INTRODUCTION

Animal bites are a reportable condition in Allegheny County, Pennsylvania. Indeed, all healthcare professionals are required to report cases of animal bites to the Allegheny County Health Department (ACHD) Infectious Diseases (ID) Program within 24 hours. In addition to concerns regarding proper care of injuries that result from animal bites, the primary concern of reporting and following up on animal bites is to assess for any possible risk for rabies and advise on proper treatment of a possible rabies exposure. As rabies is essentially fatal once symptoms develop, the best way to prevent rabies is to prevent and properly treat exposures.

1.1 ANIMAL BITES

1.1.1 Animal bite epidemiology

Animal bites are a significant source of morbidity in the United States. According to the Centers for Disease Control and Prevention's (CDC) Web-based Injury Statistics Query and Reporting System there were 346,925 non-fatal injuries due to dog bites reported to hospital emergency departments in 2013, with an age-adjusted rate of 113.22 bites per 100,000 population ("Overall Dog Bite Nonfatal Injuries and Rates per 100,000," n.d.). Dog bites are among the top 10 leading causes of nonfatal injuries in children ages five to nine ("National Estimates of the 10 Leading

Causes of Nonfatal Injuries Treated in Hospital Emergency Departments, United States – 2013," 2013). Overall, non-Hispanic whites had a higher rate of non-fatal dog bite injuries compared to blacks and Hispanics ("Overall Dog Bite Nonfatal Injuries and Rates per 100,000," n.d.). In a study conducted by Gilchrist, Sacks, White, and Kresnow from 2001 to 2003, it was estimated that about 4,521,300 people, or about 1.5% of the population, were bitten by dogs each year in the United States (2008). According to this study, it was estimated that medical treatment was sought for 885,000 (19.6%) of these bites (Gilchrist, Sacks, White, & Kresnow, 2008). Duperrex, Blackhall, Burri, and Jeannot estimated that the rate of medical treatment for dog bites is between 263 and 300 per 100,000 population and that the rate of emergency department attendance is between 73 and 300 per 100,000 population (Duperrex, Blackhall, Burri, & Jeannot, 2009). As only a small proportion of victims of dog bites seek medical treatment, it is likely that dog bites are underreported (Gilchrist et al., 2008; Sacks, Kresnow, & Houston, 1996). The majority of dog bites occur during the summer months; information regarding locations where injuries from dog bites occur most frequently is limited (Duperrex et al., 2009; Overall & Love, 2001).

Duperrex et al. estimated the rate of hospitalization for dog bites to be 2.6 to 7.7 per 100,000 population and the rate of death from dog bites to be 0.004 to 0.05 per 100,000 population (2009). About 20 to 35 deaths due to dog bites occur each year (Aziz et al., 2015). Seventy percent of dog bite-related fatalities occur in children under the age of 10 (Overall & Love, 2001). Sacks, Sinclair, Gilchrist, Golab and Lockwood reviewed dog bite-related fatalities over a period of 20 years and estimated that fatal dog bites only account for 0.00001% of all dog bite incidents annually (Sacks, Sinclair, Gilchrist, Golab, & Lockwood, 2000).

Cat bites account for a minority of animal bites but are also of public health concern (Aziz et al., 2015). Each year in the United States, there are about 400,000 cat bites and about 66,000 visits to hospital emergency departments for treatment of cat bites (World Health Organization [WHO], 2013). Cat bites are more likely to occur in women and those over the age of 75 (Aziz et al., 2015). Estimated mortality due to cat bites is not well-documented in the literature.

1.1.2 Complications of animal bites

Animal bites can result in local and/or systemic infections, hospitalizations and, rarely, death but may also cause lasting psychological issues or disfigurement (Overall & Love, 2001.). Transmission of rabies is another major health concern for victims of animal bites because rabies is essentially fatal once symptoms develop. Considerations of rabies transmission and control will be discussed in depth in the following sections.

1.1.3 Economic implications

Overall and Love estimated the total direct medical care cost of dog bites to be $164.9 million dollars in 2001 based on costs of emergency services and hospitalization (Overall & Love, 2001). Other cost considerations include insurance claims, lost income and productivity for victims, and costs associated with destruction of the offending animal (Overall & Love, 2001). More recent estimates of direct medical care costs for dog and cat bites are not well-documented.

1.2 RABIES

1.2.1 Rabies virus structure

The rabies virus belongs to the genus Lyssavirus of the family Rhabdoviridae of the order Mononegavirales (CDC, n.d.b). It is characterized by a distinct “bullet” shape and has a non-segmented, negative-stranded RNA genome enclosed in a viral envelope (CDC, n.d.b). This approximately 12 kb genome encodes five proteins: nucleoprotein, phosphoprotein, matrix protein, glycoprotein, and polymerase. With the exception of the polymerase, these proteins make up the major structural components of the virus, a helical ribonucleoprotein core and an envelope. The polymerase is integral to replication of the viral genome as well as transcription of messenger RNAs for the production of viral proteins (CDC, n.d.b).

1.2.2 Reservoirs

Terrestrial hosts for the rabies virus in the United States include bats, raccoons, skunks, foxes, and coyotes; the predominant rabies virus variant in the eastern United States, including Pennsylvania, is the raccoon variant (CDC, n.d.c). It is important to note, however, that any mammal is susceptible to rabies virus infection. Dogs, for example, are an important reservoir in many other countries throughout the world where rabies is endemic (WHO, n.d.).

1.2.3 Rabies in humans

Disease in humans results from exposure to the rabies virus. Exposure may occur from the bite or scratch of a rabid animal or through contact between mucous membranes or broken skin with saliva or brain matter from a rabid animal. The virus migrates to the central nervous system and eventually the brain by way of the host's neurons where it establishes an infection and causes encephalomyelitis and ultimately death if untreated before symptoms develop (Fooks et al., n.d.).

Two forms of clinical disease manifest in humans: furious (classic) rabies and paralytic rabies (Hemachudha, Ugolini, Wacharapluesadee, Sungkarat, Shuangshoti, & Laothamatas, 2013). Furious rabies caused by dog rabies virus variants is characterized by changes in "consciousness and … mental status, phobic or inspiratory spasms, and autonomic stimulation signs" (Hemachudha et al., 2013). Paralytic rabies caused by dog rabies virus variants "resembles Guillain-Barré syndrome" with additional characteristics of "coma, myoedema, and bladder incontinence" (Hemachudha et al., 2013). Rabies caused by bat rabies virus variants has additional distinguishing features (Hemachudha et al., 2013).

The average incubation period for rabies is between one and two months but can be as extreme as weeks to years (Hemachudha et al., 2013). By the time symptoms develop, infection is already widely established throughout the central nervous system (Hemachudha et al., 2013). Treatment of symptomatic patients is usually unsuccessful and infection usually progresses to coma and death (Hemachudha et al., 2013). Four patients are reported in the literature to have recovered from rabies; "[t]wo received coma induction therapy, one [received] standard intensive care support, and [the other] had presumptive abortive infection and did not receive any intensive support" (Hemachudha et al., 2013). To date, no single standard treatment for rabies has been proven effective for all cases (Hemachudha et al., 2013).

1.2.4 Rabies epidemiology

Rabies is a global public health concern. Disease has been reported on all continents with the exception of Antarctica but most cases occur in Africa and Asia where the disease is endemic. An estimated 59,000 human deaths occur due to rabies each year, but even this number most likely underestimates the true global burden of disease (Fooks et al., n.d.).

Although human rabies cases cause thousands of deaths worldwide each year, cases of human rabies are rare in the United States, due in large part to vaccination programs for dogs, cats, and raccoons as well as the availability and use of effective human rabies immunoglobulin (HRIG) and rabies vaccinations (CDC, n.d.d). The last reported case of human rabies in the United States occurred in 2013 and was fatal (Lankester, Hampson, Lembo, Palmer, Taylor, & Cleaveland, 2014). Prior to that, four cases were reported in 2011. Only one case in California survived; cases in Wisconsin, New York, and New Jersey died (CDC, n.d.d). Of the 2011 cases, two cases resulted from a bite exposure from a dog while in the remaining two cases the type of exposure was unknown. For one of these unknown exposures, the type of rabies virus variant was a bat rabies virus variant (CDC, n.d.d).

1.2.5 Rabies prevention strategies

As rabies is essentially fatal once symptoms develop, early recognition and proper treatment of exposures are of the utmost importance. Prevention methods include avoiding possible exposures and vaccinating humans and animals.

Exposure to wild animals is the most likely method of exposure to rabies, so avoiding wild animals is one way to prevent rabies. Similarly, utilizing proper personal protective

equipment while handling animal specimens is another way to prevent exposure to the rabies virus.

Legislation regarding vaccination of domestic animals varies from state to state. According to Pennsylvania Department of Agriculture regulations, dogs and cats must be vaccinated within four weeks of the animal reaching the age of three months ("Rabies Prevention and Control in Domestic Animals and Wildlife Act," 1986). Dogs and cats are then required to be given routine booster vaccinations in accordance with vaccine manufacturer instructions ("Rabies Prevention and Control in Domestic Animals and Wildlife Act," 1986). Routine vaccination of dogs and cats prevents development of the disease in these animals. Upon vaccination, a certificate of vaccination will be issued for the animal; however, according to the Rabies Prevention and Control in Domestic Animals and Wildlife Act, information on vaccination status cannot be used to license animals or to tax owners of animals (1986). Enforcement of the Rabies Prevention and Control in Domestic Animals and Wildlife Act merely mandates that proof of rabies vaccination must be provided upon the request of a police officer, the State dog warden, or a designated municipal animal control officer (1986). The owners of dogs and cats that are either not vaccinated or not exempt from vaccination are subject to a citation and fine ("Rabies Prevention and Control in Domestic Animals and Wildlife Act," 1986).

Two types of vaccination strategies exist for prevention of rabies in humans. Pre-exposure prophylaxis (PrEP) is recommended for those individuals who frequently come in contact with animals who may be infected with rabies. Post-exposure prophylaxis (PEP) is recommended for all individuals exposed to the rabies virus. If an exposure occurs in previously vaccinated individuals, it is still recommended that they receive booster doses of rabies vaccine

after an exposure. The Advisory Committee on Immunization Practices (ACIP) updated recommendations in 2010 to reduce the previous five-dose vaccine series to a four-dose vaccine series to prevent human rabies (Rupprecht, et al., 2010). The Pennsylvania Department of Health offers comprehensive guidance to health professionals regarding under what circumstances it is recommended to administer PEP based on the ACIP guidelines.

