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Journal of Acute Medicine 2 (2012) 95−102

www.e-jacme.com

Original Research

Environmental factors associated with the prevalence of animal bites or stings in patients admitted to an emergency department

Ming-Hau Hsiao [a], Mei-Chueh Yang [a], Shu-Hua Yan [a,b], Chia-Hui Yang [a,b], Chu-Chung Chou [a,c], Chin-Fu Chang [a], Hsiu-Ying Hsu [a,b], Yan-Ren Lin [a,c,d,*]

[a] *Department of Emergency Medicine, Changhua Christian Hospital, Changhua, Taiwan*
[b] *Department of Nursing, Changhua Christian Hospital, Changhua, Taiwan*
[c] *School of Medicine, Chung Shan Medical University, Taichung, Taiwan*
[d] *Department of Biological Science and Technology and Institute of Biochemical Engineering, National Chiao Tung University, Hsinchu, Taiwan*

Received 23 March 2012; accepted 26 September 2012
Available online 23 November 2012

Abstract

Background: Environmental factors may affect the prevalence of different animal bites; however, this area has not been well studied. The aim of this study was to report in detail on the categories of animals involved in causing bites or stings, patient characteristics, outcomes, and associated environmental factors.
Methods: This prospective study involved patients visiting an emergency department for animal bites or stings from January 2007 to December 2008. Patient demographics, type and severity of injuries, outcomes, and types of offensive animals were recorded on a predefined database. Environmental factors, including season, temperature, precipitation, and relative humidity, were collected. Analyses were undertaken to check the relationship between animal bite/sting injuries and environmental factors.
Results: Mammalian bites (65.2%) were the most common, followed by insect stings (24.9%) and reptile bites (7.2%). Dogs (54.3%), bees (12.9%), and snakes (7.0%) were the three most common animals to attack. Most of the injuries were mild, superficial, and located on limbs. Only 5.3% of patients had moderate effects and 1.5% of patients had major effects in outcomes. Poor outcome-related factors included large size of wound (maximum length of wound >3 cm; $p = 0.000$), wound type (skin defect; $p = 0.000$), and animal type (reptile bite; $p = 0.000$). The season in which the most injuries occurred was summer for insects and autumn for reptiles. No significant trend was found for mammals and other animals. We found the highest precipitation and insect bites/stings in June ($r = 0.93$, $p < 0.001$), and increased incidence of insect bites/stings in the hot months ($r = 0.83$, $p = 0.001$). We also found increased reptile bites in May to June and September to October, which may be associated with a significant change in precipitation ($r = 0.78$, $p = 0.005$).
Conclusions: The most common animal bites seen in our emergency department are from mammals, especially dogs. Although most animal bites/stings were superficial and minor, there are risks of major effects on outcome in cases with large wounds or reptile bites. Environmental factors, including the season, temperature, and precipitation, were related to insect and reptile stings/bites.

Keywords: Animal bites; Emergency department; Environmental factors; Mammalian; Outcomes; Taiwan

1. Introduction

Animal bites may result in an adverse outcome and treatment of such bites can be a challenge for emergency department (ED) physicians due to patient complications and systemic problems, including infection, allergy, and even anaphylactic shock.[1−9] Previous studies have reported that about 2% of people are affected each year and an animal (or human) will bite one in two Australians or Americans in their lifetime; overall, almost 1% of all emergency admissions involve an animal bite.[8,10,11] The diagnosis and treatment of animal bites are usually based on taking a detailed history and

* Corresponding author. Department of Emergency Medicine, Changhua Christian Hospital, 135 Nanshsiao Street, Changhua 500, Taiwan.
E-mail address: h6213.lac@gmail.com (Y.-R. Lin).

2211-5587/$ - see front matter
http://dx.doi.org/10.1016/j.jacme.2012.09.002

on animal recognition. Therefore, knowledge of how animal bites vary, including wound care and resulting complications, will help primary physicians perform an appropriate clinical assessment and predict the outcome of a given bite.

