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Retrospective clinical and epidemiological analysis of scorpionism at a referral hospital for the treatment of accidents by venomous animals in Alagoas State, Northeast Brazil, 2007-2017

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ABSTRACT

Scorpionism has a high incidence rate in Brazil. It is considered a serious public health problem mainly in tropical and subtropical regions around the world. The number of scorpion accidents have increased over the years and the highest frequencies have been reported mainly in the Brazilian Northeast region. Therefore, in this study we report a retrospective clinical and epidemiological analysis of scorpion stings from 2007 to 2017 in Alagoas State, Northeast Brazil, at a referral hospital for assistance and treatment of accidents by venomous animals. During the analyzed period, the referral hospital treated 27,988 cases, and an increase in the number of cases has taken place over the years. The highest frequency of scorpion stings was observed in females, and the age range most affected was from 20 to 29 years old. The most stung body site was the foot, followed by finger, toe or hand. Regarding the severity, most severe cases were reported in children up to 4 years old (69.4%) and 50% of the total cases treated with serotherapy corresponded to patients in this age range. Interestingly, it was also found that the occurrence of systemic manifestations and the severity of the cases were significantly associated with pediatric patients. In this way, this study highlights the scorpionism as an environmental public health problem in Alagoas State, Northeast Brazil, as well as the need to intensify the epidemiological surveillance and educational campaigns to prevent and control scorpion accidents throughout the year.

KEYWORDS: Scorpionism. Scorpion stings. Tropical medicine. Epidemiology.

INTRODUCTION

Scorpionism is a serious public health problem reaching high incidence rates and severity mainly in tropical and subtropical regions around the world[1,2]. In Brazil, scorpionism has a high incidence rate due to the wide distribution of scorpions in all the regions and ecosystems of the country[3]. The species of the genus *Tityus*, mainly *Tityus serrulatus* known as "yellow scorpion" due to its coloring, is considered the most dangerous scorpion and accounts for the highest number of accidents[2,4].

Scorpion toxin is composed of a complex mixture of low molecular weight proteins that prolong depolarization of post-ganglionic nerve endings throughout the body, leading to a massive release of neurotransmitters, which trigger the predominance of systemic effects (adrenergic and/or cholinergic)[5]. Additionally, it is known that the mediators of the inflammatory response and toxicity on

the cardiac fibers are involved in the genesis of the pulmonary edema due to the increase of permeability of the capillaries[6].

Local pain is present in almost all the cases, with different levels of intensity and irradiation being reported as a pricking or burning sensation. Other local symptoms may be present, such as hyperemia, paresthesia, hyperesthesia, edema, sweating and piloerection[2]. Furthermore, systemic manifestations may occur and are more frequent in children, usually appearing hours after the accident[1].

Scorpion envenomation cases may be classified as mild, moderate, or severe: 1) Mild cases have local signs, such as pain, erythema and local paraesthesia; 2) Moderate cases have sweating, nausea, occasional vomiting, tachycardia, agitation and mild arterial hypertension; 3) In severe cases, besides showing the signs and symptoms of mild and moderate cases, the patient also shows excessive sweating, profuse and incoercible vomiting, prostration, bradycardia, acute pulmonary edema and shock[1,7,8]. Moreover, complications such as acute pulmonary edema, shock or multiple organ failure are related to mortality[7]. The severity of clinical manifestations depends on the scorpion features (species, size and amount of venom injected) and victim factors (age, body weight and health status)[1]. The risk group for a poor prognosis includes mainly children under 5 years of age[9] and the clinical outcome may be negatively influenced by the long period from the time of sting to the medical care[1].

Epidemiology study of scorpionism in Brazil, from the years 2000 to 2012, reported 482,616 accidents and 728 deaths which shows an increase of 323% in the incidence rate between the first and last year of the study[10]. Comparing the Brazilian regions, the Northeast had the highest annual incidence and mortality rates. Alagoas State had the highest average annual incidence rate (105.9/100,000 inhabitants)[10]. However, although it is a serious public health problem, the epidemiology of scorpionism remains underreported[1,2] and until the present moment, there is no study analyzing cases of scorpion accidents solely in Alagoas State. Therefore, in this study we report a retrospective analysis of the clinical and epidemiological profile of scorpion stings at the referral Hospital for Assistance and Treatment of accidents by venomous animals in Alagoas, Northeast of Brazil, in the period from 2007 to 2017.

MATERIAL AND METHODS

The Alagoas State is in Northeast Brazil with an area of 27,767 km^2 and comprises 102 municipalities[11,12]. These municipalities are grouped into three mesoregions (East, Agreste and Sertao)[12]. The East mesoregion covers the coast and the forest zone, where the capital Maceio is located[11]. On the coast and in the forest zone, the annual range of rainfall levels is between 1,300 to 1,600 mm and the maximum annual average air temperature in this region fluctuates between 30 and 31 °C[11].

According to the 2010 Brazilian census, the resident population in Alagoas State is 3,120,494 inhabitants, composed of 48.5% men and 51.5% women[12]. Maceio is the State capital and most populous city, where 29.9% of the population resides[12].

In this study, the scorpionism cases were analyzed at a Referral Hospital for the Assistance and Treatment of venomous animals' accidents in Alagoas State, located in Maceio, and occurred from January 1, 2007 to December 31, 2017. The cases of accidents caused by venomous animals in Brazil are of compulsory notification thus being reported in notification forms and recorded in the SINAN (Sistema de Informacao de Agravos de Notificacao) database. Data were obtained from the TabWin version 3.6b software platform (Ministerio da Saude, Brasilia, DF, Brazil) from SINAN, a public domain database. It was based solely on secondary data, without access to the patients' nominal data or anything else that could lead to identification; therefore, ensuring the confidentiality of the information collected. All the ethical and legal requirements were followed as specified by Resolution Nº 466/12 from the National Health Council (CNS) of Brazil.