1.2.6 Economic implications

The United States spends more than $300 million each year on rabies detection, prevention, and control (CDC, n.d.a). These costs are associated with vaccination programs for domestic animals, animal control programs, rabies laboratory testing facilities, and medical costs. More accurate estimates of expenditures are not available, and even the exact number of courses of PEP given each year is unknown, although estimated to be around 40,000 (CDC, 2011a). The cost of receiving PEP varies but is usually over $1,000 (CDC, 2011a). In 1998, Kreindel, McGuill, Meltzer, Rupprecht, and DeMaria estimated the median cost per dose of the human diploid cell vaccine (HDCV) against rabies to be $221 and the median cost per 6.3 mL dose of HRIG (dose is determined based on body weight) to be $541 (Kreindel, McGuill, Meltzer, Rupprecht, & DeMaria, 1998). Therefore, for a complete PEP course that includes one dose of HRIG and the four doses of HDCV recommended by the ACIP in 2010, the estimated median cost of PEP alone would be $1,425. Dhankhar, Vaidya, Fishbien, and Meltzer used year-adjusted estimates to estimate the cost of PEP in 2004. Taking into account a four dose vaccine series and a single, 6.3 mL dose of HRIG, the cost would have been estimated to be $2,005 in 2004 (Dhankhar, Vaidya, Fishbien, & Meltzer, 2008). Dhankhar et al. estimated the average total cost of one course of PEP to be $4,042, taking into account direct medical costs as well indirect cost

based on Kreindel et al.'s estimates (Dhankhar et al., 2008; Kreindel et al., 1998). However, it is important to consider that these estimates are in 2004 dollars and are based on the recommended five dose vaccine series at the time.

Cost-effectiveness of PEP is a function of the risk of contracting rabies from a given exposure, the value of life, and the cost of rabies PEP (Dhankhar et al., 2008). Because virtually all known exposures are treated with PEP, it is difficult to accurately estimate the level of risk associated with different types of exposures. Vaidya et al. used the Delphi technique to estimate the risk of rabies transmission to humans for several situations (Vaidya et al., 2010). A panel of experts estimated the median risk of rabies transmission after a bite from a skunk, bat, cat and dog to be 5%, 0.1%, 0.1%, and 0.001%, respectively (Vaidya et al., 2010). A non-bite exposure (i.e. general handling or contact with intact skin) from a dog, cat, or human with rabies was estimated to have a risk of less than 0.0001% (Vaidya et al., 2010). The expert panel recommended PEP in all scenarios involving a bite exposure, but not for scenarios involving a non-bite exposure (Vaidya et al., 2010). Dhankhar et al. used the estimates of risk described in the Vaidya study to estimate cost-effectiveness of PEP (Dhankhar et al., 2008). Dhankhar et al. concluded that it is always cost saving to administer PEP to a patient that has been bitten by an animal that tested positive for rabies (Dhankhar et al., 2008). Similarly, on average, cost savings were associated with some exposures to vector species that were not available for testing, namely skunks (Dhankhar et al., 2008). Cost savings were associated with bat bites and cat bites if assumptions were made for the most cost effective model (Dhankhar et al., 2008). On average, costs per life saved were associated with administering PEP in all events of non-bite (i.e. lick on intact skin, contact with a human rabies patient) exposures as well as dog, cat, and bat bite exposures (Dhankhar et al., 2008). Dhankhar et al. concluded that for the range of costs and risk

of rabies examined in their study, if the risk of an individual developing rabies is greater than 0.7%, then administering PEP is cost saving (2008). It is important to note that these estimates are not exact and will vary greatly based on the risk of rabies transmission in each situation as well as what value is placed on lost human life in the model being used to study cost-effectiveness (Dhankhar et al., 2008).

2.0 PURPOSE

The purpose of this project is to summarize information on animal exposures reported to ACHD from January 1, 2013 to December 31, 2014 and to report results of rabies testing conducted during the same time period. This information will be used to describe the distribution of animal exposures in Allegheny County as well as the prevalence of rabies among animals tested in Allegheny County by the ACHD Public Health Lab. Additionally, the results can inform potential interventions aimed at preventing animal exposures, especially exposures involving animals at high-risk for rabies. Rabies testing results from the same time period will also be described in order to identify the types of animals that might pose the greatest risk for rabies exposure in Allegheny County. The process of utilizing these data sources and analyzing the results will also inform suggestions for improving the reporting system.

3.0 MATERIALS AND METHODS

This study was reviewed and approved as exempt from human subject regulations by the Institutional Review Board at the University of Pittsburgh. Victim, owner, animal, and bite incident information was collected from a database maintained by ACHD. Rabies test results for animals submitted to the ACHD Public Health Lab were collected from records maintained by the ACHD Public Health Lab. Information collected from these sources was analyzed for 2013 to 2014.

3.1 DATA COLLECTION

An overview of the animal exposure reporting system at ACHD is provided in Figure 1. Animal Bite Report (ABR) forms were completed by healthcare professionals caring for victims, police or animal control officers responding to an animal exposure incident, or individual victims or owners. ABR forms were then submitted to the ACHD ID Program. If the incident was reported over the phone, ID staff completed the form.

Additional information regarding the incident was collected via follow-up telephone calls to victims and owners by ID staff. Information necessary to complete the ABR form may also have been solicited from police or animal control officers, veterinary offices, and medical facilities. Current rabies vaccination status of the animal, usually requested of the owner of the

animal involved, may also have been confirmed by contacting the veterinarian for the animal. Vaccination status of the animal including date and expiration of last rabies shot may not be confirmed for every case due to time constraints. If the victim and/or owner could not be reached via telephone, a letter was sent to the individual notifying him/her that the health department is aware that an animal bite occurred and that more information is needed. Collected information was entered into a database using the Oracle database system.

Upon submission of an animal for rabies testing at the ACHD Public Health Lab, information including the species of animal, the means of death, the date of death, and the rabies test result was recorded on a lab slip. Copies of lab slips for animals involved in exposures that were submitted for testing were submitted to ID to include with the appropriate ABR form. Records of rabies testing conducted at the ACHD Public Health Lab during the study period were obtained from the Virology Supervisor.

3.2 DESCRIPTION OF DATA COLLECTED

Information collected from the victim included the following: contact information (home, cell, and work phone numbers and home address), age, sex, address where the bite or exposure occurred including county, the date and time of the bite or exposure, anatomical location of the bite or exposure, the type of exposure, the name of physician and hospital consulted, the treatment provided at the healthcare facility, and a description of the incident. The victim also may provide contact information for the owner of the animal involved as well as a description of the animal (species, breed, and animal type). The animal involved may be a pet or it may be a

feral, stray, wild, or unknown animal. In the event that the animal is not a pet, most of the information about the animal involved comes from the victim of the bite or exposure.

Information collected from the owner of the animal included the following: owner contact information (home, cell, and work phone numbers and home address), the species and breed of the animal, whether or not the animal is available for observation, the current location of the animal, whether or not the animal has ever had a rabies vaccination, the date of the last rabies vaccination, the expiration date of the animal's last rabies vaccination, the name and phone number of the animal's veterinarian, and whether or not the animal is exhibiting any neurologic symptoms that may indicate infection with rabies.

Additional information collected included the identity, agency, and phone number for whoever reported the incident; the identity, agency, and phone number for the individual who completed the report; and the name, facility, and phone number for any police or animal control officers involved. ACHD ID staff completed sections on the ABR form that indicate whether or not the animal was up to date for rabies vaccination, whether the animal was tested for rabies, whether the animal had rabies, whether a quarantine notice was given for the animal, and the duration of the quarantine.

Information collected on animals submitted for rabies testing included the species of animal, the means of death, the date of death, and the rabies test result. Each animal was assigned a reference number at the time of submission for the purposes of recordkeeping.

3.3 DATA MANAGEMENT

All data collected on the ABR forms and on lab slips from the ACHD Public Health Lab was entered into a database using the Oracle database system. Data from incidents reported between January 1, 2013 and December 31, 2014 were downloaded from the database into Microsoft Excel where the dataset was censored for duplicate entries, incidents occurring outside of the period of study, and non-exposures. Lab slip entries where an exposure was not noted were excluded from the dataset. Identifiers were removed from the dataset prior to analysis.

3.4 DATA ANALYSIS

Data was analyzed using Microsoft Excel 2010. Frequencies were calculated on basic victim and incident characteristics (victim age, victim sex, month when incident occurred, type and species of animal involved). Proportions for victim sex and age were calculated using the number of reports where the indicator was reported as the denominator. Proportions for animal type and species were calculated using the total number of reported exposures as the denominator. Proportions for behavioral descriptions associated with exposures, exposure location, exposure type, and medical treatment received were calculated using the total number of reported exposures as the denominator.

Age ranges were defined based on common age associations and standard practices in the field. Age groups were generally defined in 10 year increments using mid-decades as limits. The 0 to 4 age group was defined as such because individuals in this age group may exhibit different epidemiology and behaviors in the case of animal exposures (Overall & Love, 2001). Children

ages 0 to 4 were defined as young children and school-age children were defined as being between the ages of 5 and 14. Adolescents and young adults were defined as being between the ages of 15 and 24. Adults were defined as being between the ages of 25 and 64 and older adults were defined as being older than 65. Rates for age and sex were determined using 2010 census data for Allegheny County ("2010 Demographic Profile Data," 2010).

For analysis of exposures by location, upper extremity exposure was defined as an exposure to the shoulder, arm, forearm, wrist, or hand. Lower extremity exposure was defined as an exposure to the hip, thigh, leg, ankle, or foot. Trunk exposure was defined as any part of the body that this not included as a lower extremity, upper extremity, or the face, head, or neck.

For analysis of PEP initiations, the number of animals not available for observation was calculated as sum of animals reported as not available for observation and animals with reported "Unknown" availability for observation, as advising for PEP would be the same in either instance. That is, if an animal is not available for observation and was not sent for testing, PEP is recommended as the health of the animal cannot be verified. It is important to note that for some animals, the reason the animal was not available for observation was because the animal had been euthanized and was submitted for rabies testing.

4.0 RESULTS

A total of 3,693 animal exposures (defined as a bite, scratch, or other type of exposure) were reported to ACHD between January 1, 2013 and December 31, 2014. The ACHD Public Health Lab received 1,553 animals for testing, 1,465 of which were from Allegheny County. Rabies tests were conducted for 1,445 animals received for testing.