Epidemiological studies of animal bites have demonstrated that household pets (dogs and cats in particular) cause the majority of all bites.[12] Since the proportion of households having such pets varies greatly between countries (64% in Australia and up to 58% in England), it seems likely that the prevalence of pet bites might differ across the world.[11,13] In Taiwan, the percentage of families that have such pets is not high. Government reports have mentioned that only 14.5 % and 2.1% of households in central Taiwan have a dog and a cat as a pet, respectively. Therefore, it is reasonable that regional data regarding animal bites might differ. Region-specific events associated with wild animals are also likely to differ greatly between global locations, and it is clear that bites by different species of animal are likely to result in different outcomes. For example, rattlesnake bites are more common in America and *Vipera berus* bites are more common in Poland.[14–16] In this context, information regarding bites by specific species of animals is lacking in central Taiwan.

Environmental factors are also likely to affect the prevalence of animal bites; in America and Europe, snake bites are more frequent in the summer.[14,15] In fact, climate generally varies greatly between regions and yet local data are not available for central Taiwan. In the present study, therefore, we aim to prospectively present the region-specific demographics of animal bites in central Taiwan. Furthermore, we explore the detailed categories of animal involved in these bites, together with the factors associated with outcome as well as the environmental factors that might be associated with differences in the prevalence of animal bites.

2. Materials and methods

2.1. Study population and study design

From January 1, 2007, to December 31, 2008, 587 patients at the ED of a 2500-bed medical center/hospital covering a population of 1,600,000 individuals in central Taiwan, were diagnosed as having an animal bite. In this prospective study, information relating to patients with animal bites was recorded by the triage personnel and the staff (physicians and senior nurses) of the ED once the patients were admitted and presented with an animal bite or sting (according to the patient's statements). All information concerning the patients was eventually imported into the database of the hospital poison center and these patients were traced to evaluate follow-up treatment and outcome after discharge from the hospital. Patients where the wounds were caused by plants or a mechanical device, where the injury was a non-bite- or non-sting-related wound (scratching injury), and where the major category of animal involved could not be identified were excluded from the study. Patient characteristics, clinical features and environmental factors that might be associated with patient outcome with respect to the animal bite were analyzed in this study. The study protocol was approved by the Institutional Review Board of this hospital.

To improve accuracy and to minimize inconsistencies in recording, the recorders were trained using a practice recording before the study started. Recorders used a standardized abstraction form to guide data collection. Once a diagnosis of an animal bite had been made, photographs of the wound were taken. The quality of the data collected was discussed at regular meetings and the performance of the recorders was also monitored.

2.2. Data collection and definitions

Patients treated for an animal bite and presenting with clinical symptoms were required to remain at the ED for observation or were hospitalized until their vital signs stabilized and major symptoms had subsided. Surgical intervention was indicated when there was active bleeding and a need for debridement. Wound management, including sutures and anesthesia, was carried out using appropriate and sterile procedures. We followed the Advanced Trauma Life Support guidelines to treat traumatic injuries,[17] the Advanced Cardiac Life Support guidelines to treat complications such as anaphylaxis,[18] and the American Association of Poison Control Centers (AAPCC) categories to classify patients' outcomes.[19]

Patients in this study could generally be divided into four major groups based on the category of animal causing the bite. These were:

- mammals (dog, cat, mouse, human being, etc.);
- insects (bee, centipede, ant, etc.);
- reptiles (snake and lizard); and
- others.