The software Microsoft Excel 2010 was used to register collected data and the demographic information was obtained from the 2010 census of the Brazilian Institute of Geography and Statistics (IBGE)[12].

The fields of the SINAN Notification Form (SNF) for accidents with venomous animals are available as Supplementary Material. The variables analyzed in this study were: date of accident, gender (female or male), patient's age, skin color/ethnicity (white, black, Asian, multiracial or indigenous), accident zone (urban, peri-urban or rural), occupation, education level (based on Brazilian law and guidelines), body site of the scorpion sting, severity classification (mild, moderate or severe), local manifestations, systemic manifestations, time between the sting and the medical care, and treatment with serotherapy.

The linear regression analysis[13] for the number of cases over the years was performed using R version 3.4.4 (R Core Team, Vienna, Austria). The Student's t-test (unpaired samples)[14] was performed to compare the number of cases between male and female groups. The Analysis of Variance (ANOVA) one-way[15] with Tukey's multiple comparisons test[16] was used to establish whether there is a difference among the months by using the Graph-Pad Prism 6.00 (GraphPad Software, La Jolla, CA, USA).

The observed cases of demographic variables were compared to the frequencies from Alagoas' population, obtained from the 2010 Brazilian census[12], by applying the Pearson's Chi-square Goodness-of-Fit test[17] or Binomial Test[18] by using the GraphPad Prism version 6 software, as detailed in the Supplementary Material.

In order to evaluate the association between the occurrence of systemic clinical manifestations and the most frequent sociodemographic and clinical characteristics, the Pearson's chi-square test for independence[19] was performed using the IBM SPSS Statistics for Windows version 23.0 (IBM Corp., Armond, NY, USA). Some variables were not included because they did not meet the test assumption that no more than 20% of the expected counts are less than 5 and all individual expected counts are 1 or greater[20] (Supplementary Material). The level of significance was $p < 0.05$.

RESULTS

In this retrospective study, from 2007 to 2017, the Referral Hospital for the Assistance and Treatment of Accidents by Venomous Animals in Alagoas State, Brazil, attended 27,988 cases of scorpion stings. During this period, Alagoas State registered 63,762 cases in the SINAN database, with an average incidence rate of 177.4/100,000 inhabitants. Hence, the data collected at a referral hospital represents 44% of the total cases reported in the State. The analysis over the years showed an increase in the number of scorpion sting cases ($\beta = 0.73$; $p < 0.01$) (Figure 1A). It is worth mentioning that cases of scorpionism occurred throughout the year and no significant difference among the months was observed in the analyzed period ($p = 0.4977$) (Figure 1B).

Of the total (n=27,988), the number of cases were higher in females compared to males (Female = 61.8% vs Male = 38.2%) and the average number of cases per year was significant between different genders (male = 972.5 ± 53.6 vs female = 1575.0 ± 97.4; mean ± SEM; $p < 0.0001$).

The highest frequency of sting cases occurred in the group of 20-29 years old (16.9 %), as shown in Table 1. Regarding the geographic distribution, the urban area presented the highest frequency of cases (n = 26,494; 94.7 %), while the number of cases in the peri-urban and rural areas accounted for less than 2% of all the cases (Table 1). In this study, the multiracial group was the most representative 88.8% of the cases (n = 24,858), followed by the white group (n = 1,426; 5.1%), the black group (n = 1,243; 4.4%), the indigenous group (n = 25; 0.1%) and the Asian group (n = 16; 0.1%) (Table 1). It is important

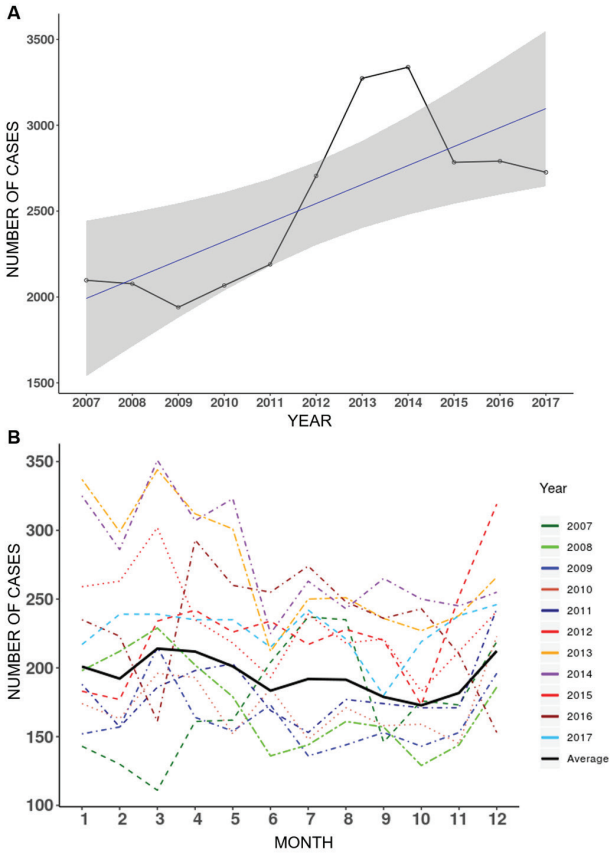

Figure 1 - Temporal distribution of scorpionism cases treated at the referral hospital for the assistance and treatment of accidents by venomous animals in Alagoas State, Northeast of Brazil, from 2007 to 2017. A) Absolute number of scorpionism cases per year (black line) analyzed by a linear regression model (blue line) ($\beta = 0.73$; $p < 0.01$); B) Absolute number of scorpionism cases distributed by month of the accident.

to emphasize that the discrepancy between the distribution of scorpion sting cases considering demographic variables (gender, age range, skin color/ethnicity and accident zone) is significantly different ($p < 0.0001$) from the population frequencies of Alagoas State (Supplementary Material). Furthermore, considering the education level, the highest number of cases occurred in the group that completed high school (n= 5,859; 20.9%) (Table 1).

