Which Dogs Bite? A Case-Control Study of Risk Factors

Kenneth A. Gershman, MD, MPH*; Jeffrey J. Sacks, MD, MPH‡; and John C. Wright, PhD§

ABSTRACT. *Objective.* Dog bites cause an estimated 585 000 injuries resulting in the need for medical attention yearly and children are the most frequent victims. This study sought to determine dog-specific factors independently associated with a dog biting a nonhousehold member.

Methods. A matched case-control design comprising 178 pairs of dogs was used. Cases were selected from dogs reported to Denver Animal Control in 1991 for a first-bite episode of a nonhousehold member in which the victim received medical treatment. Controls were neighborhood-matched dogs with no history of biting a nonhousehold member, selected by modified random-digit dialing based on the first five digits of the case dog owner's phone number. Case and control dog owners were interviewed by telephone.

Results. Children aged 12 years and younger were the victims in 51% of cases. Compared with controls, biting dogs were more likely to be German Shepherd (adjusted odds ratio (ORa) = 16.4, 95% confidence interval (CI) 3.8 to 71.4) or Chow Chow (OR$_a$ = 4.0, 95% CI 1.2 to 13.7) predominant breeds, male (OR$_a$ = 6.2, 95% CI 2.5 to 15.1), unneutered (OR$_a$ = 2.6, 95% CI 1.1 to 6.3), residing in a house with ≥1 children (OR$_a$ = 3.5, 95% CI 1.6 to 7.5), and chained while in the yard (OR$_a$ = 2.8, 95% CI 1.0 to 8.1).

Conclusions. Pediatricians should advise parents that failure to neuter a dog and selection of male dogs and certain breeds such as German Shepherd and Chow Chow may increase the risk of their dog biting a nonhousehold member, who often may be a child. The potential preventability of this frequent public health problem deserves further attention. *Pediatrics* 1994;93:913–917; *dog bite, epidemiology, risk factor.*

ABBREVIATIONS. DMAS, Denver Municipal Animal Shelter; CI, confidence interval; OR, odds ratio.

Dog bites are an underrecognized public health problem.[1,2] Every year in the United States, dog bites cause about 20 deaths[3] and an estimated 585 000 injuries resulting in need for medical attention or restricted activity.[4] Children are the most frequent victims.[2,5–9] A survey of 3238 Pennsylvania school children determined that by, 12th grade, 46% of students had been bitten by a dog and 17% had received medical attention for dog bites.[10] Among children,

dog bites frequently involve the face,[2] resulting in severe lacerations.[11] Dog bites may cause infection,[12–14] cause disability,[15] and incur substantial costs.[15]

Dog bites may be characterized according to the dog, the victim, the dog-victim interaction, and the environment. Dog-specific factors associated with biting include breed,[1,5,6,9,16–19] gender,[6,9,17,18,20] age,[6,17] and size.[2,17,20] These previous studies, however, have been potentially flawed by the choice of the comparison group or by the lack of a comparison group. For example, several studies used licensed or registered dogs as the denominator for bite-rate calculations or as a comparison group.[5,6,16,18] Licensed or registered dogs are unlikely to be representative of the entire dog population. Additionally, none of these studies have used multivariate analysis to assess the independent contribution of bite-related factors while controlling for the potentially confounding effects of other factors.

We conducted a matched case-control study to determine dog-specific factors independently associated with biting a person who was not a member of the dog's household. The identification of such factors, especially modifiable ones, could help reduce the number of dog bite injuries.

METHODS

Study Population

We identified biting dogs (cases) from all 1991 reports to the Denver Municipal Animal Shelter (DMAS), the animal control agency for Denver County. Eligible cases were dogs reported to DMAS in 1991 for biting a nonhousehold member and whose victim received medical treatment as indicated on the bite report. We excluded dogs if they had bitten a nonhousehold member before the reported bite in 1991 because owners, in response, may have changed dog-rearing practices, discipline, and training, and because dogs that repeatedly bite are likely to be removed from the household. We also excluded dogs if more than one dog was involved in the bite episode, the dog had been owned for <6 months before the reported bite, the owner was not a Denver County resident, or the owner's telephone number was not listed on the bite report.

To identify control dogs (nonbiting dogs) from the same geographic area as case dogs, we used the first five digits of the phone number of the owner of the case dog and randomized the last two digits. We then called households until an eligible control dog was found. We excluded dogs from being controls if they had bitten a nonhousehold member or been acquired by the owner after July 1991 (to ensure at least 6 months ownership). For households with multiple dogs, we randomly selected one for participation in the study.

