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Clinical and epidemiologic features of persons accessing emergency departments for dog and cat bite injuries in California (2005–2019)

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OBJECTIVE
To describe the clinical and epidemiologic features of persons with dog and cat bite injuries who presented to emergency departments.

SAMPLE
Records of 648,492 dog and cat bite–related emergency department visits in California from 2005 to 2019.

PROCEDURES
Visits were selected by standardized International Classification of Diseases, Ninth or Tenth Revision, Clinical Modification codes that indicated a bite as an external cause of injury in the medical record. Incidence rates were calculated for patient demographics, location and month of bite incident, characteristics of bite injury, infection, patient outcome/disposition, and expected source of payment. Cross-sectional descriptive analysis was performed.

RESULTS
The average annual incidence of dog bites was highest in children aged < 10 years and males, while that of cat bites was highest in adults aged ≥ 80 years and females. Bites were more likely to occur in rural settings, in private residences, and during the summer. The median household income for zip codes in which animal bite patients resided was lower than the statewide median household income. Both dog and cat bite injuries were more likely to occur to upper limbs. Bacteria were isolated from 3% of dog bite injuries and 21.5% of cat bite injuries at initial presentation.

CLINICAL RELEVANCE
Epidemiologic findings about persons presenting to emergency departments for animal bite injuries can inform bite prevention efforts by identifying at-risk populations. Effective animal bite prevention demands an ongoing multisectoral program of veterinarians and other health professionals, collaborating with community and governmental organizations, to develop and implement integrated strategies within the context of other socially contributory factors.

Numerous physical, psychological, and sociological health benefits have been associated with persons having a pet in the household.[1] However, pet ownership is not without inherent risk of disease and injury.[2,3] Approximately half of Americans will be bitten by an animal at some point during their lifetime.[4]

Most animal bites do not result in significant injuries that warrant medical attention. Of the approximately 4.5 million people bitten by dogs each year, 885,000 (20%) seek medical care for resultant injuries or infections.[5] In California, where 35 million pets reside in over half of households, these figures translate to approximately 560,000 dog bites and 112,000 victims seeking medical care each year. Estimated costs for dog bite–related (DBR) injuries range from $416 to $1,917 for treatment at an emergency department (ED)[6–8] or roughly $50 million annually in direct medical costs alone in California.

California state regulations require that any bite to a person from an animal susceptible to rabies (ie, any mammal) be reported to the local health officer. However, not all bites are reported to authorities, medical consequences to the bite victim are rarely documented, and the information collected on bite reports is neither standardized nor routinely shared across local jurisdictions. Therefore, despite 35,300

to 53,400 animal bites documented in California every year from 2005 to 2019,[9] the epidemiology of animal bite injuries and their impact on the healthcare system remain largely undescribed.

For this study of animal bite morbidity in California, we examined records of persons who presented to EDs for injuries resulting from animal bites during the 15-year period of 2005 to 2019. The objectives of this study were to describe the epidemiologic and clinical features of persons with dog and cat bite injuries who presented for emergent medical care and to identify populations poised to best benefit from focused preventive communication and intervention.

Materials and Methods

Records were reviewed for all presentations to 360 emergency medical facilities at California hospitals between January 1, 2005, and December 31, 2019. These records were retrieved from a centralized database of all EDs in the state. Records contained data on patient attributes (age, date of birth, Social Security number [SSN], gender, race/ethnicity, and zip code and county of residence) and ED visits (diagnosis, procedures, payer type, and disposition). Data were coded according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) for visits before October 1, 2015, and International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) for visits on and after October 1, 2015.

An ED record was eligible for inclusion in the study if the patient presented for injuries sustained by a bite from a dog or cat. Bites from dogs were identified by ICD-9 E-code E906.0 (dog bite) and ICD-10 E-code W54.0 (dog bite). Cat bites were identified by ICD-9 E-code E906.3 (cat, moray eel, rodent other than rat, or shark bite) and ICD-10 E-code W55.01 (cat bite). For the purposes of this study, all records with ICD-9 E-code E906.3 were considered cat bites.

Records were associated to a unique patient by SSN. For records without a valid SSN, zip code of residence and date of birth were used to identify individual patients. The first ED visit for a given patient in the 15-year study period was considered an incident visit. Visits that occurred within 30 days following any earlier visit were considered re-presentations for the same complaint. Thirty days was considered an appropriate time period for a patient to present with significant sequelae from a bite event.[7] Any visit by a patient 30 or more days after a previous visit was classified as a new incident visit. Because a given individual may have presented as a patient for more than 1 animal bite–related (ABR) event during the 15-year study period, each incident visit was the primary unit of analysis for this study.

Incidence rates (IRs) of ABR visits were calculated on the basis of the number of incident visits, as each incident visit was assumed to represent a unique bite event. IR estimates were calculated using published population figures[10] and, except where otherwise indicated, are expressed as number of cases/100,000 population per year. Data on median household income by zip code were obtained from the US Census Bureau.[10] Patients' residences were categorized using the US Census Bureau's urban-rural classification scheme. Only records for which California residency was verified by the patient's self-reported county and zip code of residence were included in population-based incidence estimates.