4.1 DISTRIBUTION OF ANIMAL EXPOSURES

Between January 1, 2013 and December 31, 2014 there were a total of 3,693 animal exposures reported to ACHD ID. The distribution of exposures by month for each year is symmetrical with the summer months of June, July, and August having the highest number of exposures for each respective year (Figure 2). Generally, each month in 2014 had a higher number of reported exposures than each month in 2013 (Figure 2).

All age groups were represented in exposures with the majority (89.5%) of exposures occurring in those individuals under the age of 65 (Figure 3). The 25 to 34 year old age group had the highest exposure rate averaged over the two years of the study period (two-year average exposure rate) at 19.1 exposures per 10,000 population. This age group also had the highest number of reported exposures (n=603; 18.0% of total exposures). School-age children ages 5 to 14 and young children ages 0 to 4 also had relatively high exposure rates (18.1 exposures per

10,000 population and 15.1 exposures per 10,000 population, respectively). A total of 480 exposures (14.3% of total exposures) were reported for the 5 to 14 age group and 192 exposures (5.7% of total exposures) were reported for the 0 to 4 age group. A total of 483 exposures (14.4% of total exposures) were reported in the 15 to 24 age group; the two-year average exposure rate for this age group was 14.3 exposures per 10,000 population. Among adults ages 25 to 64, 1,851 exposures (55.1% of total exposures) were reported over the period of study for a two-year average exposure rate of 14.2 exposures per 10,000 population. A total of 351 exposures (10.5% of total exposures) were reported for older adults over the age of 65; the two-year average exposure rate for this age group was 8.6 exposures per 10,000 population.

Stratifying by age group confirmed that the number of reported animal exposures is generally higher during the spring and summer compared to fall and winter months across all age groups (Figure 4). Quarter 3 generally had the highest number of reported exposures for all age groups.

The majority (58.4%) of victims were female and females had a two-year average exposure rate of 15.9 exposures per 10,000 population (data not shown). Males had a two-year average exposure rate of 12.4 exposures per 10,000 population (data not shown).

4.2 ANIMALS INVOLVED IN EXPOSURES

There were 23 different species of animals involved in animal exposures during the study period (Table 1). Domestic animals (i.e. dogs and cats) accounted for 92.7% of animals involved in animal exposures while wild animals considered to be at high-risk for rabies accounted for 3.5% of reported exposures (Table 1). Low-risk wild animals accounted for 0.4% of reported

exposures (Table 1). Dogs accounted for the highest proportion of domestic animals in reported animal exposures (68.3%) followed by cats (24.4%) (Table 1). Bats accounted for the highest proportion of high-risk wild exposures (2.4%) followed by raccoons (0.7%) (Table 1). Squirrels accounted for the highest proportion of low-risk wild exposures (0.2%) (Table 1). A variety of other animals were reported as being involved in an exposure, including animals such as birds and reptiles that are not considered to pose any risk of rabies as they are not mammals (Table 1).

The majority (76.4%) of animal exposures involved pets (Figure 5). Stray, feral, and wild animals accounted for 11.7% of reported animal exposures. Generally, exposures to all animal types and species increased in quarter 3 when the majority of animal exposures occurred (data not shown). Reported exposures where the animal type was unknown or missing accounted for 11.9% of exposures (n=440).

Dogs were involved in 2,522 animal exposures in 2013 to 2014 (68.3% of reported animal exposures). Breed information was recorded for 72.7% of exposures to dogs; the top 25 dog breeds involved in reported animal exposures are displayed in Figure 6. Overall, 52 different dog breeds were reported. Pitbulls were reported most frequently (n=400; 15.9% of dog exposures) followed by mixed breeds (n=386; 15.3% of dog exposures) and German Shepherds (n=165; 6.5% of dog exposures). Breeds included in the “Other” category included Australian Cattle Dog, Belgian Malinois, and Bloodhound. Breed information was missing for 461 reported exposures. Breed information for cats was reported in 20.2% of cases (data not shown). Domestic short hair was the most frequently reported cat breed (n=142; 15.7% of cat reported exposures). As the total number of dogs and cats of each breed in Allegheny County is not available, breed-specific rates cannot be calculated and conclusions regarding breed and exposure rate cannot be made.

Of all dogs involved in exposures, 64% (n=1,626) had a reported previous vaccination against rabies; only 53% of cats involved in exposures (n=1,626) had a reported previous vaccination against rabies (Figure 7). A higher percentage of cats compared to dogs were known to not be vaccinated against rabies (Figure 7). Especially for exposures to cats, there was a significant proportion of reports where previous rabies vaccination history was unknown. The proportion of cases where vaccination status was not reported were similar between dogs and cats. It is important to note that vaccination history was obtained by oral report from the owner and was not always confirmed with vaccination records from a veterinary professional. Additionally, pets who received a rabies vaccination in the past may currently be out of date with their rabies vaccine.

4.3 BEHAVIORS ASSOCIATED WITH ANIMAL EXPOSURES

Behaviors associated with animal exposures were ranked by frequency of occurrence (Figure 8). Across all exposures, playing with the animal (n=326; 8.8%), breaking up a fight (n=264; 7.1%), and scaring/surprising the animal (n=220; 6.0%) were the most frequently reported behaviors associated with animal exposures. A behavioral description was not provided for 20.5% of incidents (n=757).

Behaviors were broken down by type of animal involved. For exposures to pets (Figure 9), playing with the animal was the behavior most frequently reported (n=295; 10.5%). Breaking up a fight (n=231; 8.2%) and startling/surprising the animal (“The animal got spooked”) (n=189; 6.7%) were the next most frequently reported behaviors. A behavioral description was not provided in 17.2% (n=485) of reported exposures to pets. For exposures to stray, feral, or wild

animals (Figure 10), trying to capture the animal was the behavior most frequently reported behavior (n=39, 9.0%). Waking up in a room with a bat (n=32, 7.4%) and trying to pet the animal (n=18, 4.2%) were the next most frequently reported behaviors. A behavioral description was not provided in 30.6% (n=132) of reported exposures.

Across all age groups, startling or surprising the animal and playing with the animal were among the top three behaviors associated with animal exposures (Figure 11). Specifically among the younger age groups (ages 0 to 4 and 5 to 14), trying to pet the animal was one of the top three behaviors associated with animal exposures, with playing with the animal the most frequently reported behavior. Among the older age groups (ages 15 to 24, 25 to 64, and over 65), breaking up a fight was one of the top three behaviors associated with animal exposures. This behavior was the most frequently reported behavior for adolescents and young adults ages 15 to 24 and adults ages 25 to 64. Among older adults over the age of 65, playing with the animal and scaring/surprising the animal were the most frequently reported behaviors associated with exposures.

4.4 EXPOSURE TYPES AND PEP INITIATIONS

The majority of animal exposures reported to ACHD are bites (n=2,963; 72.9%) (Table 2). Other types of exposures reported to ACHD include incidents where the skin was broken (n=2,042; 55.3%), scratches (n=560; 15.2%), deep wounds (n=473; 12.8%), and other exposures (n=233; 6.3%) that might include waking up in a room with a bat or coming in contact with saliva, blood, or brain material. To be sure, a single exposure may involve multiple wounds and therefore multiple exposure types. Additionally, a bite may be classified as both a bite and a deep wound.

The majority of animal exposures resulted in injury to an upper extremity (n=2214; 60.0%) (Table 3). Exposures to lower extremities were the next most frequently reported exposure (n=663; 18.0%), followed by head, face, and neck injuries (n=588; 15.9%) and trunk injuries (n=110; 3.0%). Exposure location was not reported for 276 exposures (7.5%). As was the case for exposure type, exposure locations may not be mutually exclusive and one incident may result in exposures to multiple body parts.

Of 3,693 animal exposures over the study period, the most reported type of medical treatment received was an antibiotic, which was given in 72.2% of exposures (n=2,666) (Table 4). The wound was cleansed in 66.2% of exposures (n=2,443) and a tetanus shot was given in 35.4% of exposures (n=1,306). In 226 exposures (6.1% of exposures), PEP was initiated for the victim. Human diploid cell vaccine (HDCV), a human rabies vaccine, was given in 2.7% of reported exposures and human rabies immunoglobulin (HRIG) was given in 2.6% of reported exposures. Administration of HDCV and HRIG is part of the recommended PEP procedure. In light of this, HDCV was reportedly administered in 43.4% of cases and HRIG was reportedly administered in 42.5% of cases where PEP was reportedly initiated.

Of the reported 226 exposures where PEP was initiated, a female victim was reported for 113 cases (50%) and a male victim was reported for 106 cases (46.9%); sex of the victim was not reported for 7 cases (3.1%) (data not shown). Both females and males in Allegheny County had a rate of PEP initiation of 0.9 cases per 10,000 population (data not shown).

The age group with the highest number of reported PEP initiations was the 25 to 34 age group, 51 cases over the two-year study period (22.6% of PEP initiations) (Table 5). This age group also had the highest rate of PEP initiations, with 1.6 PEP initiations per 10,000 population. The 15 to 24 age group had the next highest number of reported PEP initiations (n=39; 17.3% of

PEP initiations) and PEP initiation rate (1.2 cases per 10,000 population). The 5 to 14 age group had a similar PEP initiation rate of 1.1 cases per 10,000 population; 28 PEP initiations (12.4% of PEP initiations) were reported for this age group over the study period.

The majority of cases where PEP was initiated involved pets (n=77; 34.1%) (Table 6). Dogs were involved in the majority of PEP cases involving pets (n=63; 81.8%). Stray animals accounted for 21.2% of PEP cases (n=48). Cats were involved in the majority of PEP cases involving stray animals (n=28; 58.3%). Wild animals accounted for 19.0% of PEP cases (n=43). Bats were involved in the majority of PEP cases involving wild animals (n=31; 72.1%). Animals whose animal type was not known accounted for 21.2% of PEP cases (n=48). Dogs were involved in the majority of PEP cases involving this type of animal (64.6%). Feral cats were involved in 4.4% of PEP cases (n=10). Of 266 cases, 8 cases (3.0%) involved exposures to animals that tested positive for rabies. The majority of animals involved in animal exposures that tested positive for rabies (62.5%) were high-risk wild animals, namely raccoons and bats. Raccoons involved in PEP cases tested positive for rabies in 33.3% of cases and bats involved in PEP cases tested positive for rabies in 6.5% of cases.

Although individuals initiated PEP for certain exposures, no cases of human rabies were reported in Allegheny County during the study period.

