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Epidemiology of fatal snakebites in the United States 1989–2018

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ABSTRACT

Background: There are 5000–10,000 snake envenomations annually in the United States. Fortunately, few are fatal. In this study we review the epidemiology of fatal snakebites.
Methods: Native snakebite cases from the American Association of Poison Control Centers (AAPCC) National Poison Data System from 1989 to 2018 were reviewed. Additional cases that were not reported to the AAPCC were identified by reviewing Wikipedia and by searching PubMed and online news outlets using various combinations of relevant keywords.
Results: We identified 101 fatal bites from native snakes. Rattlesnakes accounted for 74 (90.2%) of the 82 deaths for which the species was known or which occurred where rattlesnakes are the only native crotalids. There were five fatalities attributed to copperheads, two due to cottonmouths, and one caused by an eastern coral snake. Males were disproportionately affected. The median age for victims was 40 years old. In cases for which data were available, many of the snake interactions were intentional, e.g. religious services, animal husbandry, and attempting to kill the snake.
Conclusions: Death following envenomation from a native U.S. snake is unlikely, particularly if medical attention is sought promptly. Rattlesnake envenomations are more likely to be fatal than bites from other species. Intentionally engaging with a venomous snake raises the risk of incurring a fatal bite, as does concurrent alcohol or drug use. Age less than 12 years old does not appear to be a risk factor for a fatal outcome, while elderly patients may have a slightly increased risk of death.

1. Introduction

There are 5000–10,000 snake envenomations annually in the United States (U.S.) [1-30]. Crotalids, also known as pit vipers, are responsible for >97% of these bites [1-30]. Copperheads (*Agkistrodon contortrix* and *A. laticinctus*) cause 45–50% of bites. Various rattlesnakes from the genera *Crotalus* and *Sistrurus* are implicated in 30–40% of bites, while cottonmouths (*A. piscivorus* and *A. conanti*) comprise 10–15% of bites. The only native elapids are coral snakes from the genera *Micrurus* and *Micruroides*, and the three U.S. species account for fewer than 3% of venomous bites. Non-native snake species found in zoos and private collections comprise 1% of envenomations.

Fewer than 8% of snakebite victims experience severe systemic toxicity or limb-threatening effects [1-30]. Death is exceptionally uncommon. A review of U.S. snakebites from 2001 to 2004 estimated nearly 9900 annual envenomations with a mortality rate of 0.05% [31]. However, this included patients who received treatment at a medical facility. The untreated lethality rate for copperheads may be <1%, but it is estimated to be as high as 30–40% for the Mohave rattlesnake, *C. scutulatus* [32,33].

The few previous studies that have evaluated the epidemiology of U.S. snakebites have relied on limited datasets and/or did not delve into the circumstances of the bites, particularly the fatal envenomations [34-37]. In this report, we discuss the epidemiology of fatal bites from native U.S. snakes, including demographics, the responsible snake species, and the circumstances of the envenomation. Clinical details, including whether the victim sought treatment and time from envenomation to death, are also provided when available.

2. Methods

Native snakebite cases from the American Association of Poison Control Centers (AAPCC) National Poison Data System (NPDS) from 1989 to 2018 were reviewed. Envenomations from non-native snakes and bites from non-venomous snakes were excluded. All fatalities attributed to

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native snake species were included. Additional cases that were not reported to the AAPCC were identified by reviewing Wikipedia, a free online encyclopedia, and by searching PubMed and online news outlets using various combinations of the following keywords: bite, copperhead, coral snake, cottonmouth, death, died, envenomation, fatal, fatalities, rattlesnake, snake, snakebite, venom, water moccasin, *Agkistrodon, Crotalus*, *Micrurus*, and *Sistrurus*.

Duplicate cases were identified and consolidated. Demographic information, including age, sex, and location of the victim, was recorded when available. The circumstances of envenomation, including species, the activity that led to the snakebite, and the anatomic location of the bite were documented when the information was available. Species identifications were made in accordance with naming guidelines from the Society for the Study of Amphibians and Reptiles [38]. When the species could not be confirmed, clinical features and geography were considered. Snakebites characterized by typical signs of pit viper envenomation, e.g. swelling, bruising, tissue injury, and hematologic abnormalities, were listed as "unknown crotalid" in regions where multiple types of snakes are endemic. In areas where rattlesnakes are the only native crotalids, or if a rattle was reportedly visualized but the snake was not definitively identified, the classification of "unknown rattlesnake" was used.

The study was exempted from formal review by the authors' institutional review boards because it is a systematic analysis of aggregated, published, de-identified data.

3. Results

We identified 101 fatal bites from native snakes reported between 1989 and 2018. There were 59 listed in NPDS, including 41 that were not mentioned in Wikipedia [1-30]. Wikipedia identified 39 deaths, including 21 that were not reported by the AAPCC [39]. Every case listed in Wikipedia was confirmed by one or more additional references [40-126]. We identified 21 additional snakebite fatalities using PubMed and online news reports [127-146].

Rattlesnakes accounted for 74 (90.2%) of the 82 deaths for which the species was known or which occurred where rattlesnakes are the only native crotalids. The timber rattlesnake, *C. horridus*, was most often implicated, with 22 deaths. There were five fatalities attributed to copperheads, two due to cottonmouths, and one caused by an eastern coral snake, *Micrurus fulvius* (Table 1).

Males were disproportionately affected; 83 males and 14 females incurred fatal snakebites. Sex was not reported in four patients. The median age for victims of fatal snakebites was 40 years old, with a range of 23 months to 87 years. Age was not reported in one case (Fig. 1).

The geographic location of the fatal bites was available for 66 victims. Twenty-two states reported fatalities. Georgia and Kentucky each reported seven, and there were six in Texas, Alabama, Arizona, and Florida. No other state had more than three (Fig. 2).

