Animal bite epidemiology and surveillance for rabies postexposure prophylaxis

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Objectives—To understand the epidemiology of animal bites and exposure, evaluate the animal exposure reporting system for surveillance of rabies postexposure prophylaxis (PEP), and identify opportunities to reduce PEP.

Design—Period prevalence survey.

Study Population—Pennsylvania residents in 1995.

Procedure—Data from animal bite reports from Pennsylvania county health offices were summarized for 1995. Animal bite incidences for the state, counties, various age groups, and various population densities were calculated. Animal species, treatment, location of wounds, and PEP recommendations were evaluated for exposures.

Results—More than 16,000 animal-related potential rabies exposures were reported from 65 of 67 counties in Pennsylvania. The highest incidence was in children less than 5 years old (324/100,000). Of the 75% of victims requiring wound treatment, 50% received antimicrobials, 29% received a tetanus toxoid, and 19% had wounds sutured, were admitted to hospitals, or were referred for plastic surgery. Although 75% of exposures were to dogs, victims exposed to cats were 6 times as likely to receive PEP (relative risk, 6.1; 95% confidence interval, 5.1 to 7.4). Thirty percent of 556 PEP were given for exposures to dogs, 44% for cats, 7% for raccoons, 4% for bats, 2.5% for squirrels, 2.1% for groundhogs, 2% for foxes, and 8% for exposures to other species. Fifty-nine percent of owned dogs were up-to-date on rabies vaccinations compared with 41% of owned cats.

Conclusion—Interventions, such as dog bite prevention education, vaccination of pets against rabies, appropriate use of PEP, and reduction of feral cat populations, should be instituted, enhanced, or better enforced in communities. (*J Am Vet Med Assoc* 2000;217:190–194)

Veterinarians are an important source of information for the public. The roles that private practitioners have in public health and prevention of zoonoses have been described.[1]

Veterinarians and animal owners should be aware of the risks of, and consequences for, animals that bite. Despite decades of animal bite surveillance by public health agencies, animal bites remain an important community health problem. An estimated 1 of every 2 Americans is bitten by an animal at some time during his or her life, and bite wounds account for approximately 0.5 to 1% of all visits to hospital emergency rooms.[2] Two to 30% of all animal bite wounds become infected; however, up to 50% of cat bites may become infected.[3] Although bites are common, they are severely underreported.[4]

In a raccoon rabies endemic state, such as Pennsylvania, animal bite reporting is the first step in identifying the need for rabies **postexposure prophylaxis (PEP)**. Raccoon rabies was first reported in Pennsylvania in 1982 as part of the mid-Atlantic states' epidemic and spread to all but 2 counties by 1995.[5] Raccoon rabies incidence remains high and has resulted in a higher incidence of rabies in other animal species in the state, making rabies an important concern after an animal bite.

Postexposure prophylaxis is given in response to a perceived need for rabies prophylaxis in the event of a bite, scratch, or other human exposure to a potentially or definitively rabid animal. Often, PEP is administered without confirmation of rabies exposure (to err on the side of caution) even though guidelines for treatment exist.[6,7] Rabies PEP is expensive and not without potential adverse effects.[8] Local reactions at the injection site or systemic problems, such as muscle aches, fever, or vomiting, may develop.

The United States Public Health Service set a Healthy People 2000 goal for the nation to reduce PEP for rabies by one-half by the year 2000.[9] For states to reach this goal, baseline information on the current rate of PEP is required. Animal bite or exposure reports may be one source of information about PEP.

The primary reason for reporting animal bites to local health departments is the immediate need to follow up on possible rabies exposure. In Pennsylvania, animal bites treated by health care providers must be reported to the state or local health departments. The need for PEP is determined by obtaining an accurate history, and decisions to administer PEP often are made in counsel with a rabies exposure expert. Although individual case follow up is of primary importance, animal bite surveillance data can also help local health departments to allocate resources for prevention efforts, track animal bite statistics to develop more effective programs for animal control and injury prevention, and monitor the administration of PEP. Surveillance data are important for "identifying condi-

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tions that require further investigation and for providing sensible solutions from imperfect data to facilitate public health action."[10]

The purposes of the study reported here were to understand the epidemiology of animal bites and exposure in a raccoon rabies endemic area, evaluate the animal bite reporting system for surveillance of PEP, and identify opportunities to reduce PEP.