4.5 DISTRIBUTION OF ANIMALS TESTED FOR RABIES

A total of 1,553 animals were submitted to the ACHD Public Health Lab for testing between January 1, 2013 and December 31, 2014; 724 animals were submitted in 2013 and 829 animals were submitted in 2014 (Table 7). These animals were not necessarily involved in animal

exposures but may have been found dead and submitted for rabies testing. Of the animals received for testing, 1,465 (94.3%) were animals from Allegheny County; the remainder were from surrounding counties. Rabies testing was conducted for 1,445 of these animals. The majority of animals from Allegheny County submitted for testing were cats (n=454; 31.0%) followed by dogs (n=414; 28.3%). Cats had a percent positive rate of 0.7%, whereas no dogs submitted for testing tested positive for rabies. Skunks had the highest percent positive rate for rabies at 12.5% followed by bats at 5.7% and raccoons at 5.6%. No low-risk animals tested positive for rabies during the study period.

A total of 377 animals involved in animal exposures were tested for rabies (10% of total exposures) (data not shown). As the records analyzed were exposures or cases where exposure status was not provided, all 377 incidents are either exposures or cases where exposure status is "unknown." The majority of rabies tests conducted were for dogs (n=165; 43.8%) and cats (n=138; 36.6%); bats (n=39; 10.3%) and raccoons (n=16; 4.2%) accounted for the majority of wild animal exposures where an animal was tested. Overall, raccoons involved in exposures had the highest percent positive rate of all animals tested and involved in animal exposures (18.8%) followed by bats (12.8%) and cats (2.2%). Information on whether or not a rabies test was conducted was not reported for 52.7% of exposures.

5.0 DISCUSSION

5.1 SUGGESTED PUBLIC HEALTH MESSAGES AND INTERVENTIONS

Based on the distribution of reported animal exposures in Allegheny County, PA, it would be advisable to target interventions and the dissemination of public health messages in April or May, before the peak in reported animal exposures occurs during the summer months. Public health messages and interventions should be designed to address individual behavior that puts one at risk for animal bites as well as trying to decrease the risk for contracting rabies for animals involved in exposures.

As individuals ages 25 to 34 had the highest two-year average exposure rate (19.1 exposures per 10,000 population), public health messages should target knowledge and behaviors that put this age group at risk more frequently than other age groups. Specifically for this age group, the behavior most associated with animal exposures was breaking up a fight. To that end, particular emphasis could be placed on educating individuals how to recognize potential fight situations between animals as well as providing guidance on how to avoid and prevent such situations. A possible intervention could utilize educational signs and/or posters at local community areas and dog parks where interactions between animals are most likely to occur that offer strategies on how to recognize and avoid potential conflict between animals. Point of care delivery of messages that occur either in veterinary offices or in medical facilities where an

individual is receiving care for an animal exposure may also be an effective intervention point to educate individuals on how to avoid such exposures in the future. Interventions that focus on adults are not well-described in the literature.

As children ages 5 to 14 and young children ages 0 to 4 also had relatively high exposure rates (18.1 exposures per 10,000 population and 15.1 exposures per 10,000 population, respectively), public health messages could be targeted to parents of children in these age groups to prevent exposures. Such public health messages may focus on the importance of supervising children when an animal is present and teaching children how to appropriately approach and interact with animals. As playing with the animal was the behavior most frequently associated with animal exposures for these age groups, appropriate play and strategies for recognizing potentially hazardous situations should be emphasized. Educational messages may be appropriate for older children who are able to understand and comprehend the content of such messages. Potential interventions may include working with local pediatricians and/or veterinarians to incorporate messages regarding proper handling of pets into routine office visits. Veterinarians could offer strategies for appropriately initiating new animals into society so that animals are more socialized and less likely to encounter an uncomfortable situation. Additionally, an educational curriculum could be developed for young schoolchildren to educate them on how to appropriately approach and interact with animals.

Patronek, Sacks, Delise, Cleary, and Marder support that dog bite prevention interventions should be targeted at parents/guardians of young children to remind them that children under the age of 6 should always be supervised with a dog (Patronek, Sacks, Delise, Cleary, & Marder, 2013). Morrongiello et al. similarly stress the importance of interventions that focus on parent supervisory behavior as well as child behavior (Morrongiello et al., 2013).

Dixon, Pomerantz, Hart, Lindsell, and Mahabee-Gittens evaluated the effectiveness of a video-based dog bite prevention intervention program administered in a pediatric emergency department in Cincinnati, OH (2013). The results of the study indicate that a video-based intervention administered at the time of visit to the emergency department is capable of increasing knowledge about safe dog interactions in children ages 5-9 (Dixon et al., 2013). The effectiveness of school-based educational interventions for preventing dog bites in children and adolescents was reviewed by Dupperex et al. (2009). The authors concluded that educational interventions have a "probable positive effect" on changing the level of knowledge of safe dog handling behaviors in the short term, but indicate that the link between changing knowledge and decreasing the rate of dog bites is not well documented (Duperrex et al., 2009). One study conducted by Morrongiello et al. found that an interactive, computer-based program that has parents interact with children to help them decide how to respond in certain situations involving dogs only marginally changed child behavior towards dogs and parental supervisory and risk behaviors (2013). To that end, more work should be done to investigate interventions that result in behavior change, not just increases in knowledge.

The majority of animal exposures involved pets (dogs and cats) that should receive routine rabies vaccinations. However, only 65% of dogs and 53% of cats involved in animal exposures had reportedly received at least one previous rabies vaccination. Cats and dogs also accounted for the highest proportion of animals involved in exposures where victims initiated PEP. This suggests the importance of keeping domestic animals up to date on rabies vaccinations. Additionally, public health messages could encourage people to inquire as to the vaccination status of an animal that has bitten or scratched them when possible. A possible intervention could involve increased advertising of low-cost rabies vaccination clinics, especially

in areas characterized by lower socioeconomic status. Educational materials or a fact sheet could be made available that describe important questions to ask and steps to take if a person is bitten by an animal. Descriptions of interventions that address increasing vaccination rates among domestic animals are not readily available in the literature.

Although pets were involved in the majority of animal exposures that resulted in PEP, exposures to wild animals generally have a higher risk of rabies transmission. Therefore, it is important to emphasize this risk to the public and encourage individuals to not handle or approach wild animals. Disseminating this public health message may take the form of an educational campaign warning of the risks of handling wild animals and/or instructing people to contact Animal Control in events where exposure to a wild animal is possible.

5.2 SUGGESTIONS FOR IMPROVING THE FOLLOW-UP PROGRAM

The ACHD ID Program takes a very proactive approach with regard to animal exposure follow-up. Every ABR form that is submitted to ACHD is assigned for follow up to a public health nurse. Additionally, the ABR form has the potential to collect a wealth of information on animal exposures. The extent to which ABR forms are filled out as well as the quality and accuracy of the information collected directly affects the quality of the information obtained on animal exposures in the county. Preserving the integrity of the data from ABR form to entry into the animal bite database is also essential to providing accurate information on reported animal exposures.

Currently, information from both rabies testing lab slips and ABR forms is entered into the animal bite database. One of the ways that the system could be improved is to add data entry

fields into the database that are specifically for information from rabies testing lab slips. Often, when information from a lab slip is entered into the database, fields corresponding to information collected on ABR forms are left blank in the record. By specifying the record as a lab slip entry with either no accompanying ABR form or as a lab slip entry to accompany information on an ABR form, potential misclassification of exposures could be mitigated.

The fact that so much information is requested on ABR forms increases the probability that not all information will be collected for every case. To that end, the ACHD may wish to strategically identify information that is of the most interest to the program and communicate this to the public health nurses who conduct the follow-up activities. This would help ensure that the most important information is collected as frequently as possible and that additional information is only collected thereafter. Table 8 describes the extent of indicator data that was not reported in reported animal exposures analyzed in this project. Key information such as victim age and sex as well as the animal type and vaccination status of the animal are crucial to determining the level of risk for rabies transmission during case follow-up. Other information, such as some types of medical treatment received (antibiotic given, tetanus shot, wound cleansed) are not as important for considerations of possible rabies transmission and would be in patient records maintained by the reporting medical facility. To that end, perhaps collecting this type of information could be made a second priority after more critical information has been collected.

This comprehensive approach requires significant investment of time and personnel in following up on all reported animal exposures. To be sure, the ultimate goal of preventing human rabies cases in Allegheny County requires constant vigilance, but there are certainly situations where the risk for such an event is very low. For example, cases that involve an individual bitten by their own vaccinated animal constitute a very low risk of rabies transmission yet still require

follow-up by a public health nurse. In order to decrease the amount of time that is devoted to animal exposure follow-ups that constitute virtually no risk for rabies, the ACHD might consider establishing a triage procedure. Such a procedure could prioritize higher-risk exposures for more thorough follow-up compared to a low-risk exposure. An additional strategy to improve the quality and completeness of information received as well as decrease the amount of time spent on follow-up that ACHD may wish to investigate is the use of an electronic form. The form could be formatted such that certain fields would need to be completed prior to submission, which would decrease the amount of information the public health nurse would have to obtain during follow-up. However, one would have to balance the desire to have as complete of a form as possible with the reality that individuals filling out the form may not have access to the requested information at the time the form is being submitted. Additionally, one would want to make sure that requiring certain fields of information would not disincentivize the reporting procedure as a whole.

On a similar note, exposure information could be included on rabies testing lab slips for the ACHD Public Health Lab. While there is a "Comments" section where submission information (name of individual(s) submitting the animal for testing and contact information) can be recorded, the process is not systematic. This would not only improve the quality of information maintained by the ACHD Public Health Lab but also be potentially useful for triage and reporting procedures. For example, if it was known that an animal submitted for testing was involved in an exposure, this animal could be earmarked for more rapid testing and reporting of the test result. It would also be beneficial to have such information available in future cases where it may be of interest to know the number of animals tested by the ACHD Public Health Lab that were involved in an animal exposure.

5.3 LIMITATIONS

The results of this study are limited by the accuracy and completeness of ABR forms. As described previously, data was not reported for a significant proportion of select indicators. The analysis presented here described the degree to which certain information was not reported, but did not take this into account in the interpretation of the results. Therefore, it is important to keep in mind the extent to which missing information may impact the patterns in the data observed and presented in this study. This issue highlights the importance of proper training of individuals who use and/or complete the ABR form as well as the importance of ease of use of the form.

5.4 CONCLUSION

Individuals ages 25 to 34 had the highest two-year average exposure rate over the study period, followed by school-age children ages 5 to 14 and young children ages 0 to 4. Pets were most frequently involved in animal exposures, although exposures to wild animals are of greater risk for rabies. This information can be used in the development of public health messages specific to Allegheny County, which supports the public health significance of this study. Such messages and interventions may focus on increasing knowledge and, more importantly, changing behaviors of those individuals most at risk for animal exposures. Changing behaviors that put an individual at higher risk for rabies transmission should be emphasized.

