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ORIGINAL ARTICLE

EPIDEMIOLOGICAL ASPECTS OF SNAKEBITES IN THE STATE OF AMAZONAS, BRAZIL, FROM 2007 TO 2017

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ABSTRACT

This study comprises a retrospective analysis of snakebites in the State of Amazonas, Brazil, from 2007 to 2017. Data were collected from the Notifiable Diseases Information System (NDIS). 17,056 snakebites were recorded in Amazonas between 2007 and 2017. During the study period, the Rio Negro and Tefé micro-regions had the highest accumulated incidence, while small municipalities such as São Gabriel da Cachoeira, Uarini and Alvarães presenting a high incidence rate during the same period. Snakes in the genera *Bothrops* and *Lachesis* caused 69.5% and 20.3% snakebites. Snakebites occurred more frequently in the Amazonian winter, between January and April, and most of the snakebite victims (78.6%) were men. The most affected individuals were between 20 and 39 years of age (59.4%). The time elapsed between snakebites and medical assistance varied from one to six hours (51.4%). 7,705 of the snakebite cases, were classified as moderate, 7,328 as mild, and 1,299 as severe. Of the 104 deaths that occurred in the period, *Bothrops* genus caused the highest mortality (68.3%). The State of Amazonas recorded both high numbers of snakebites in the period 2007-2017 and the time elapsed between snakebite and medical assistance, which may affect the clinical status of patients.

KEY WORDS: *Bothrops; Lachesis*; Amazon; snakes; *Viperidae*.

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INTRODUCTION

The Amazon is one of the world's largest biodiversity hotspots, and snakes are among the most striking elements of its fauna. Snakes are able to quietly slide on leaves and branches allowing them to go unnoticed by the vast majority of people walking through forests and fields. However, although snakes often go unnoticed, they are numerous in species, individuals, and life habits (Fraga et al., 2013).

Among the venomous snakes dangerous to humans are those belonging to the Elapidae and Viperidae families. In the family Elapidae, snakes in the genus *Micrurus* (coral snakes), and in the family Viperidae, snakes in the genera *Bothrops* (pit vipers), *Crotalus* (rattlesnakes), and *Lachesis* (bushmasters) frequently bite people (Santos et al., 1995; Gomes, 2008). Snakes from these genera are the most important groups to cause public health concern, as they cause the majority of registered snakebite incidents, not only in Brazil, but also in other American countries (Sant'Ana Malaque et al., 2015).

According to Magalhães et al. (2019), from 2010 to 2015, 70,816 snakebite cases were reported in the Brazilian Amazon, with Pará presenting 30,693 cases (43.3%) and Amazonas 9,386 cases (13.3%). The State of Amazonas had the second highest incidence rate of 62.8 cases per 100,000 inhabitants, followed by Tocantins (65/100,000). During this period, Amazonas was the third State to present the highest number of deaths due to snakebites and a lethality rate of 0.6%. Feitosa et al. (2015) showed that snakebites in the Amazon are an occupational health problem for rural workers, due to the large number of accidents reported.

The prognosis is generally good in snakebite cases classified as mild or moderate, particularly in patients seen in the first few hours after being bitten (Brazil, 2001). However, patients bitten in the leg, who use a tourniquet, who are treated more than 6 hours after being bitten, and who are treated with incorrect administration of anti-venom serum, have a poor prognosis, including complications that often lead to death (Silveira & Nishioka, 1992; França, 1998; Magalhães et al., 2019).

In Amazonas, as the main means of transport are fluvial, patients often arrive at a hospital or health center many hours after being bitten. As such, many patients do not receive the appropriate serum in time, while some snakebite victims do not seek medical attention at all. Therefore, snakebites often go unreported, and the true number of cases is likely to be much higher than stated in official statistics (Santos et al., 1995; Gutiérrez et al., 2006).

In spite of the lack of more precise data on snakebite incidents, and the scarcity of information on this topic in the State of Amazonas, both of paramount importance to health services, this paper describes the epidemiological and clinical aspects of snakebites in the State of Amazonas from 2007 to 2017.

MATERIAL AND METHODS

This is a retrospective study, in which information about snakebite incidents recorded from 2007 to 2017 was collected from the Notifiable Diseases Information System (DATASUS-TABNET). The data included epidemiological aspects, such as the type of snake involved, the number of cases per micro-region and municipality, month of snakebite occurrence, sex and age of the patient, severity classification of the snakebite (mild, moderate, or severe), how the case developed, and the time elapsed from when the patient was bitten to when they obtained medical assistance. The classification of the severity of clinical manifestations resulting from snakebites was based on what patients reported according to Brazil (2001).