Table 1
: Snakebites by year and species

	CPD	CTM	TIM	WDB	EDB	MO	SP	NP	GB	PR	UR	UC	EC	**Total**
1989				1	1					1	1			**4**
1990											1			**1**
1991			1							1	1			**3**
1992								1			1			**2**
1993														**0**
1994						2					1			**3**
1995			2								2			**4**
1996														**0**
1997											2	1		**3**
1998			1								1			**2**
1999											2	2		**4**
2000			1		1						2			**4**
2001		1									3			**4**
2002			1		1						1			**3**
2003							1		1					**2**
2004	1		3									2		**6**
2005			1	1	1						3	2		**8**
2006			1								2	2	1	**7**
2007			1		1	1		1						**4**
2008			1								1	1		**3**
2009			1								2	1		**4**
2010			1	1							1			**3**
2011	1	1	1			1								**4**
2012	1		1											**2**
2013			1								1			**2**
2014	1		1								1	2		**5**
2015	1		1									5		**7**
2016			1	1						1				**3**
2017											1	1		**2**
2018			1							1				**2**
Total	**5**	**2**	**22**	**4**	**5**	**4**	**1**	**2**	**1**	**4**	**31**	**19**	**1**	**101**

CPD – copperhead, *Agkistrodon contortrix, A. laticinctus.*
CTM – cottonmouth, *A. piscivorus, A. conanti.*
TIM – timber rattlesnake, *Crotalus horridus.*
WDB – western diamond-backed rattlesnake, *C. atrox.*
EDB – eastern diamond-backed rattlesnake, *C. adamanteus.*
MO – Mohave rattlesnake, *C. scutulatus.*
SP – southern Pacific rattlesnake, *C. helleri.*
NP – northern Pacific rattlesnake, *C. oreganus.*
GB – Great Basin rattlesnake, *C. lutosus.*
PR – prairie rattlesnake, *C. viridis.*
UR – unknown rattlesnake species.
UC – unknown crotalid species.
EC – eastern coral snake, *Micrurus fulvius.*

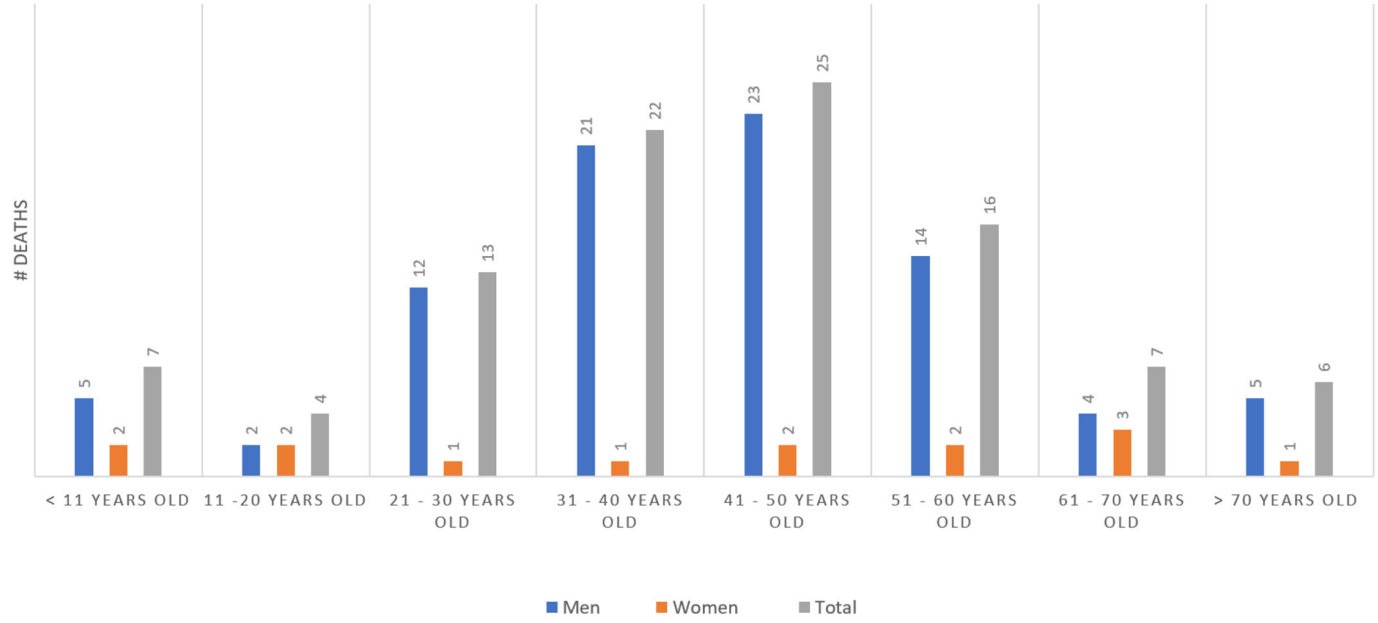

Fig. 1. Snakebite fatalities by age and sex.

Fatal envenomations occurred in every month. Data were available for 61 bites. The three-month period with the most bites was May–July (Fig. 3).

The circumstances of the bite were known in 64 cases. Unintentional interaction with the snake led to 31 envenomations. Of the 33 cases in which the interaction was known to be intentional, only two involved women. Thirteen fatal bites, including the two in female victims, occurred during religious ceremonies involving snakes. Timber rattlesnakes were the only snakes identified in the religious service cases, 7/13 (53.8%) of which occurred in Kentucky. Another eight bites were incurred during animal husbandry. Twelve victims were intentionally engaging with the snake for other reasons. Four victims were attempting to kill the snake, and another one was bitten while removing the rattle from a snake he mistakenly believed was dead. One male was bitten by a snake that had recently been decapitated. Six victims were deliberately "free handling" the snake, including one suicide by Mohave rattlesnake. The circumstances surrounding the fatal bites from the six most common species can be seen in Fig. 4.

Ethanol was specifically mentioned as a contributing factor in 10 envenomations. The median blood alcohol level of the eight victims for whom levels were available was 214 mg/dL.

The anatomic location of the fatal bite was reported in 52 cases. There were 34 bites to the upper extremity, including 11 to the arm and 23 to a finger or hand. Sixteen bites were to the lower extremity. There were six ankle bites, eight to the leg, and two to the thigh. All but one of the lower extremity bites followed an unintentional snake

Fig. 2. Snakebite fatalities by state.