Materials and Methods

The Division of Epidemiology, Pennsylvania Department of Health, solicited copies of animal bite reports from local public health centers in 67 counties of Pennsylvania for 1995. Because animal saliva exposures were not always differentiated from bites, "animal exposure" was used to identify any potential rabies exposure or animal exposure leading to medical follow up. Copies of paper animal exposure reports were reviewed for 60 counties, and fields common to most reports were entered into a computerized database.[a] Additional reports from 5 counties were summarized from computerized records. Two county health offices did not provide records. One office was in a major urban county, and one was in a low population density county. Duplicate records were eliminated, using date of exposure and personal identifiers. The surveillance system was evaluated, using the Centers for Disease Control and Prevention's guidelines for evaluating surveillance systems.[11]

Victim information was entered into a computerized database and included residence, age, location of bite wounds, wound treatment given, and postexposure treatment. Only the 60-county paper report data set was used to compile this information. The 5 counties submitting computerized reports used different reporting forms and different methods of data entry. One county was located in a major urban area, 2 were suburban counties of a major urban center, and the remaining counties had moderate to low population densities (< 350,000 people). Incidences (numbers of new cases/population at risk) of animal exposures were calculated, using 1994 estimated populations and assuming a steady-state population.[12] Data were analyzed, using a statistical software program.[b] County incidences of animal exposures were compared with historical and current rabies-positive sample submissions to the Pennsylvania Department of Agriculture and Department of Health laboratories to identify reasons for high and low incidence of animal exposure reporting. Animal exposure report data were aggregated by 4 county human population density ranges: < 90, 91 to 200, 201 to 400, or > 400 people/mile^2.

Animal information summarized included species, breed, whether the animal responsible was owned, stray, or feral, rabies vaccination status, and rabies test status. Rabies vaccination status was based on the date of the animal's last rabies vaccination and duration of conferred immunity.

Results

Animal exposure reports were collected from 65 of 67 counties in Pennsylvania. Sixteen thousand four hundred sixteen animal exposures among residents were reported for an incidence of 137.2 exposures/100,000 person-years. Incidences by county ranged from 24.2 to 414.5 exposures/100,000 person-years (median, 153.5 exposures/100,000 person-years). From laboratory data, all but 2 counties had at least 1 case of rabies in 1995. However, county-specific animal exposure incidence was not associated with either the 1994 or 1995 annual county-specific percentage of rabies-positive submissions to the state's rabies testing laboratories ($R^2 < 0.01$).

Animal exposure incidences were 218.4, 172.8, 163.8, and 108.0/100,000 person-years for human population density categories of < 90, 91 to 200, 201 to 400, and > 400 people/mile^2, respectively. There was a significant trend toward higher incidence for counties with low population densities (χ^2 for trend, 34.7; $P < 0.01$). Animal exposure report rate was 2 times higher in counties with low population densities compared with the most densely populated counties (risk ratio, 2.02; 95% **confidence interval [CI]**, 1.93 to 2.12).

Most animal exposure reports indicated species or type of animal. More than 75% were dogs, 17.2% cats, 1.3% small rodents, 1% squirrels and chipmunks, 0.7% raccoons, 0.4% bats, 1.6% unknown, and 1.9% other species. The incidence of dog exposures was 104.0/100,000 person-years and the incidence of cat exposures was 23.6/100,000 person-years. Owned dogs (owner identified on the report) were responsible for 92.6% of dog exposures. Of 9,057 owned dogs identified in paper reports, 5,369 (59.3%) were reported to be up-to-date on rabies vaccinations. Sixty-two percent of cats were pets. Of these, 41.4% had up-to-date rabies vaccinations.