Descriptive analyses were conducted using commercially available statistical software (SAS version 9.4; SAS Institute Inc) and spreadsheet software (Excel; Microsoft Corp). Categorical variables were described as counts and proportions, and continuous variables were described by use of medians and ranges.

Results

Records were reviewed for 161,048,925 ED visits that occurred between January 1, 2005, and December 31, 2019. Records for 549,316 DBR visits and 99,176 cat bite–related (CBR) visits, representing 602,381 total unique patients, met eligibility criteria for inclusion in the study.

There were 523,689 DBR incident visits **(Table 1)**, with a median annual IR of 97.6. The DBR IR increased from 69.2 in 2005 to 113.0 in 2019. There were 99,497 CBR incident visits with a median annual IR of 18.2 and 15-year increase from 15.3 to 19.2.

The median age of patients with DBR injuries was 28 years (range, 1 day to 119 years). The IR was highest for children aged 5 to 9 years (148.0), and IRs generally decreased with age **(Figure 1)**. Over the 15-year study period, the DBR IR for children aged < 15 years was 121.0 in 2005, peaked at 142.9 in 2010, then decreased to 123.9 in 2019. From 2005 to 2019, IRs increased between 42.0% (40 to 44 years of age) and 192.5% (65 to 69 years of age) in all other age groups. The median age of patients with CBR injuries was 46 years (range, 1 day to 104 years). IRs for CBR visits generally increased with patient age, with the highest for adults aged ≥ 80 years (33.6). Between 2005 and 2019, IRs decreased by 48.7% for children aged < 15 years and decreased 18.9% for adults aged 40 to 49 years, while rates increased between 5.3% (50 to 54 years of age) and 148.6% (65 to 69 years of age) for other age groups.

The IR for DBR visits was higher for males than females overall (99.4 vs 88.1) and for every age group younger than 45 to 49 years or older than 70 to 74 years. The IR for CBR visits was higher for females (24.3) than males (11.2) overall and across all age groups. From 2005 to 2019, rates of DBR and CBR visits increased for both females (76.9% for DBR and 31.2% for CBR) and males (52.7% for DBR and 12.9% for CBR).

IRs were highest among patients who identified as White or Other race for both DBR injuries (106.6 and 142.3) and CBR injuries (31.1 and 19.6; Table 1). From 2005 to 2019, IRs increased the most for Hispanics (107.7% for DBR and 100.5% for CBR) and Asian/Pacific Islanders (171.8% for DBR and 139.9% for CBR).

The estimated IRs for both DBR (704) and CBR (134) visits for patients from rural areas were near-

Table 1—Dog bite– and cat bite–related emergency department (ED) visit incidence rates (IRs)/100,000 person-years in California from 2005 to 2019.

Variable	Person-years	No. of ED visits for dog bites	Dog bite IR	No. of ED visits for cat bites	Cat bite IR
Age group (y)					
< 5	37,969,995	53,761	141.6	3,939	10.4
5–9	37,587,585	55,623	148.0	3,439	9.1
10–14	38,863,950	40,753	104.9	2,978	7.7
15–19	42,359,100	36,796	86.9	3,973	9.4
20–29	82,655,370	84,470	102.2	14,731	17.8
30–39	77,205,705	65,087	84.3	12,179	15.8
40–49	79,484,250	62,112	78.1	13,857	17.4
50–59	71,502,720	59,822	83.7	16,578	23.2
60–69	47,036,325	36,161	76.9	13,339	28.4
70–79	26,081,235	18,952	72.7	8,422	32.3
≥ 80	18,063,105	10,152	56.2	6,062	33.6
Total	**558,809,340**	**523,689**	**97.6**	**99,497**	**18.2**
Gender					
Female	281,041,890	247,532	88.1	68,323	24.3
Male	277,767,450	276,039	99.4	31,156	11.2
Total[1]	**558,809,340**	**523,571**	**93.7**	**99,479**	**17.8**
Race/ethnicity					
White	224,343,795	239,069	106.6	69,877	31.1
Black	32,457,060	33,702	103.8	2,255	6.9
Hispanic	210,205,785	178,384	84.9	17,433	8.3
Asian/Pacific Islander	73,554,705	35,744	48.6	4,427	6.0
American Indian/ Alaskan Native	2,433,750	2,424	99.6	469	19.3
Other	15,814,245	22,496	142.3	3,096	19.6
Total[1]	**558,809,340**	**511,819**	**91.6**	**97,557**	**17.5**
Residential setting					
Urban	501,415,335	119,593	23.9	22,498	4.5
Rural	57,394,005	404,096	704.1	76,999	134.2
Total	**558,809,340**	**523,689**	**93.7**	**99,497**	**17.8**

[1]Numbers may not sum to total (523,689 dog bites and 99,497 cat bites) due to missing values.

