

# The “T’s” of snakebite injury in the USA: fact or fiction?

Joshua D Jaramillo,<sup>1</sup> Nicholas A Hakes,<sup>1</sup> Lakshika Tennakoon,<sup>2</sup> David Spain,<sup>2</sup> Joseph D Forrester<sup>2</sup>

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/tsaco-2019-000374>).

<sup>1</sup>General Surgery, Stanford University, Stanford, California, USA

<sup>2</sup>Department of Surgery, Stanford University, Stanford, California, USA

## Correspondence to

Dr Joseph D Forrester, Department of Surgery, Stanford University, Stanford, CA 94305, USA; [jdf1@stanford.edu](mailto:jdf1@stanford.edu)

Received 28 August 2019  
Accepted 2 October 2019

## ABSTRACT

**Background** Venomous snakebites can result in serious morbidity and mortality. In the USA, the “T’s of snakebites” (testosterone, teasing, touching, trucks, tattoos & toothless (poverTy), Texas, tequila, teenagers, and tanks) originate from anecdotes used to colloquially highlight venomous snakebite risk factors. We performed an epidemiologic assessment of venomous snakebites in the USA with the objective of evaluating the validity of the “T’s of snakebites” at a national level.

**Methods** We performed a retrospective analysis of the National Emergency Department Sample. Data from January 1, 2016 to December 31, 2016 were obtained. All emergency department (ED) encounters corresponding to a venomous snakebite injury were identified using the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) codes. Primary outcomes were mortality and inpatient admission. Demographic, injury, and hospital characteristics were assessed. Data were analyzed according to survey methodology. Weighted values are reported.

**Results** In 2016, 11 138 patients presented to an ED with a venomous snakebite. There were 4173 (37%) persons aged 18 to 44, and 7213 (65%) were male. Most snakebites were reported from the South (n=9079; 82%), although snakebites were reported from every region in the USA. Only 3792 (34%) snakebites occurred in rural counties. Persons in the lowest income quartile by zip code were the most heavily represented (n=4337; 39%). The most common site of injury was the distal upper extremity (n=4884; 44%). Multivariate analysis revealed that species of snake (OR=0.81; 95% CI 0.73 to 0.88) and older age (OR=1.42; 95% CI 1.08 to 1.87) were associated with hospital admission. There were <10 inpatient deaths identified, and no variables were predictive of death.

**Discussion** Some of the “T’s of snakebites” may be valid colloquial predictors of the risk for venomous snakebites. Based on national data, common demographics of venomous snakebite victims include lower income, Caucasian, and adult men in the South who are bit on the upper extremity. Understanding common demographics of venomous snakebite victims can effectuate targeted public health prevention messaging.

**Level of evidence** IV.

## BACKGROUND

Over 100 species of snakes are found in the USA, 20 of which are venomous.<sup>1</sup> The two families of indigenous venomous snakes are Viperidae (pit

vipers), which includes rattlesnakes, cottonmouths (also known as water moccasins), and copperheads, and Elapidae, which includes coral snakes.<sup>1–3</sup> Exotic (non-native) venomous snakes may be kept as pets, either legally or illegally. Bites by both indigenous and exotic venomous snakes can result in morbidity and mortality, making snakebites an important public health issue in the USA. Recent studies using national snakebite and injury registries predict 8000 to 10 000 venomous and non-venomous snakebites annually.<sup>4 5</sup> During the past 3 years, the American Association of Poison Control Centers (AAPCC) has reported 5000 snakebites per year, one-third of which are venomous.<sup>6–8</sup>

Risk factors for venomous snakebites are attributed to colloquial nouns, verbs, and adjectives that start with the letter T: the so-called “T’s of snakebites.” The risk factors include testosterone, teasing, touching, trucks, tattoos & toothless (poverTy), Texas, tequila, teenagers, and tanks (vivarium) (online supplementary file).<sup>9–11</sup> Yet there is limited research describing risk factors for venomous snakebites among a nationwide cohort.<sup>12–16</sup> We performed an epidemiologic assessment of venomous snakebites in the USA with the objective of evaluating the validity of the “T’s of snakebites” at a national level.