More than 100 dog breeds or their crossbreeds were represented in the reports. However, breed identification was absent in almost one-third of the reports implicating dogs. Because of this and because breed prevalence information does not exist for Pennsylvania, animal exposure rates by breed could not be calculated. For reports in which dog breed was identified, German Shepherd Dogs and their crossbreeds were implicated in 10%. The next most common breeds reported were unidentified crossbreeds (7.1%), Labrador Retriever (6.8%), Rottweiler (4.3%), Cocker Spaniel and Cocker Spaniel crossbreeds (3.2%), pit bull-type dogs (2.9%), Siberian Husky (2.8%), and Chow Chow (2.4%).

Age-specific rates for animal exposures were also calculated (**Table 1**). Adjusting for the population size of each age group, children < 5 years old were 3.13 times more likely to be victims compared with people > 14 years old (CI, 2.51 to 3.90). Most victims were bitten on the arm, hand, or finger (47%); 21.4% were bitten on the head, neck, or face; 18.8% on the leg, foot, or toe; and

Table 1—Age-specific rates of reported animal exposures. Data from 60 counties in Pennsylvania, 1995*

Age group (years)	Number of exposures	1994 Population estimate†	Rate per 100,000 person-years
< 5	2,232	686,921	324.9
5–9	1,828	700,544	260.9
10–14	1,386	703,174	197.1
15–19	684	659,281	103.7
20–24	596	689,285	86.5
25–29	668	693,096	96.4
30–34	624	786,488	79.3
35–39	633	831,327	76.1
40–44	612	758,135	80.7
45–49	461	645,909	71.4
50–54	322	519,341	62.0
55–59	269	444,628	60.5
> 59	1,008	902,458	111.7
Total	**11,323**	**9,020,587**	**125.5‡**

*Age missing on 1,557 of 12,880 total reports. †US Bureau of Census 1994 estimates. ‡Represents mean rate.

Table 2—Frequency of animal exposure by wound location and victim age. Data from 60 counties in Pennsylvania, 1995*

Age group (years)	Number of injuries (%)			
	Head, face, or neck	Trunk, back, or buttocks	Arm, hand, or finger	Leg, foot, or toe
< 5	909 (40.7%)	69 (3.1%)	636 (28.5%)	189 (8.5%)
5–9	663 (36.3%)	147 (8.0%)	593 (32.4%)	283 (15.5%)
10–14	298 (21.5%)	104 (7.5%)	555 (40.0%)	325 (23.4%)
15–19	111 (16.2%)	37 (5.4%)	332 (48.5%)	163 (23.8%)
20–24	86 (14.4%)	24 (4.0%)	320 (53.7%)	134 (22.5%)
25–29	76 (11.4%)	30 (4.5%)	391 (58.5%)	147 (22.0%)
30–34	54 (8.6%)	20 (3.2%)	379 (60.7%)	144 (23.1%)
35–39	53 (8.4%)	18 (2.8%)	368 (58.1%)	164 (25.9%)
40–44	47 (7.7%)	19 (3.1%)	365 (59.6%)	149 (24.4%)
45–49	37 (8.0%)	14 (3.0%)	279 (60.5%)	103 (4.8%)
50–54	20 (5.4%)	7 (1.9%)	251 (67.5%)	74 (19.9%)
55–59	11 (4.1%)	7 (2.6%)	176 (65.4%)	60 (22.3%)
> 59	39 (4.0%)	25 (2.6%)	675 (70.0%)	223 (23.0%)
Mean %	14.4%	4.0%	54.1%	19.9%

*2,477 of 12,880 total reports for 60 counties were missing age or wound location.

4.5% on the trunk, back, or buttocks. Eight percent of reports lacked information on wound or exposure location. Children < 10 years old were more likely to be bitten on the head, neck, or face compared with people > 19 years old ($P < 0.01$, **Table 2**).

The primary location of bite wounds varied with biting species. Almost 40% of dog bites resulted in wounds to the arm or hand, and 26% involved the head, neck, or face. Cat bites were predominantly on the arm or hand (72%) and leg or foot (11%). Dog bites were 3.5 times more likely to have been on the head, neck, or face compared with cat bites (CI, 3.0 to 4.1). More than 48% of children < 5 years old who were bitten by dogs had head or neck wounds.