We ascertained information about case and control dogs through structured telephone interviews of the owners, conducted by trained interviewers from the Telephone Survey Unit of the Colorado Department of Health. Because of the need to determine eligibility and explain the study to respondents, interviewers were not blinded to case or control status. Interviewers were aware of the general purpose of the study but not of any specific study questions. We collected information regarding the dog's charac-

teristics (breed, sex, age, weight, neuter status), house and outdoor environment, discipline and training, behavior, and owner's dog-rearing practices. We defined predominant breed as whatever breed the owner considered the dog. If the owner specified only one breed, we asked if the dog was purebred. If the owner mentioned more than one breed, we asked which breed they considered predominant. We abstracted DMAS bite reports for the age and sex of the victim; the location, severity and circumstances of the bite; and license and rabies vaccine status. All data were double-keypunched to ensure accurate data entry.

Statistical Analysis

We performed univariate analysis of the results with the use of SAS statistical software for personal computers.[21] We used the McNemar's test to compare categorical variables and the Wilcoxon rank sum test to compare continuous variables. We used EGRET statistical software for personal computers[22] to perform multivariate conditional logistic regression analysis. The initial (full) model included meaningful variables significant at the $P \le .05$ level in univariate analysis, as well as several variables of a priori interest that approached significance. We tested the addition to the full model of individual effect modifiers (interaction terms) that might be epidemiologically meaningful with a likelihood ratio test. We used a stepwise, backward, variable-selection procedure based on the likelihood ratio test to determine the order and extent of variable deletion. In addition, we restricted the final model to matched pairs in which the bite victim was ≤12 years of age, the median age of bite victims in this study.

RESULTS

Of the 991 dog bites reported to DMAS in 1991, we identified 357 potentially eligible cases from bite reports (representing approximately 94% of all potentially eligible cases in 1991; due to filing problems at DMAS, the other reports were unavailable). Of these, 114 (31.9%) owners were unlocatable by phone (nonworking phone number, owner had moved, no answer, or owner not there on repeated attempts), 33 (9.2%) were ineligible (dog had previously bitten a nonhousehold member, dog owned for <6 months, owner said no bite had occurred, or owner was not a Denver resident), 10 (2.8%) owners refused to be interviewed, and for 22 (6.2%) no control was found. This left 178 cases (50% of those identified as potentially eligible; 18% of all reported dog bites to DMAS in 1991) that we included in this report with their matched controls.

The median age of the bite victims of case dogs was 12 years (range, 1 to 83 years); 64.7% of bite victims were males. The anatomic locations of bites were as follows: 62 (34.8%) upper extremities; 51 (28.7%) lower extremities; 41 (23.0%) face, head, or neck; 15 (8.4%) trunk; and 9 (5.1%) some combination of extremities and trunk. Of the 83 bite victims ≤12 years of age, 33 (40%) were bitten on the face, head, or neck. Although not standardized, bite severity was indicated on report forms for 135 (75.8%) incidents; 103 (76.3%) of these were minor bites and 32 (23.7%) were recorded as severe. Bite report forms indicated where the bite episode occurred for 101 (56.7%) of the incidents. Of these, 51 (50.5%) took place on the sidewalk, street, alley, or playground (no further characterization of these locations in relation to the owner's house was made); 30 (29.7%) in the owner's yard; 14 (13.9%) in the owner's house; and 4 (4.0%) in the victim's yard. Data on whether bites were provoked was not systematically recorded on bite report forms.

Dogs predominantly of Chihuahua, Golden Retriever, Labrador Retriever, Poodle, Scottish Terrier,

and Shetland Sheepdog breeds were more common among nonbiting than among the biting dogs (Table 1). None of the cases and only one control dog was a Pit Bull Terrier (new ownership of Pit Bull Terriers has been prohibited in Denver County since 1989). Dogs predominantly of German Shepherd, Chow Chow, Collie, and Akita breeds were substantially more frequent among biting than nonbiting dogs. The total numbers of dogs predominantly of Collie (n = 9) and Akita (n = 5) breeds were small compared with the total numbers of German Shepherd (n = 47) and Chow Chow (n = 40) predominant breed dogs; therefore, subsequent breed analyses focus on German Shepherds and Chow Chows.

Several dog characteristics were associated with biting (Table 2). Biting dogs were significantly more likely than nonbiters to be Chow Chow or German Shepherd predominant breed, male, not neutered, >50 pounds, and <5 years of age.

Several environmental factors were also associated with biting (Table 2). Biting dogs were significantly more likely to reside in homes with one or more children ≤10 years of age and to be chained while in the yard. Of the 83 dogs chained while in the yard (cases plus controls), 44 (53%) had growled or snapped at visitors to the house. This behavior was also reported, however, of 116 (44%) of 263 dogs not chained while in the yard ($P = .20$, χ^2 test).