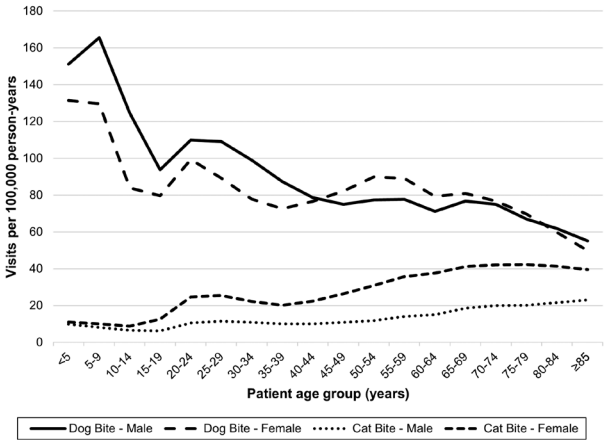

Figure 1—Dog and cat bite–related emergency department visit incidence rates by patient age and gender in California from 2005 to 2019.

ly 30 times higher than those for patients from urban areas (23.9 and 4.5, respectively). The median household incomes of residential zip codes for DBR and CBR patients were $42,774 and $46,858, respectively—lower than the median household income of $54,283 for the state of California. The median household income was marginally higher for patients who lived in rural areas ($42,970 for DBR and $47,031 for CBR) compared to patients from urban areas ($41,952 for DBR and $46,175 for CBR).

More bites occurred at residences than in public settings for both DBR (33,162/45,477 [72.9%]) and CBR (6,584/7,673 [85.8%]) visits. The highest proportion of dog bites that occurred in residences was for patients aged < 5 years (93.0%), and the highest proportions of cat bites that occurred in residences were for patients aged < 5 years (92.3%) and adults aged ≥ 55 years (92.3% to 98.9%). More DBR and CBR visits occurred in the summer (53,306 DBR and 10,388 CBR in July) than in winter (35,656 DBR and 6,528 CBR in February).

The anatomic site of the bite injuries was recorded for 91% of DBR (476,342) and CBR (90,409) visits. Approximately half of DBR injuries were on the upper limbs (312,449 [51.4%]), followed by the head, face, and neck (149,090 [24.5%]); lower limbs (122,475 [20.1%]); and trunk (24,393 [4.0%]; **Figure 2; Table 2**). The IR of DBR injuries to the head/face/neck collectively was highest for children aged < 5 years (106.4) and decreased with age (5.0 for adults aged ≥ 70 years). Approximately half of all head/face/neck injuries that occurred in DBR patients (69,964/149,090) were in children aged < 10 years. The IR of upper limb injuries was lowest for children aged < 5 years (31.8) and highest for patients aged 10 to 24 years (52.9) and adults aged 50 to 69 years (64.0). More than 80%

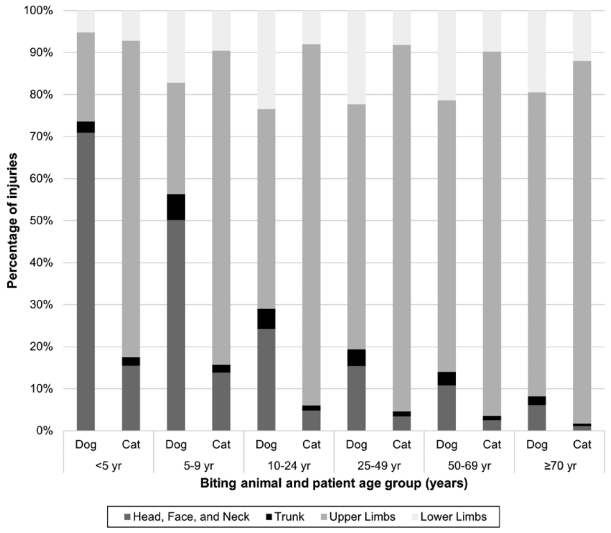

Figure 2—Anatomic location of dog and cat bite injuries for patients presenting to emergency departments in California from 2005 to 2019.

of CBR injuries were on the upper limbs (106,051 [86.0%]), followed by the lower limbs (11,442 [9.3%]), head/face/neck (4,470 [3.6%]), and trunk (1,331 [1.1%]). The IR of CBR injuries to the upper limbs was higher than all other locations across all age groups and generally increased with age, from 7.6 for children aged < 5 years to 38.1 for adults aged ≥ 70 years. Injuries to 2 or more sites were observed in 28,672 (6.0%) DBR and 2,116 (2.3%) CBR patients.