APPENDIX A: TABLES

Table 1. Distribution of exposures by species of animal.

Risk of animal	Species	Number of reported incidents	Percentage of incidents
Domestic	Dog	2,522	68.3
	Cat	902	24.4
High-risk wild	Bat	89	2.4
	Raccoon	26	0.7
	Groundhog	6	0.2
	Skunk	4	0.1
	Fox	3	0.0
Low-risk wild	Squirrel	8	0.2
	Chipmunk	6	0.2
Other	Rat	7	0.2
	Hamster	4	0.1
	Mouse	4	0.1
	Horse	3	0.0
	Rabbit	2	0.0
	Camel	1	0.0
	Chinchilla	1	0.0
	Ferret	1	0.0
	Gerbil	1	0.0
	Guinea pig	1	0.0
	Monkey	1	0.0
	Pig	1	0.0
No risk	Bird	8	0.2
	Reptile	6	0.2
Not reported	Not reported	86	2.3
Total	---	3,693	100.0

Table 2. Types of exposures reported in 2013-2014.

Type of exposure	Number of reported incidents
Bite	2,693
Skin broken	2,042
Scratch	560
Deep wound	473
Other	233

Table 3. Description of locations of exposures reported in 2013-2014.

Location of exposure	Number of reported incidents
Upper extremity	2,214
Lower extremity	663
Face/head/neck	588
Trunk	110
Missing	276

Table 4. Description of type of medical treatment received.

Treatment received	Number of reported exposures
Antibiotic given	2,666
Cleansed wound	2,443
Tetanus shot	1,306
PEP	226
HDCV	98
HRIG	96

PEP: Post-exposure prophylaxis
HDCV: Human diploid cell vaccine (rabies vaccine)
HRIG: Human rabies immunoglobulin.

Table 5. Distribution of PEP cases by age group.

Age Group	Number of reported PEP cases	PEP initiation rate (per 10,000 population)
0-4	3	0.2
5-14	28	1.1
15-24	39	1.2
25-34	51	1.6
35-44	22	0.8
45-54	25	0.7
55-64	18	0.6
65-74	16	0.8
75-84	5	0.3
85+	2	0.3
Not reported	17	---

Table 6. Description of animal exposures where PEP was initiated.

Total PEP initiated	Type of animal	Species of animal	Number of reported incidents	Number available for observation	Number not available for observation	Number tested for rabies	Number positive for rabies
226	Pet	Cat	14	12	1	1	0
		Dog	63	22	23	2	0
	Stray	Cat	28	2	20	1	1
		Dog	20	1	16	1	0
	Wild	Bat	31	0	21	5	2
		Groundhog	2	0	2	0	0
		Mouse	1	0	1	1	0
		Other	1	0	1	0	0
		Raccoon	7	0	7	4	3
		Squirrel	1	0	1	0	0
	Unknown	Cat	5	0	3	1	0
		Dog	31	2	25	0	0
		Other	2	0	1	0	0
		Raccoon	2	0	2	0	0
		Skunk	1	0	0	0	0
		Not reported	7	0	3	0	0
	Feral	Cat	10	1	5	3	2

Table 7. Results of rabies tests for Allegheny County animals submitted to the ACHD Public Health Lab.

Risk of animal	Species	Number received	Number tested	Number positive	Percent positive
Domestic	Cat	454	453	3	0.7
	Dog	414	414	0	0.0
High-risk wild	Bat	314	300	17	5.7
	Raccoon	181	178	10	5.6
	Groundhog	44	44	2	4.6
	Skunk	16	16	2	12.5
	Fox	7	7	0	0.0
Low-risk	Squirrel	16	16	0	0.0
	Rat	5	5	0	0.0
	Opossum	6	6	0	0.0
	Chipmunk	3	2	0	0.0
	Ferret	1	1	0	0.0
	Gerbil	1	1	0	0.0
	Guinea Pig	1	1	0	0.0
	Mouse	1	1	0	0.0
	Vole	1	0	0	0.0
Total		1,465	1,445	34	2.4

Table 8. Extent of missing data for key indicators.

Indicator	Percent not reported
Cat breed	65.4
PEP	35.2
Behavior	20.5
Dog breed	18.3
Vaccination status	12.5 (Dog), 10.9 (Cat)
Age	9.1
Animal type	8.6
Location	7.5
Sex	5.8
Species	2.3
Date	0.1

APPENDIX B: FIGURES

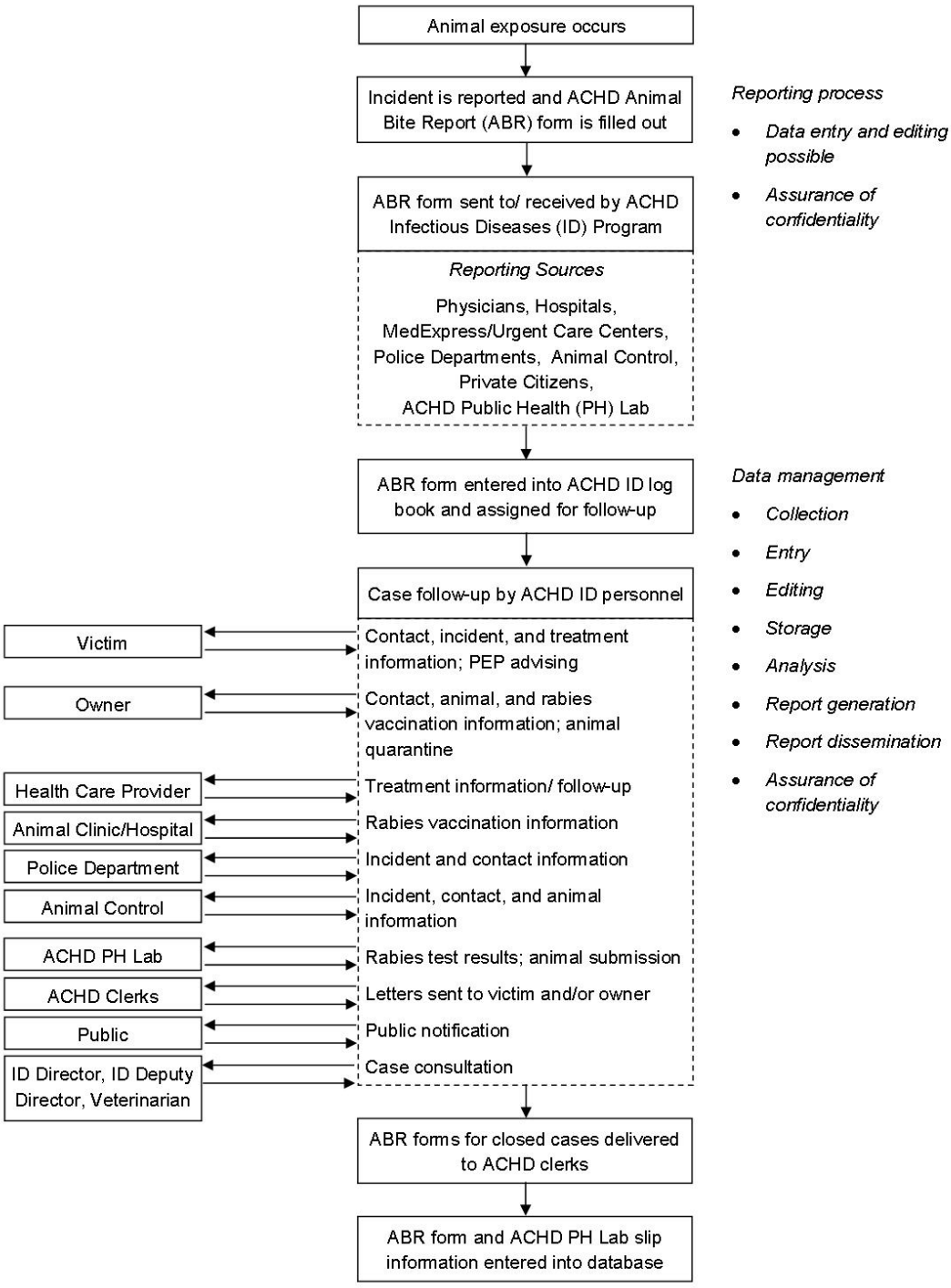

Figure 1. Flow chart of the ACHD animal exposure reporting system.

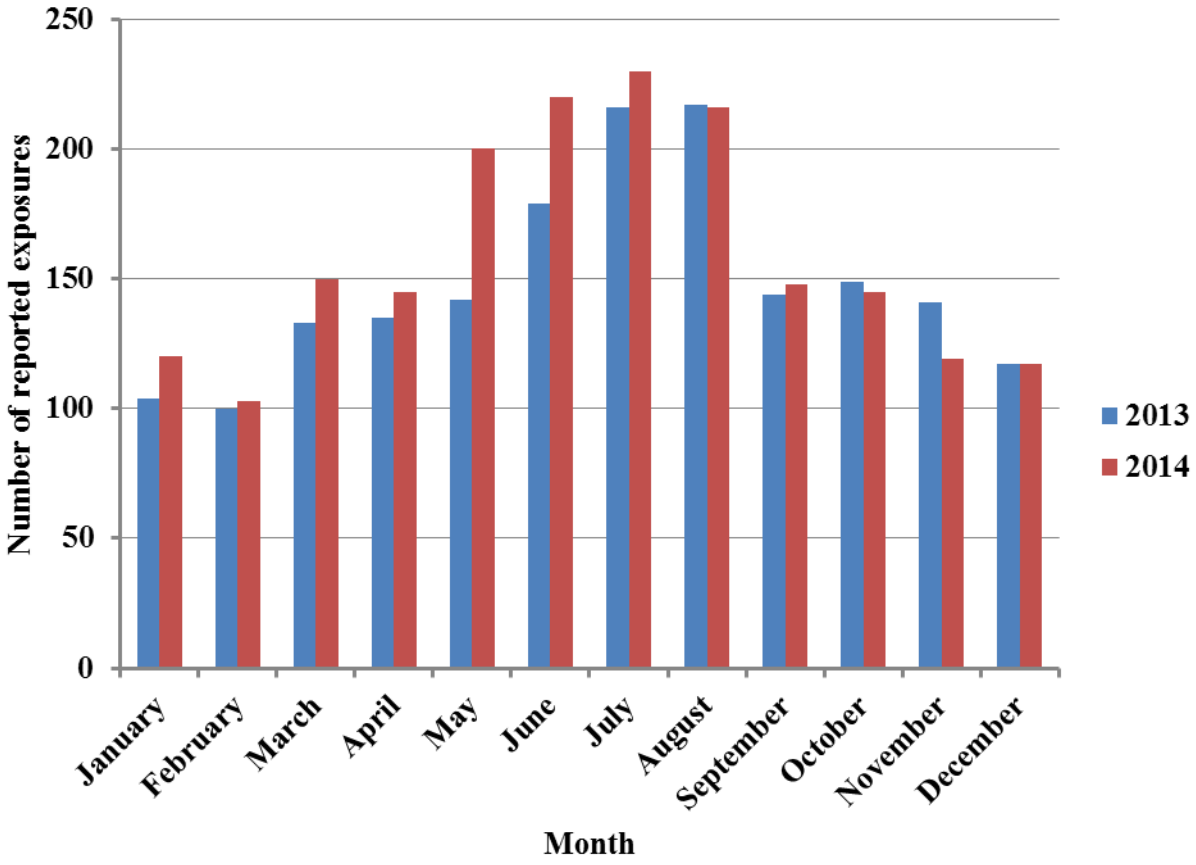

Figure 2. Distribution of 2013-2014 exposures by month.

