Childhood Victims of Snakebites: 2000–2013

Joann Schulte, DO, MPH, Kristina Domanski, MD, Eric Anthony Smith, MS, Annelle Menendez, MD, Kurt C. Kleinschmidt, MD, Brett A. Roth, MD

BACKGROUND: Snakebites are not a reportable condition (to state health departments), and 1 major assessment of US children with snakebites was published 50 years ago. Increasing urbanization, population shifts south and west, newer antivenom therapy, and the importation of exotic snakes may have changed snakebites. Poison control centers are often consulted on treatment and collect surveillance data.

METHODS: Generic codes for venomous, nonvenomous, and unknown snakebites were used to characterize victims aged ≤18 years reported to US poison control centers between 2000 and 2013. Data included demographic characteristics, snake types, and outcomes.

RESULTS: Callers reported 18,721 pediatric snakebites (annual mean, 1,337). Two-thirds were male (n = 12,688 [68%]), with a mean age of 10.7 years. One-half of the snakebites were venomous (n = 9,183 [49%]), with copperheads (n = 3,602 [39%]) and rattlesnakes (n = 2,859 [31%]) the most frequently identified. Reported copperhead bites increased 137% and unknown crotalids (venomous) increased 107%. Exotic (nonnative) exposures were reported in 2% of cases. All 50 states reported snakebites, but one-quarter occurred in Texas and Florida. Rates for total snakebites and venomous snakebites were highest in West Virginia, Oklahoma, and Louisiana. One-fifth required ICU admission. Limited data for 28% of bites for antivenom treatment suggests increasing use. Four victims died.

CONCLUSIONS: The epidemiology of pediatric snakebites is changing. One-half of the reported exposures were venomous, and copperhead bites and exotic species are being reported more frequently. Although snakebite-related deaths are rare, ICU admission is common. Antivenom treatment is incompletely reported, but its use is increasing.

WHAT’S KNOWN ON THIS SUBJECT: Few comprehensive assessments of pediatric snakebites have been published.

WHAT THIS STUDY ADDS: Reported snakebites average 1,300 annually. One-half of the 18,721 snakebites reported were venomous, and 2% involved exotic snakes. Antivenom treatment of bites from copperheads and unknown snake types has increased. About 20% required ICU admission, and 4 deaths were reported.

Dr Schulte conceptualized and designed the study, obtained institutional review board approval, obtained the data, performed the data analysis, interpreted the data, and drafted the initial manuscript and revisions; Mr Smith performed data analysis and helped draft the initial manuscript and revisions; Dr Domanski assisted in interpretation of data, helped draft the initial manuscript, and critically revised the manuscript for important intellectual content; Dr Menendez assisted in interpretation of data and helped draft the initial manuscript; Dr Kleinschmidt assisted in design of the study, assisted in interpretation of data, and critically revised the manuscript for important intellectual content; Dr Roth assisted in design of the study, oversaw data analysis, helped draft the initial manuscript, and critically revised the manuscript for important intellectual content; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Address correspondence to Joann Schulte, DO, MPH, North Texas Poison Control Center, Parkland Hospital, 5201 Harry Hines Blvd, Dallas, TX 75235. E-mail: joann.schulte@louisvilleky.gov
Snakebites are not a reportable condition (to state health departments), and few comprehensive surveillance assessments exist. One often-cited study assessing snakebites among US children was published in 1965 (50 years ago) and used data from individual hospitals in 10 states. Since that date, increasing urbanization, population shifts to the southern and western states, development of new antivenom treatments, and the emergence of exotic snakes as an industry have altered the population and the circumstances in which snakebites may occur. Increasing numbers of US households are estimated to own a snake, which can lead to bites and even death.

The main objective of the present study was to characterize snakebites to children and adolescents aged ≤18 years reported to US poison control centers between 2000 and 2013. We investigated the trends in, and epidemiologic characteristics of, pediatric snakebites and the resulting consequences, including hospital admissions and possible antivenom treatment.

METHODS

Data Sources

This study was based on data collected in the National Poison Data System (NPDS), which is maintained by the American Association of Poison Control Centers. Poison control centers offer 24-hour advice and consultation for individuals and hospitals using an 800 number, with calls routed on the basis of the caller's area code. The collected documentation for each call includes exposure (in this study, type of snake), basic demographic data on the exposed person, subsequent medical information related to the exposure, and other information regarding the incident. US Census Bureau data were used to calculate population-based rates for total snakebites and venomous snakebites.