The professional occupation was recorded in 71.6% (n = 20,042) of the cases in the SNF. Of them, 32% were students, followed by housewives (21.5%) and retirees/pensioners (8.4%). Among the female victims, most of them were housewives (n = 4,263; 32.7%), followed by students (n = 3,425; 26.3%) and retirees/pensioners (n = 1,204; 9.3%). In the male group, most were students (n = 2,554; 36.4%), followed by retirees/pensioners (n = 479, 6.8%) and bricklayers (n = 307; 4.4%). However, it is worth mentioning that only 0.7% of all scorpion sting cases were reported as work-related accidents in the SNF.

Table 1 - Distribution of scorpion sting cases at the referral hospital for the assistance and treatment of accidents by venomous animals in Alagoas State, Northeast of Brazil, from 2007 to 2017, according to the gender, age, accident zone, skin color/ethnicity and education level of patients.

Sociodemographic characteristics		Gender				Total	
		Female		Male			
		N	**%**	**N**	**%**	**N**	**%**
Age Range in years	*< 1-year-old*	79	0.5	78	0.7	157	0.6
	1- to 4	1,030	6.0	1,049	9.8	2,079	7.4
	5- to 9	1,216	7.0	1,183	11.1	2,399	8.6
	10- to 14	1,234	7.1	1,056	9.9	2,290	8.2
	15- to 19	1,377	8.0	980	9.2	2,357	8.4
	20- to 29	2,909	16.8	1,833	17.1	4,742	16.9
	30- to 39	2,682	15.5	1,474	13.8	4,156	14.8
	40- to 49	2,384	13.8	1,230	11.5	3,614	12.9
	50- to 59	2,017	11.7	865	8.1	2,882	10.3
	60- to 69	1,390	8.0	583	5.5	1,973	7.0
	70- to 79	717	4.1	269	2.5	986	3.5
	≥80-years	260	1.5	93	0.9	353	1.3
Accident zone	*Urban*	16,420	94.9	10,074	94.2	26,494	94.7
	Peri-urban	128	0.7	98	0.9	226	0.8
	Rural	138	0.8	125	1.2	263	0.9
	Ignored/Omitted	609	3.5	396	3.7	1,005	3.6
Skin color/Ethnicity	*White*	921	5.3	505	4.7	1,426	5.1
	Black	745	4.3	498	4.7	1,243	4.4
	Asian	10	0.1	6	0.1	16	0.1
	Multiracial	15,332	88.6	9,526	89.1	24,858	88.8
	Indigenous	15	0.1	10	0.1	25	0.1
	Ignored/Omitted	272	1.6	148	1.4	420	1.5
Educational level	*Unlettered*	654	3.8	269	2.5	923	3.3
	Uncomplete primary school	1,555	9.0	1,079	10.1	2,634	9.4
	Complete primary school	857	5.0	484	4.5	1,341	4.8
	Uncomplete middle school	2,571	14.9	1,740	16.3	4,311	15.4
	Complete middle school	1,448	8.4	858	8.0	2,306	8.2
	Uncomplete high school	970	5.6	563	5.3	1,533	5.5
	Complete high school	3,907	22.6	1,952	18.3	5,859	20.9
	Uncomplete higher education	465	2.7	319	3.0	784	2.8
	Complete higher education	1,135	6.6	513	4.8	1,648	5.9
	Not applicable	2,174	12.6	1,309	12.2	3,483	12.4
	Ignored/Omitted	1,559	9.0	1,607	15.0	3,166	11.3

Regarding the severity classification, 98.1% (n=27,469) of the cases were classified as mild, while just a few cases were classified as moderate (n=381; 1.4 %) or severe (n=98; 0.4%) (Table 2). Local (LM) and systemic (SM) manifestations were reported in 95.4% (n = 26,707) and 1.9% (n = 525) of the cases, respectively. The most frequent LM was local pain (98.3%) and the most frequent SM was vagal hyperactivity manifestations (60.6%), including nausea and vomiting. We observed an association between the occurrence of SM and the patient's age ($p < 0.001$), in most cases (61.2%) detected in patients up to 9 years of age. In addition, the association between age and severity

Table 2 - Distribution of clinical characteristics of scorpion sting cases at the referral hospital for the assistance and treatment of accidents by venomous animals in Alagoas State, Northeast of Brazil, from 2007 to 2017, according to the severity, sting location, local and systemic manifestations and serotherapy.