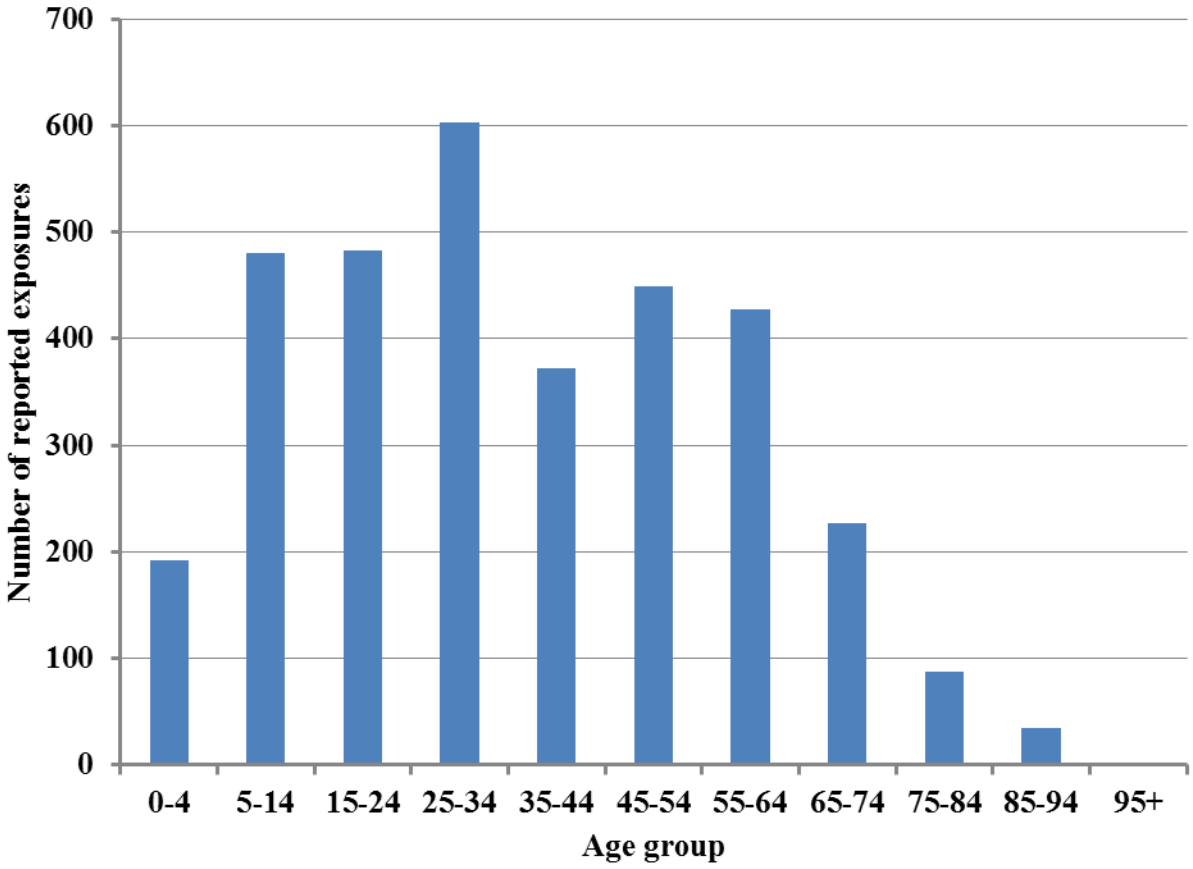

Figure 3. Distribution of 2013-2014 exposures by age group.

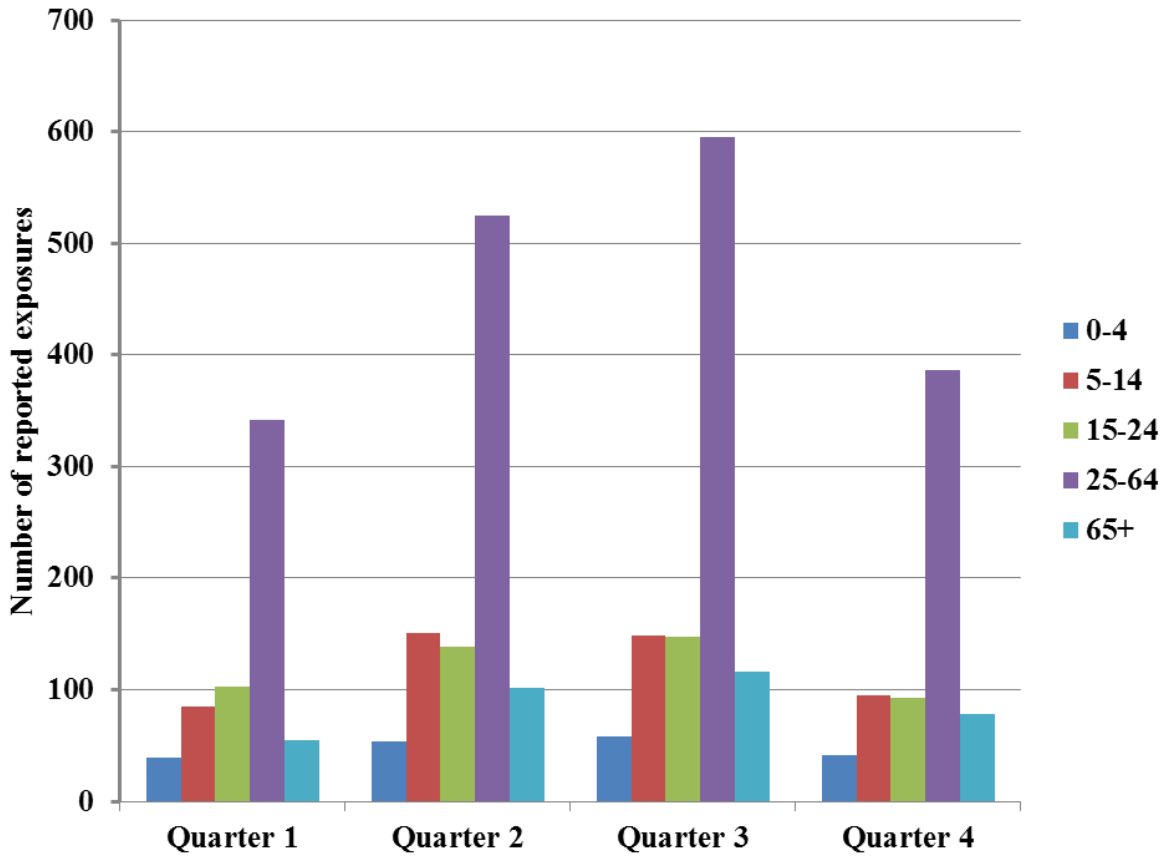

Figure 4. Distribution of 2013-2014 exposures by quarter and age group.

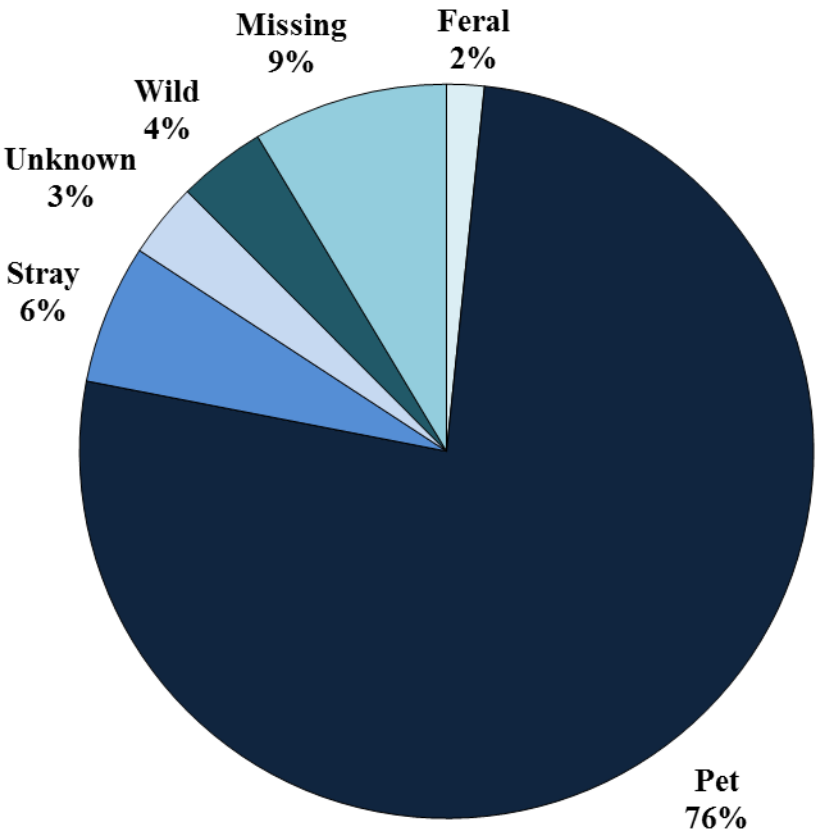

Figure 5. Distribution of 2013-2014 exposures by animal type.