Data Selection and Conditions

NPDS data were obtained for all single snakebite exposures among persons with a known age of ≤18 years that were reported to any US poison control center between calendar years 2000 and 2013. Cases were limited to those in which the victim was in or referred to a health care facility (HCF).

Snakebite Variables

Snakebites are defined with NPDS generic codes identifying venomous, nonvenomous, and unknown snakes, both species indigenous to the United States and exotic varieties that are nonnative to the United States. Specific codes for the domestic snakes are unknown types of snake envenomation (13700); unknown or known nonpoisonous snakebites (137102); rattlesnake envenomation (137103); coral snake envenomation (137104); copperhead envenomation (137106); cottonmouth/water moccasin envenomation (137107); and unknown crotalid envenomation (137105). Rattlesnakes, copperheads, and cottonmouths/water moccasins are all pit vipers and are classified as unknown crotalids if not specifically identified.

Codes for the exotic snakes, nonnative to the United States, include exotic snake poisonous (137108), exotic snake nonpoisonous (137109), and exotic snake unknown if poisonous (137110).

Antivenom Therapy

During the study period, antivenom therapy for domestic snakebites evolved. Before 2000, the major antivenom used for all domestic venomous snakes (except coral) was a polyvalent product of equine origin manufactured by Wyeth (US Food and Drug Administration, personal communication, 2016). The last lot of that antivenom expired in March 2007, and it was generally only used in severe envenomations because it could produce serious adverse effects, including anaphylaxis and serum sickness. Concurrent use of epinephrine to treat possible anaphylaxis was common. A separate Wyeth antivenom, specific to coral snakes, had been available in limited supply with an expiration date of May 2016 (US Food and Drug Administration, personal communication, 2016).

The Fab antivenom that has become the therapeutic cornerstone for many US snakebites, including those to children, was granted approval by the US Food and Drug Administration in 2000. This Fab antivenom (CroFab [BTG International Inc, West Conshohocken, PA]) is derived from sheep and is considered less antigenic because it lacks the Fc antibody fragment. In this article, the newer antivenom is referred to as Fab antivenom. The older Wyeth antivenoms are called polyvalent antivenom and coral snake antivenom and, collectively, as older antivenoms.

Collected information on antivenoms is coded as recommended, performed, recommended and performed, and recommended, known not performed. We consolidated those categories into treated and any consideration of antivenom on use.
Definition of Treatable Envenomation

Most snakebites, whether venomous or not, will have some type of local tissue effect, including minor pain and erythema. Venomous snakebites may cause a variety of symptoms, including pain, swelling, tissue necrosis, low blood pressure, convulsions, hemorrhage, respiratory paralysis, kidney failure, coma, and death. However, not all venomous snakes are identified as such, and unknown snakes can be venomous but unrecognized.

The decision to treat a specific bite with antivenom is made by a treating provider, often in consultation with a poison control center. Antivenom treatment may be administered for victims bitten by known venomous snakes or bites in which an unknown snake type produces serious complications in the provider's judgment.

A potentially treatable envenomation was defined as one in which a bitten patient was at risk for complications because the bite involved an identified domestic venomous snake or an unknown domestic snake (n = 15,422) (Fig 1). The domestic venomous snakes considered included rattlesnakes, copperheads, cottonmouths, coral snakes, and unknown crotalids.

Other Variables

Geographic location is the state where the snakebite occurred. Exposure site was collapsed to residence (either the child’s own home or another) versus all other sites. In NPDS, level of treatment at an HCF is categorized as seen at HCF, no HCF treatment, and patient refused referral/did not arrive at the HCF. The description of being seen at HCF includes admission to a critical care unit (ICU), admitted to a noncritical care unit (floor), being treated/evaluated, and released (<24-hour stay).

Statistical Analysis and Ethical Considerations

SAS version 9.3 (SAS Institute, Inc, Cary, NC) and Epi Info (Centers for Disease Control and Prevention, Atlanta, GA) were used for data analysis. The institutional review board at UT Southwestern approved this study.