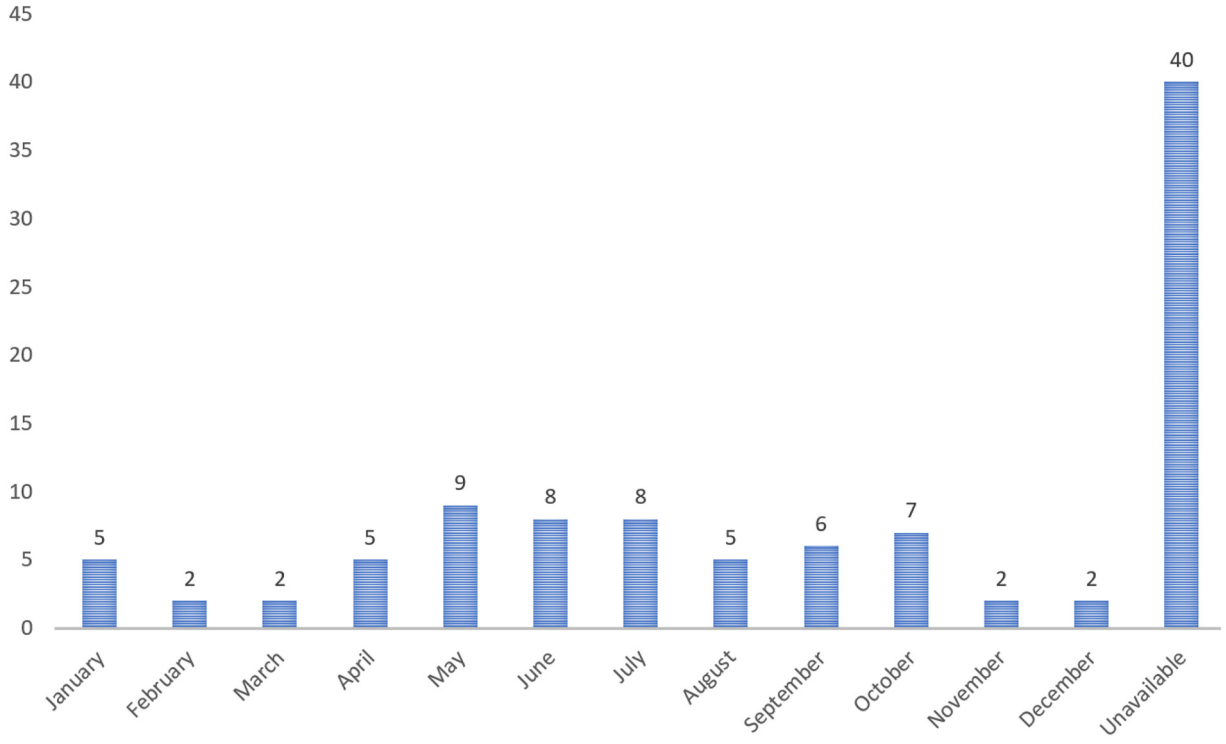

Fig. 3. Snakebite fatalities by month.

encounter. One thigh bite occurred during a religious ceremony. One victim was bitten on the chest, another received a bite to the lips, and one male was bitten on both the hand and neck.

At least 19 victims did not seek medical attention. These include nine people who were envenomated during a religious ceremony. Two others were intoxicated. One committed suicide using his pet snake. One died before he could seek care. It is unknown why six victims did not seek treatment.

Data quantifying the time from envenomation to death were available for 49 victims. Nineteen people died within the first six hours. Four deaths occurred between six and 24 h. Six victims died between 24 and 72 h. Twenty deaths occurred after 72 h, including one on day 42 following a prolonged intensive care unit admission. Deaths within the first six hours were due to airway swelling and/or cardiovascular collapse. Deaths after 72 h were attributed to multiorgan failure.

4. Discussion

Snakebites are rarely fatal in the U.S. The reason for the high survival rate is likely multifactorial. Although several native snake species, e.g. the eastern diamond-backed rattlesnake (*C. adamanteus*) and the Mohave rattlesnake (*C. scutulatus*) have untreated lethality rates >10%, it is estimated to be <1% for copperheads, which are responsible for the plurality of native snake envenomations [32,33,147]. Bites from

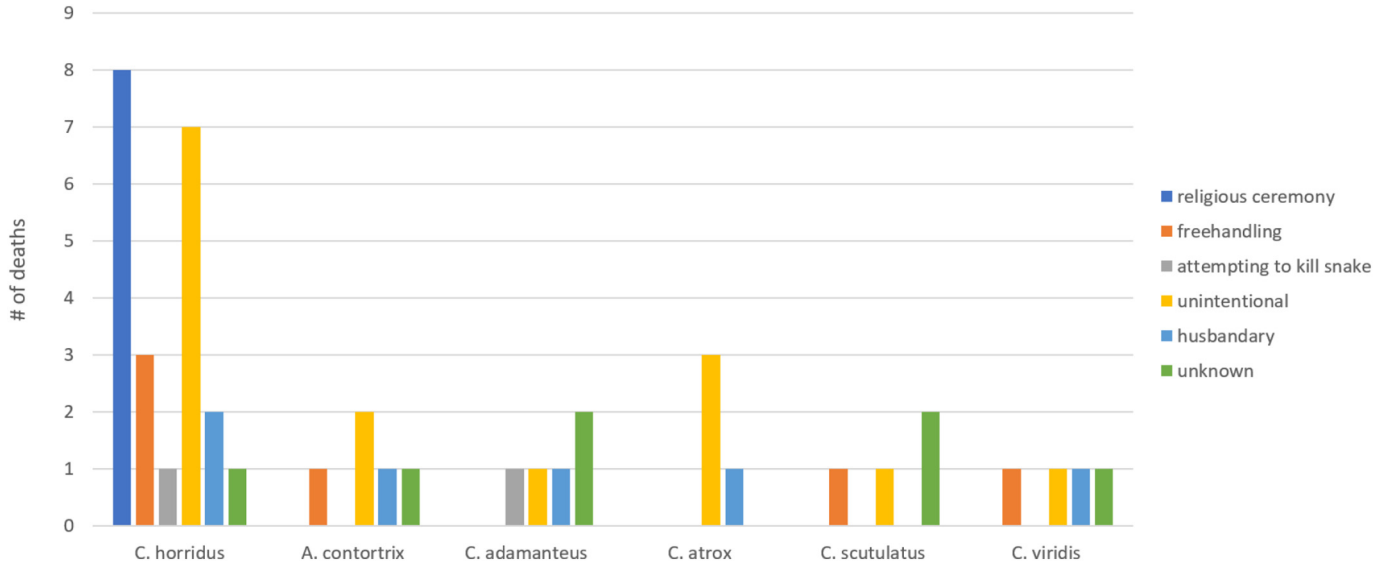

Fig. 4. Circumstances of envenomation for the most commonly implicated species.

most U.S. venomous species are more likely to cause local tissue injury and hematologic laboratory abnormalities than systemic toxicity such as respiratory failure or cardiovascular collapse [148-152]. Furthermore, most snakebite victims seek medical attention. Nearly all U.S. hospitals can provide critical care, and most hospitals located in areas where snakebites are common either stock or can easily procure antivenom.

Males accounted for 85.6% of patients for whom sex was reported. In a study of the epidemiology of all snakebites reported to the North American Snakebite Registry (NASBR), 69.3% of victims were males [34]. The discrepancy is likely because males are more likely to intentionally engage with the snakes. In the NASBR article, only 19% of all bites, and 42.6% of bites to the upper extremity, resulted from intentional interaction [34]. In the current study, 52% of bites were incurred while handling the snake.