The injured tissue was recorded for 90% of DBR (470,506) and CBR (89,448) visits. Approximately 98% of recorded DBR injuries were dermatological (485,495), including 436,192 open wounds, 35,872 contusions, and 13,309 cellulitides/abscesses. Musculoskeletal injuries—including fractures, dislocations, sprains, strains, and crushing injuries—were reported in 11,826 (2.4%) DBR patients. Of the 638 skull fractures, 99 were in children aged < 5 years. Of the 280 internal injuries, 232 were intracranial and 48 were intrathoracic, intra-abdominal, or pelvic. Approximately 99% of CBR injuries were dermatological (103,510), including 78,357 open wounds, 19,812 cellulitides/abscesses, 5,338 contusions, and 3 cases of subcutaneous emphysema. Musculoskeletal and internal injuries were reported for 737 (0.7%) and 20 (0.02%) CBR patients, respectively. Multisystem injuries were sustained by 8,244 (1.8%) DBR patients and 497 (0.6%) CBR patients.

Infections of skin, subcutaneous tissue, joints, or bones were diagnosed in 15,494 (3.0%) DBR patients. The proportion of patients who developed DBR wound infection generally increased with age, with the least among patients aged 10 to 14 years (420/40,753 [1.0%]) and the greatest among patients aged ≥ 85 years (357/4,665 [7.7%]; **Figure 3**). Infection was diagnosed in 21,395 (21.5%) CBR patients. CBR wound infections were proportionately least frequent in patients aged 5 to 9 years (280/3,439 [1.3%]) and most frequent in patients aged 55 to 59 years (2,247/8,338 [10.5%]).

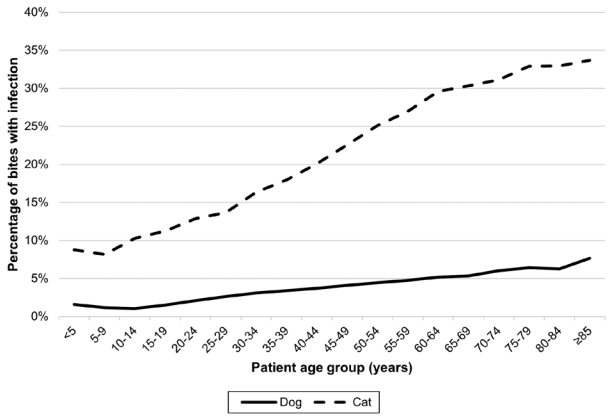

Figure 3—Wound infections in dog and cat bite victims presenting to emergency departments in California from 2005 to 2019.

Table 2—Injuries diagnosed during dog and cat bite–related ED visits by injury type and patient age group in California from 2005 to 2019 (number of injuries and IR/100,000 person-years, for each age range).

		Injuries to head, face, and neck		Injuries to trunk		Injuries to upper limbs		Injuries to lower limbs	
Animal	Age group (y)	n	IR	n	IR	n	IR	n	IR
Dog	< 5	40,418	106.4	1,558	4.1	12,079	31.8	2,974	7.8
	5–9	29,546	78.6	3,658	9.7	15,623	41.6	10,178	27.1
	10–24	33,034	26.9	6,517	5.3	64,918	52.9	42,582	34.7
	25–49	31,226	15.8	8,125	4.1	95,132	48.1	45,074	22.8
	50–69	12,669	10.7	3,790	3.2	75,871	64.0	21,101	17.8
	≥ 70	2,197	5.0	745	1.7	21,593	48.9	7,029	15.9
	Total	**149,090**	**26.7**	**24,393**	**4.4**	**312,449**	**55.9**	**122,475**	**21.9**
Cat	< 5	592	1.6	75	0.2	2,881	7.6	275	0.7
	5–9	465	1.2	65	0.2	2,515	6.7	323	0.9
	10–24	781	0.6	199	0.2	14,029	11.4	1,299	1.1
	25–49	1,423	0.7	500	0.3	36,066	18.2	3,390	1.7
	50–69	987	0.8	380	0.3	33,745	28.5	3,825	3.2
	≥ 70	222	0.5	112	0.3	16,815	38.1	2,330	5.3
	Total	**4,470**	**0.8**	**1,331**	**0.2**	**106,051**	**19.0**	**11,442**	**2.0**

Bacteria were identified in 106 DBR wound infections at 105 incident visits. The bacteria most frequently isolated from DBR wounds were *Staphylococcus* spp (60 [56.6%]) and *Pasteurella* spp (28 [26.4%]; **Figure 4**). Bacteria were identified in 233 CBR wound infections at 230 incident visits. The bacteria most frequently isolated from CBR wounds were *Pasteurella* spp (156 [67.0%]), *Bartonella* spp (49 [21.0%]), and *Staphylococcus* spp (18 [7.7%]). Approximately half of *Staphylococcus* spp isolates from both DBR (29) and CBR (10) infections were resistant to methicillin-type antibiotics. Polymicrobial infections were identified at 1 DBR visit and 3 CBR visits.

Four percent (20,913) of patients presenting for DBR injuries returned to the ED a median of 3 days (range, 1 to 30 days) following the incident visit, for a total of 25,627 re-presentations. Infections were noted at 3,794 (24.6%) re-presentations with 3,199 (84.3%) DBR infections not previously documented at the incident visit. Approximately 6% of patients with CBR injuries (5,246 patients) returned a median of 2 days (range, 1 to 30 days) following the incident visit, for a total of 6,408 re-presentations. Infections were noted at 2,437 (11.4%) re-presentations with 1,392 (57.1%) CBR infections not documented at the incident visit.