## METHODS

We performed a retrospective analysis of the Agency for Healthcare Research and Quality’s National Emergency Department Sample (NEDS). Data from January 1, 2016 to December 31, 2016 were obtained. NEDS is the largest all-payor emergency department (ED) database capturing ED encounters resulting in admission, discharge, and transfer. NEDS is constructed using survey methodology from state databases. The stratified, unweighted sample includes approximately 20% of all US ED encounters (~33 million ED visits to 953 hospitals), and when weighted provides estimates of all 144 million US ED encounters in 2016.<sup>17</sup> We identified all ED visits corresponding to a venomous snakebite (ICD-10-CM T63.0). The study design and data provide level IV evidence. Primary outcomes were mortality and inpatient admission. Subgroup analysis of geographic regions was performed. The variables analyzed included age, sex, region, payor status, income quartile, season, day of the week, bodily region of injury, discharge destination, inpatient procedures, species of snake, and cost of encounter. Seasons were designated as winter: December to February; spring: March to

© Author(s) (or their employer(s)) 2019. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

**To cite:** Jaramillo JD, Hakes NA, Tennakoon L, *et al.* *Trauma Surg Acute Care Open* 2019;**4**:e000374.

May; summer: June to August; and fall: September to November. A rural county was defined using guidelines established by the National Center for Health Statistics.<sup>18</sup> Intensive level of care was characterized as any patient requiring intubation or vaso-pressor medications. Need for transfusion was defined as any patient requiring any blood product, excluding albumin. Values less than 10 are not reported in accordance with NEDS data use agreements.

All statistical analyses employed the NEDS sampling strata and discharge weights to produce nationally weighted patient-level estimates, with 95% CIs that account for clustering of patients among hospitals. The 2016 population reported by the US Census Bureau was used for population estimates.<sup>19</sup> Fisher's exact and Mann-Whitney U tests were used for univariate analysis. Multivariate logistic regression was performed to compensate for survey methodology. Stata V.12.0 was used for statistical analysis. Any variable with  $p < 0.1$  was included in the multivariate regression models.  $P < 0.05$  was considered significant.

## RESULTS

In 2016, 11 138 patients presented to an ED with a venomous snakebite (table 1). This corresponded to 3.4 snakebites per 100 000 people. There were 4173 (37%) persons aged 18 to 44, and 7213 (65%) were male. Patients 0 to 17 years old had lower odds of venomous snakebite (OR=0.94; 95% CI 0.90 to 0.99;  $p=0.009$ ). The greatest age-adjusted odds of venomous snakebite was seen among patients 45 to 64 years old (OR=1.14; 95% CI 1.10 to 1.20;  $p < 0.0001$ ). Most snakebites were reported from the South ( $n=9079$ ; 82%), although bites were reported from all regions in the USA. Only 3792 (34%) snakebites occurred in rural counties. Half ( $n=5558$ ; 50%) of the identified snakebites transpired during summer months and 3592 (32%) took place during the weekend. All payor categories were represented. Persons in the lowest income quartile by zip code were the most heavily represented ( $n=4337$ ; 39%). The most common site of injury was the distal upper extremity, with 4884 (44%) of snakebites affecting the wrist, hand, or fingers. In the lower extremity, 1751 (16%) snakebites occurred in the knee or lower leg, whereas 3351 (30%) of snakebites occurred in the ankle or foot. There were 2423 (22%) patients admitted as an inpatient, and  $< 10$  (0%) patients died.

Most snakes did not have species-level identification ( $n=5080$ ; 46%) or were identified broadly as "other" venomous species ( $n=2634$ ; 24%). Among the identified snakes, 2067 (19%) were rattlesnakes and 1203 (11%) were other venomous North or South American snakes. Snakebites were classified as accidental ( $n=10 692$ ; 96%), unspecified intent ( $n=461$ ; 4%), assault ( $n=19$ ; 0%), or intentional self-harm ( $n < 10$ ; 0%). Most encounters ( $n=10 690$ ; 96%) corresponded to the initial presentation for the snakebite.

Persons admitted after a venomous snakebite were older (47% vs 41% ( $\geq 45$  years old);  $p=0.001$ ). The frequency of male patients admitted was equivalent to the frequency of male patients not admitted. There were fewer persons in rural counties admitted (29%;  $p=0.02$ ). Seasonality and day of the week among patients admitted and patients not admitted were similar ( $p=0.8$  and  $p=0.3$ , respectively). Admitted patients were more commonly bit in the head, proximal upper or lower extremities, or multiple body regions ( $p=0.01$ ). Persons bit by rattlesnakes constituted 983 (41%) of the admitted patients, the greatest of any identified snake species ( $p < 0.0001$ ). Fifty-nine (2%) admitted patients required intensive care unit-level care and 39 admitted patients (2%) required a blood transfusion. There

**Table 1** Epidemiology of patients presenting to an emergency department and those admitted as an inpatient after a snakebite, USA 2016