Gerardo et al. previously identified several risk factors for severe snake envenomation, including a treatment delay of more than six hours, larger snake size, and age younger than 12 years [153]. Our data suggest that young age is associated with a lower risk of death. Children <12 years old account for 20–30% of all U.S. snakebite victims, but we found that children <12 years old only accounted for 7% of fatalities. Conversely, 6.7% of bites included in the NASBR were in patients >65 years old [34]. In the current study, 10% of the fatalities involved elderly victims.

We do not know the total number of victims in this study who were intoxicated by ethanol or other substances of abuse. A study of AAPCC data found that concurrent use of ethanol and/or drugs was observed in ~1% of all snakebites but in 17% of fatal snake envenomations [154]. The mean blood alcohol level of 214 mg/dL for our study subjects in whom it was measured was nearly three times the legal threshold for driving while intoxicated.

We cannot determine from our data which rattlesnake is "most dangerous." In nearly half of the cases, the species was not identified. Timber rattlesnakes were responsible for 43% of fatalities in which the snake was identified. However, *C. horridus* has a large geographic distribution and appears to be the preferred species for religious ceremonies, which are associated with an increased risk of being envenomated and of not seeking medical attention following snakebite.

Similarly, the greater number of fatalities from copperheads than from cottonmouths and coral snakes is not proof that copperheads are more dangerous. Copperheads have a larger geographic distribution and account for a much greater percentage of all envenomations. Furthermore, many healthcare professionals consider cottonmouths and coral snakes more dangerous and may be inclined to treat those envenomations more aggressively than they treat copperhead bites [155-157].

Because there was only one fatal coral snake envenomation in the study, few conclusions can be made about native U.S. elapids. Several studies have suggested that eastern coral snake envenomations can cause skeletal and respiratory muscle paralysis requiring antivenom and/or mechanical ventilation [157,158]. A study of Texas coral snake (*Micrurus tener*) envenomations found that only 7.3% of bites caused systemic effects, none of which were life-threatening [159]. In a case series of envenomations from the Sonoran coral snake, *Micruroides euryxanthus*, patients experienced pain, paresthesias, and incoordination, but respiratory insufficiency was not reported [160].

A limitation of this study is that many of the data are unconfirmed. Poison center data are typically collected over the phone and may be incomplete or inaccurate. It is unclear how some snake species were confirmed. Many people, including physicians, are often unable to distinguish a copperhead from a cottonmouth [161]. Fortunately, there were only seven deaths attributed to *Agkistrodon* species. Patients and bystanders may be unwilling or unable to provide reliable information. News agencies, to attract readership, often sensationalize stories [162]. Wikipedia articles rely on these potentially inaccurate stories and may perpetuate inaccuracies. Fortunately, we were able to confirm the details of every snakebite fatality reported in Wikipedia with one or more additional references. Furthermore, many of the data, e.g. age, sex, anatomic location, and city/state in which the bite occurred are straightforward and less susceptible to sensationalism.

Despite these limitations, the available data do permit some conclusions. Death following envenomation from a native U.S. snake is unlikely, particularly if medical attention is sought promptly. Rattlesnake envenomations are more likely to be fatal than bites from other venomous species. Copperhead bites should not be minimized, because death is possible. Intentionally engaging with a venomous snake raises the risk of incurring a fatal bite, as does concurrent alcohol or drug use. Age less than 12 years old does not appear to be a risk factor for a fatal outcome, while elderly patients may have a slightly increased risk of death.

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Declaration of Competing Interest

The authors report no conflicts of interest.

References

[1] Litovitz TL, Schmitz BF, Bailey KM. 1989 annual report of the American Association of Poison Control Centers National Data Collection System. Am J Emerg Med. 1990; 8:394–442.
[2] Litovitz TL, Bailey KM, Schmitz BF, Holm KC, Klein-Schwartz W. 1990 annual report of the American Association of Poison Control Centers National Data Collection System. Am J Emerg Med. 1991;9:461–509.
[3] Litovitz TL, Holm KC, Bailey KM, Schmitz BF. 1991 annual report of the American Association of Poison Control Centers National Data Collection System. Am J Emerg Med. 1992;10:452–505.
[4] Litovitz TL, Holm KC, Clancy C, Holm KC, Schmitz BF, et al. 1992 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1993;11:494–555.
[5] Litovitz TL, Clark LR, Soloway RA. 1993 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1994;12:546–84.
[6] Litovitz TL, Felberg L, Soloway RA, Ford M, Geller R. 1994 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1995;13:551–97.
[7] Litovitz TL, Felberg L, White S, Klein-Schwartz W. 1995 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1996;14:487–537.
[8] Litovitz TL, Smilkstein M, Felberg L, Klein-Schwartz W, Berlin R, Morgan JL. 1996 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1997;15:447–500.
[9] Litovitz TL, Klein-Schwartz W, Dyer KS, Shannon M, Lee S, Powers M. 1997 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1998;16:443–97.
[10] Litovitz TL, Klein-Schwartz W, Caravati EM, Youniss J, Crouch B, Lee S. 1998 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 1999;17:435–87.
[11] Litovitz TL, Klein-Schwartz W, White S, Cobaugh DJ, Youniss J, et al. 1999 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 2000;18:517–74.
[12] Litovitz TL, Klein-Schwartz W, White S, Cobaugh DJ, Youniss J, et al. 2000 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 2001;19:337–95.
[13] Litovitz TL, Klein-Schwartz W, Rodgers Jr GC, Cobaugh DJ, Youniss J, et al. 2001 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 2002;20:391–452.
[14] Watson WA, Litovitz TL, Rodgers Jr GC, Klein-Schwartz W, Youniss J, et al. 2002 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 2003;21:353–421.
[15] Watson WA, Litovitz TL, Klein-Schwartz W, Rodgers GC, Youniss J, et al. 2003 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 2004;22:335–404.
[16] Watson WA, Litovitz TL, Rodgers GC, Klein-Schwartz W, Reid N, et al. 2004 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med. 2005;23:589–666.
[17] Lai MW, Klein-Schwartz W, Rodgers GC, Abrams JY, Haber DA, et al. 2005 annual report of the American Association of Poison Control Centers' National poisoning and exposure database. Clin Toxicol (Phila). 2006;44:803–932.