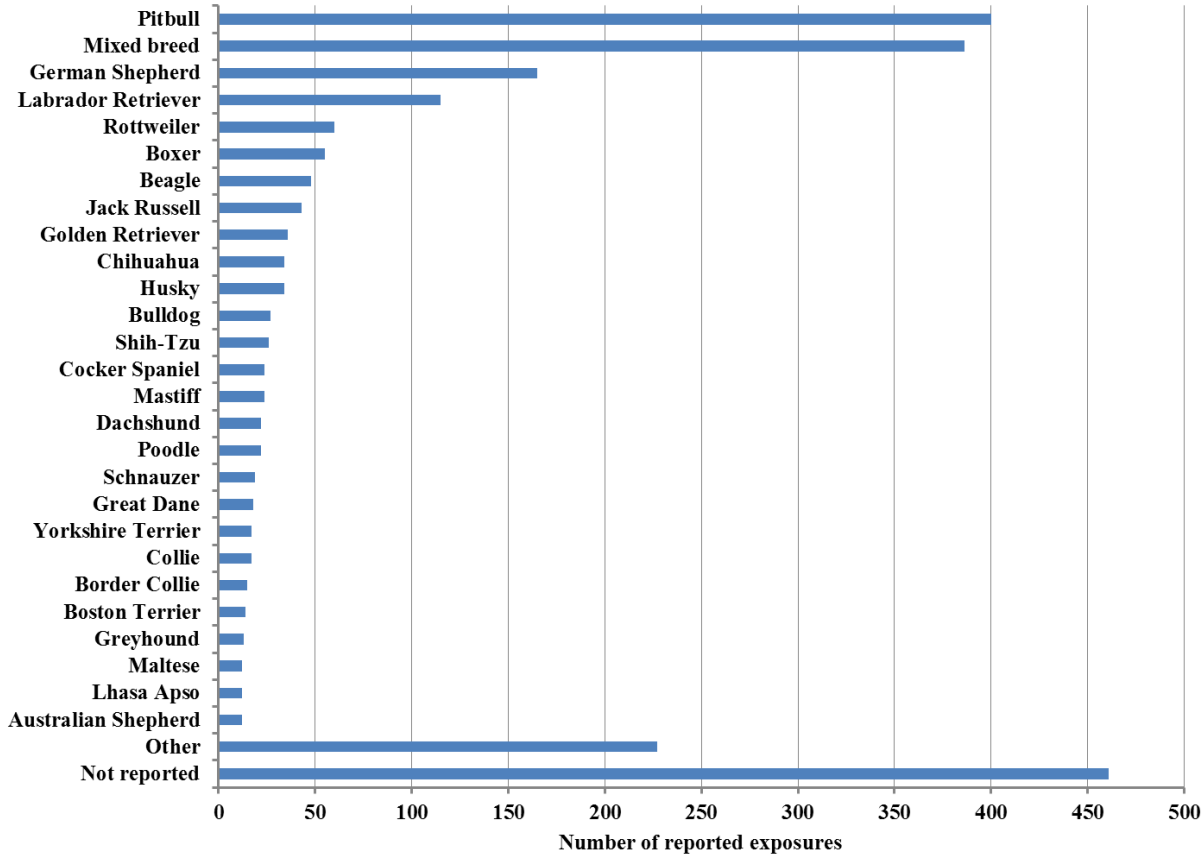

Figure 6. Distribution of dog breeds reported for 2013-2014 exposures to a dog.

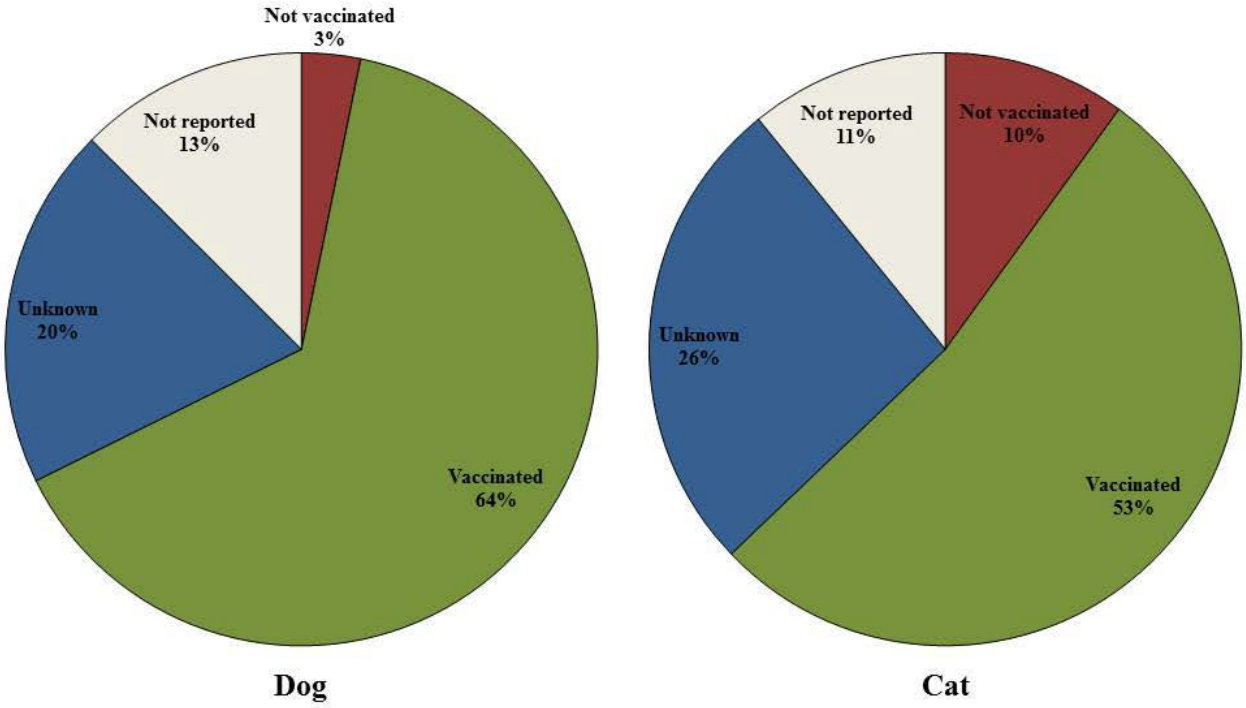

Figure 7. Vaccination status of dogs and cats involved in exposures in 2013-2014.

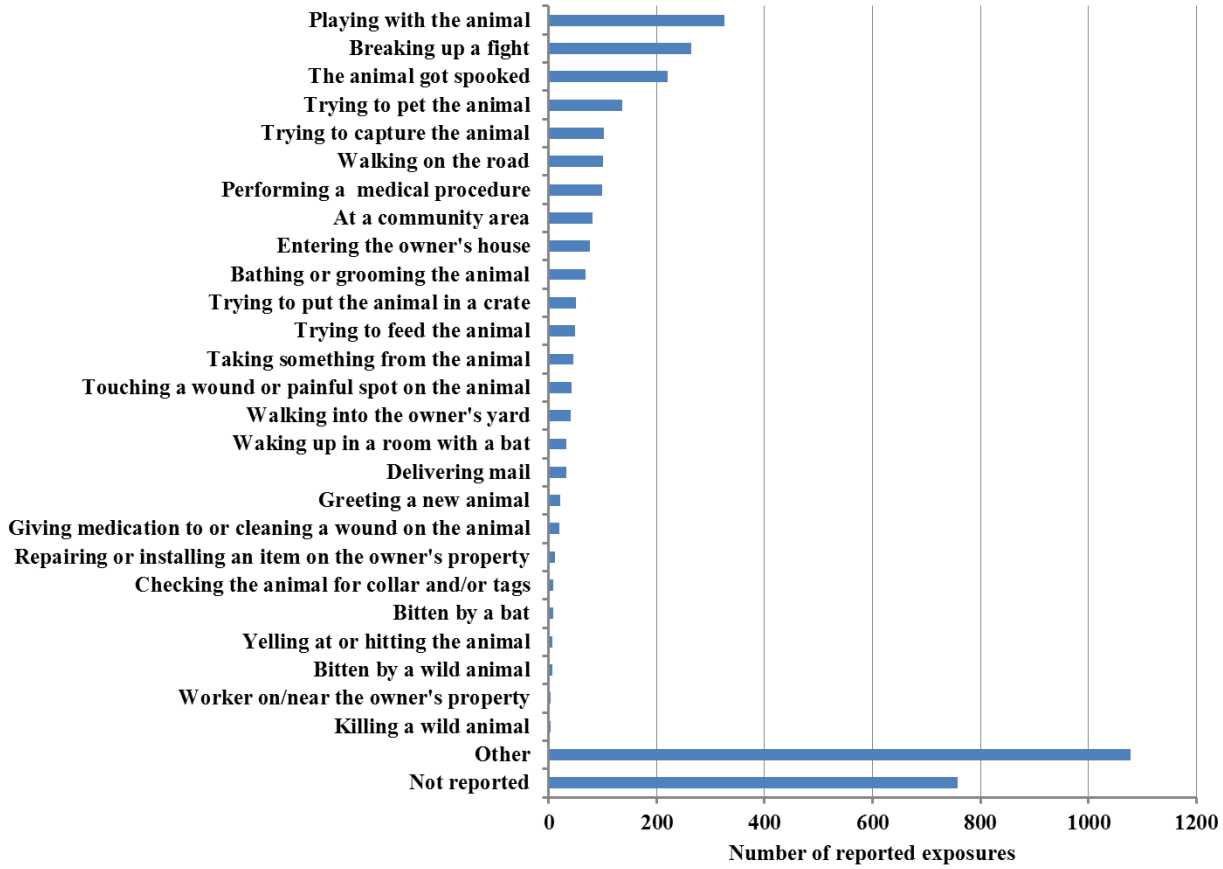

Figure 8. Distribution of behaviors associated with animal exposures in 2013-2014.