Information relating to the animal bite was obtained from the hospital poison center database. Demographic data included sex, age, occupation, major clinical presentations, condition of the wound, treatments, and outcome. The major clinical presentations were categorized into six groups of constitutional symptoms:

(1) skin only problems (localized and well defined pain, swelling and redness);
(2) respiratory tract symptoms (cough, rhinorrhea, sore throat, or shortness of breath);
(3) cardiovascular symptoms (chest pain, new onset of cardiac dysrhythmia, or unstable blood pressure);
(4) neurological symptoms (dizziness, vertigo, convulsion, headache, or change in consciousness);
(5) gastrointestinal symptoms (nausea, vomiting, diarrhea, or abdominal pain); and
(6) multiple symptoms (two or more symptoms).

The conditions associated with the wound were also collected, including the main site of wound – head and neck, trunk, upper or lower limbs, and multiple (two or more) main

wound sites – the number of wounds, the maximum length of the wound (<1, 1–3, >3 cm) and the major type of wound (abrasion, laceration, penetration, and skin defect).

The types of medical treatment that improved the symptoms were recorded. Antihistamines, either H_1-antagonists or H_2-antagonists, corticosteroids, antibiotics, and topical antibiotic ointments were used to treat patients with animal bites. When a patient was bitten by a snake, snake venom antiserum was used to treat individuals who had experienced envenomation. The dosages of the medications were based on body weight and the patient's clinical condition in all cases. Medications were administered via injection only in patients who required hospitalization or further surveillance in the ED observation unit.

The severities of outcomes were generally categorized into three levels based on the comments of AAPCC. These were:

- major effect: the patient exhibited signs or symptoms as a result of the exposure that were life-threatening or resulted in significant residual disability or disfigurement;
- moderate effect: the patient exhibited signs or symptoms as a result of the exposure that were more pronounced, prolonged, or systemic in nature than minor symptoms; usually, some form of treatment was indicated, but the symptoms were not life-threatening; and
- minor effect: the patient developed some signs or symptoms as a result of the exposure, but these were minimally bothersome and generally resolved rapidly with no residual disability or disfigurement.[19]

All variables that were likely to be related to the mild, moderate, and severe effects were analyzed in order to determine the factors associated with animal bite severity. Patients who suffered major, moderate and prolonged minor effects (presenting with persistent symptoms or feeling severe discomfort after initial treatment in the ED) were required to undergo hospitalization and the decisions on hospitalization were made by the treating physicians. The short-term observation in the observation room was not regarded as hospitalization.

Environmental factors that might be associated with the prevalence and outcomes of the animal bites were also analyzed. The season in which the injury occurred was recorded. The seasons in Taiwan usually have different weather conditions and consist of spring (March to May), summer (June to August), autumn (September to November) and winter (December to February). Other environmental factors, including rainfall, temperature, and relative humidity on the date of the animal bite, were used to analyze the prevalence of animal bite with regard to these factors. The information on environmental factors during the study period is publicly available and was obtained from the Central Weather Bureau of Taiwan.[20]

2.3. Statistical methods

The information collected was analyzed using Pearson's chi-squared test, Spearman's rank correlation test, and descriptive statistics. The results of the descriptive statistics (age, sex, occupation, clinical presentation, condition of wound, category of animal, treatments, outcome, and environmental factors) are reported as numbers, percentages, and mean ± standard deviation. Variables that might be related to the mild, moderate, and severe effects were analyzed using Pearson's chi-squared test. The prevalence of different categories of animal bite between the four seasons and between the three environmental factors (rainfall, temperature, and relative humidity) were analyzed using Pearson's chi-squared test and Spearman's correlation, respectively. A p value <0.05 was regarded as significant. All statistical analyses were performed on a personal computer using the statistical package SPSS for Windows Version 15.0 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Demographics, clinical presentation, and treatment