	All patients presenting to emergency department after a snakebite	Patients admitted as an inpatient after a snakebite	P value
n (% total animal encounters)	11 138	2423 (22)	
Age category (years)			
0–17	2421 (22)	384 (16)	0.001
18–44	4173 (37)	910 (38)	
45–64	3211 (29)	792 (33)	
65–74	942 (8)	235 (10)	
75–84	330 (3)	84 (3)	
>85	60 (1)	18 (1)	
Male (%)	7213 (65)	1582 (65)	0.8
Region			
Northeast	115 (1)	<10*	<0.0001
Midwest	756 (7)	143 (6)	
South	9079 (82)	1843 (76)	
West	1188 (11)	434 (18)	
Rural county (%)	3792 (34)	702 (29)	0.02
Weekend (%)	3592 (32)	789 (33)	0.8
Season (%)			
Winter	267 (2)	50 (2)	0.3
Spring	2463 (22)	501 (21)	
Summer	5558 (50)	1169 (48)	
Fall	2851 (26)	704 (29)	
Payor data (%)			
Medicare	1637 (15)	424 (18)	0.04
Medicaid	2223 (20)	421 (17)	
Private insurance	4433 (40)	962 (40)	
Self-pay	2058 (18)	420 (17)	
No charge	27 (0)	14 (1)	
Other	758 (7)	183 (8)	
Household income compared with the patient's zip code (%)			
0–25th	4337 (39)	881 (36)	0.1
26th–50th	3255 (29)	683 (28)	
51st–75th	2089 (19)	549 (23)	
76th–100th	1457 (13)	309 (13)	
Anatomic location of injury (%)			
Head	128 (1)	67 (3)	0.01
Neck	29 (0)	–	
Thorax	51 (0)	–	
Abdomen, pelvis, genitalia	47 (0)	–	
Shoulder or upper arm	118 (1)	–	
Elbow or forearm	610 (5)	90 (4)	
Wrist, hand, finger	4884 (44)	787 (32)	
Hip or thigh	38 (0)	25 (1)	
Knee or lower leg	1751 (16)	903 (37)	
Ankle or foot	3351 (30)	507 (21)	
Multiple body regions	129 (1)	44 (2)	
Type of snake			

Continued

Table 1 Continued

	All patients presenting to emergency department after a snakebite	Patients admitted as an inpatient after a snakebite	P value
Rattlesnake	2067 (19)	983 (41)	<0.0001
Coral snake	123 (1)	38 (2)	
Taipan	<10*	–	
Cobra	20 (0)	<10*	
North or South American snake	1203 (11)	392 (16)	
Australian snake	–	–	
Asian or African snake	<10*	<10*	
Other snake	2634 (24)	541 (22)	
Unspecified venomous snake	5080 (46)	459 (19)	
<b>Circumstances of bite</b>			
Accidental	10 692 (96)	2360 (97)	0.06
Intentional self-harm	<10*	–	1.0
Assault	19 (0)	<10*	0.2
Unspecified intent	461 (4)	58 (2)	0.02
Fatalities (%)	<10*	–	1.0

\*Values less than 10 are not reported in accordance with the Healthcare Cost and Utilization Project (HCUP) data use agreement.

were 128 (5%) admitted patients who required surgical intervention; all surgical interventions were incision of soft tissue or drainage of an abscess. Multivariate analysis revealed that the species of snake (OR=0.81; 95% CI 0.73 to 0.88) and older age (OR=1.42; 95% CI 1.08 to 1.87) were associated with admission. No multivariate assessment of death was possible due to the small number of observed deaths.

Regional variation was identified among patients presenting with a venomous snakebite (table 2). Patients in the Midwest and the South more commonly presented at EDs in rural counties (n=346 (46%) and n=3194 (35%), respectively; p<0.0001). In the Midwest and the South, there were 295 (39%) and 3797 (42%) patients in the lowest income quartile by zip code, compared with 218 (18%) and 21 (18%) in the West and the Northeast (p<0.0001). Unlike other regions, in the Northeast, 94 (82%) snakebites affected the upper extremity (p=0.02) and <10 (3%) snakebites were caused by rattlesnakes (p<0.0001).

## DISCUSSION

Venomous snakebites are an important public health issue in the USA, possibly occurring more frequently than previously described. We identified more than 11 000 patients treated for venomous snakebites in the USA in 2016, a quantity approximately 2.5 times larger than the number of venomous snakebites in the USA in 2016 reported by the AAPCC.<sup>7</sup> Existing research using national injury registries reported even fewer venomous snakebites, with annual averages ranging from 2825 to 3188.<sup>2,5</sup> These discrepant results illustrate limitations of registries dependent on passive surveillance and highlight the need to perform a comprehensive national assessment using NEDS.