RESULTS

Demographic Characteristics of Bitten Children and Adolescents

Poison control centers received 18,721 reports of snakebites to children and adolescents aged ≤18 years during the study period. More than two-thirds of those bitten were male (n = 12,688 [68%]), with a mean age of 10.7 years. Bite numbers were highest among children aged 3 to 9 years (n = 6,717 [36%]) and 10 to 14 years (n = 5,917 [32%]). Four deaths were reported. Exposures were reported in all months, with one-third in June and July (n = 6,461 [33%]). Most exposures were in residential home settings (n = 14,824 [89%]). Calls were distributed equally among the 7 weekdays, and more than one-quarter of calls (n = 5,048 [27%]) were made between 7:00 and 10:00 PM. Most patients (n = 14,980 [80%]) were in an HCF when the poison control center was called.

Deaths

Four separate deaths of children were reported; 3 by rattlesnakes (Texas, Georgia, and Florida) and 1 by an unknown type of snake (Florida). All deaths were considered directly related to the snakebites. A 2-year-old girl who died in Texas in 2010 had 2 bites on her ankle; a rattlesnake was found at the lake where she visited. She had a generalized seizure before transport to a hospital 2 hours away where she was given 6 vials of Fab antivenom and admitted to the ICU. She was started on vasopressor agents but became hypotensive and pulseless. She died 5 hours after being bitten.

A 3-year-old boy was bitten in Georgia in 2000 by a rattlesnake, received 36 vials of polyvalent crotalid antivenom, and developed disseminated intravascular coagulopathy. He died within several hours of the envenomation. In 2000, a 2-year-old boy from Florida was bitten on the knee by a rattlesnake and received 90 vials of polyvalent crotalid antivenom. He had only 1 fang mark and bled from a cutdown site, oral orifices, and the gastrointestinal tract. He received...
vasopressor agents and transfusions but had had no response to pain within 24 hours and was declared brain dead.

A 17-year-old female, bitten on the right hand by an unknown type of snake in 2001 in Florida, was initially seen at a fire station. She was thought to be having an allergic reaction and given epinephrine. She had 2 puncture marks on her right hand, with no local swelling or ecchymosis. She had a seizure en route to the emergency department and became hypotensive. She was intubated, received a total of 34 vials of Fab antivenom, and had no response to vasopressor agents. She died on day 5 of hospitalization.

**Geographic Distribution of All Snakebites**

An annual mean of 1337 snakebites were reported (range, 1184–1527). One-half of all the reported snakebites (domestic and exotic) were venomous (n = 9182 [49%]). Other totals were nonvenomous (n = 3156 [17%]) and unknown type of snake (n = 6382 [34%]). Among the venomous snakes, copperheads (n = 3602 [39%]) and rattlesnakes (n = 2859 [31%]) were most common. Lower numbers were reported for unknown crotalids (n = 1853 [20%]), cottonmouths (n = 511 [6%]), coral snakes (n = 232 [3%]), and exotic venomous snakes (n = 126 [1%]).

Snakebites were reported in 50 states, Washington, DC, and Puerto Rico, but 39% (n = 7238) were reported by 4 states: Texas (n = 2627 [14%]), Florida (n = 2199 [12%]), Georgia (n = 1237 [7%]), and North Carolina (n = 1174 [6%]). Prevalence rates per 1 million population (Fig 2) for all snakebites were highest in West Virginia (762.3), Louisiana (625.5), and Oklahoma (557.5).

**Geographic Distribution of Venomous Snakebites**

Venomous snakebites were reported in 48 states, Washington, DC, and Puerto Rico. Forty percent (n = 3789) of snakebites were reported in 4 states: Texas (n = 1431 [16%]), Florida (n = 895 [10%]), North Carolina (n = 815 [9%]), and California (n = 648 [7%]). Texas and North Carolina reported one-third of the copperhead bites (n = 1203). Arizona and California reported 40% (n = 1154) of the rattlesnake bites. Florida reported 60% of coral snake bites (n = 160) and 25% of cottonmouth bites (n = 124). Prevalence rates per 1 million populations for venomous bites (Fig 3) were highest in West Virginia (421.4), Oklahoma (383.2), and Louisiana (354).

**Trends in Reported Snakebite Exposures and Antivenom Use**

Use of any antivenom therapy was considered in 5279 (28%) reported snakebites and administered in 4817 (25.7%) exposures. During the study period, Fab antivenom use increased 298%, spiking after the last lot of polyvalent antivenom expired.
Figure 4 shows trends in reported exposures for domestic snakes (venomous and unknown) that might be treated with antivenom therapy (as discussed in the Definition of Treatable Envenomation section). Between 2000 and 2013, copperhead reports increased 137% and unknown crotalid reports increased 107%.