[18] Bronstein A, Spyker D, Cantilena Jr L, Green J, Rumack BH, Heard SE. 2006 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS). Clin Toxicol (Phila). 2007;45(10):815–917.
[19] Bronstein A, Spyker D, Cantilena Jr L, Green J, Rumack BH, Heard SE. 2007 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 25th annual report. Clin Toxicol (Phila). 2008;46(10):927–1057.
[20] Bronstein A, Spyker D, Cantilena Jr L, Green J, Rumack BH, Giffin SL. 2008 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 26th annual report. Clin Toxicol (Phila). 2009;47(10):911–1084.
[21] Bronstein A, Spyker D, Cantilena Jr L, Green J, Rumack BH, Giffin SL. 2009 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 27th annual report. Clin Toxicol (Phila). 2010;48(10):979–1178.
[22] Bronstein A, Spyker D, Cantilena Jr L, Green J, Rumack BH, Dart RC. 2010 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 28th annual report. Clin Toxicol (Phila). 2011;49(10):910–41.
[23] Bronstein A, Spyker D, Cantilena Jr L, Rumack BH, Dart RC. 2011 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 29th annual report. Clin Toxicol (Phila). 2012;50(10):911–1164.
[24] Mowry JB, Spyker DA, Cantilena Jr LR, Bailey JE, Ford M. 2012 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 30th annual report. Clin Toxicol. 2013 Dec 1;51(10):949–1229.
[25] Mowry JB, Spyker DA, Cantilena Jr LR, McMillan N, Ford M. 2013 annual report of the American association of poison control centers' national poison data system (NPDS): 31st annual report. Clin Toxicol. 2014 Dec 1;52(10):1032–283.
[26] Mowry JB, Spyker DA, Brooks DE, McMillan N, Schauben JL. 2014 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 32nd annual report. Clin Toxicol. 2015 Nov 26;53(10):962–1147.
[27] Mowry JB, Spyker 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 Nov 25;54(10):924–1109.
[28] Gummin DD, Mowry JB, Spyker 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(10):1072–252.
[29] Gummin DD, Mowry JB, Spyker 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(12):1213–415.
[30] Gummin DD, Mowry JB, Spyker DA, Brooks DE, Beuhler MC, et al. 2018 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 36th annual report. Clin Toxicol. 2019;57(12):1220–413.
[31] O'Neil ME, Mack KA, Gilchrist J, Wozniak EJ. Snakebite injuries treated in United States emergency departments, 2001-2004. Wilderness Environ Med. 2007;18(4):281–7.
[32] The University of Adelaide clinical toxinology resources – *Agkistrodon contortrix*. Available at http://www.toxinology.com/fusebox.cfm?fuseaction=main.snakes.display&id=SN0331. Accessed July 25, 2020.
[33] The University of Adelaide clinical toxinology resources – *Crotalus scutulatus*. Available at http://www.toxinology.com/fusebox.cfm?fuseaction=main.snakes.display&id=SN0469. Accessed July 25, 2020.
[34] Ruha AM, Kleinschmidt KC, Greene S, Spyres M, Brent J, et al. The epidemiology, clinical course, and management of snakebites in the North American Snakebite Registry. J Med Toxicol. 2017;13:309–20.
[35] Walter FG, Stolz U, Shirazi F, McNally J. Epidemiology of severe and fatal rattlesnake bites published in the American Association of Poison Control Centers' Annual Reports. Clin Toxicol (Phila). 2009;47:663–9.
[36] Walter FG, Stolz U, Shirazi F, Walter CM, McNally J. Epidemiology of the reported severity of copperhead (Agkistrodon contortrix) snakebite. South Med J. 2012;105:313–20.
[37] Walter FG, Stolz U, French RN, Chase PB, McNally J, Shirazi F. Epidemiology of the reported severity of cottonmouth (Agkistrodon piscivorus) snakebite. South Med J. 2014;107:150–6.
[38] Crother BI, Boundy J, Burbrink FT, Ruane S. Squamata (in part) — snakes. In: Crother BI, editor. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in our Understanding. , 8th ed.Topeka, KS: SSAR Herpetological Circular; 2017. p. 1–102.
[39] List of fatal snakebites in the United States – Wikipedia. Available at https://en.wikipedia.org/wiki/List_of_fatal_snake_bites_in_the_United_States. Accessed July 18, 2020.
[40] Golfer dies after being bitten by rattlesnake at South Dakota golf course. Available at https://www.wvlt.tv/content/news/Golfer-dies-after-being-bitten-by-rattlesnake-at-South-Dakota-golf-course-485064581.html. Accessed August 20, 2020.
[41] Golfer dies after snake bite. Available at https://www.newspapers.com/image/440807449/. Accessed August 20, 2020.
[42] 'You don't mess with snakes,' wife says after rattler kills husband on birthday trip. Available at https://www.kansas.com/news/nation-world/national/article210310494.html. Accessed August 20, 2020.
[43] Oklahoma man, 57, dies after rattlesnake bites him twice: 'Don't mess with snakes'. Available at https://www.foxnews.com/science/oklahoma-man-57-dies-after-rattlesnake-bites-him-twice-dont-mess-with-snakes. Accessed August 20, 2020.
[44] Hiker from Golden dies after being bitten by rattlesnake. Available at https://www.denverpost.com/2017/10/07/hiker-dies-after-being-bitten-rattlesnake-jefferson-county/. Accessed August 20, 2020.
[45] Endurance athlete in Colorado dead after rattlesnake bite. Available at https://www.cbsnews.com/news/daniel-hohs-endurance-athlete-dead-colorado-rattlesnake-bite/. Accessed August 20, 2020.
[46] SC conservationist dies after rattlesnake bite at nature preserve. Available at https://www.charlotteobserver.com/news/state/south-carolina/article83632887.html. Accessed August 20, 2020.
[47] Questions continue over snake bite death at national wildlife refuge. Available at https://www.thestate.com/news/local/article83824427.html. Accessed August 20, 2020.
[48] Kentucky man dies after snakebite during Pentacostal church service. Available at https://www.nydailynews.com/news/national/ky-man-dies-snakebite-church-service-article-1.2307696. Accessed August 20, 2020.
[49] Kentucky man dies from snake bite at church service. Available at https://www.cbsnews.com/news/kentucky-man-dies-from-snake-bite-at-church-service/. Accessed August 20, 2020.
[50] Beaver Co. Man dies after being bitten by rattlesnake while camping. Available from: https://www.wpxi.com/news/local/beaver-co-man-dies-after-being-bitten-rattlesnake-/32093909/. Accessed August 20, 2020.
[51] Horror at the campfire: Pennsylvania rattlesnake claims first victim in decades. Available at https://patch.com/pennsylvania/newtown-pa/horror-campfire-pennsylvania-rattlesnake-claims-first-victim-decades. Accessed August 20, 2020.
[52] Case closed: No grounds for homicide investigation in fatal snakebite of Nixa man. Available at https://www.news-leader.com/story/news/local/ozarks/2015/09/18/case-closed-grounds-homicide-investigation-fatal-snakebite-nixa-man/72403660/. Accessed August 20, 2020.
[53] Woman wakes up to find her boyfriend, 37, dead in bed next to her one day after he was bitten by venomous cottonmouth snake. Available at https://www.dailymail.co.uk/news/article-3099453/Woman-wakes-boyfriend-37-dead-bed-one-day-bitten-poisonous-water-snake-refused-treatment.html. Accessed August 20, 2020.
[54] Snakebite claims life of Watkinsville man. Available at http://www.oconeeenterprise.com/news/article_0ed5546e-ff00-11e4-a74d-6b0eeeff7035.html. Accessed August 20, 2020.
[55] Snakebite kills Missouri man. Available at https://www.usatoday.com/story/news/nation-now/2014/07/13/snake-bite-missouri-man-dead-camping/12593291/. Accessed August 20, 2020.
[56] St. Charles man, 52, dies after being bitten by copperhead. Available at https://www.newspapers.com/image/148534965/. Accessed August 20, 2020.
[57] 4-year-old boy bitten by rattlesnake. Available at https://www.news4jax.com/news/2014/06/14/4-year-old-boy-bitten-by-rattlesnake/. Accessed August 20, 2020.
[58] Two weeks after rattlesnake bite, Nassau County boy, 4, dies. Available at https://www.jacksonville.com/news/crime/2014-06-20/story/two-weeks-after-rattlesnake-bite-nassau-county-boy-4-dies. Accessed August 20, 2020.
[59] Boy killed by rattlesnake bite laid to rest. Available at https://www.news4jax.com/news/2014/06/21/boy-killed-by-rattlesnake-bite-laid-to-rest/. Accessed August 20, 2020.
[60] Snakebite death of Middlesboro pastor was quick, son says; medical treatment refused. Available at https://www.kentucky.com/article44471886.html. Accessed August 20, 2020.
[61] Believers unshaken by pastor's death. Available at https://www.newspapers.com/image/116615816/?terms=jamie%2Bcoots. Accessed August 20, 2020.
[62] Cherokee County man dies from rattlesnake bite, a rare occurrence in Alabama. Available at https://www.al.com/east-alabama/2013/09/cherokee_county_man_dies_from.html. Accessed August 20, 2020.
[63] Rattlesnake bite kills Cherokee County resident. Available at https://issuu.com/consolidatedpublishing/docs/20131002piedmontjournal. Accessed August 20, 2020.
[64] Armuchee man dies from rattlesnake bite. Available at https://www.northwestgeorgianews.com/rome/news/local/armuchee-man-dies-from-rattlesnake-bite/article_0908796c-e472-11e2-9ec1-001a4bcf6878.html. Accessed August 20, 2020.
[65] Floyd County man dies from rattlesnake bite. Available at https://www.weisradio.com/floyd-county-man-dies-from-rattlesnake-bite/. Accessed August 20, 2020.
[66] Camper dies after copperhead bite along Current River. Available at https://www.stltoday.com/news/local/metro/camper-dies-after-copperhead-bite-along-current-river/article_ad3fafde-c504-11e1-933b-001a4bcf6878.html. Accessed August 19, 2020.
[67] Mo. fatal copperhead bite is only state's 2nd. Available at https://www.kmbc.com/article/mo-fatal-copperhead-bite-is-only-state-s-2nd/3671242. Accessed August 19, 2020.
[68] Pastor dies from snake bite. Available at https://www.newspapers.com/image/424552140/. Accessed August 19, 2020.
[69] Serpent-handling pastor profiled earlier in Washington Post dies from rattlesnake bite. Available at https://www.washingtonpost.com/lifestyle/style/serpent-handling-pastor-profiled-earlier-in-washington-post-dies-from-rattlesnake-bite/2012/05/29/gJQAJef5zU_story.html. Accessed August 19, 2020.
[70] Paige man dies from rattlesnake bite. Available at https://texags.com/forums/34/topics/3017413. Accessed August 19, 2020.
[71] UPDATED: Official cause of death determined in snake bite case. Available at https://www.wrcbtv.com/story/13940577/story?S=13940577. Accessed August 19, 2020.
[72] TN man dies after being bitten by snake. Available at https://www.14news.com/story/13935466/tenn-man-dies-after-being-bitten-by-snake/. Accessed August 19, 2020.
[73] La Jolla man dies from rattlesnake bite. Available at https://www.sandiegouniontribune.com/sdut-la-jolla-man-dies-rattlesnake-bite-2010oct15-story.html. Accessed August 19, 2020.