Clinical Characteristics		Gender				Total	
		Female		Male			
		N	%	**N**	**%**	**N**	**%**
Severity	*Mild*	16,998	98.3	10,471	97.9	27,469	98.1
	Moderate	225	1.3	156	1.5	381	1.4
	Severe	54	0.3	44	0.4	98	0.4
	Ignored/omitted	18	0.1	22	0.2	40	0.1
Sting location	*Head*	151	0.9	139	1.3	290	1.0
	Arm	491	2.8	348	3.3	839	3.0
	Forearm	336	1.9	289	2.7	625	2.2
	Hand	1,715	9.9	1,197	11.2	2,912	10.4
	Finger	3,105	18.0	2,079	19.4	5,184	18.5
	Torso	753	4.4	598	5.6	1,351	4.8
	Leg	614	3.6	440	4.1	1,054	3.8
	Thigh	490	2.8	423	4.0	913	3.3
	Foot	5,373	31.1	2,717	25.4	8,090	28.9
	Toe	2,690	15.6	1,399	13.1	4,089	14.6
	Ignored/Omitted	1,577	9.1	1,064	10.0	2,641	9.4
Local manifestations	*Yes*	16,592	95.9	10,115	94.6	26,707	95.4
	No	537	3.1	446	4.2	983	3.5
	Ignored/omitted	166	1.0	132	1.2	298	1.1
Systemic manifestations	Yes	327	1.9	198	1.9	525	1.9
	No	16,828	97.3	10,404	97.3	27,232	97.3
	Ignored/omitted	140	0.8	91	0.9	231	0.8
Serotherapy	*Yes*	272	1.6	186	1.7	458	1.6
	No	16,999	98.3	10,480	98.0	27,479	98.2
	Ignored/omitted	24	0.1	27	0.3	51	0.2

was significant (p <0.001) (Supplementary Material), in which 59.3% of the moderate and 83.7% of the severe cases occurred in the group up to 9 years of age (Table 3). It is important to emphasize that in the group of children up to 4 years old, 69.4% were classified as severe cases, and from the total cases treated with serotherapy, 50% of them were in this age group (Table 4).

The analysis comparing the body sites of scorpion stings revealed a higher frequency in the foot (28.9%), followed by the finger (18.5%), the toe (14.6%) and the hand (10.4%) (Table 3). In addition, the frequency distribution of the stung body site was very similar for both male and female groups (Figure 2). Considering the case severity, the most common body sites were the foot, finger, and toe in the mild and moderate cases. However, in the severe cases, the most commonly stung site was also the foot (27.6%), followed by both the hand and toe with the same frequencies (both at 13.3%) (Table 3).

Considering the time between the scorpion sting and the medical care assistance, 56.6% of all the cases were treated at the hospital within the first hour after the accident (Table 3), and an association was detected between the occurrence of systemic manifestations (SM) and the time elapsed until medical care (p <0.001) (Supplementary Material). In addition, SM were not observed in 64.2% of the cases which were treated up to one hour after the accident, therefore suggesting that a faster medical assistance after a scorpion sting contributes to a better prognosis.

The serotherapy was administered to 1.6% of all the cases, of which, 78.5% of the moderate cases and 89.8% of the severe cases were treated with anti-scorpion venom serum (Table 3).

Table 3 - Distribution of scorpion sting cases according to the severity considering the age range, sting location, the time between the sting and the medical care after the incident and serotherapy reported at the referral hospital for the assistance and treatment of accidents by venomous animals in Alagoas State, Northeast of Brazil, from 2007 to 2017.

		Severity									
		Mild		Moderate		Severe		Ignored/omitted		Total	
		N	%	N	%	N	%	N	%	N	%
Age Range (years)	*< 1-year-old*	126	0.5	21	5.5	10	10.2	0	0.0	157	0.6
	1- to 4	1,877	6.8	140	36.7	58	59.2	4	10.0	2,079	7.4
	5- to 9	2,318	8.4	65	17.1	14	14.3	2	5.0	2,399	8.6
	10- to 14	2,269	8.3	15	3.9	0	0.0	6	15.0	2,290	8.2
	15- to 19	2,341	8.5	12	3.1	1	1.0	3	7.5	2,357	8.4
	20- to 29	4,706	17.1	27	7.1	1	1.0	8	20.0	4,742	16.9
	30- to 39	4,122	15.0	25	6.6	4	4.1	5	12.5	4,156	14.8
	40- to 49	3,587	13.1	17	4.5	6	6.1	4	10.0	3,614	12.9
	50- to 59	2,847	10.4	29	7.6	0	0.0	6	15.0	2,882	10.3
	60- to 69	1,955	7.1	15	3.9	1	1.0	2	5.0	1,973	7.0
	70- to 79	972	3.5	13	3.4	1	1.0	0	0.0	986	3.5
	≥80-years	349	1.3	2	0.5	2	2.0	0	0.0	353	1.3
Sting Location	*Head*	282	1.0	5	1.3	2	2.0	1	2.5	290	1.0
	Arm	824	3.0	11	2.9	3	3.1	1	2.5	839	3.0
	Forearm	615	2.2	9	2.4	1	1.0	0	0.0	625	2.2
	Hand	2,849	10.4	46	12.1	13	13.3	4	10.0	2,912	10.4
	Finger	5,106	18.6	62	16.3	9	9.2	7	17.5	5,184	18.5
	Torso	1,340	4.9	6	1.6	3	3.1	2	5.0	1,351	4.8
	Leg	1,045	3.8	6	1.6	2	2.0	1	2.5	1,054	3.8
	Thigh	898	3.3	13	3.4	2	2.0	0	0.0	913	3.3
	Foot	7,923	28.8	126	33.1	27	27.6	14	35.0	8,090	28.9
	Toe	4,014	14.6	59	15.5	13	13.3	3	7.5	4,089	14.6
	Ignored/omitted	2,573	9.4	38	10.0	23	23.5	7	17.5	2,641	9.4
Time between the sting and the medical care	*< 1 hour*	15,604	56.8	166	43.6	39	39.8	22	55.0	15,831	56.6
	1 to 3 hours	5,022	18.3	91	23.9	33	33.7	5	12.5	5,151	18.4
	3 to 6 hours	1,515	5.5	32	8.4	11	11.2	2	5.0	1,560	5.6
	6 to 12 hours	1,130	4.1	16	4.2	4	4.1	2	5.0	1,152	4.1
	12 to 24 hours	759	2.8	23	6.0	2	2.0	1	2.5	785	2.8
	> 24 hours	298	1.1	11	2.9	1	1.0	0	0.0	310	1.1
	Ignored/omitted	3,141	11.4	42	11.0	8	8.2	8	20.0	3,199	11.4
Serotherapy	*Yes*	69	0.3	299	78.5	88	89.8	2	5.00	458	1.6
	No	27,365	99.6	81	21.3	9	9.2	24	60.0	27,479	98.2
	Ignored/omitted	35	0.1	1	0.3	1	1.0	14	35.0	51	0.2