Most patients (556,778 [97.0%]) received no further care at an ED. Approximately 1% (5,402) of patients required additional medical care, with 4,193 discharged to hospital including 492 patients with an infection, 809 to a nonhospital medical facility, 357 to organized care at home, and 43 to hospice.

Twenty-seven patients presenting with DBR injuries died at the ED—26 at the incident visit and 1 at re-presentation. Nineteen deceased patients were male, and 11 were children aged < 5 years—including 3 infants aged < 12 months—and 2 adults aged ≥ 85 years. Two patients with CBR injuries died at the ED. Both patients were adult females aged ≥ 60 years.

Neither itemized nor total ED charges were available. Expected sources of payment were recorded as private insurance (252,334 [40.5%]) and publicly funded programs (248,168 [39.8%]), the latter including Medi-Cal (163,973 [26.3%]), Medicare (72,997 [11.7%]), and other government programs (11,198 [1.8%]) such as Veterans Affairs. From 2005 to 2019, the percentage of visits covered by publicly funded programs increased 80.4%.

Discussion

This study provided further data on the epidemiologic and clinical features of persons with injuries sustained from dog and cat bites. The concordance of results of this study with those of numerous previous studies underscores that the same populations are consistently recognized to be at elevated risk. These invariable observations, along with increasing annual incidence rates over the study period, suggest that public health interventions have been largely unsuccessful in ameliorating the landscape of animal bite morbidity in the US. Effective prevention may require transformative and innovative strategies to address the recurrent risk factors for animal bites identified by this and previous studies through integrated, multidimensional prevention efforts that empower individual and community engagement.

More than 5 times as many DBR ED visits were observed than CBR visits. Numerous studies have identified dogs as contributing to most ABR incidents.[11–13] Dog bites may not only occur with greater general frequency, but the gravity of the actualized or potential health effects of a dog bite may motivate victims to both report the bite to local authorities and seek medical care. The large size of some dogs presents the potential for serious injury, as they can cause crushing injuries, deep lacerations, and fractures and also damage sizeable regions of skin and other tissues, particularly in proportion to the diminutive size of children.

The IR of DBR visits for children aged < 10 years was 50% higher than that of older children and teenagers and nearly double that of adults. In contrast,

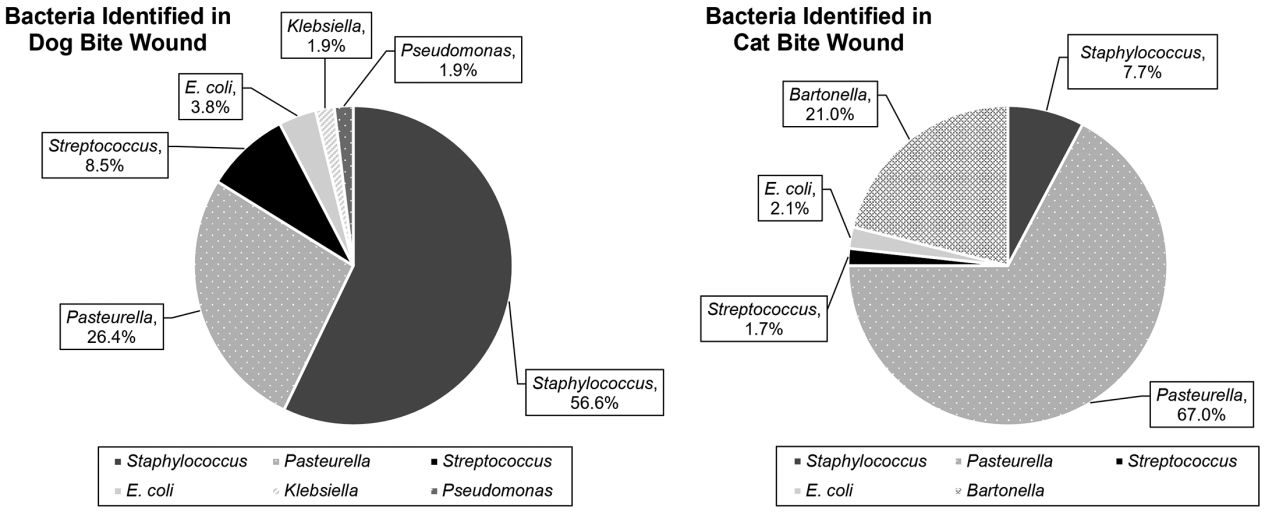

Figure 4—Bacterial species identified in wounds for patients presenting to emergency departments for dog bites and cat bites in California from 2005 to 2019.