The State of Amazonas is divided into 13 micro-regions (Figure 1), including Alto Solimões (Municipalities of Tabatinga, Atalaia do Norte, São Paulo de Olivença, Benjamin Constant, Amaturá, Santo Antônio do Içá, Fonte Boa, Jutaí and Tonantins), Boca do Acre (Municipalities of Boca do Acre and Pauini), Coari (Municipalities of Anomã, Anori, Beruri, Caapiranga, Coari and Codajás), Itacoatiara (Municipalities of Itacoatiara, Itapiranga, Nova Olinda do Norte, Silves and Uricurituba), Japurá (Municipalities of Japurá and Maraã), Juruá (Municipalities of Carauari, Eirunepé, Envira, Guarajá, Ipixuna, Itamarati and Juruá), Madeira (Municipalities of Apuí, Borba, Humaitá, Manicoré and Novo Aripuanã), Manaus (Municipalities of Autazes, Careiro, Careiro da Várzea, Iranduba, Manaquiri, Manacapuru and Manaus), Parintins (Municipalities of Barreirinha, Boa Vista de Ramos, Maués, Nhamundá, Parintins, São Sebastião do Uatumã and Urucará), Purus (Municipalities of Canutama, Lábrea and Tapauá), Rio Negro (Municipalities of São Gabriel da Cachoeira, Barcelos, Santa Isabel do Rio Negro and Novo Airão), Rio Preto da Eva (Municipalities of Rio Preto da Eva and Presidente Figueiredo) and Tefé (Municipalities of Alvarães, Tefé and Uarini).

The accumulated incidence by micro-region was calculated based on the number of annual cases and on the population in 2007, while the incidence in the municipalities considered the population each year. Data on snakebites was collected for each micro-region. The Kruskal Wallis test was used to verify the number of snakebites, genus of snakes, seasonality of snakebites and sex of victims.

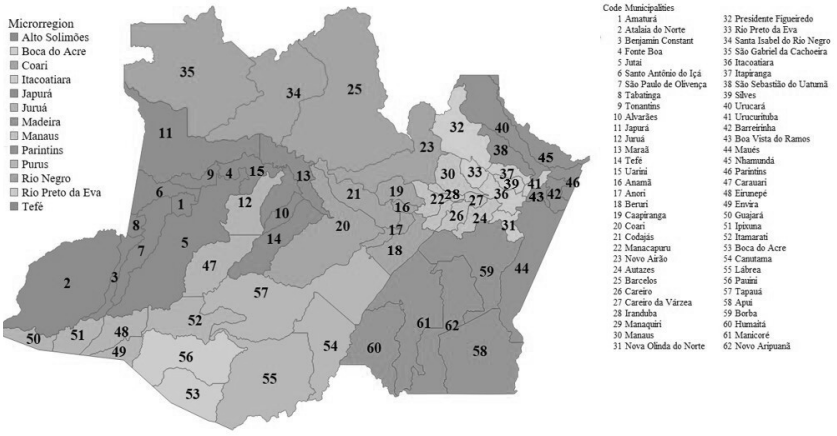

Figure 1. Micro-regions in the State of Amazonas, Brazil.

RESULTS

From 2007 to 2017, 17,056 snakebite cases were recorded in the State of Amazonas. There was no difference between the number of cases over the study period (p = 0.4315), with an annual average of 1,551 cases (Figure 2)

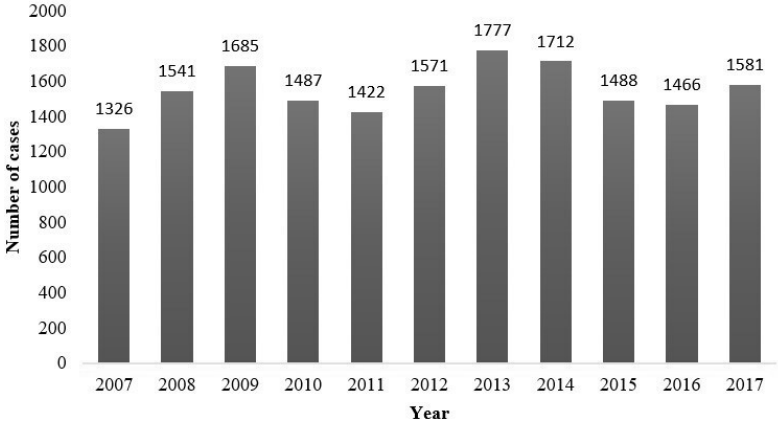

Figure 2. Annual number of snakebites in the State of Amazonas, Brazil, from 2007 to 2017.