DISCUSSION

Scorpion envenomation is one of the most serious health challenges in tropical and subtropical regions, and epidemiological research can identify factors attributed to scorpion stings which guide public health policies. In light of these, over the years, our study has shown an increase in the number of cases of scorpion stings treated at a referral hospital for the treatment of accidents by venomous animals in Alagoas State.

In a previous study conducted with SINAN data encompassing all Brazilian States in the years 2000 to 2012,

Table 4 - Distribution of serotherapy administrated to the cases after the scorpion sting according to patients' age at the referral hospital for the assistance and treatment of accidents by venomous animals in Alagoas State, Northeast of Brazil, from 2007 to 2017.

Age Range (years)	Serotherapy							
	Yes		No		Ignored/omitted		Total	
	N	%	N	%	N	%	N	%
< 1	30	6.6	127	0.5	0	0.0	157	0.6
1- to 4	199	43.4	1,876	6.8	4	7.8	2,079	7.4
5- to 9	83	18.1	2,314	8.4	2	3.9	2,399	8.6
10- to 14	10	2.2	2,278	8.3	2	3.9	2,290	8.2
15- to 19	12	2.6	2,338	8.5	7	13.7	2,357	8.4
20- to 29	23	5.0	4,706	17.1	13	25.5	4,742	16.9
30- to 39	24	5.2	4,124	15.0	8	15.7	4,156	14.8
40- to 49	18	3.9	3,593	13.1	3	5.9	3,614	12.9
50- to 59	28	6.1	2,846	10.4	8	15.7	2,882	10.3
60- to 69	16	3.5	1,954	7.1	3	5.9	1,973	7.0
70- to 79	11	2.4	975	3.5	0	0.0	986	3.5
≥80	4	0.9	348	1.3	1	2.0	353	1.3

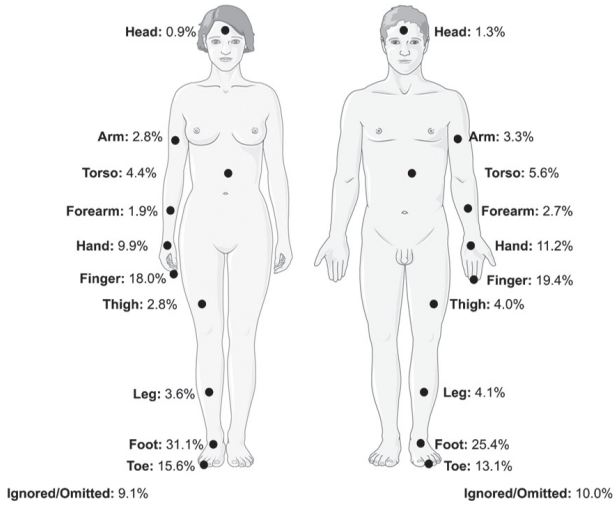

Figure 2 - Frequency distribution of body sites of scorpion stings cases treated at the referral hospital for the assistance and treatment of accidents by venomous animals in Alagoas State, Northeast of Brazil, from 2007 to 2017.

Alagoas presented the highest annual average incidence rate[10]. When comparing with the period analyzed in our study, the rate increased more than 60%, raising alarm to this public health problem. The literature points out that during the hottest and rainiest periods of the year there are the highest incidences of scorpion stings in Brazil[21]. However, we did not observe a significant difference in the number of cases of scorpion stings among the months in the analyzed period in Alagoas. This result can be explained by the slight temperature variations mainly in Maceio and the forest zone regions of Alagoas State[11], which should have allowed the same level of scorpion activity throughout the year. In the same way, previous studies performed in the Northeast region of Brazil had also failed to detect significant differences in the number of cases over the months[22,23].

The highest frequency of scorpion stings was observed in females compared to the male group of patients. These data corroborate results of other studies carried out in the Northeast region of Brazil[22,24-26]. This exposure relationship can be explained by the longer period of time that women usually stay in the home environment, compared to men, as previously reported[27]. The home environment is a shelter for scorpion feeding and proliferation, due to the abundant presence of synanthropic opportunistic arthropods which constitute its diet[28]. On the other hand, it is important to note that studies carried out in the Brazilian North, South and Southeast regions detected a higher incidence rate of scorpion stings in males, related to the exposure in the workplace[29,30]. Another fact that may explain the disparity among genders is probably the higher propensity to seek medical care by women. In this way, aspects of gender identity reinforced by cultural standards can influence those seeking medical treatment, therefore, resulting in the self-neglected care needed to maintain the quality of health[31,32].

The patient's occupation highlights the home environment as a risky place for scorpion stings because most of the patients were students, housewives and retired/pensioners. However, it is important to emphasize that, while the SNF provides a field for reporting occupational accidents, a field detailing the patient's activity at the time

of the accident could better clarify and establish a more accurate relationship between exposure to risks.