Animal bites accounted for 0.29% ($n = 587$) of all emergency visits ($n = 202{,}506$) during the study period. The 587 patients that were included in this study comprised 308 (52.5%) men and 279 (47.5%) women. There were eight patients excluded from this study due to lack of information on the animal causing the bite. The most common occupation was housekeeper (19.6%), followed by student (11.9%). Most patients (94%) presented with skin-only problems. This was followed by neurological symptoms (4.1%), multiple symptoms (0.7%), respiratory symptoms (0.5%), cardiovascular symptoms (0.5%), and gastrointestinal symptoms (0.2%). The wounds caused by the animals were mainly located on upper limbs (44.5%) followed by lower limbs (33.3%). Minor (length <1 cm, 81.3%) and superficial (abrasion, 52.9%) wounds were the most common injuries. Mammals (65.2%) were the most common category of animal causing injury, followed by insects (24.9%) and reptiles (7.2%). Fewer patients suffered an injury in winter than in the other seasons and oral antibiotics were the most common treatment given. The outcomes were generally good for all patients. Nevertheless, 42 patients were admitted to hospital due to severe clinical symptoms and their median duration of hospitalization was 6 days (Table 1).

3.2. Detailed categories of animals causing injury

Detailed information on the categories of animals causing the bites is presented in Table 2. Dogs (54.3%) and cats (6.1%) were animals that caused the most injuries among mammals. The other mammals involved were mice (3.7%), human beings (0.3%), pigs (0.3%) and rabbits (0.3%). Insect bites were the second most common animal involved, with bees (12.9%) and centipedes (3.9%) being the frequent offenders. Mosquitoes (0.7%) and spiders (0.5%) caused the other insect-related injuries. Snakes were responsible for 7% of the animal bites affecting our patients. Overall, venomous bites were identified in 67 (11.4%) cases. Hornet ($n = 32$) and bamboo viper ($n = 15$) bites were the two most common venomous bites.

Table 1
Demographics, clinical presentation, and treatment of patients with animal bites.

	Patients with animal bites ($n = 587$)	
	Number of patients	Percentage
Sex		
Male	308	52.5
Female	279	47.5
Age (yr)		
≤20	143	24.4
21–40	184	31.3
41–60	184	31.3
≥61	76	13.0
Major clinical presentations		
Only skin problems	552	94.0
Respiratory symptoms	3	0.5
Cardiovascular symptoms	3	0.5
Neurological symptoms	24	4.1
Gastrointestinal symptoms	1	0.2
Multiple symptoms	4	0.7
Coexistent pyrexia	6	1.0
Main site of wound		
Head and neck	63	10.7
Trunk	32	5.5
Upper limb	261	44.5
Lower limb	196	33.3
Multiple	35	6.0
Number of wounds (median)	1	
Maximum length of wound (cm)		
<1	477	81.3
1–3	83	14.1
>3	27	4.6
Major classification of wound		
Abrasion	310	52.9
Laceration	168	28.6
Penetration	97	16.5
Skin defect	12	2.0
Major category of animal		
Mammal	383	65.2
Insect	146	24.9
Reptile	42	7.2
Others	16	2.7
Season of injury		
Spring (March to May)	152	25.9
Summer (June to August)	169	28.8
Autumn (September to November)	149	25.4
Winter (December to February)	117	19.9
Treatment		
Antihistamines (oral/injection[a]/both)	34/14/70	5.8/2.4/11.9
Steroids (oral/injection[a]/both)	27/5/25	4.6/0.8/4.3
Antibiotics (oral/injection[a]/both)	320/13/48	54.5/2.2/8.2
Topical antibiotic ointment	109	18.6
Outcome		
Minor effect	547	93.2
Moderate effect	31	5.3
Major effect	9	1.5
Admitted to hospital	42	7.2
Median duration of hospitalization ($n = 42$) (days)	6	

[a] Including intravenous or intramuscular injections.

Table 2
Detailed categories of animals causing injury.