In the reported cases (n = 17,056), there was reference to the genus of the snake that bit the patient in 15,801 cases (92.6% of all cases) and in 1,255 cases (7.4%) the genus of the snake was not identified. Regarding all the reported cases, there was a higher occurrence of cases by snakes of the *Bothrops* genus 69.5% (11,852 cases, p <0.0001), followed by 20.3% cases (3,467) by *Lachesis*, 0.5% (81) by *Micrurus* and 0.4% (63) by *Crotalus*. Bites from non-venomous snakes comprised 2% of cases, and in the remaining 7.4% of cases (1,225), the genus of the snake was not identified or was not included in the records.

Of the 13 micro-regions of Amazonas, the highest snakebite prevalence was recorded in the micro-region of Manaus, presenting 3,390 registered cases, followed by the micro-regions of Parintins (2,250 cases), Alto Solimões (1,904 cases), Itacoatiara (1,625 cases) and Madeira (1,541cases) (Table 1).

Table 1. Number of snake bites, accumulated incidence in the micro-regions of the State of Amazonas and the municipality in each micro-region that registered the highest number of cases from 2007 to 2017.

Micro-regions	Nº Cases	Incidence	Municipalities – cases
Manaus	3,390	181.8	Manaus – 1,809
Parintins	2,250	974.7	Parintins – 780
Alto Solimões	1,904	895.8	São Paulo de Olivença - 393
Itacoatiara	1,625	1,095.0	Itacoatiara – 953
Madeira	1,541	1,029.9	Manicoré – 437
Coari	1,290	1,011.1	Coari – 622
Rio Negro	195	1,254.6	São Gabriel da Cachoeira - 676
Tefé	1,162	1,354.5	Tefé – 662
Juruá	756	635.4	Eirunepé – 222
Purus	665	980.5	Lábrea - 437
Rio Preto da Eva	563	1,143.9	Rio Preto da Eva – 319
Boca do Acre	348	772.8	Boca do Acre – 223
Japurá	153	671.4	Japurá – 81
Total	16,842	522.7	-

The micro-regions with the highest accumulated incidence were Tefé and Rio Negro. Municipalities such as São Gabriel da Cachoeira and Uarini (Rio Negro micro-region) and Alvarães (Tefé micro-region) presented the highest incidence rates of snakebites from 2007 to 2017 (Figure 3).

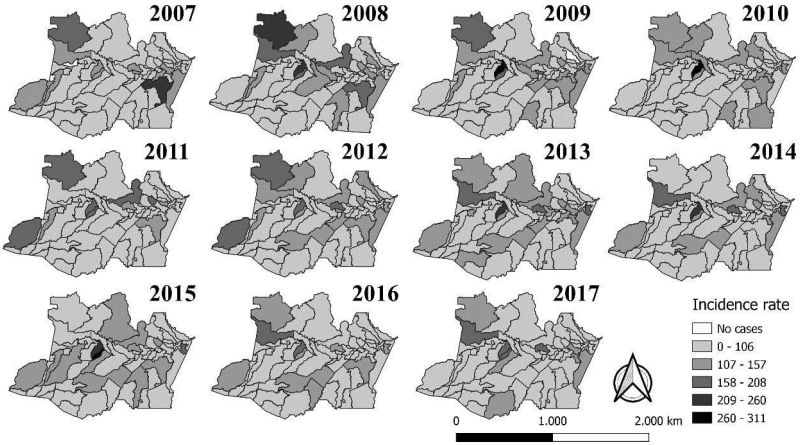

Figure 3. Incidence rate of snakebites by municipality in the State of Amazonas, Brazil, from 2007 to 2017.

Regarding seasonality of snakebite occurrences, the number of snakebites in Amazonas increased from November to May, presenting a pattern with a marked increase between January and April (Figure 4).