The NEDS data enable us to characterize the epidemiology of venomous snakebites in the USA and challenge the validity of the “T’s of snakebites” at the national level. Having never been rigorously evaluated, the “T’s of snakebites” originate from anecdotes used to humorously highlight colloquial risk factors for venomous snakebites. These risk factors include testosterone,

teasing, touching, trucks, tattoos & toothless (poverTy), Texas, tequila, teenagers, and tanks (vivarium) (online supplementary file).

### Testosterone: “maleness”

Male sex has been described as a risk factor for venomous snakebites among regional and national reports, with 69% to 80% of snakebite victims having been reported as male.<sup>2–4 13 20–23</sup> Our study found that 65% of snakebite victims were male. There are several potential explanations. First, existing studies have used data which may be subject to selection bias inherent to smaller locoregional sample sizes. Another possible explanation is a change in demographics over time. However, previous studies describing the sex distribution of venomous snakebite victims vary considerably, suggesting changing demographics are not responsible. Ultimately, irrespective of the differences between NEDS and previously reported data, males more commonly present with venomous snakebites than females.

### Teasing and Touching: intentional interaction

Among patients in the NEDS data set, 50% of snakebite victims were bit in the upper extremity, with 44% snakebites affecting the wrist, hand, and fingers. These upper extremity snakebites may represent encounters where the person was attempting to touch or grasp the snake. In studies that have examined snakebites incurred through intentional contact, more than 90% of victims were males and almost all were associated with upper extremity snakebites.<sup>2–4 12 21 24</sup> Unfortunately, NEDS does not capture intentionality at a detailed enough level to assess whether a venomous snakebite victim was trying to touch or grasp a snake versus inadvertently having his or her hand in close proximity to a venomous snake. Other injury registries differentiate intention based on whether the victim saw the snake and could have avoided the encounter.<sup>25</sup> The only intentional acts captured in NEDS are injuries caused by intentional self-harm or assault. Overall, the large number of snakebites that occur on the hands and distal upper extremity suggest that teasing and touching may be reasonable risk factors for venomous snakebites.

### Trucks: “ruralness”

“Trucks” suggests that living in rural areas is a risk factor for venomous snakebites. While 19% of the US population lives in a rural county, we found that 34% of snakebite victims presented to a hospital in a rural county, suggesting that venomous snakebites may be more common in rural areas.<sup>26</sup> However, more than double the number of patients presents to non-rural-county EDs than rural-county EDs. There are several possible explanations. First, because most snakebites are not immediately lethal, a rural snakebite victim may travel to a suburban or urban area to receive medical treatment. Second, patients may seek care from larger, urban academic medical centers believing they offer more advanced clinical capabilities.<sup>27–30</sup> A third explanation is that human expansion and snake habitat loss may put humans in traditionally non-rural areas in closer proximity to venomous snakes.<sup>31–33</sup> Snakes may seek shelter and prey in barns, garages, sheds, gardens, and wood or dirt piles; prior studies have reported that most snakebites occur within 1.61 kilometers (one mile) of the home.<sup>34</sup> So although being in a rural area appears to be associated with a disproportionate number of ED presentations for venomous snakebites, this risk factor may change over time. Using “trucks” as a proxy for “ruralness” does not adequately capture the epidemiology of venomous snakebite