	Patients with animal bites ($n = 587$)	
	Number of patients	Percentage
Mammal ($n = 383$)		
Dog	319	54.3
Cat	36	6.1
Mouse	22	3.7
Human	2	0.3
Pig	2	0.3
Rabbit	2	0.3
Insect ($n = 146$)		
Bee	76	12.9
Centipede	23	3.9
Ant	10	1.7
Mosquito	4	0.7
Spider	3	0.5
Other	30	5.1
Reptile ($n = 42$)		
Snake	41	7
Lizard	1	0.2
Other ($n = 16$)		
Fish	4	0.7
Crab	3	0.5
Shrimp	2	0.3
Jellyfish	2	0.3
Chicken	2	0.3
Pigeon	1	0.2
Goose	1	0.2
Duck	1	0.2

3.3. Environmental factors related to the prevalence of animal bites

3.3.1. Animal bites vary between different seasons

In this study, we found that the prevalence of animal bites differed significantly between the categories of animals according to different seasons ($p = 0.001$) (Fig. 1). Mammals were the leading cause of animal bites and the numbers of bites were evenly distributed over all four seasons. The incidence of insect bites was greatly influenced by season and was more common in summer (37%) and less common in winter (13.7%). In contrast, reptile bites were more predominant in autumn (42.9%) than in spring (23.8%), summer (31%) or winter (2.4%).

3.3.2. Temperature, rainfall, and relative humidity

Detailed environmental factors during the study period that may be associated with the prevalence of different categories of animal bite are listed in Fig. 2. We noted that reptile and insect bites were both positively correlated with rainfall in different months. The prevalence of insect bites was proportional to rainfall, with an increase in rainfall being associated with an increase in insect bites. Rainfall and insect bites were both highest in June ($r = 0.93$, $p < 0.001$). Reptile bites were also associated with rainfall. We noted that when there was an obvious increase in rainfall (May and June) or a clear decrease in rainfall (September and October), there was a significant correlation with increased reptile bites ($r = 0.78$, $p = 0.005$).

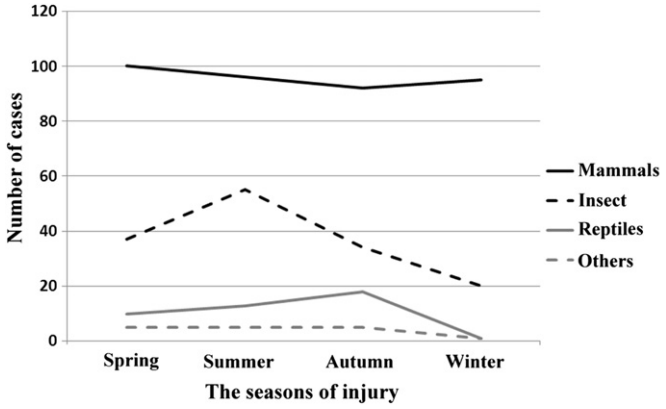

Fig. 1. The prevalence of animal bites across the categories of animals in the different seasons ($p = 0.001$).

Temperature, however, was not associated with reptile bites. There was, however, an association between higher temperatures and a higher prevalence of insect bites (r = 0.83, $p = 0.001$).

3.4. Factors associated with outcomes

Allergic reactions and wound infections were the most common complications in patients. Systemic allergic reactions, including urticaria and anaphylaxis, were present in 24 (4.1%) patients. Only two patients suffered anaphylaxis due to bee stings, and they recovered without severe complications after initial treatment at the ED. Localized soft tissue infection (cellulitis, erysipelas, and subcutaneous abscess) was present in 70 (11.9%) patients and was more predominant in patients with mammalian bites ($n = 58$; $p = 0.009$). No patient suffered rabies and all patients survived to discharge. Overall, only 6.8% ($n = 40$) of patients suffered moderate or major effects.

In this study, the factors associated with outcome are presented in Table 3. We found that maximum length of wound, classification of the wound, and the category of animal were all significantly associated with the severity of outcome (all $p < 0.05$). Furthermore, a wound length >3 cm, a skin defect, and a reptile bite were all indicative of a poor outcome. However, age, sex, occupation, clinical presentation, the main site of the wound, the number of wounds, and the season when the injury took place were not statistically associated with outcome.