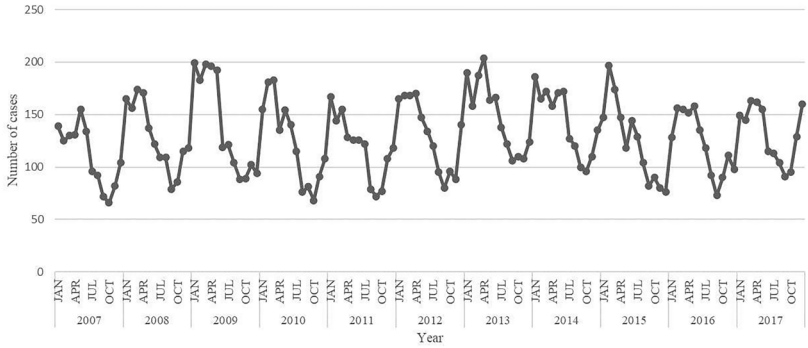

Figure 4. Temporal analysis of snakebites in the State of Amazonas, Brazil, from 2007 to 2017.

Of the cases evaluated, 78.6% occurred in men and 21.4% in women ($p<0.001$). The greatest number of snakebites was observed in the 20-39 age group (37.2%), followed by the 40-59 age group (22.2%) (Table 2).

27.4% snakebite victims obtained medical assistance from 1 to 3 hours after being bitten, a further 24.1% in the 3-6 hour (Table 2).

Table 2. Distribution of snakebite cases according to socio-demographic and clinical variables: gender, age, severity of clinical manifestations and time elapsed until medical assistance in the State of Amazonas, Brazil, from 2007 to 2017.

Variable	Cases	
	N	%
Gender		
Male	13,411	78.6%
Female	3,644	21.4%
Unknown	1	0.001%
Age range, years		
≤1	199	1.2%
1-4	350	2.1%
5-9	1,074	6.3%
10-14	1,897	11.1%
15-19	2,097	12.3%
20-39	6,346	37.2%
40-59	3,781	22.2%
60-64	528	3.1%
65-69	343	2.0%
70-79	353	2.1%
>80	86	0.5%
Unknown	2	0.01%
Clinical manifestations		
Mild	7,328	43.0%
Moderate	7,705	45.2%
Severe	1,299	7.6%
Unknown	724	4.2%
Time elapsed to medical assistance (hours)		
0-1	2,729	16.0%
1-3	4,670	27.4%
3-6	4,106	24.1%
6-12	2,033	11.9%
12-24	1,351	7.9%
>24	1,301	7.6%
Unknown	866	5.1%

Of all the recorded snakebites, 7,715 (45.2%) were classified as moderate, 7,338 (43%) as mild, and 1,301 (7.6%) as severe (Table 2). Of the reported cases, 104 (0.6%) patients died due to snakebites, nine died from other causes (0.05%), 15,798 (92.6%) were cured and 1,145 (6.7%) cases presented no records of patient evolution. Evaluation of snakebite outcomes based on the genus of the snake showed that the genus *Bothrops* was the cause of the largest number of deaths (68.3% - 71 cases), followed by the genus *Lachesis* (26.9% - 28 cases) and in 4.8% of the cases (five) the genus of the snake was unknown.

DISCUSSION

Although there was no increase in the number of recorded snakebites during the study period, it is likely that snakebites are still under reported, as it is still difficult for riverine and indigenous people to reach health centers due to the great distances and lack of reliable means of transport (Feitosa, 2015; Wen et al., 2015; Magalhães et al., 2019).

Snakes are the main cause of accidents in Brazil, with 80 to 90% of cases caused by snakes in the genus *Bothrops*. Snakes in the genus *Bothrops* are highly adaptable, can be found in different types of environments, and are common in the Amazon region (França & Málaque, 2003). The genus *Lachesis* includes the species *L. muta,* which inhabits the dense parts of forests in the Amazonian and Atlantic Forest. Snakes in the *Lachesis* genus are the second most common cause of snakebites in Amazonas, due to the higher prevalence of this type of snake in this region, unlike in states in the northeastern, southeastern, southern, and midwestern regions of Brazil (Silva et al., 2009; Feitosa et al., 2015).

Amazonas is the largest Brazilian State in area, and includes diverse ecosystems such as flooded forests, floodplains, blackwater-flooded forests (known locally as igapó), and lowland ecosystems known as terra-firma. The characteristics of the different ecosystems differ among the micro-regions presenting the highest prevalence of snakebites. The present study corroborates the findings of Feitosa (2015), who reported a high incidence of snakebites in areas that extend from the northeastern part of Amazonas (micro-regions of Manaus, Parintins, Itacoatiara, and Madeira) to the central region of the State (micro-regions of Coari, Rio Negro, and Tefé), as well as a high annual incidence in small municipalities such as Alvarães, São Gabriel, and Uarini.