Among measures of discipline and training (Table 2), biting dogs were significantly less likely than nonbiting dogs to have been disciplined by a takedown or stringup maneuver (methods sometimes used to discipline dogs with aggression problems); however, only a few dogs were disciplined by these methods. Only five dogs (four cases and one control) had received guard or attack training. No measures of aggressive behaviors or obedience were significantly associated with biting (Table 2).

TABLE 1. Predominant Breed*† Distribution of 178 Biting and 178 Nonbiting Dogs, Denver, 1991

Predominant Breed	No. (%)		P Value‡
	Biting Dogs	Nonbiting Dogs	
Akita	5 (2.8)	0 (0.0)	.06§
Chihuahua	2 (1.1)	6 (3.4)	NS
Chow Chow	31 (17.4)	9 (5.1)	<.001
Cocker Spaniel	8 (4.5)	10 (5.6)	NS
Collie	8 (4.5)	1 (0.6)	.04§
Doberman Pinscher	6 (3.4)	5 (2.8)	NS
German Shepherd	34 (19.1)	13 (7.3)	<.01
Golden Retriever	2 (1.1)	13 (7.3)	.01
Labrador Retriever	9 (5.1)	14 (7.9)	NS
Poodle (standard)	4 (2.2)	14 (7.9)	.03
Scottish Terrier	3 (1.7)	7 (3.9)	NS
Shetland Sheepdog	2 (1.1)	6 (3.4)	NS
Unknown	18 (10.1)	18 (10.1)	
All other breeds	46 (25.8)	62 (34.8)	
Total	178 (100.0)	178 (100.0)	

* Owners were asked what breed they consider their dog; if more than one breed was specified, they were asked which breed they considered to be predominant.
† Only breeds represented by frequencies ≥5 in either the biting or nonbiting group are listed.
‡ Unmatched analysis conducted with Yates corrected Chi-square test unless otherwise noted.
§ Fisher's exact test (two-tailed).

TABLE 2. Characteristics of 178 Biting and 178 Nonbiting Dogs, Denver, 1991

Variable	No./Total No. (%)*		Matched Odds Ratio† (95% CI)
	Biting Dogs	Nonbiting Dogs	
Demographics			
Predominant breed‡			
Chow Chow	28/128 (22)	9/156 (6)	5.5 (2.1–14.2)
German Shepherd	31/131 (24)	12/159 (8)	3.4 (1.6–7.6)
Male sex	136/178 (76)	91/178 (51)	3.0 (1.9–4.8)
Age <5 years	106/177 (60)	84/177 (47)	1.7 (1.1–2.7)
Weight >50 lbs	94/169 (56)	68/174 (39)	1.9 (1.2–3.0)
Not neutered	100/176 (57)	52/177 (29)	3.5 (2.2–5.7)
Not purebred	97/171 (57)	81/172 (47)	1.5 (0.9–2.2)
House/environment			
Got as stray	15/177 (8)	8/176 (5)	2.3 (0.9–5.9)
Got from pet store	9/177 (5)	8/176 (5)	1.1 (0.4–3.1)
≥1 child in house§	102/178 (57)	53/178 (30)	2.7 (1.8–4.2)
≥1 other dogs in house	70/178 (39)	55/178 (31)	1.4 (0.9–2.1)
>8 h/d in yard	88/173 (51)	60/162 (37)	1.6 (1.0–2.6)
Chained while in yard	55/174 (32)	28/171 (16)	2.4 (1.4–4.0)
Discipline/training			
Ever went to obedience school	21/175 (12)	34/174 (20)	0.6 (0.3–1.0)
Ever trained at home	45/178 (25)	32/177 (18)	1.6 (0.9–2.6)
Ever guard/attack-trained	4/174 (2)	1/177 (1)	4.0 (0.5–30.3)
Ever disciplined by takedown/stringup‖	5/173 (3)	14/177 (8)	0.3 (0.1–0.9)
Behavior			
Obedience score ≤3¶	70/173 (40)	50/169 (30)	1.5 (1.0–2.3)
Ever nipped household member	47/178 (26)	46/177 (26)	1.0 (0.6–1.6)
Ever bit household member	19/177 (11)	18/178 (10)	1.1 (0.6–2.2)
Ever growled/snapped at visitors	90/178 (51)	74/178 (42)	1.4 (0.9–2.1)
Barks excessively at passers by	14/178 (8)	11/178 (6)	1.3 (0.6–2.8)
Owner behavior			
Not licensed in past year	86/172 (50)	40/170 (24)	3.3 (2.0–5.3)
No rabies vaccine in past year	33/176 (19)	16/173 (9)	2.5 (1.3–5.0)
Registered with AKC/UKC**	34/170 (20)	31/173 (18)	1.2 (0.7–2.0)
Female dogs			
≥1 litter	19/40 (47)	8/86 (9)	7.0 (1.2–42.3)