[74] Fisherman bitten by rattlesnake at Cuyamaca dies. Available at https://www.eastcountymagazine.org/fisherman-bitten-rattlesnake-cuyamaca-dies. Accessed August 19, 2020.
[75] Toddler dies after being bitten by rattlesnake. Available at http://www.newspapers.com/image/652498800/. Accessed August 19, 2020.
[76] Peyton's Project raising rattlesnake awareness. Available at https://www.timesrecordnews.com/story/news/local/2017/05/24/peytons-project-raising-rattlesnake-awareness/102109492/. Accessed August 19, 2020.
[77] Yancey dies after rattlesnake bite. Available at https://www.ancestry.com/boards/surnames.yancey/1724#:~:text=According%20to%20relatives%2C%20the%20snake%20bit%20George%20Yancey,over%20to%20their%20house%2C%20right%20next%20to%20his. Accessed August 19, 2020.
[78] Boy couldn't save snakebit grandpa. Available at https://www.ajc.com/news/local/boy-couldn-save-snakebit-grandpa/6jF3XgQ7fEZFNpkFSl5KxK/. Accessed August 19, 2020.
[79] Winder man killed by rattlesnake bite. Available at https://www.mainstreetnews.com/barrow/news/winder-man-killed-by-rattlesnake-bite/article_3a9dee5f-e1e4-50e9-9062-9bb03d959e0a.html. Accessed August 19, 2020.
[80] Obituary for James Bear. Available at https://www.findagrave.com/memorial/81012954/james-david-bear. Accessed August 19, 2020.
[81] Snakebite deaths still rare, but are mounting. Available at http://tucsoncitizen.com/morgue/2007/10/13/65431-snakebite-deaths-still-rare-but-are-mounting/. Accessed August 19, 2020.
[82] Paulden woman dies of rattlesnake bite. Available at https://www.findagrave.com/memorial/22094325/jackie-ledwell. Accessed August 19, 2020.
[83] Timber rattlesnake bite. Available at https://www.snakesareus.com/timber_rattlesnake_bite/. Accessed August 19, 2020.
[84] Mr. Douglas John Hiler. Available at https://www.legacy.com/obituaries/gainesvilletimes/obituary.aspx?pid=96223839. Accessed August 19, 2020.
[85] Woman dies after snakebite in church. Available at https://www.cbsnews.com/news/woman-dies-after-snakebite-in-church/. Accessed August 19, 2020.
[86] Snakebite at church kills Kentucky woman. Available at https://www.newspapers.com/image/131122070/. Accessed August 19, 2020.
[87] Fatal snake bite: intoxicated Florida man is first killed by coral snake in over 40 years. Available at https://www.fieldandstream.com/pages/fatal-snake-bite-intoxicated-florida-man-first-killed-coral-snake-over-40-years/. Accessed August 19, 2020.
[88] Coral snake bite cause of man's death. Available at http://www.newspapers.com/image/221379348/. Accessed August 19, 2020.
[89] Snake bite is deadly for Putnam fire official. Available at https://www.gainesville.com/article/LK/20051011/News/604184078/GS. Accessed August 19, 2020.
[90] Former Collier firefighter dies from snake bite. Available at https://www.firefighterclosecalls.com/former-collier-firefighter-dies-from-snake-bite/. Accessed August 19, 2020.
[91] Snakebite fatality prompts warning. Available at https://www.newspapers.com/image/221702259/. Accessed August 19, 2020.
[92] Snakebite death spurs warnings. Available at https://www.myheraldreview.com/news/willcox/snakebite-death-spurs-warnings/article_4ec42dbd-8e23-5e5f-93cd-04a9a5758501.html. Accessed August 19, 2020.
[93] Missing woman found dead, bitten by snake. Available at https://www.myplainview.com/news/article/Missing-woman-found-dead-bitten-by-snake-8562708.php. Accessed August 19, 2020.
[94] Missing Wimberley woman's body found. Available at https://www.newspapers.com/image/357449790/. Accessed August 19, 2020.
[95] Man dies from snake bite at creek in Loachapoka. Available at http://venomousreptiles.org/forums/Experts/8395. Accessed August 19, 2020.
[96] Fatal Snake Bite. Available at https://www.wtvy.com/content/news/fatal-snake-bite-846297.html. Accessed August 19, 2020.
[97] Snake-bitten man dies after driving to hospital instead of calling 911. Available at https://www.newspapers.com/image/285066931/. Accessed August 19, 2020.
[98] Man takes Bible verse literally, gets fatal snake bite in church. Available at https://www.newspapers.com/image/152862590/. Accessed August 19, 2020.
[99] Snake handlers put their faith to a deadly test. Available at https://www.newspapers.com/image/561320036/. Accessed August 19, 2020.
[100] Rattlesnake bites linked to weather, says Stanford research. Available at https://www.mercurynews.com/2018/09/24/rattlesnake-bites-linked-to-weather-says-stanford-research/. Accessed August 19, 2020.
[101] Worshipper is killed by snakebite. https://www.newspapers.com/image/258182891/. Accessed July 18, 2020.
[102] Worshipper's faith led to fatal snake bite. Available at https://www.newspapers.com/image/113194307/. Accessed August 19, 2020.
[103] Preacher won't be charged in snake-bite death. Available at https://www.newspapers.com/image/111198797/. Accessed August 19, 2020.
[104] State police probe death of snake-bit preacher. Available at https://www.newspapers.com/image/110558561/. Accessed August 19, 2020.
[105] Safe handling seen as a sign of God's anointment. Available at https://www.newspapers.com/image/107433416/. Accessed August 19, 2020.
[106] TRAGEDY. A 22-year-old snake handler has died. Available at https://www.orlandosentinel.com/news/os-xpm-1989-08-28-8908283026-story.html. Accessed August 19, 2020.
[107] Handler killed by snake had wanted reptiles to be liked. Available at https://www.newspapers.com/image/322655613/. Accessed August 19, 2020.
[108] Snake bite kills church member. Available at https://www.newspapers.com/image/591771807/. Accessed August 20, 2020.