Figures 5, 6, and 7 show trends in reported snakebites and antivenom use for rattlesnake, copperhead, and unknown crotalid bites, respectively. In each case, the Fab antivenom drove most of the increase and increased markedly starting in 2007.

**Level of Health Care and Treatment**

Almost 40% \((n = 7106 [38\%])\) of pediatric cases caused hospital admissions, and 1 in 5 reported cases were admitted to ICUs \((n = 3541 [19\%])\). One-half of the patients \((n = 9397)\) were treated and released, and <1\% \((n = 11)\) were admitted to a psychiatric facility.

Antivenom use (Table 1) was highest for rattlesnake bites \((n = 1181 [41\%])\). More than one-third of bites by copperheads \((n = 1278 [34\%])\), cottonmouths \((n = 175 [35\%])\), and unknown crotalids \((n = 684 [37\%])\) were treated with antivenom. Lower treatment percentages were reported for coral snakes \((n = 36 [20\%])\) and unknown types of snakes \((n = 1816 [28\%])\).

Among 15 422 patients with potentially treatable snakebites, rattlesnake victims were 3.8 times (odds ratio, 3.80 [95% confidence interval, 3.48–4.13]) more likely to be admitted to an HCF than those patients bitten by all other types of snakes. Children bitten by rattlesnakes were 3.9 times (odds ratio, 3.92 [95% confidence interval, 3.53–4.35]) more likely to be admitted to an HCF than those bitten by copperheads.

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**Exotic Snakes**

Two percent \((n = 368)\) of the exposures reported involved exotic snakes. Almost one-half of the exotic snakes were boa constrictors \((n = 182 [49\%])\), and 31 different exotic venomous species were reported. Nine percent of children \((n = 76)\) with exotic snake encounters were admitted to the hospital, and 4\% \((n = 37)\) were ICU admissions.

**DISCUSSION**

The last comprehensive assessment of epidemiology of snakebites among children and adolescents of which we are aware was published in 1965 when inpatient hospital records were collected. The increase in reported exposures and the use of antivenom are concerning, especially with the increase in Fab antivenom use starting in 2007. The lack of standardized reporting and the variability in treatment practices highlight the need for ongoing surveillance and research to better understand the epidemiology and management of pediatric snakebites.
in 10 states were reported. The present study provides data from 50 states, Puerto Rico, and Washington, DC, and finds both similarities and differences. Copperheads and rattlesnakes remain the most common domestic venomous snakes reported; most snakebites are reported during summer months; and few deaths occurred. More than 1100 children and adolescents are bitten each year, and ~20% of victims require ICU admission. Almost 50% of the reported snakebites were venomous, but 84% of all domestic snakebites could have been potentially treated with antivenom therapy.

Every state reported snakebite victims, but copperhead reports were focused in the southeastern US and rattlesnakes in the west. Three states (West Virginia, Oklahoma, and Louisiana) had the highest prevalence rates of both total bites and venomous bites. These findings suggest the potential benefit of prevention efforts tailored to states reporting large numbers of snakebites (Texas, Florida, Georgia, North Carolina, Arizona, and California) or have high prevalence rates (Oklahoma, West Virginia, and Louisiana).

We found that the use of antivenom for rattlesnake, copperhead, and unknown crotalid bites increased during the study period, especially after 2006. This finding is similar to those of earlier studies examining the use of antivenom for briefer time periods. Much of the augmented use is driven by copperhead bites, which increased 107% during the study period; use of Fab antivenom for those bites increased 775%. Traditionally, antivenom treatment of copperheads was less common because their venom is less toxic, producing milder symptoms than bites by rattlesnakes or cottonmouths. More recent studies have found that residual copperhead venom effects, including swelling, pain, and functional disability, may persist for 13 days. Treatment with the newer Fab antivenom has become more common and can be expensive. Initial treatment requires at least 4 to 6 vials of antivenom, and the patient’s charges for just the antivenom can be almost $100 000.