**Table 2** Regional variation in snakebite injury resulting in presentation to an emergency department, USA 2016

	South	West	Midwest	Northeast	Significance (p value)
n	9079	1188	756	115	
Age category (years) (%)					
0–17	162 (21)	180 (24)	159 (21)	33 (28)	0.07
18–44	290 (38)	208 (27)	318 (42)	51 (44)	
45–64	213 (28)	259 (34)	214 (28)	28 (24)	
65–74	66 (9)	65 (9)	47 (6)	<10*	
75–84	20 (3)	45 (6)	18 (2)	–	
>85	<10*	–	–	–	
Male (%)	5849 (64)	824 (69)	460 (61)	79 (69)	0.4
Rural (%)	3194 (35)	225 (19)	346 (46)	27 (23)	<0.0001
Weekend (%)	2874 (32)	390 (33)	286 (38)	42 (37)	0.3
Season (%)					
Winter	155 (2)	64 (5)	37 (5)	<10 (4) (4)	0.01
Spring	2008 (22)	276 (23)	156 (21)	23 (20)	
Summer	4614 (51)	539 (45)	358 (47)	54 (47)	
Fall	2302 (25)	309 (26)	204 (27)	35 (30)	
Payor data (%)					
Medicare	1341 (15)	181 (15)	102 (14)	12 (11)	<0.0001
Medicaid	1651 (18)	314 (26)	208 (27)	52 (45)	
Private insurance	3613 (40)	482 (41)	296 (39)	41 (36)	
Self-pay	1859 (20)	87 (7)	116 (15)	0 (0)	
No charge	27 (0)	0 (0)	0 (0)	0 (0)	
Other	591 (7)	124 (10)	35 (5)	10 (8)	
Household income compared with the patient's zip code (%)					
0–25th	3797 (42)	218 (18)	295 (39)	21 (18)	<0.0001
26th–50th	2596 (29)	367 (31)	275 (36)	17 (15)	
51st–75th	1655 (18)	295 (25)	115 (15)	27 (24)	
76th–100th	1031 (11)	308 (26)	70 (9)	50 (43)	
Anatomic location of injury (%)					
Head	35 (0)	39 (5)	38 (5)	–	0.02
Neck	29 (0)	–	–	–	
Thorax	–	–	55 (7)	–	
Abdomen, pelvis, genitalia	–	32 (4)	–	–	
Shoulder or upper arm	117 (1)	0 (0)	–	–	
Elbow or forearm	392 (4)	76 (10)	81 (11)	16 (14)	
Wrist, hand, finger	3867 (43)	353 (47)	364 (48)	78 (68)	
Hip or thigh	38 (0)	–	–	–	
Knee or lower leg	1486 (16)	121 (16)	88 (12)	–	
Ankle or foot	2986 (33)	135 (18)	129 (17)	20 (18)	
Multiple body regions	128 (1)	–	–	–	
Type of snake (%)					
Rattlesnake	1088 (12)	879 (74)	95 (13)	<10*	<0.0001
Coral snake	126 (2)	–	–	–	
Taipan	–	–	–	<10*	
Cobra	10 (0)	10 (1)	–	–	
North or South American snake	1074 (12)	12 (1)	104 (14)	13 (11)	
Asian or African snake	<10*	–	<10 (4) (0)	–	
Other snake	2423 (27)	46 (4)	154 (20)	12 (10)	
Unspecified venomous snake	4357 (48)	242 (20)	401 (53)	80 (70)	

\*Values less than 10 are not reported in accordance with the HCUP data use agreement.



injury and does not adequately reflect the rural–suburban–urban distribution of venomous snakebite injury.

### **poverTy: socioeconomic status**

The colloquial “T’s” of “tattoos” and “toothless” are offensive terms historically used as descriptors for risk factors for snake envenomation. As neither of the prior terms are able to be analyzed in NEDS, we elected to use “poverTy” as a substitute. Socioeconomic statuses of snakebite victims have rarely been characterized.<sup>35</sup> We found that most snakebite victims (39%) were in the lowest quartile for household income compared with zip code, validating that lower socioeconomic status may be a risk factor for venomous snakebites. Supporting this finding, a prior study of institutional-level venomous snakebite data found that only 29% of snakebite victims were employed.<sup>35</sup> We found 20% of venomous snakebite victims were on Medicaid, similar to the 19% of the USA enrolled in Medicaid, suggesting that being on Medicaid is not a risk factor.<sup>36</sup> However, 18% of snakebite victims in NEDS were self-pay or uninsured, compared with only 8% of the general US population.<sup>36</sup> The higher frequency of patients in the lowest income quartile and uninsured patients lends credence to the “T’s” suggesting increased risk with lower socioeconomic status.

A strong interrelationship exists between socioeconomic status and race. Few prior studies comment on the race of snakebite victims. In a study from 1966, the weighted incidence of snakebites per 100 000 population was estimated as 4.99 for white males, 5.87 for non-white males, 2.44 for white females, and 2.48 for non-white females.<sup>37</sup> In the same study, whites had higher venomous snakebite rates than non-whites in 42 of 50 (84%) states. Unfortunately, NEDS does not report race data. However, among patients admitted after a venomous snakebite in the National Inpatient Sample, 84% were white (2019 Forrester JD, unpublished data).<sup>38</sup> The same year, 73% of the US population were white.<sup>39</sup> Therefore, the colloquial terms used to describe risk associated with white patients belonging to lower socioeconomic classes may be valid.