[109] Southeast Texas child dies following rattlesnake bite. Available at https://www.newspapers.com/image/589286618. Accessed August 20, 2020.
[110] Man dies from rattlesnake bite. Available at https://www.newspapers.com/image/589286618. Accessed August 21, 2020.
[111] "Pet" albino rattlesnake bites, kills ex-Huns Club president. Available at https://www.newspapers.com/image/579318515. Accessed August 21, 2020.
[112] Who's the best killer? They slugged out the issue. Available at https://www.newspapers.com/image/192824504/. Accessed August 21, 2020.
[113] Jackie Wayne Windham, sawmill worker. Available at https://www.newspapers.com/image/192824504/. Accessed August 21, 2020.
[114] Snake fancier dies of pet rattler's bites. Available at https://www.newspapers.com/image/124315438/. Accessed August 21, 2020.
[115] Teen-ager who died in lake had been bitten by a snake. Available at https://www.newspapers.com/image/629391127. Accessed August 21, 2020.
[116] Number of snakes, bites disputed among experts. Available at https://www.newspapers.com/image/185823171/. Accessed July 15, 2020.
[117] Tanksley William Tommy. Available at https://www.newspapers.com/image/318479502. Accessed August 21, 2020.
[118] Woman dies after being bitten by snake in home. Available at https://www.newspapers.com/image/328479737. Accessed August 21, 2020.
[119] S. Arizona restaurateur dies after bite by snake. Available at https://www.newspapers.com/image/125490567/. Accessed August 19, 2020.
[120] Jury: doctors not to blame for snakebite death. Available at https://www.newspapers.com/image/329573454/. Accessed August 19, 2020.
[121] No help from Hollywood. Available at https://www.businessobserverfl.com/article/coffee-talk-tampa-edition-15. Accessed August 19, 2020.
[122] Snake kills worshiper three years after one killed his wife. Available at https://www.newspapers.com/image/110404337/. Accessed August 19, 2020.
[123] Custody of 'snake-bite orphans' split between grandparents. Available at http://edition.cnn.com/US/9902/12/snake.bite.family/. Accessed August 19, 2020.
[124] Knox man dies from snake bite during religious ceremony in Bell. Available at https://newspaperarchive.com/corbin-times-tribune-dec-16-1997-p-1/. Accessed August 19, 2020.
[125] Man dies after being bitten while handling snake during Bell County church service. Available at https://www.kentucky.com/news/state/kentucky/article44612514.html. Accessed August 19, 2020.
[126] Snake bite kills Sierra Vista man. Available at http://tucsoncitizen.com/morgue2/2002/08/20/46562-snake-bite-kills-sierra-vista-man/. Accessed August 19, 2020.
[127] Norris RL, Wilkerson JA, Feldman J. Syncope, massive aspiration, and sudden death following rattlesnake bite. Wilderness Environ Med. 2007;18:206–8.
[128] Dothan man likely killed by snake bite to the neck. Available at https://www.al.com/live/2009/09/dothan_man_likely_killed_by_sn.html#:~:text=–%20A%20Dothan%20man%20has%20died%20from%20apparent,first%20that%20Lewis%20died%20from%20heat%20stroke%20. Accessed July 20, 2020.
[129] Schulte J, Domanski K, Smith EA, Menendez A, Kleinschmidt KC, Roth BA. Childhood victims of snakebites: 2000–2013. Pediatrics. 2016;138:e20160491.
[130] Snakebite proves fatal to minister. Available at http://www.sullivan-county.com/nf0/ep/snake_bite.htm. Accessed July 15, 2020.
[131] Jailed man dies from rattlesnake bite. Available at https://archive.seattletimes.com/archive/?date=19980813&slug=2766339. Accessed July 24, 2020.
[132] Youngster dies after snakebite. Available at https://www.newspapers.com/image/9598345. Accessed July 15, 2020.
[133] Man dies from snake bite in Chattahoochee. Available at https://www.newspapers.com/image/244593153. Accessed July 15, 2020.
[134] Snake-handling preacher dies from bite of snake during weekend service. Available at https://www.newspapers.com/image/268397674. Accessed July 15, 2020.
[135] Pet snake's bite kills Gillette man. Available at https://www.newspapers.com/image/412541651. Accessed July 15, 2020.
[136] Biting by pet snake kills owner. Available at https://www.newspapers.com/image/167600531. Accessed July 15, 2020.
[137] Suicide snake. Available at https://www.newspapers.com/image/472684149. Accessed July 15, 2020.
[138] Stringer man may have died of snakebite. Available at https://www.newspapers.com/image/184116424. Accessed July 15, 2020.
[139] North Carolina teen killed by snakebite. Available at https://www.newspapers.com/image/657660279. Accessed July 15, 2020.
[140] Woman, 18, bitten by snake dies. Available at https://www.newspapers.com/image/399811386. Accessed July 15, 2020.
[141] Man wanted for Indiana pharmacy robbery found dead in Alabama. Available at https://www.newspapers.com/image/107562358. Accessed July 15, 2020.
[142] Man dies from pet snake's bite. Available at https://www.newspapers.com/image/225663281. Accessed July 15, 2020.
[143] Snakebite kills Roundup man. Available at https://www.newspapers.com/image/412239589. Accessed July 15, 2020.
[144] Dead snakes still bite. Available at https://www.newspapers.com/image/124440388. Accessed July 15, 2020.
[145] Man dies from snakebite. Available at https://www.newspapers.com/image/581538883. Accessed July 15, 2020.
[146] Snake may have killed illegal entrant. Available at https://www.newspapers.com/image/225911314. Accessed July 15, 2020.
[147] The University of Adelaide clinical toxinology resources – *Crotalus adamanteus*. Available at http://www.toxinology.com/fusebox.cfm?fuseaction=main.snakes.display&id=SN0418#:~:text=WCH%20Clinical%20Toxinology%20Resources&text=Largest%20of%20all%20the%20rattlesnakes,maximum%20of%20about%202.51%20metres. Accessed July 26, 2020.