The largest number of cases occurred in adult patients, corroborating other previous studies that highlighted this economically active population as the most susceptible to scorpion stings[10,22,24,25]. Moreover, the majority of the cases in this study occurred in urban areas, as previously reported in different regions of Brazil[10,22,24,25]. In this way, socio-demographics factors such as urbanization, high-density population, low-income population, poor housing conditions and lack of sanitation are determining factors for the increase in the number of cases of scorpionism[3,30]. In addition, the high density of the scorpion population can be justified by both, adaptations to the urban environment and the rapid spread of the scorpion species by parthenogenesis reproduction[33].

Several body sites can be targeted by scorpions. In the present study, the majority of scorpion stings occurred on the lower limbs followed by upper limbs as reported in some studies[24,34]. Moreover, the foot was the most affected body site corresponding to 28.9 % of all cases. In contrast, other studies carried out in other locations around Brazil, have detected the upper limbs as the most affected anatomical sites[22,30,35,36]. It is important to emphasize that the extremities of the body are generally the most affected sites and are usually associated with routine activities such as wearing shoes without careful observation[36].

The elapsed time between the sting and early medical treatment is a crucial factor that greatly influences the prognosis of scorpion accidents[7], as our study revealed that approximately 75% of all the patients received medical treatment up to 3 hours after the accident, in accordance with other previous studies[22-24,26,29]. In addition, in pediatric patients, a known risk group for scorpionism[9,37], it was shown that prompt medical care may result in a better prognosis and therefore in mild cases[38]. The observation that the majority of cases with moderate or severe cases was detected in the age group up to 9 years old highlights the need for additional care with pediatric patients. Moreover, the frequencies of moderate and severe cases observed in this age group were higher than those previously reported[39,40]. The severity of scorpion envenomation depends on several factors such as the anatomical location of the bite, age, weight, and health status of the victim[1]. In pediatric patients, both the lowest blood volume and the lowest total body volume contributed to the excessive concentration of scorpion venom in the plasma, favoring the manifestation of severe symptoms and consequently, a higher risk of death[5,41].

The treatment with serotherapy is indicated only in moderate and severe cases[7], and in consonance with this indication, we observed that the antitoxin sera was administered to 1.6 % of the total cases; which is a result similar to the frequency reported by another epidemiological study in Brazil[36].

In Brazil, accidents with venomous animals require a mandatory report, filling all the fields in the SNF, according to the Ministry of Health[42]. It is important to emphasize that certain data such as the education level, the occupational employment, sting location and time elapsed between the accident and the medical care were sometimes ignored and unfilled which undermines the epidemiological analysis. This lack of information has also been reported for other diseases with mandatory reporting[43-45]. Therefore, the awareness among healthcare professionals of the importance of completing the SNF ensures the integrity of the collected and reported data.

The SINAN data has the purpose of identifying priority areas, monitoring and evaluation[46]. Our study highlights the urgent necessity of public policies that promote monitoring and treatment, but mainly control strategies. In this sense, actions to prevent proliferation, through monitoring, control, management, and environmental education[46] should be implemented by the State. For monitoring, it is necessary to use indicators that clarify the level and intensity of home infestations, which can be carried out by community health agents and/or endemic agents[46]. Some species of scorpions are adapted to human environments and play an important role in the ecological balance[47]. Therefore, the eradication of these species is neither possible nor viable.

The control and population management of the species is based on the removal of scorpions and the modification of environmental conditions, disfavoring the occurrence, permanence, and proliferation of these animals[46]. The actions of health managers must embrace efforts in urban cleaning, sanitation, public works, and environmental education, while incorporating control measures into the daily life of the population[46].

In summary, this study reported scorpionism as a serious public health problem in previous years in Alagoas State, Northeast Brazil, with an enormous number of cases occurring from 2007 to 2017. The clinical and epidemiological factors of scorpionism raised in this endemic area can collaborate to health surveillance of scorpion accidents, mainly in tropical and subtropical regions throughout the world. The results have also highlighted the need to establish and/or intensify prevention and education campaigns to avoid scorpion stings that may result in the reduction of its morbidity.

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AUTHORS' CONTRIBUTIONS

LGM, JTS, MBS, LMS, RMBC, SRUV, LA and EJB designed the study, analyzed the data and wrote the manuscript. LGM collected the data. JTS and GSR performed statistical analysis of the data. AAM, CTM, LA and EJB reviewed the manuscript and contributed with the discussion. All the authors reviewed the final version of the manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

ETHICAL APPROVAL

All the data were based only on secondary data, without access the patients' nominal data or anything else that could identify and following the ethical and legal requirements as requested by Resolution Nº 466/12 from the National Health Council (CNS), Brazil. The data collection for this study was authorized by Teaching Assistance Management at *Hospital Escola Dr. Hélvio Auto, Maceió*, Alagoas, Brazil.