* Totals may vary for different variables because of missing data or for predominant breed because of mutually exclusive categories.
† Odds ratios are from matched univariate analysis. CI denotes confidence interval.
‡ Owners were asked what breed they considered their dog; if more than one breed was specified, they were asked which breed they considered to be predominant. The "unexposed" or reference group of 100 biting and 147 nonbiting dogs is composed of all dogs for which the owner did not mention Chow Chow or German Shepherd as one of the breeds; Akitas and Collies are included. Chow Chow–German Shepherd and German Shepherd–Chow Chow mixes are excluded from the analysis.
§ Children ≤10 years of age.
‖ A "takedown" is defined as pinning a dog to the floor/ground on its back while holding it by the scruff of the neck. A "stringup" is defined as lifting a dog off the ground by its chain.
¶ Obedience score is the sum of one point each for a dog regularly on command: sitting, staying, coming to owner, lying down, and walking on its leash without pulling; maximum score = 5 points.
** American Kennel Club/United Kennel Club.

Among cases, the owners' report of license and vaccine status compared with information abstracted from the DMAS bite reports showed substantial disagreement. Current licensure was confirmed by the bite report for only 44% of case dogs which the owner reported as licensed in the past year; for rabies vaccination this figure was 66%.

Nine factors remained in the multivariate conditional logistic regression model (Table 3). Biting dogs were significantly more likely than control dogs to be German Shepherd or Chow Chow predominant breeds, to be male, to reside in a house with one or more children, and not to be neutered. Biting dogs were also more likely to be chained while in the yard; this association reached borderline significance. When we restricted this model to those cases in which

the bite victim was a child ≤12 years of age, elevated odds ratios of similar magnitude were obtained. The variables for the Chow Chow predominant breed and for those not neutered, however, were no longer statistically significant, because wider 95% confidence intervals resulted from the smaller sample size (Table 3).

DISCUSSION

This study of dog bites, we believe, is the first to use a multivariate approach to determine dog-specific factors independently associated with biting. Our study has several potential limitations. We were able to reach only half of potentially eligible biting dog owners. Our selection of cases from reported bites to nonhousehold members in which victims sought medical attention is not representative of all bites. We

TABLE 3. Multivariate Models of Risk Factors for Dogs Biting, Denver, 1991

Variable	All Ages		Victims ≤12 Years Old	
	AOR*	95% CI†	AOR*	95% CI†
Predominant breed‡				
German Shepherd	16.4	(3.8–71.4)	22.1	(2.4–207.4)
Chow Chow	4.0	(1.2–13.7)	3.7	(0.8–18.4)
Male	6.2	(2.5–15.1)	5.3	(1.4–19.8)
≥1 child in house	3.5	(1.6–7.5)	6.9	(1.8–26.1)
Not neutered	2.6	(1.1–6.3)	2.3	(0.7–7.3)
Chained while in yard	2.8	(1.0–8.1)	5.4	(0.7–39.4)
No obedience school	1.9	(0.7–4.9)	1.4	(0.2–8.2)
Purebred	1.7	(0.7–4.0)	1.8	(0.5–6.9)
Weight >50 lbs	1.5	(0.7–3.1)	1.3	(0.4–4.2)

* AOR, adjusted odds ratio; adjusted for all other variables in the model.
† CI, confidence interval.
‡ The "unexposed" or reference group of 100 biting and 147 nonbiting dogs, all dogs for which the owner did not mention Chow Chow or German Shepherd as one of the breeds; Akitas and Collies are included. Chow Chow-German Shepherd and German Shepherd-Chow Chow mixes are excluded from the analysis.

restricted our study to bites of nonhousehold members, because bites involving the owner or owner's family may involve different scenarios, risk factors, and likelihood of reporting. The majority of reported bites appear to occur to nonhousehold members.[2,10,12,18,20]

Although we did not verify the validity of reported bite events, we used the victims' seeking medical attention as a surrogate measure of events likely to be real bites. To the extent that some nonbites may have been misclassified as bites, this would have biased odds ratios of true risk factors toward the null. If bite victims of certain breeds such as Chow Chow or German Shepherd are more likely than those of other breeds to report bites or to seek medical attention, then the associations we found between biting and these breeds could be partly spurious. In contrast, it is extremely unlikely that bite victims knew their attacking dog's sex, neuter status, or whether children reside in the same house and based their decision to report the bite and seek medical attention on this information. Thus, these latter associations appear real.