### **Texas: geography**

Venomous snakes are more common in the warmer climates of the southwestern, southern, and southeastern USA.<sup>1 16 37</sup> An analysis of 20 years of National Vital Statistics System data found three southern states—Texas, Florida, and Georgia—accounted for 44% of venomous snakebite deaths in the USA.<sup>2 40</sup> In a pediatric snakebite registry review, most cases were reported in Texas, Florida, Georgia, North Carolina, Arizona, and California.<sup>41</sup> Concordantly, our data indicate that 82% of snakebites occurred in the South, 11% in the West, 7% in the Midwest, and 1% in the Northeast. Although Texas appears to be an accurate term to describe venomous snakebite risk, the term does not capture the broader risk associated with being in the southern and western USA.

### **Tequila: alcohol consumption**

Alcohol consumption may be a risk factor for snake envenomations.<sup>14</sup> Existing literature has reported variable proportions of snakebites related to alcohol consumption, with findings ranging from 1% to 64%.<sup>13 14 21 42–44</sup> A recent report of US poison control data reported that only 1% of snakebites were associated with alcohol or drug use.<sup>31</sup> Unfortunately, NEDS has limited alcohol and drug use data, so no national-level estimates are provided. Further research is needed to determine if “tequila”

is an appropriate moniker to describe the frequency of drug and alcohol use among venomous snakebite victims.

### **Teenagers: age**

Age-specific venomous snakebite rates are valuable when targeting prevention efforts. In 1966, 52% of snakebites were reported among individuals younger than 20 years old, with a rate of 6 snakebites per 100 000 population for children and teenagers aged 5 to 19.<sup>37</sup> Existing research concluded that 28% of snakebites affected children less than 12 years old, and that children 0 to 14 years old and 15 to 19 years old accounted for 22% and 9% of all snakebites, respectively.<sup>2 4</sup> Our study found that 22% of snakebite victims were aged 0 to 17. However, after age-adjusting the NEDS data using the 2016 US population, patients aged 0 to 17 had lower odds of venomous snakebite, and the greatest odds were seen among patients 45 to 64 years old. Unfortunately, this may be confounded by outdoor recreational activities that inadvertently expose persons to venomous snakes; it is not known which activities are more likely to put a person at risk and which age groups are more likely to be participating in these activities.<sup>45</sup> Broadly speaking, teenagers do not appear to be at increased risk for venomous snakebite injury; “teenagers” may be an inappropriate “T.”

Age correlated with snakebite location.<sup>12</sup> In our study, we found that 63% of snakebites in individuals 0 to 17 years old affected the lower extremities, whereas 58% of snakebites affected the upper extremities in individuals >18 years old. Similarly, among children 0 to 10 years of age, prior studies report the lower extremity as the most common snakebite site, with 75% of snakebites affecting the leg, ankle, and foot.<sup>10</sup> The differences in snakebite location based on age question the role of intentionality; it is possible that children are less likely to be bitten by a venomous snake while intentionally trying to grasp the reptile. Instead, children may unintentionally walk near a venomous snake and fail to notice the presence of the reptile or fail to recognize the signs of an impending snakebite. This may represent an opportunity for public health intervention.

### **Tanks: pets and exotic snake species**

We found that a small fraction of injuries are caused by exotic snakes, consistent with existing literature.<sup>6–8</sup> Exotic snakes are becoming increasingly popular pets in the USA, whether legally or illegally.<sup>9</sup> Most exotic snakebites affect individuals employed at zoos or pet stores or owners of private collections.<sup>16</sup> From 1995 to 2004, the Toxic Exposure Surveillance System database of the AAPCC recorded envenomation by 77 species of exotic snakes, averaging 39.9 per year with a total of three fatalities.<sup>9 20</sup> We identified only 34 exotic snakebites in 2016, with the cobra species the most common exotic venomous snake responsible for biting humans, similar to prior assessments.<sup>34</sup> However, without a denominator of the number of persons possessing exotic venomous snakes, attribution of increased risk is not possible.

### **Limitations**

There are several limitations to this study. First, only snakebite victims in the USA were analyzed, limiting extrapolation to other countries. Second, misclassification bias may exist in the ICD-10 coding, as the validity of the coding is dependent on the quality of the coder. Third, the large number of unidentified snakes could lead to over-representation or under-representation of certain snake species. Fourth, NEDS only collects event-level data without unique identifiers for individual patients, meaning that a person bit twice during the course of

1 year would be categorized as two separate patients rather than a repeat encounter. Fifth, reporting bias may affect procedural code capture; not all patients had procedural codes reported. Sixth, 81% of snakebites were not identified at a species level. Finally, although NEDS is the most comprehensive survey of ED visits in the USA, sampling error and regional variability of snake species may lead to an overestimation or underestimation of snakebites.