CBR visits occurred more commonly in persons middle aged and older with a median age that was higher than that for DBR patients. The inverse associations of dog and cat bites with age may reflect differences in the evolution of both quantitative and qualitative interactions with these animals as individuals age. Previous studies have consistently identified children aged 5 to 9 years as the highest risk group for DBR injuries.[11,14–19] Children engage dogs often in the context of active play in a manner substantially more frequent, intimate, and assertive than they would be disposed to engage with cats, which are often perceived to be less reciprocative to a child's overtures of affection or invitations to play.[20,21] However, some dogs may perceive as threats children's play-related quick and unpredictable movements, high-pitched and loud vocalizations, and direct eye contact.[22] Children may fail to appreciate dispositional differences between individual dogs, assuming that all animals are, like familiar pets, reliably friendly and approachable.[23] The higher IR of CBR injuries in older populations, in contrast to DBR injuries, is consistent with the average age of cat owners reportedly being older than dog owners.[24] The less demanding physicality required for interacting with a cat, including during play, may align better with the typically diminishing physical capacity and inclination attendant with an owner's advancing age. A multicountry survey of cat owners with young children showed that cats, in turn, appeared to prefer the company of and were more likely to be affectionate with adults over children.[20]

Dog bite patients were more commonly male, as observed in previous studies.[10,14–17,25,26] DBR injuries have been reported more frequently in male than female children aged ≤ 14 years but similar between males and females aged > 14 years.[26] Psychological studies have indicated that boys have less intentional control and prefer or are encouraged to participate in more physical forms of play.[27,28] As such, boys may be more inclined to engage with dogs in actions that precipitate an aggressive or protective response.

Cat bite patients were more commonly female, consistent with other studies of CBR injuries.[13,25,29] The overrepresentation of females with CBR injuries may be due in part to cat ownership being traditionally more prevalent among females than males.[24] The higher IR of CBR injuries in females may also be due to females being more likely than males to seek interactions with cats or to prefer cats in general. An Italian study[30] showed that cats spent more time with female owners than male, suggesting that cats themselves may prefer the company of females over males.

Dog ownership may be neither the sole nor preeminent factor that contributes to dog bite risk across racial/ethnic groups. While IRs of DBR injuries mirrored national dog ownership survey data[24] for Whites, Asian/Pacific Islanders, and Hispanics over the study period, the IR of DBR injuries for Black patients was inconsistent with these previously published survey data.[24] IRs in the present study were comparable between Whites and Blacks, despite survey data indicating that 44.2% of White households own a dog, compared to only 22.3% of Black households. However, pet ownership surveys are vulnerable to biases of information and mis- or underrepresentation of certain groups that can limit their validity when applied to other populations.[31]

Whether by the victim's own animal or someone else's, most dog and cat bites in this study occurred on residential property—a finding consistent with many previous studies.[6–8,11,14,16,19,25,26,32–34] In particular, > 90% of animal bites in the youngest and oldest patients occurred at a residence. Very young and very old individuals may spend a greater proportion of time at their residences, affording opportunity for frequent or continuous exposure to household pets. Caregivers for individuals in these age groups may provide less direct supervision within the home environment where pets are presumed congenial toward family members. Laws and ordinances enacted over the last century primarily to control rabies—particularly animal confinement mandates—may reduce the prevalence of free-roaming dogs in the community but also shift the ratio of dog bites from public places to private residences.

The incidence of ABR visits was higher in the summer and lower in the winter, a seasonal trend that has been observed in previous studies.[7,8,13,14,17,18,32] It is most frequently proposed that increased daylight hours and warmer weather, as well as scholastic summer breaks, motivate people, particularly children, to be more active outdoors and consequentially expand opportunities for interactions with dogs that could lead to more bite incidents.[13,17,22,33]

Upper limbs were the most frequent anatomic site for ABR injuries, possibly because hands and arms are often placed into vulnerable positions during a bite event, either proactively (eg, reaching to pet an animal) or protectively to deflect an attack. Younger children are more likely to sustain injuries to the head, face, and neck—a consistently recognized phenomenon most commonly attributed to children's shorter stature.[17,18,26,33] Children also may be more disposed to initiate intimate contact with animals, through hugging or kissing, which brings their heads close to the biting animal.

The most frequently identified bacteria in infected bite wounds were *Pasteurella* spp (chiefly cats) and *Staphylococcus* spp (dogs and cats), which as normal commensal oral and skin flora, respectively, are commonly cultured from dog and cat bite wounds.[11,14,29] Infections develop in up to 50% of dog bite wounds and up to 75% of cat bite wounds.[11,25] In the present study, infections were noted in records for 3% incident and 24.6% re-presentation visits for dog bites and 21.5% incident and 11.4% re-presentation visits for cat bites. The percentages of cases with reported wound infections at incident and re-presentation visits suggest that wound infection may be a greater motivation for CBR patients to initially seek emergency medical care compared to DBR patients. The comparatively benign tissue trauma of CBR puncture wounds belies the deep penetration into subcutaneous tissue that both resists thorough cleansing through first aid wound care and provides a hospitable environment for bacterial growth. Nearly 90% of CBR injuries in the

present study were to the upper extremities, where superficial proximity to tendon sheaths and joints in the hand and wrist makes this area particularly concerning for deep infections.[29]