We did not verify predominant breed as stated by the owner; however, we ascertained breed similarly for both cases and controls. Because of small numbers, we were unable to assess in multivariate analysis whether breeds other than Chow Chow and German Shepherd (eg, Akita, Collie, and Pit Bull Terrier) were more likely to bite. Additionally, we did not assess the role of the victim's behavior in dog bite events.

Our findings are in agreement with previous studies which have indicated that male dogs[9,18,20] and German Shepherds[1,5,6,16,18] are overrepresented among biting dogs. Our finding that Chow Chow is also a high-risk breed for biting has not been previously reported.

Canine behavioral literature has, like our study, suggested that intact males are more aggressive than neutered males.[23,24] Unlike our findings, however, the literature suggests that unneutered female dogs may be less likely to bite than neutered female dogs.[23–25] We were unable to further assess the role

of having one or more litters as an independent risk factor for female dogs biting.

The increased risk of biting for dogs residing in houses with one or more children has not been previously reported. This association might be explained partly by dogs having greater opportunity to express protective (of the home, yard, or owner), possessive (approached while in possession of food, toys, or objects), or fear-induced (approached, reached for, or threatened) aggression[26] in the context of young playmates visiting with household children.

Our finding that being chained in the yard may be a risk factor for biting is in agreement with prior studies which have demonstrated that chained dogs account for a substantial proportion of serious[27] and fatal bites.[3] A dog may be chained as the result of having exhibited aggressive behavior which itself may be a risk factor for biting, rather than chaining somehow causing a dog to bite. One measure of aggressive behavior may be growling or snapping at visitors to the house. Our results, however, showed no significant difference in this behavior for dogs chained while in the yard and those not chained, suggesting that chaining was not likely to have been the result of aggressive behavior.

An estimated 36.5% of American households owned a dog in 1991 for a total dog population of 53.5 million.[28] Given the large numbers of canines and the magnitude of the dog bite problem, more attention needs to be devoted to the prevention of dog bites. Prevention strategies have been proposed which focus on victims, dogs, and owners including: educational programs on canine behavior especially directed at children,[29] laws for regulating dangerous or vicious dogs,[30,31] and educational programs regarding responsible dog ownership.[29,31] The effectiveness of these strategies has not been assessed. Improved surveillance for dog bites is needed if we are to understand better how to reduce the incidence of dog bites and evaluate prevention efforts.

Our study suggests that owners, through their selection and treatment of a pet, may be able to reduce the likelihood of owning a dog that will eventually bite. Further study is needed to confirm our findings, especially in other geographic areas where different breed propensities for biting may exist. In the meantime, given the numbers of dog bites and the high proportion of victims who are children, we believe that the potential preventability of this public health problem deserves further attention by pediatricians and parents. Pediatricians currently offer anticipatory injury prevention guidance to parents.[32] We urge pediatricians to also advise parents that failure to neuter a dog and selection of male dogs and certain breeds, such as German Shepherd and Chow Chow, may increase the chances of their dog biting a nonhousehold member, who often may be a child.

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TIME TO THROW IN THE TOWEL?

England must take the credit—or blame—for the reinvention of boxing. The sport was a popular part of the Roman games but had vanished by the 5th century. It returned some 1200 years later, when bare-fist prizefights began to be held in and around London. With help from the Marquess of Queensberry, boxing spread around the world, making money for a considerable number of boxing promoters and a smaller number of boxers.

It is appropriate, then, that the British Medical Association should be actively involved in examining the sport. In its latest report, *The Boxing Debate,* which was issued last week, it repeats its call for a ban on boxing and asks for an independent inquiry into its safety.

The briefest reading of the report should persuade even boxing's proponents of the need for an inquiry. In its appendix the report prints abstracts of recent research on what happens to boxers after they have been battered in the ring.

For professional boxers, several studies make unpleasant reading. One using computerised tomography found 87 per cent of boxers, in a sample of 18, showed evidence of brain damage. Another records that 15 out of 19 young boxers register as impaired on a battery of neuropsychological tests.

Particularly disturbing are three studies which show that changes found in the brains of ex-boxers are immunochemically similar to those seen in Alzheimer's disease. That raises the possibility that even boxers who retire from the ring healthy may pay the price in middle age with early onset of Alzheimer's disease.

Time to throw in the towel? *New Scientist.* June 19, 1993:3.

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