## CONCLUSION

Snakebites remain an important public health issue in the USA. Some of the “T’s of snakebites”—testosterone, teasing, touching, poverty, and Texas—may be valid colloquial predictors of venomous snakebite injury. Based on national data, common demographics of snakebite victims include lower income, Caucasian, and adult men who are bit on the upper extremity. Children are more likely to be bit on the lower extremity. The South was the region with the most snakebites. Exotic snakebites represent a small minority of venomous snakebites. Among identified snake species, rattlesnakes are responsible for the majority of snakebites that result in ED presentation. Overall, a better understanding of the common demographics of snakebite victims can effectuate targeted public health prevention messaging.

**Contributors** JDJ: data interpretation, writing, literature review. NAH: writing, literature review. LT: data collection, data analysis. DS: data interpretation, writing. JDF: writing, data analysis, data interpretation.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** After review by the Stanford Institutional Review Board, this study was determined to be exempt as no personally identifiable data were analyzed or presented.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

## REFERENCES

- Gold BS, Dart RC, Barish RA. Bites of venomous snakes. *N Engl J Med Overseas Ed* 2002;347:347–56.
- O’Neil ME, Mack KA, Gilchrist J, Wozniak EJ. Snakebite injuries treated in United States emergency departments, 2001–2004. *Wilderness Environ Med* 2007;18:281–7.
- Plowman DM, Reynolds TL, Joyce SM. Poisonous snakebite in Utah. *West J Med* 1995;163:547–51.
- Ruha A-M, Kleinschmidt KC, Greene S, Spyras MB, Brent J, Wax P, Padilla-Jones A, Campleman S, ToxIC Snakebite Study Group. The epidemiology, clinical course, and management of snakebites in the North American snakebite registry. *J Med Toxicol* 2017;13:309–20.
- Langley R, Mack K, Haileyesus T, Proescholdbell S, Annett JL. National estimates of noncanine bite and sting injuries treated in US hospital emergency departments, 2001–2010. *Wilderness Environ Med* 2014;25:14–23.
- Mowry JB, Spyer DA, Brooks DE, Zimmerman A, Schauben JL. 2015 annual report of the American Association of Poison Control Centers’ National Poison Data System (NPDS): 33rd annual report. *Clin Toxicol* 2016;54:924–1109.
- Gummin DD, Mowry JB, Spyer DA, Brooks DE, Fraser MO, Banner W. 2016 annual report of the American Association of Poison Control Centers’ National Poison Data System (NPDS): 34th annual report. *Clin Toxicol* 2017;55:1072–254.
- Gummin DD, Mowry JB, Spyer DA, Brooks DE, Osterthaler KM, Banner W. 2017 Annual Report of the American Association of Poison Control Centers’ National Poison Data System (NPDS): 35th Annual Report. *Clin Toxicol* 2018;56:1213–415.
- Warrell DA. Commissioned article: management of exotic snakebites. *QJM* 2009;102:593–601.
- Pudovka O, Gross GA. *Management of snakebites: study manual and guide for health care professionals*. First Edition. Victoria, BC, Canada: Friesen Press, 2011.
- Nathanson A, Everline C, Renneker M. *Surf survival: the surfer’s health handbook*. New York: Skyhorse Publishing, Inc, 2011.
- Downey DJ, Omer GE, Moneim MS. New Mexico rattlesnake bites: demographic review and guidelines for treatment. *J Trauma* 1991;31:1380–6.
- Spano S, Macias F, Snowden B, Vohra R. Snakebite survivors club: retrospective review of rattlesnake bites in central California. *Toxicol* 2013;69:38–41.
- Wingert WA, Chan L. Rattlesnake bites in Southern California and rationale for recommended treatment. *West J Med* 1988;148:37–44.
- Russell FE, Carlson RW, Wainschel J, Osborne AH. Snake venom poisoning in the United States. Experiences with 550 cases. *JAMA*
- Cowles LA, Colletti LM. Presentation and treatment of venomous snakebites at a northern academic medical center. *Am Surg* 2003;69:445–9.
- HCUP. The HCUP Nationwide Emergency Department Sample (NEDS). 2016. [https://www.hcup-us.ahrq.gov/db/nation/neds/NEDS\\_Introduction\\_2016.jsp](https://www.hcup-us.ahrq.gov/db/nation/neds/NEDS_Introduction_2016.jsp) (19 May 2019).