4. Discussion

Some previous studies have reported that dog, cat, and human bites are the three most common categories of mammalian bites.[1,21,22] The prevalence of human bites ranges from 8.7% to 23.1%.[21,22] Bites inflicted by humans are often more serious than those inflicted by animals because of the presence of various pathogens (alpha-hemolytic *Streptococci*,

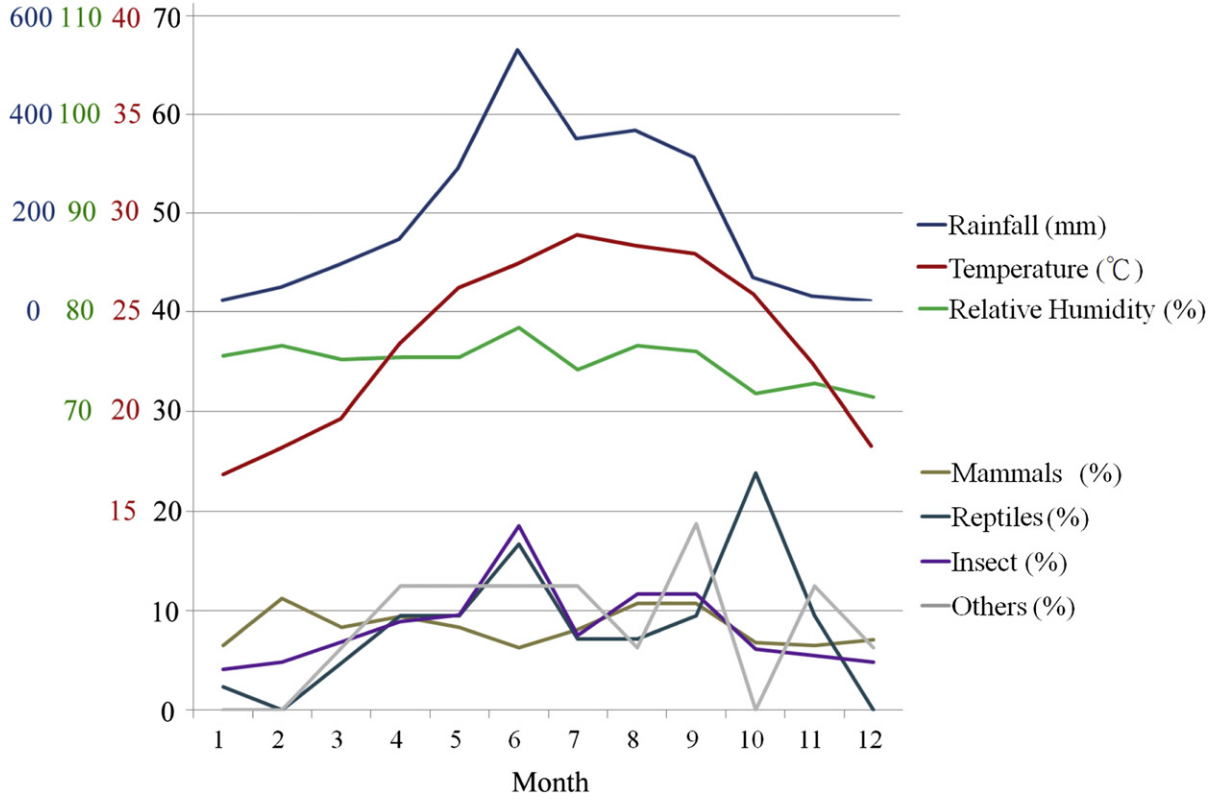

Fig. 2. Environmental factors and the prevalence of animal bites across the different categories of animals. Reptile and insect bites were associated with rainfall and temperature. The trends for rainfall and insect bites were very similar. Rainfall and the prevalence of insect bites were both the highest in June (r = 0.93, $p < 0.001$). Reptile bites were also associated with rainfall. Obvious increases (May and June) and decreases (September and October) in rainfall at various times were significantly associated with an increase in the prevalence of reptile bites (r = 0.78, $p = 0.005$). Temperature was associated with insect bites, with a higher temperature resulting in an increased prevalence of insect bites (r = 0.83, $p = 0.001$).