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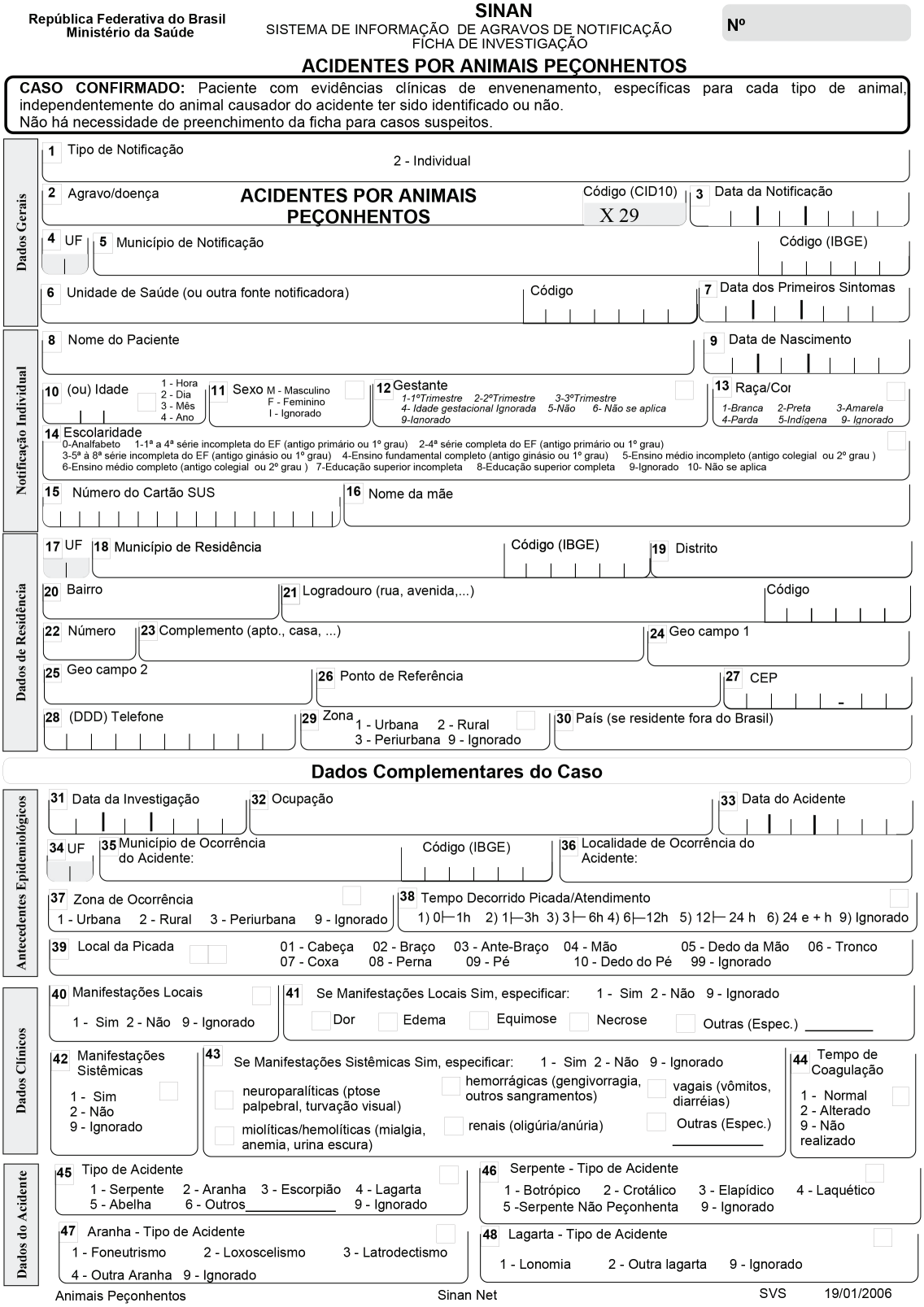
SUPPLEMENTARY MATERIAL

S.1 - SINAN NOTIFICATION FORM (SNF)

https://portalsinan.saude.gov.br/images/documentos/Agravos/AAP/Animais_Peconhentos_v5.pdf



República Federativa do Brasil
Ministério da Saúde

SINAN
SISTEMA DE INFORMAÇÃO DE AGRAVOS DE NOTIFICAÇÃO
FICHA DE INVESTIGAÇÃO

Nº

ACIDENTES POR ANIMAIS PEÇONHENTOS

CASO CONFIRMADO: Paciente com evidências clínicas de envenenamento, específicas para cada tipo de animal, independentemente do animal causador do acidente ter sido identificado ou não.
Não há necessidade de preenchimento da ficha para casos suspeitos.

Dados Gerais

1 Tipo de Notificação — 2 - Individual

2 Agravo/doença — ACIDENTES POR ANIMAIS PEÇONHENTOS — Código (CID10) X 29 — 3 Data da Notificação

4 UF — 5 Município de Notificação — Código (IBGE)

6 Unidade de Saúde (ou outra fonte notificadora) — Código — 7 Data dos Primeiros Sintomas

Notificação Individual

8 Nome do Paciente — 9 Data de Nascimento

10 (ou) Idade — 1 - Hora 2 - Dia 3 - Mês 4 - Ano — 11 Sexo M - Masculino F - Feminino I - Ignorado — 12 Gestante 1-1ºTrimestre 2-2ºTrimestre 3-3ºTrimestre 4- Idade gestacional Ignorada 5-Não 6- Não se aplica 9-Ignorado — 13 Raça/Cor 1-Branca 2-Preta 3-Amarela 4-Parda 5-Indígena 9- Ignorado

14 Escolaridade
0-Analfabeto 1-1ª a 4ª série incompleta do EF (antigo primário ou 1º grau) 2-4ª série completa do EF (antigo primário ou 1º grau) 3-5ª à 8ª série incompleta do EF (antigo ginásio ou 1º grau) 4-Ensino fundamental completo (antigo ginásio ou 1º grau) 5-Ensino médio incompleto (antigo colegial ou 2º grau) 6-Ensino médio completo (antigo colegial ou 2º grau) 7-Educação superior incompleta 8-Educação superior completa 9-Ignorado 10- Não se aplica

15 Número do Cartão SUS — 16 Nome da mãe

Dados de Residência

17 UF — 18 Município de Residência — Código (IBGE) — 19 Distrito

20 Bairro — 21 Logradouro (rua, avenida,...) — Código

22 Número — 23 Complemento (apto., casa, ...) — 24 Geo campo 1

25 Geo campo 2 — 26 Ponto de Referência — 27 CEP

28 (DDD) Telefone — 29 Zona 1 - Urbana 2 - Rural 3 - Periurbana 9 - Ignorado — 30 País (se residente fora do Brasil)