According to the Ministry of Health (2008), the northern region of Brazil, unlike the other regions of the country, does not present clearly defined seasons, as the local climate consists of high temperatures and high humidity throughout the year. However, the months in which the highest numbers of snakebites were recorded were those with the highest rainfall (average of 200-400 mm), i.e. January to April. In Amazonas, high rainfall may result in river

flooding and, consequently, the displacement of snakes to drier regions, where they are more likely to come upon people (Santos et al., 1995).

In Brazil, most snakebite victims are male individuals (Araújo et al., 2003; Guimarães et al., 2015; Magalhães et al., 2019, Feitosa et al., 2015). In addition, several studies have found a strong relationship between snakebites and patterns of human activity (Gutiérrez et al., 2006).

According to Feitosa et al. (2015), snakebites in the Amazon mainly occur in workers in the 20-59 age group, and snakebite victims often work in subsistence agriculture. The greater risk of snakebites during periods of flooding is usually associated with the lack of appropriate safety equipment required in logging activities, such as gloves and appropriate footwear. Many people in the Amazonas region lack adequate protective clothing when they enter forests or other environments commonly inhabited by snakes, and thereby run the risk of being bitten on exposed parts of the body (Brazil, 2001). In the central region of the Purus River, in Amazonas, forestry, agriculture, and hunting were the main activities related to snakebites (Waldez & Vogt, 2009).

Snakebite victims took between one and six hours to reach medical assistance. This may be due to the dependence on river transportation for commuting between communities and health centers in Amazonas. In addition, the initial search for healers can lead to delays or even, in more severe cases, death of the snakebite victims even before being seen by the official health services (Borges et al., 2014, Feitosa et al., 2015).

Classification of snakebite severity is based on local and systemic manifestations, serving as tools for treatment with the appropriate anti-venom. Thus, the number of ampules used to treat a given snake bite depends on whether the case is mild, moderate, or severe (França & Málaque 2003). Most cases were considered mild and moderate (88.1%), but severe snakebites involve the need for hospitalization, kidney alterations, respiratory failure, sepsis, hemorrhagic shock, the onset of secondary infections, amputations in addition to the development of psychological changes (Ribeiro et al., 1998; Habib & Brown, 2018; Sprignolli et al., 2011).

The number of snakebites resulting in death was highest in victims bitten by snakes of the genus *Bothrops*. According to França and Málaque (2003) death resulting from a bothropic snakebite is related to time elapsed until treatment after the bite, death being more frequent when treatment is started six hours after the bite.

Bites by snakes of the genus *Bothrops* can trigger local and systemic symptoms with different degrees of severity. Patients present local pain and edema, as well as bruises and bullous lesions, and bleeding may appear at the site of the bite (Filho, 1997). In severe cases, soft tissue necrosis, abscess formation, and the development of compartment syndrome may occur (Jorge et al., 1990; Brazil, 1998; Pinho & Pereira, 2001). Systemic symptoms include nausea, vomiting, sweating, hypotension, and hemorrhages such as

gingivorrhagia, epistaxis, hematemesis, and hematuria. Systemic complications such as shock, acute renal failure, septicemia, and disseminated intravascular coagulation are frequent causes of death (Brazil, 1998; Ribeiro et al., 1998).

It is well known that snakebite diagnosis is clinical and epidemiological; however, the identification of snake species increases accuracy in medical assistance. In this sense, patients affected by snakebites usually try to take the snake that bit them to the hospital or to the health center, but when this is not possible, or when the snakes cannot be correctly identified, non-specific serum administration may occur. In addition, when *Lachesis* anti-venom serum or *Bothrops/Lachesis* anti-venom serum is not available, *Bothrops* anti-venom has been administered to treat bites by *L. muta*, leading to increased severity in cases (Bard et al., 1994).

Snakebites were frequently recorded in the state of Amazonas between 2007 and 2017. Most snakebites occurred in the Rio Negro and Tefé micro-regions, with most cases occurring in the months presenting heaviest rainfall.

Males in the 20-59 age group were the most affected, and most snakebites were attributed to snakes in the genus *Bothrops*. The time elapsed between snakebite and medical assistance is considered high.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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