[148] Lavonas EJ, Ruha AM, Banner W, Bebarta V, Bernstein JN, et al. Unified treatment algorithm for the management of crotaline snakebite in the United States: results of an evidence-informed consensus workshop. BMC Emerg Med. 2011;11(1):2.
[149] Tanen DA, Ruha AM, Graeme KA, Curry SC, Fischione MA. Rattlesnake envenomations: unusual case presentations. Arch Intern Med. 2001 Feb 12;161(3):474–9.
[150] Hogan DE, Dire DJ. Anaphylactic shock secondary to rattlesnake bite. Ann Emerg Med. 1990 Jul 1;19(7):814–6.
[151] Camilleri C, Offerman S. Anaphylaxis after rattlesnake bite. Ann Emerg Med. 2004 Jun 1;43(6) 784–5.X.
[152] Hinze JD, Barker JA, Jones TR, Winn RE. Life-threatening upper airway edema caused by a distal rattlesnake bite. Ann Emerg Med. 2001 Jul 31;38(1):79–82.
[153] Gerardo CJ, Vissoci JRN, Evans CS, Simel DL, Lavonas EJ. Does this patient have a severe snake envenomation? The rational clinical examination systematic review. JAMA Surg. 2019;154(4):346–54.
[154] 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.
[155] Domanski K, Kleinschmidt KC, Greene S, Ruha AM, Bebarta V, et al. Cottonmouth snake bites reported to the ToxIC north American snakebite registry 2013–2017. Clin Toxicol (Phila). 2020;58(3):179–82.
[156] Gerardo CJ, Quackenbush E, Lewis B, Rose SR, Greene S, et al. The efficacy of crotalidae polyvalent immune fab (ovine) antivenom versus placebo plus optional rescue therapy on recovery from copperhead snake envenomation: a randomized, double-blind, placebo-controlled, clinical trial. Ann Emerg Med. 2017;70(2):233–44.
[157] Kitchens CS, Van Mierop LH. Envenomation by the eastern coral snake (*Micrurus fulvius fulvius*): a study of 39 victims. JAMA. 1987;258(12):1615–8.
[158] Wood A, Schauben J, Thundiyil J, Kunisaki T, Sollee D, et al. Review of eastern coral snake (*Micrurus fulvius fulvius*) exposures managed by the Florida poison information center network: 1998–2010. Clin Toxicol (Phila). 2013;51:783–8.
[159] Morgan DL, Borys DJ, Stanford R, Kjar D, Tobleman W. Texas coral snake (*Micrurus tener*) bites. South Med J. 2007;100(2):152–7.
[160] Russell FE. Bites by the Sonoran coral snake *Micruroides euryxanthus*. Toxicon. 1967;5:39–42.
[161] Cox RD, Parker CS, Cox ECE, Marlin MB, Galli RL. Misidentification of copperhead and cottonmouth snakes following snakebites. Clin Toxicol (Phila). 2018;56(12):1195–9.
[162] Hayes WK, Mackessy SP. Sensationalistic journalism and tales of snakebite: are rattlesnakes rapidly evolving more toxic venom? Wilderness Environ Med. 2010;21:35–45.