Almost 75% of reports indicated some form of wound treatment. Of 10,021 reports in which wound treatments were recorded, 29.3% of victims had wounds cleaned, lavaged, or dressed. About 50% received antimicrobials, 29% received a tetanus toxoid, and 19% had wounds sutured, were admitted to a hospital, or were referred to a plastic surgeon. Twenty percent of children < 10 years old had their wounds sutured, were hospitalized, or were referred for plastic surgery compared with 10.9% of people > 19 years old. The kind of treatment given differed depending on wound location. Eighty-one percent of plastic surgery referrals were for wounds on the head, neck, or face. Fifty-three percent of victims whose wounds were sutured, but who did not undergo plastic surgery, had head and neck wounds sutured, and 33% had hand or arm wounds sutured. Hospital admissions were primarily for head and neck (41.8%) and hand and arm (40.6%) wounds.

Thirty-five percent (4,538) of reports from 60 counties lacked complete follow-up information for PEP. More than 60% (7,786) of reports indicated that PEP was not given. More than 4% (556) of victims received PEP as a result of an animal bite, scratch, or other exposure from various animal species. Using this number, as a minimum, the state's total PEP incidence rate was 4.6/100,000 person-years. Administration of PEP was reported for exposures to 23 different types of animals. Thirty percent of the 556 PEP given resulted from exposures to dogs, 44% to cats, 7.2% to raccoons, 4.1% to bats, 2.5% to squirrels, 2.1% to groundhogs, 2.0% to foxes, 1.4% to skunks, and 6.7% to other animal species (ferret, cow, horse, mouse, rat, chipmunk, beaver, sheep, coyote, mink, opossum, and weasel). Victims received PEP following exposure to 5 dogs and 1 cat that were reported to be up-to-date on rabies vaccinations (**Table 3**). Victims exposed to cats were 6 times more likely to have received PEP compared with victims exposed to dogs (relative risk, 6.1; CI, 5.1 to 7.4). Of 556 known administrations of PEP, 123 (22%) were given for exposures to pet (owned) animals (Table 3). Of 228 victims given PEP who were exposed to cats, 82% were exposed to a feral, stray, or unowned cat.

Population rates of known PEP were highest in younger age groups; 15.7/100,000 person-years in children < 5 years old. The rate was 8.7/100,000 person-years for 5 to 9 year olds, 7.7/100,000 person-years for 10 to 14 year olds, 7.1/100,000 person-years for 20 to 24 year olds, and 6.2/100,000 person-years for 15 to 19 year olds. Almost one-third of PEP was administered to victims < 10 years old.

A complete follow-up report for PEP was considered to include a written recommendation for PEP or information on the vaccination or rabies test status of the animal from which a recommendation for PEP could be derived. Rabies testing involved submission of the animal to the laboratory for fluorescent antibody testing and histopathologic examination of brain tissue. Complete reporting of written PEP recommendations and follow-up information on animal exposure reports differed by county, ranging from 0 to 90%, with a median of 20%. In addition, rabies test status of animals was missing from 1,569 of the 12,880 reports. Many animals (4,417) were reported to have not been tested, and

Table 3—Ownership and rabies vaccination status of dogs and cats for which post-exposure prophylaxis was administered to bitten or exposed human victims, Pennsylvania, 1995

Species	Ownership status	Rabies vaccination status				Total
		Current	Not current	Not vaccinated	Unknown*	
Dogs	Owned (pet)	5	8	18	39	70
	Stray/wild	0	1	0	37	38
	Unknown	0	0	1	58	59
Cats	Owned (pet)	1	4	26	11	42
	Stray/wild	0	2	9	175	186
	Unknown	1	0	0	16	17

*No information regarding rabies vaccination status was provided on the report.