Table 3
Factors associated with the severity of outcome.

	Medical outcome (n = 587)						
	Minor effect (n = 547)		Moderate effect (n = 31)		Major effect (n = 9)		p-value
	No.	%	No.	%	No.	%	
Sex							
Male	286	52.3	18	58.1	4	44.4	0.730
Female	261	47.7	13	41.9	5	55.6	
Age (yr)							
≤20	137	25.0	5	16.1	1	11.1	0.079
21−40	174	31.8	6	19.4	4	44.4	
41−60	170	31.1	13	41.9	1	11.1	
≥61	66	12.1	7	22.6	3	33.3	
Clinical presentations							
Only skin problems	514	94.0	30	96.8	8	88.9	0.808
Respiratory symptoms	3	0.5	—	—	—	—	
Cardiovascular symptoms	3	0.5	—	—	—	—	
Neurological symptoms	23	4.2	—	—	1	11.1	
Gastrointestinal symptoms	1	0.2	—	—	—	—	
Multiple symptoms	3	0.5	1	3.2	—	—	
Main site of wound							
Head and neck	59	10.8	3	9.7	1	11.1	0.124
Trunk	32	5.9	—	—	—	—	
Upper limb	240	43.9	19	61.3	2	22.2	
Lower limb	186	34.0	5	16.1	5	55.6	
Multiple	30	5.5	4	12.9	1	11.1	
Number of wounds (median)		1		1		1	0.052
Maximum length of wound (cm)[a]							
≤1	451	82.4	21	67.7	5	55.6	0.000
1−3	75	13.7	7	22.6	1	11.1	
>3	21	3.8	3	9.7	3	33.3	
Classification of wound[a]							
Abrasion	298	54.5	11	35.5	1	11.1	0.000
Laceration	151	27.6	13	41.9	4	44.4	
Penetration	90	16.5	5	16.1	2	22.2	
Skin defect	8	1.5	2	6.5	2	22.2	
Category of animal[a]							
Mammal	361	66.0	17	54.8	5	55.6	0.000
Reptile	30	5.5	8	25.8	4	44.4	
Insect	142	26.0	4	12.9	—	—	
Other	14	2.6	2	6.5	—	—	
Season of injury							
Spring (March to May)	140	25.6	10	32.3	2	22.2	0.847
Summer (June to August)	158	28.9	9	29.0	2	22.2	
Autumn (September to November)	138	25.2	7	22.6	4	44.4	
Winter (December to February)	111	20.3	5	16.1	1	11.1	

[a] Significant factors associated with the severity of outcome.

Staphylococcus aureus, *Eikenella corrodens*, *Haemophilus* spp. and various anaerobic bacteria).[10,21,23] Mammals were the leading cause of bites in our patients, followed by insect stings, and then reptile bites. Although dog, cat, and human bites have been reported as the leading causes of mammalian bites,[10] our results were different. Dog bites remained the most common cause, followed by cat bites, but the 3rd most common bites came from mice. This finding also differs from previous studies, with a report by the AAPCC mentioning that the prevalence of rodent bites was 0.27% of non-human exposures.[19]

In this study, we noted that some factors were significantly associated with the outcomes of patients. The first factor was the maximum length of the wound. Most patients (n = 477, 81.3%) presented with small wounds (<1 cm) and their overall outcome was generally good. However, when the maximum length of wound was longer, they had a significantly higher chance of suffering a moderate or major effect from it. The percentages of individuals with a maximum wound length of <1 cm, 1−3 cm and >3 cm suffering from moderate or major effects were 5.5%, 9.6%, and 22.2%, respectively. The maximal length of the wound has an impact on tissue

destruction and complications, to some extent. In some cases of venous stings or bites, anti-venous (or anti-allergy) treatments should be given immediately and not be delayed, even when the wound is small. The classification of the wound was another factor associated with outcome. We found that patients with a skin defect or a laceration experienced poor outcomes. Based on these two findings, we suspect that early intervention, including prophylactic antibiotic therapy and wound care, should be emphasized in patients with a complex or large wound.