Rabies is an infectious consequence of animal bites that is of paramount concern to many bite victims and clinicians providing their care. During the study period, 3 Californians died of rabies, 2 of whom were bitten by canids outside the US and the third was bitten by a bat in California.[35] The absence of rabies deaths in California attributable to autochthonous dog bites contrasts sharply with the 27 patients in the present study who died prior to discharge from the ED, presumably from the DBR injuries they sustained. The 2 deceased cat bite patients were older adult females, whereas dog bite patients who died were predominantly young (< 5 years) males. Reviews of US data on fatalities from DBR attacks revealed that deceased patients were more likely to be young males; approximately 11% of deaths occurred in children aged < 1 year and 32% of deaths occurred in children aged 1 to 4 years.[34,36]

This study provides an additional perspective into the epidemiology of dog bites and cat bites through the lens of bite victims who sought medical care at an ED. It was not the objective to describe the general epidemiology of all animal bites, as only approximately 8% of dog bite victims seek medical care at an ED.[6] Data derived from ED records may preferentially represent patients with truly serious and medically exigent injuries, patients whose anxieties or uncertainties exceed the gravity of their injuries, or patients for whom EDs are the only practical or economically tenable health-care option. The present study did not include persons who judged their injuries as adequately treatable with at-home or on-site first aid. Nor did the study include persons who sought medical attention through their primary health-care provider, at urgent care clinics, or from nontraditional health-care agents. Nonetheless, ED records are useful for capturing animal bites that result in serious injuries or were inflicted to particularly vulnerable victims (eg, very young, very old, infirmed, or those with limited access to health-care resources).[5] Animal-human interactions that result in injuries that have serious medical consequences or impact the health-care delivery network are the subset critical for public health analysis, understanding, and intervention.

The validity of results of this study relies in part on completeness and accuracy of coding in medical records, which likely varied to an inestimable degree across the 360 EDs. ABR visits may not be captured if an injury is misclassified in hospital records; conversely, an ICD code indicating an ABR injury may be recorded mistakenly. The absence of an ICD code for chief complaint and the lack of triage notes in the data set precluded exploration for other animal-related injuries (eg, cat scratches) that were not assigned an animal bite ICD code. Moreover, without a recorded chief complaint, the reason a patient returned to the ED within 30 days following a previous visit could only be assumed to be for the same injury. Wound infections were assumed to be consequential to the bite event, though this causal association could not be confirmed. The list of bacteria with ICD codes is not exhaustive, and the methods of diagnosis (eg, culture) and corresponding sensitivity and specificity are unknown. The data set did not contain free-text fields for written medical notes, so data on the circumstances of the bite event were limited to coded fields. Codes for the setting where the animal bite occurred were instituted only with the ICD-10; thus, these data were not available for ED visits prior to October 1, 2015. Finally, inclusion of multiple species within the ICD-9 code for cat bites meant that we were unable to determine which visits with that ICD-9 code were due to specifically cat bites.

A pet's predisposition to bite, the potential bite victim's behavior, and the environmental context all play roles in the occurrence of animal bites. Weighing the relative contributions of these elements in a given bite event can be challenging. Multiple factors contribute to a pet's predisposition to bite, including heredity, medical and behavioral health, reproductive status, socialization and training, and past experience.[8,19,34] A clear assessment of "provocation" is difficult as most people, particularly children, are unaware of the subtleties of animal behavior cues, yet conversely expect pets to understand human motivations. In a national study[37] of children hospitalized for facial injuries from dog bites, most children reported that the bite followed a positive intended interaction (eg, hugging) rather than a negative intended interaction. In their testimonial accounts of a bite event, the victim or other witnesses may report only grossly evident actions as provocative. In a study[8] of patients hospitalized for dog bites in Minnesota, nearly all the bites (96%) to children younger than 1 year of age were reported to occur while the child was approaching, teasing, or otherwise "provoking the dog." Nonetheless, 44.6% of self-identified dog bite victims in the UK blamed themselves, 40% blamed the dog's owner, and only 12.7% blamed the dog.[38] These findings suggest that most persons recognize and acknowledge that the dog generally behaved according to its nature and it was a human who misread (victim) or mismanaged (owner) the situation. Considering the challenges associated with preempting animal bites, it is important for pet owners to receive information on animal behavior and handling and supervise interactions between children and pets.

The practicing veterinarian is frequently expected to include education on animal behavior and bite prevention within the expanse of preventive and therapeutic health care. Beyond the challenge of providing this information comprehensively to all clinic clientele, some pet owners never make it as far as the examination room due to geographic displacement—where veterinary clinics are nonexistent, rare, or require transportation unavailable to residents—or practical economic barriers.