- Ingram DD, Franco SJ. 2013 NCHS urban-rural classification scheme for counties. *Vital Health Stat 2* 2014;1–73.
- National population by characteristics: 2010–2017. <https://www.census.gov/data/datasets/2017/demo/popest/nation-detail.html> (9 Jun 2019).
- Seifert SA, Boyer LV, Benson BE, Rogers JJ. AAPCC database characterization of native U.S. venomous snake exposures, 2001–2005. *Clin Toxicol* 2009;47:327–35.
- Morandi N, Williams J. Snakebite injuries: contributing factors and intentionality of exposure. *Wilderness Environ Med* 1997;8:152–5.
- Chippaux J-P. Incidence and mortality due to snakebite in the Americas. *PLoS Negl Trop Dis* 2017;11:e0005662.
- Curran-Sills G, Kroeker J. Venomous snakebites in Canada: a national review of patient epidemiology and antivenom usage. *Wilderness Environ Med* 2018;29:437–45.
- Wasko DK, Bullard SG. An analysis of media-reported venomous snakebites in the United States, 2011–2013. *Wilderness Environ Med* 2016;27:219–26.
- ACMT. ACMT - The ToxIC North American Snakebite Registry. [https://www.acmt.net/cgi/page.cgi/Snakebite\\_Registry.html](https://www.acmt.net/cgi/page.cgi/Snakebite_Registry.html) (20 May 2019).
- United States Census Bureau. Our changing landscape. <https://www.census.gov/library/visualizations/2016/comm/acs-rural-urban.html> (29 May 2019).
- Shahian DM, Nordberg P, Meyer GS, Blanchfield BB, Mort EA, Torchiana DF, Normand S-LT. Contemporary performance of U.S. teaching and nonteaching hospitals. *Acad Med* 2012;87:701–8.
- Carlin CS, Kralewski J, Savage M. Sources of information used in selection of surgeons. *Am J Manag Care* 2013;19:e293–300.
- Carr BG, Branas CC, Metlay JP, Sullivan AF, Camargo CA. Access to emergency care in the United States. *Ann Emerg Med* 2009;54:261–9.
- Lack WD, Carlo JO, Marsh JL. Payer status and increased distance traveled for fracture care in a rural state. *J Orthop Trauma* 2013;27:113–8.
- Harrison RA, Hargreaves A, Wagstaff SC, Faragher B, Lalloo DG. Snake envenoming: a disease of poverty. *PLoS Negl Trop Dis* 2009;3:e569.
- Needleman RK, Neylan IP, Erickson T. Potential environmental and ecological effects of global climate change on venomous terrestrial species in the wilderness. *Wilderness Environ Med* 2018;29:226–38.
- Wu J. Detecting and attributing the effects of climate change on the distributions of snake species over the past 50 years. *Environ Manage* 2016;57:207–19.
- Minton SA. Bites by non-native venomous snakes in the United States. *Wilderness Environ Med* 1996;7:297–303.
- Spiller HA, Bosse GM. Prospective study of morbidity associated with snakebite envenomation. *J Toxicol Clin Toxicol* 2003;41:125–30.
- Health insurance coverage in the United States. 2017. <https://www.census.gov/library/publications/2018/demo/p60-264.html> (29 May 2019).
- Parrish HM. Incidence of treated snakebites in the United States. *Public Health Rep Wash DC* 1896 1966;81:269–76.
- HCUP. HCUP-US NIS overview. <https://www.hcup-us.ahrq.gov/nisoverview.jsp> (29 May 2019).
- American FactFinder - results. [https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS\\_17\\_1YR\\_B02001&prodType=table](https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_1YR_B02001&prodType=table) (29 May 2019).
- Morgan BW, Lee C, Damiano L, Whitlow K, Geller R. Reptile envenomation 20-year mortality as reported by US medical examiners. *South Med J* 2004;97:642–4.
- Schulte J, Domanski K, Smith EA, Menendez A, Kleinschmidt KC, Roth BA. Childhood victims of snakebites: 2000–2013. *Pediatrics* 2016;138:e20160491.
- Curry SC, Horning D, Brady P, Requa R, Kunkel DB, Vance MV. The legitimacy of rattlesnake bites in central Arizona. *Ann Emerg Med* 1989;18:658–63.
- Schulte J, Kleinschmidt KC, Domanski K, Smith EA, Haynes A, Roth B. Differences between snakebites with concomitant use of alcohol or drugs and single snakebites. *South Med J* 2018;111:113–7.
- Kurecki BA, Brownlee HJ. Venomous snakebites in the United States. *J Fam Pract* 1987;25:386–92.
- Outdoor Industry Association. 2018 Outdoor participation report. <https://outdoorindustry.org/resource/2018-outdoor-participation-report/> (9 June 2019).