The category of animals causing the wound is also a key factor in predicting the outcomes of patients. Patients with mammal or reptile bites have poorer outcomes than that those with insect bites. We noted that localized soft tissue infections were more common among patients with mammal bites, and allergic reactions were more predominant among patients with insect bites. Snake bites usually cause severe complications, especially when the bite is venomous.[24] Overall, 28.6% of patients who presented with a snake bite had a moderate or major effect from the bite, and most of these individuals not only suffered from localized envenomation but also presented with soft tissue infection. The species of snake that cause the most injuries differ across the world. In America, rattlesnakes account for almost all bites.[14] In central Taiwan, however, we found that bamboo viper was the most common cause of venomous snake bite. This is similar to the findings for southern Taiwan.[25] Indeed, we suggest that diagnosis and treatment should be based on clinical presentation and the symptoms of envenomation, with identification of the snake being an additional aid.

Environmental factors also influence the prevalence of animal bites. We found that the prevalence of bites from different categories of animal changed as the seasons changed. Matter et al. reported that the prevalence of vertebrate animal bites was highest during the summer months in Switzerland.[26] In this study, we noted that the prevalence of mammalian bites was almost equal across all four seasons; however the prevalence of insect and reptile bites was significantly higher in the summer and autumn, respectively. We suspect that this result is strongly influenced by the natural behavior of the animals and clothing habits of humans. For example, people usually wear less clothing in the summer than in other seasons. In addition, windows and doors are more likely to be kept open in summer due to high temperatures. A higher prevalence of insect bites is therefore more likely in the summer. We found that temperature was not the only environmental factor that contributed to the higher prevalence insect bites.

The association between animal bites and rainfall has never been well studied in the literature. We noted that the trends for rainfall and insect bites were very similar, with both rainfall and the prevalence of insect bites being highest in June.

Almost all reptile bites in this study were caused by snakes. Previous studies in the United States and Europe have mentioned that most snake bites occur during the summer.[14,15] Our findings differ from these studies. A higher prevalence of snake bites was identified in the autumn in central Taiwan. One factor that may be responsible for this is that the Tropic of Cancer runs through Taiwan, making the climate relatively stable and quite warm during all four seasons compared to the United States or Europe. Rainfall may also be a key factor associated with the prevalence of snake bites because floods occupy the habitat of snakes and force them out during wet weather and that dry weather may increase the snakes' activity and hunting.

4.1. Limitation

This study only provides region-specific data. Good external validity might require a multiple-center study.

5. Conclusion

Mammal and insect bites were the most predominant categories of animal bites at our ED in central Taiwan. Dog, bee and snake bites were the main categories of mammalian, insect and reptilian bites, respectively. Patient outcomes varied and were dependent on a number of key factors. Poor wound condition on presentation at the ED, a skin defect, a laceration, and maximum wound length of >3 cm were all indicative of a poor outcome. Localized soft tissue infections were more common in wounds caused by mammals than in those caused by other categories of animals. Most importantly, environmental factors, including the season, temperature, and rainfall, strongly influenced the prevalence of different categories of animal bites.

Conflicts of interest statement

The authors declare that they have no conflicts of interest related to this study.

Acknowledgments

We thank the Changhua Christian Hospital (100-CCHKMU-020 and 100-CCH-IRP-110) for financially supporting this research.

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