4,770 had no testing status recorded. Of 373 animals reported to have been tested for rabies, results for 41 (11%) were positive, results for 189 (50.7%) were negative, and 143 reports (38.3%) did not indicate the results of testing. Of the 41 animals for which rabies tests were positive, 35 victims were reported to have received PEP. Seventeen victims were given PEP despite negative test results, although it was not clear whether PEP had been discontinued once negative results were available (ie, they may have only received a portion of the complete PEP). Forty-four (11.8%) animals whose test results were positive for rabies were reported to be up-to-date on rabies vaccinations.

Discussion

Animal bites are an important community health problem. More than 1 person in 100 was bitten by, or adversely exposed to, animals in Pennsylvania in 1995 and required medical follow-up. Serious injuries, particularly to children, and the need for rabies PEP are major consequences. Because of the combined efforts of local and state health departments, animal control offices, and the veterinary community, rabies in humans is rare[13] and results primarily from sporadic exposures to the bat strain of rabies.[14] Continued surveillance and rabies control is still necessary to protect public health, but new issues such as the relative costs and benefits associated with various control measures have emerged.

In Healthy People 2000, the US Public Health Service specified a goal of reducing rabies PEP to no more than 9,000 administrations/year (a reduction of one-half from an annual 18,000 estimated treatments in 1987).[9] To evaluate their progress, most states need to obtain a baseline estimate of their current rate of administration. One way to determine this rate is to summarize animal bite surveillance data. Analyzing surveillance data can also help identify ways to reduce the need for rabies PEP and prevent its inappropriate administration. Although many 1995 Pennsylvania animal bite reports contained incomplete information regarding recommendations for rabies PEP, the data did indicate some important target areas for reducing its administration.

Reducing the need for PEP includes reducing rabies in wild animal populations through such methods as bait vaccination of raccoons.[15] Rabies in raccoons is the most important reservoir for human and domestic animal exposure in Pennsylvania, and raccoon exposures resulted in at least 40 PEP treatments in 1995.[c] In addition, control of feral cat populations should be considered, because our study results indicate that 82% of PEP given for exposures to cats were a result of contact with stray or feral cats. Means by which the number of feral cats and rabies in feral cats may be reduced include euthanasia; trapping and relocation; or trapping, testing, neutering, and vaccination of feral cats.[16]

Another way to reduce the need for rabies PEP is to increase vaccination rates for pet (owned) animals. Our study revealed that only 59% of pet dogs and 41% of pet cats were up-to-date on rabies vaccinations. One way to improve vaccination rates is to mandate rabies vaccination before licensing dogs. Although Pennsylvania law requires that all dogs be licensed, obtaining a license does not require that the dog be vaccinated against rabies. A survey of health districts in Ohio[17] revealed that 83% of dogs that bit from districts that required rabies vaccination for licensing were vaccinated, whereas only 62% of dogs that bit from districts requiring rabies vaccination but not linking this to licensing were vaccinated. Only 54% of dogs that bit were vaccinated in districts with no mandatory vaccination requirement. Therefore, linking the ability to obtain a dog license with a requirement for rabies vaccination would likely improve the rate of rabies immunization of dogs and reduce the need for administration of rabies PEP to dog bite victims.

A final way to reduce the need for PEP is by educating children and adults about bite prevention. Dogs were responsible for most reported bites in our study. Other studies indicate that most victims are bitten by dogs that are owned by, or are familiar to, the victim.[18,19] In a study of peoples' judgments of the likelihood that a given dog would bite, Moss and Wright found that subjects actually moved closer to a dog displaying dominant signals than to one displaying submissive signals.[18] These results indicate that health education should include information on dog behavior. In a case-control study, biting dogs, compared with nonbiting, neighborhood-matched control dogs, were more likely to be German Shepherd Dogs or Chow Chows, unneutered males, reside in a household with 1 or more children, be chained while in the yard, not be licensed or vaccinated for rabies during the past year, and have a low obedience score.[20] The care and management of dogs and the interface between dogs and people appear to be major issues, especially for households with or near children.