Placing animal bite incidence within the broader socioeconomic context is imperative to engage allies outside the veterinary and human health-care net-

work. Elected officials and civic leaders must recognize animal bite prevention as a social and community problem. Like previous studies, this study identified residents of lower income households and rural communities as having significantly elevated risk of animal bite injuries.[7,8,14,16–18,32,39,40] The race/ethnicity findings in the present study suggest that the risk of animal bites aligns less with pet ownership, for the individual or the aggregate community, and perhaps more with some of the same social determinants that contribute to other recognized health disparities (eg, hypertension, coronary heart disease, and diabetes) among persons in lower socioeconomic strata.[41] Pet owners from rural and low income areas may lack access to veterinary care, including spay/neuter services, and other resources to support pet ownership. Physicians and health-care facilities may be beyond the practical or economic reach of residents. Preventive care may be minimal and therapeutic care for exigent medical issues accessible solely through EDs. Publicly funded health insurance programs were the expected source of payment for 40% of ED visits in the present study, which may reflect preferential or necessitated use of EDs for medical services and underscore how the burden of individual ABR injuries reverberates to the broader community.

Many of this study's findings about the epidemiology of animal bites, including the most impacted populations, reiterate findings from comparable studies published over the last several decades. The present study identified a curvilinear trend in IRs for DBR visits for children aged < 15 years across the 15-year study period. However, by the end of the study period, dog bites were still the ninth leading cause of nonfatal emergency department visits for children aged 5 to 9 years nationwide and in the top 20 leading causes for all other age groups.[42] Public health agencies, medical associations, and other organizations have typically adopted a chiefly didactic posture for animal bite prevention and developed numerous modes of delivery to children, including coloring books,[43,44] games, and whimsical videos.[45] However, these organizations rarely have the luxury of time, expertise, and resources to validate materials, target marketing and distribution, and measure the efficacy of these materials to instill enduring retention and practical application of their key learning objectives. Animal bite prevention messaging has traditionally focused on dog bites and has been directed toward children or individuals who are at higher risk by virtue of occupation or avocation, including veterinarians, animal control officers, postal carriers, and wildlife biologists. The present and other studies highlight other demographic groups (eg, elderly women) who are more vulnerable to medical complications of animal bites due to immunosenescence, comorbidities, and/or use of immunosuppressive medications[29] but whose needs for aid in prevention of bites from other animals (ie, cats) have been largely overlooked. To craft effective preventive strategies, studies of dog and cat bite morbidity must respect and reflect not only the frequency of pet interaction but how these relationships qualitatively change with age and life circumstance.

Animal bites remain a public health problem that demands multisector engagement and enduring commitment of dedicated resources. Existing community efforts on bite prevention are largely carried out through animal control ordinances and municipal animal control agencies responsible for enforcement. Domestic dog vaccination and licensing regulations were instituted in the mid-20th century as public health measures to contain and control rabies transmission. With the eradication of the canine rabies virus variant in North America, the focus of rabies prevention has shifted to certain wild animal reservoirs (ie, bats, raccoons, skunks, and foxes).[46] Nonetheless, the extant rabies laws and animal control institutions remain in place with the intent of protecting the public (eg, animal confinement requirements), with containment of rabies now representing a mostly secondary and indirect objective. A study of current animal control ordinances demonstrated that they may emphasize control issues over animal welfare concerns and disproportionately impact low-income communities in the US.[47,48]

The role that animal control agencies play in supporting pets and pet owners in their jurisdictions should be reimagined from an agency that is often perceived to erect obstacles and constraints on pet ownership to one that facilitates healthful relationships between residents and companion animals through greater proactive community engagement and education. Reallocating resources to community collaboration and support would allow animal control agencies to build trust with their communities and work to become a community resource that strengthens human-animal relationships, including through bite prevention. This transformed mission away from reactive, punitive animal law enforcement would be particularly beneficial to low-income and other communities that are overrepresented in animal bite incidence.

Civic leaders need to recognize the public health benefit of implementing other actions to address morbidity of animal bites. Educators can incorporate safe animal handling skills into age-appropriate curricula for pre- and elementary schools. Much as courses in sexual and drivers' education have been universally incorporated into curricula of middle and high schools—with the objective to imbue students with knowledge and guidance to pursue these activities, both as teenagers and adults, in a manner that protects their and others' safety—classes in animal interaction could be adopted in pre- and elementary schools to enable children to develop lifelong skills that would allow them to enjoy the positive benefits of engaging with pets and other animals while mitigating risk of adverse events, including bites and transmission of zoonotic pathogens.

Despite decades of data that have identified the groups at highest risk for animal bites and the individual and community factors that contribute to these risks, minimal progress has been made to reduce the incidence of animal bites. New approaches that engage multiple entities and avoid assigning responsibility for messaging and intervention to a single profession are required if bite preventive efforts are to be successful. Animal bite prevention is a complicated issue that requires action

from not only public health and clinical care professionals but nontraditional partners such as governmental agencies and civic organizations. Expanding the mission and funding of animal control agencies to engagement and public health education can help prevent animal bites and foster positive relationships within a community. Factors that limit access to veterinary and human health-care resources must be identified and resolved to reduce health disparities and predisposition toward animal bites in impacted communities.

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