Our study also prompts questions concerning the data regarding antivenom treatment. We had data on antivenom therapy for only 28% of pediatric reports, but up to 83% of all domestic snakebites were potentially treatable with antivenom according to our estimates. The seeming discrepancy may be explained by the variation in bites and symptoms that the bites produce. Up to 20% of venomous snakebites are dry, and the amount of venom injected varies among bites. Dry bites occur because a specific snake may have hunted and used all venom supplies. The severity of clinical manifestations can vary greatly, with minimal symptoms

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>Rattlesnake (n = 2859)</th>
<th>Copperhead (n = 3602)</th>
<th>Cottonmouth (n = 511)</th>
<th>Coral (n = 232)</th>
<th>Unknown Crotalid (n = 1853)</th>
<th>Unknown Snake (n = 6382)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, y</td>
<td>10.6</td>
<td>10.8</td>
<td>12.2</td>
<td>12.2</td>
<td>10.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Male</td>
<td>2035 (71)</td>
<td>2325 (65)</td>
<td>396 (78)</td>
<td>187 (81)</td>
<td>1194 (64)</td>
<td>4289 (67)</td>
</tr>
<tr>
<td>HDF admit</td>
<td>1361 (48)</td>
<td>798 (22)</td>
<td>123 (24)</td>
<td>98 (42)</td>
<td>466 (25)</td>
<td>634 (10)</td>
</tr>
<tr>
<td>ICU admit</td>
<td>500 (17)</td>
<td>383 (10)</td>
<td>121 (24)</td>
<td>29 (13)</td>
<td>566 (31)</td>
<td>944 (15)</td>
</tr>
<tr>
<td>Antivenom treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fab antivenom</td>
<td>958 (34)</td>
<td>1110 (31)</td>
<td>135 (26)</td>
<td>NA</td>
<td>571 (31)</td>
<td>823 (13)</td>
</tr>
<tr>
<td>Older antivenom</td>
<td>223 (8)</td>
<td>168 (5)</td>
<td>40 (8)</td>
<td>36 (16)</td>
<td>113 (6)</td>
<td>993 (16)</td>
</tr>
<tr>
<td>Any antivenom</td>
<td>1181 (41)</td>
<td>1278 (36)</td>
<td>175 (34)</td>
<td>NA</td>
<td>684 (37)</td>
<td>1816 (28)</td>
</tr>
</tbody>
</table>

Data are presented as n (%) unless indicated otherwise. NA, not applicable.

* Either polyvalent crotalid or monovalent coral snake.
to life-threatening complications, and they may not develop or progress slowly or rapidly. Systemic manifestations, usually attributed to venomous bites, can include rapid swelling, ecchymosis, and progression to hypotension, altered sensorium, tachycardia, respiratory distress, and severe coagulation abnormalities and require admission to the ICU. In many exposures, the exact snake is unidentified. This fact can complicate decisions about whether to use antivenom.

We found only 4 pediatric victims who died during the study period. This finding is consistent with earlier assessments that ~5 persons of all ages die each year of snakebites in the United States. The type of snakebites that poison control centers are consulted about is also changing. Fifty years ago, no exotic species were reported. In our report, only 2% of pediatric exposures were exotic species, but pet industry groups have estimated that 846,000 households own snakes. Some exotic species (all of them constrictors) have been restricted from further importation and from interstate transport by the federal government. It is reasonable to expect that the calls to poison control centers about exotic snakes will become more common.

The present study has a number of limitations. Our assessment was based on described exposures reported to US poison control centers by voluntary callers, which does not capture all incidents. The NDDS also does not capture detailed information on the anatomic site of the bite, the degree of envenomation, or the amount of antivenom used in treatment. HCFs may treat snakebites and not consult with a poison center, especially not if they choose to use antivenom. Some data may be miscoded. In addition, our data likely do not completely reflect the time of day when the snakebite occurred. The national data collection includes time of call but no data regarding time of exposure.

CONCLUSIONS

Our study found changes in the venomous snakebites reported, with increased numbers of copperhead bites, increased use of newer antivenom therapies, and the emergence of exotic species. Educational prevention efforts should focus on states reporting large numbers of snakebites or high prevalence rates. The present study has a number of limitations. Our assessment was based on described exposures reported to US poison control centers by voluntary callers, which does not capture all incidents. The NDDS also does not capture detailed information on the anatomic site of the bite, the degree of envenomation, or the amount of antivenom used in treatment. HCFs may treat snakebites and not consult with a poison center, especially not if they choose to use antivenom. Some data may be miscoded. In addition, our data likely do not completely reflect the time of day when the snakebite occurred. The national data collection includes time of call but no data regarding time of exposure.

FIGURE 7

Reported unknown crotalid bite and antivenom use, 2000 to 2013.
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