Reducing rabies PEP also includes minimizing unnecessary administration of PEP. The species of animal responsible for an exposure is one consideration. Twenty of 556 reported PEP resulted from exposures to mice, rats, squirrels, or chipmunks. Although 5 squirrels had positive results of rabies testing in Pennsylvania between 1982 and 1996, no results for submissions of mice, rats, or chipmunks were positive.[c] Rabies exposure consultants must weigh the risk of rabies with the costs and benefits of PEP. At the time of this study, 1991 recommendations for rabies prevention were in use.[6] When dealing with exposures to livestock, rodents, and lagomorphs, physicians were asked to consult public health officials and reminded that "bites from squirrels, hamsters, guinea pigs, gerbils, chipmunks, rats, mice, other rodents, rabbits and hares almost never require anti-rabies treatment."[6] Similar recommendations are given in the newest rabies prevention guidelines.[7]

Administration of PEP to victims bitten by animals currently vaccinated against rabies is not recommended. Although the Pennsylvania data seem to indicate sporadic administration in such cases, it was not clear from the reports if some PEP series may have been initiated and then discontinued once the vaccination status of the animal was determined. It also appeared that PEP may have been given to victims of animals having negative test results for rabies, but it was not clear if these PEP series were completed. In addition, animal quarantine information was not available from these

reports, although it should be considered when making decisions regarding PEP.

The estimated incidence of PEP was 4.6/100,000 person-years. This falls within the range of 0.53 to 41.23/100,000 person-years established by a 21-state survey in which the highest incidences were found in states with low population densities such as North Dakota and South Dakota.[21] Although animal bite rates in Pennsylvania were highest in counties with the lowest population densities, PEP rates by county and population density could not be determined because of incomplete reporting. Even with possible under-reporting, costs of PEP were still high. If a series of immunizations is estimated to cost $2,000 per person,[8] at least $1,112,000 was spent in Pennsylvania for PEP in 1995. Although PEP is very effective at preventing rabies in people, it is not without adverse effects. In a study of adverse reactions among 375 people who received PEP after exposure to a rabid kitten, 85% complained about at least one immunization in the PEP series.[22]

Our study data should be interpreted with a few caveats. First, 1 major metropolitan area was excluded from the study, because officials did not provide animal exposure reports. Vaccination rates may be higher in metropolitan areas, and results of our calculation of the proportion of dogs and cats vaccinated may be low. In addition, the number of exposure reports and the species of animals involved were used to determine incidence rates for all 65 reporting counties, however, other important victim and animal information was not available from 5 counties with computerized records. Finally, it was not possible to discover how rabies vaccination status was determined (ie, whether it was by the owner's word or proof of vaccination). However, it is assumed that PEP recommendations made by health department officials would not be based on hearsay.

A weakness of the reporting system was incomplete recording of rabies PEP administration and other information. State health officials need to institute several changes if such reports are to be used effectively for PEP surveillance in the future. First, the method of reporting should be standardized so that data are simple (but complete) and easy to enter and summarize at local and state levels. Second, continuing education for health officials responsible for reporting animal exposures should be conducted to reiterate recommended PEP guidelines and the importance of complete reporting, establish or reestablish the network of rabies exposure consultants, and help identify additional problems with the reporting system.

Public health strategies for animal bite and rabies prevention include educating adults and children about responsible pet ownership and bite prevention, precautions around wildlife, and appropriate wound care.[4,23] Rabies PEP can be reduced by reminding pet owners of the importance of rabies vaccination in rabies-endemic states, instituting training programs for county health personnel, and improving surveillance strategies.

Efforts to reduce rabies in humans through animal vaccination and PEP have been highly successful.[13] New efforts should focus on reducing injuries from animal bites, particularly in children. Various educational campaigns have already been developed, including one by the AVMA in cooperation with State Farm Insurance Companies and Auburn University.[24] Continued surveillance of animal bites and PEP will be an important part of evaluating the success of such programs.

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[a]EPI INFO, Centers for Disease Control and Prevention, Atlanta, Ga.
[b]SAS, Version 6.12, SAS Institute Inc, Cary, NC.
[c]Moore DA. *The epidemiology of raccoon rabies and animal bites in Pennsylvania*. The Pennsylvania State University. Dissertation 1998;131.

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