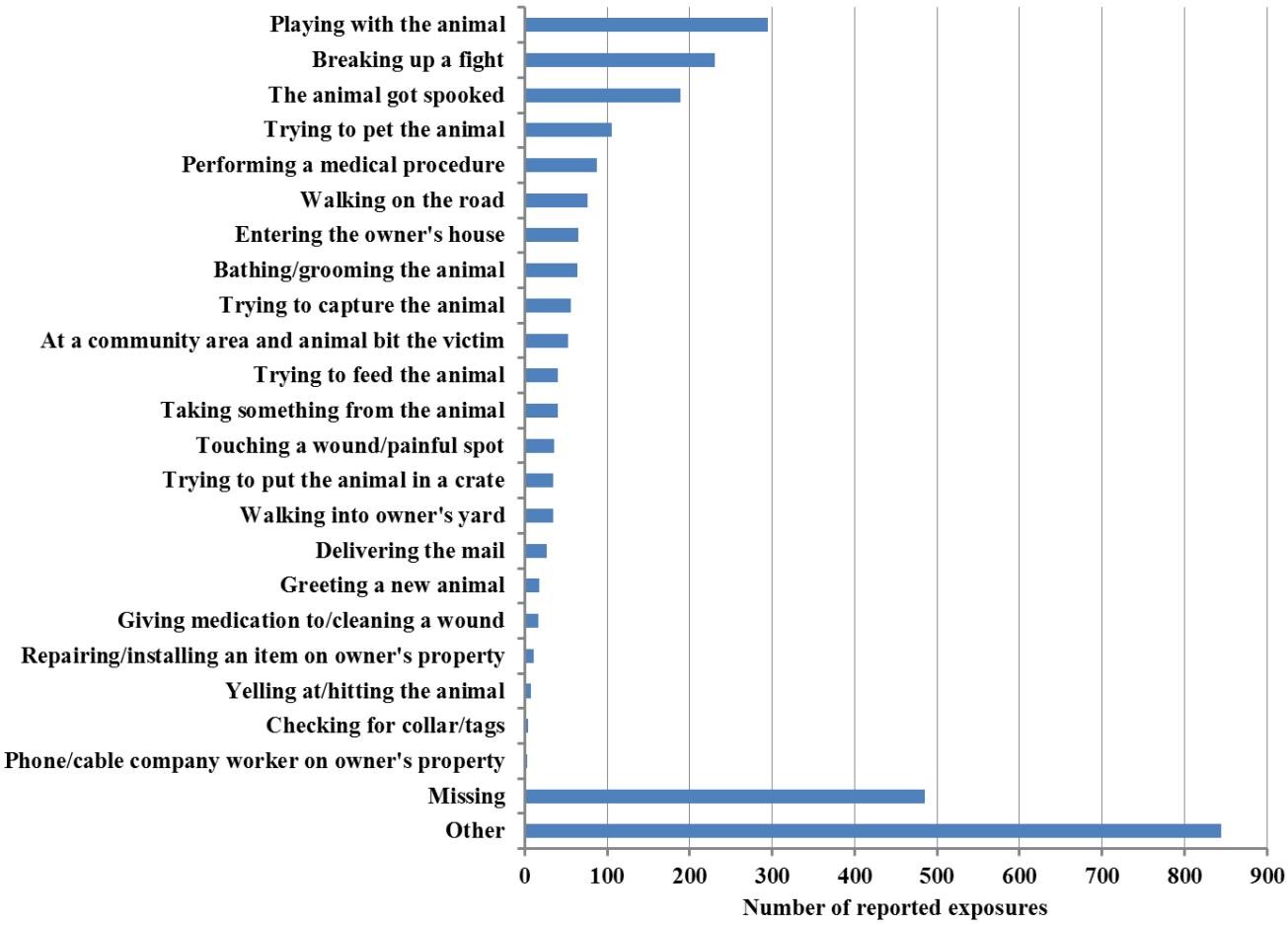

Figure 9. Distribution of behaviors associated with exposures to a pet in 2013-2014.

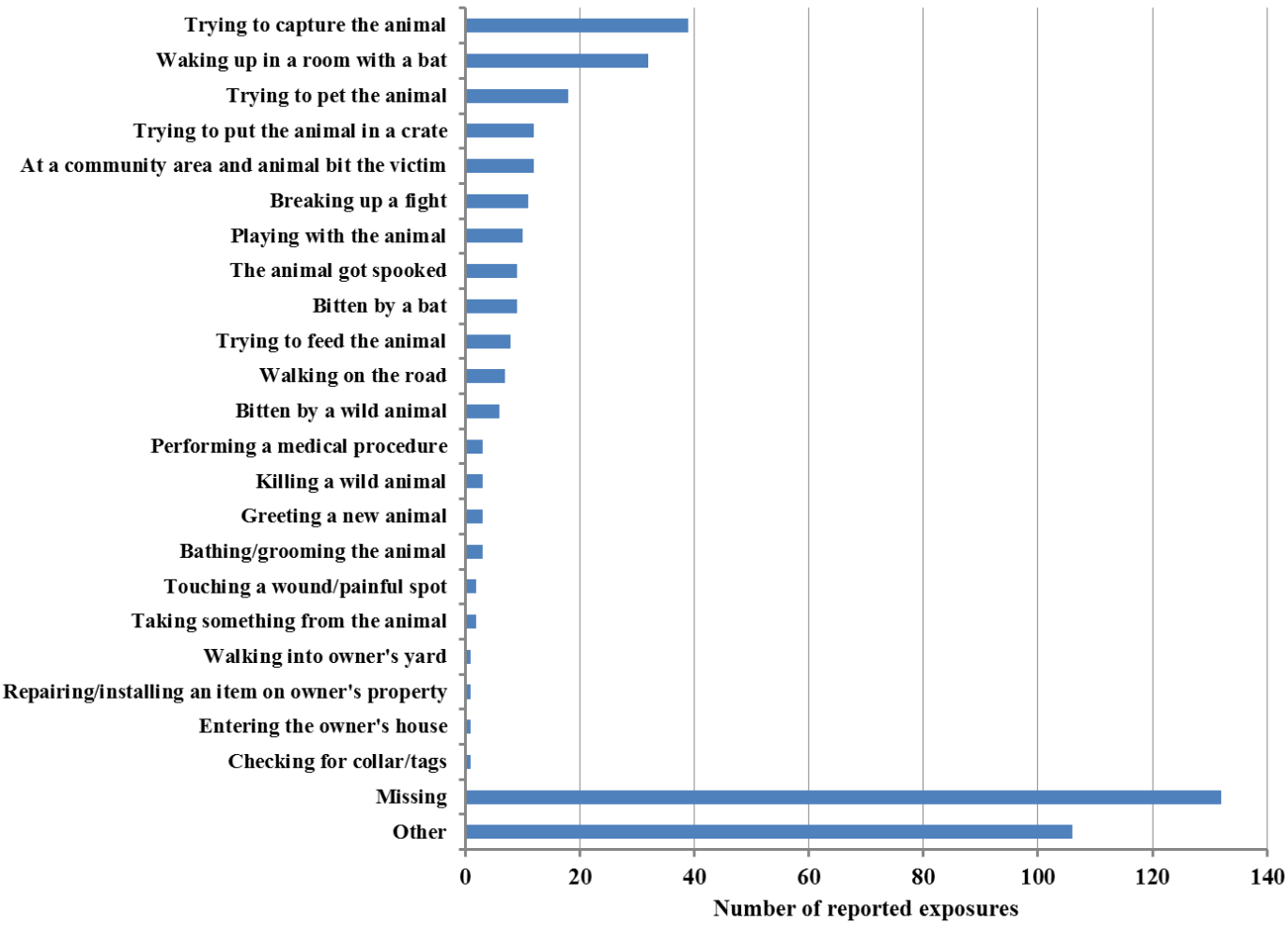

Figure 10. Distribution of behaviors associated with exposure to a stray, feral, or wild animal in 2013-2014.

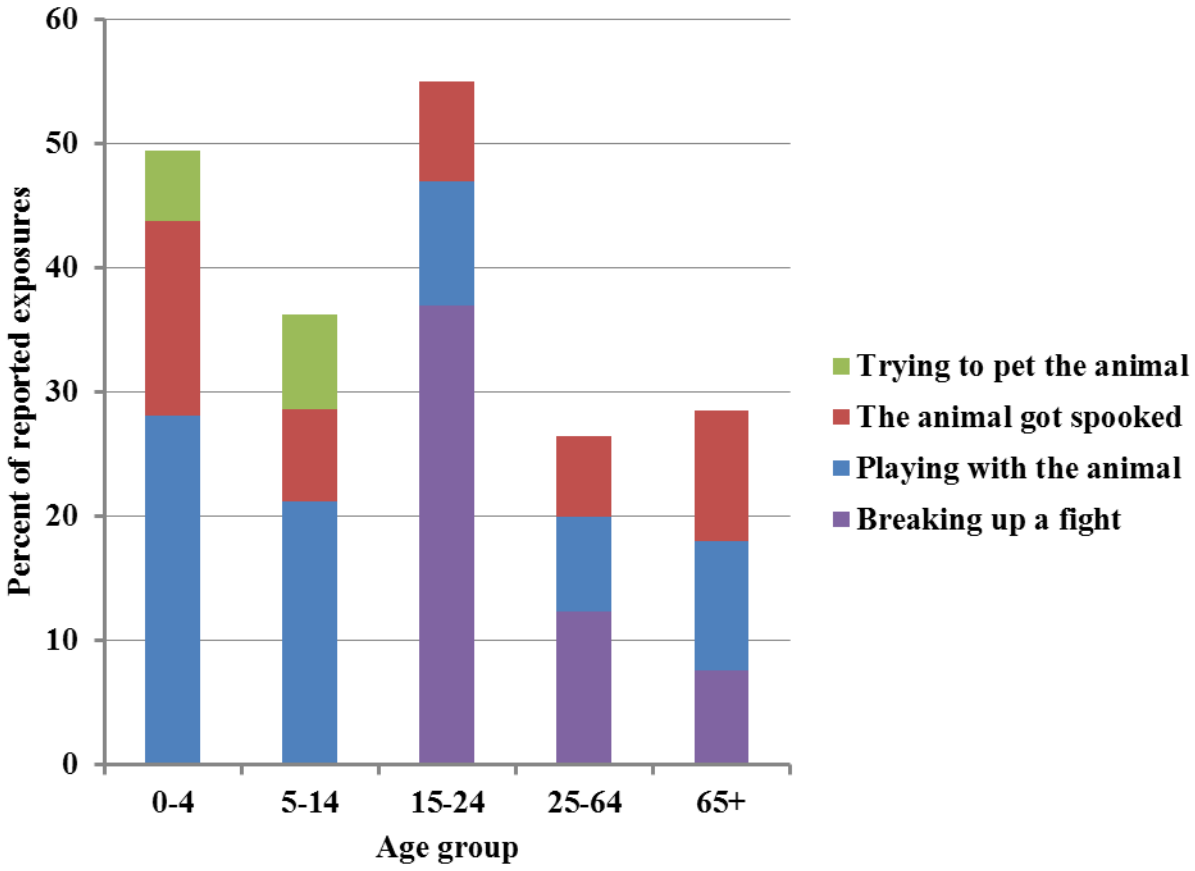

Figure 11. Distribution of common behaviors associated with animal exposures in 2013-2014 by age group.

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