Dados Complementares do Caso

Antecedentes Epidemiológicos

31 Data da Investigação — 32 Ocupação — 33 Data do Acidente

34 UF — 35 Município de Ocorrência do Acidente: — Código (IBGE) — 36 Localidade de Ocorrência do Acidente:

37 Zona de Ocorrência 1 - Urbana 2 - Rural 3 - Periurbana 9 - Ignorado

38 Tempo Decorrido Picada/Atendimento 1) 0⊢1h 2) 1⊢3h 3) 3⊢ 6h 4) 6⊢12h 5) 12⊢ 24 h 6) 24 e + h 9) Ignorado

39 Local da Picada — 01 - Cabeça 02 - Braço 03 - Ante-Braço 04 - Mão 05 - Dedo da Mão 06 - Tronco 07 - Coxa 08 - Perna 09 - Pé 10 - Dedo do Pé 99 - Ignorado

Dados Clínicos

40 Manifestações Locais 1 - Sim 2 - Não 9 - Ignorado

41 Se Manifestações Locais Sim, especificar: 1 - Sim 2 - Não 9 - Ignorado — Dor — Edema — Equimose — Necrose — Outras (Espec.) _____

42 Manifestações Sistêmicas 1 - Sim 2 - Não 9 - Ignorado

43 Se Manifestações Sistêmicas Sim, especificar: 1 - Sim 2 - Não 9 - Ignorado — neuroparalíticas (ptose palpebral, turvação visual) — hemorrágicas (gengivorragia, outros sangramentos) — vagais (vômitos, diarréias) — miolíticas/hemolíticas (mialgia, anemia, urina escura) — renais (oligúria/anúria) — Outras (Espec.) _____

44 Tempo de Coagulação 1 - Normal 2 - Alterado 9 - Não realizado

Dados do Acidente

45 Tipo de Acidente 1 - Serpente 2 - Aranha 3 - Escorpião 4 - Lagarta 5 - Abelha 6 - Outros_____ 9 - Ignorado

46 Serpente - Tipo de Acidente 1 - Botrópico 2 - Crotálico 3 - Elapídico 4 - Laquético 5 -Serpente Não Peçonhenta 9 - Ignorado

47 Aranha - Tipo de Acidente 1 - Foneutrismo 2 - Loxoscelismo 3 - Latrodectismo 4 - Outra Aranha 9 - Ignorado

48 Lagarta - Tipo de Acidente 1 - Lonomia 2 - Outra lagarta 9 - Ignorado

Animais Peçonhentos — Sinan Net — SVS — 19/01/2006

Tratamento

49 Classificação do Caso
1 - Leve 2 - Moderado 3 - Grave 9 - Ignorado

50 Soroterapia
1 - Sim 2 - Não 9 - Ignorado

51 Se Soroterapia Sim, especificar número de ampolas de soro:

Antibotrópico (SAB)	Anticrotálico (SAC)	Antiaracnídico (SAAr)
Antibotrópico-laquético (SABL)	Antielapídico (SAE)	Antiloxoscélico (SALox)
Antilbotrópico-crotálico (SABC)	Antiescorpiônico (SAEs)	Antilonômico (SALon)

52 Complicações Locais
1 - Sim 2 - Não 9 - Ignorado

53 Se Complicações Locais Sim, especificar: 1 - Sim 2 - Não 9 - Ignorado
Infecção Secundária | Necrose Extensa | Síndrome Compartimental | Déficit Funcional | Amputação

54 Complicações Sistêmicas
1 - Sim 2 - Não 9 - Ignorado

55 Se Complicações Sistêmicas Sim, especificar: 1 - Sim 2 - Não 9 - Ignorado
Insuficiência Renal | Insuficiência Respiratória / Edema Pulmonar Agudo | Septicemia | Choque

Conclusão

56 Acidente Relacionado ao Trabalho
1 - Sim
2 - Não
9 - Ignorado

57 Evolução do Caso
1-Cura
2-Óbito por acidentes por animais peçonhentos
3-Óbito por outras causas
9-Ignorado

58 Data do Óbito

59 Data do Encerramento

Acidentes com animais peconhentos: manifestações clínicas, classificação e soroterapia

	Tipo	Manifestações Clínicas	Tipo Soro	Nº ampolas
OFIDISMO	**Botrópico** *jararaca jararacuçu urutu caiçaca*	Leve: dor, edema local e equimose discreto	SAB	2 - 4
		Moderado: dor, edema e equimose evidentes, manifestações hemorrágicas discretas		4 - 8
		Grave: dor e edema intenso e extenso, bolhas, hemorragia intensa, oligoanúria, hipotensão		12
	Crotálico *cascavel boicininga*	Leve: ptose palpebral, turvação visual discretos de aparecimento tardio, sem alteração da cor da urina, mialgia discreta ou ausente	SAC	5
		Moderado: ptose palpebral, turvação visual discretos de início precoce, mialgia discreta, urina escura		10
		Grave: ptose palpebral, turvação visual evidentes e intensos, mialgia intensa e generalizada, urina escura, oligúria ou anúria		20
	Laquético *surucucu pico-de-jaca*	Moderado: dor, edema, bolhas e hemorragia discreta	SABL	10
		Grave: dor, edema, bolhas, hemorragia, cólicas abdominais, diarréia, bradicardia, hipotensão arterial		20
	Elapídico *coral verdadeira*	Grave: dor ou parestesia discreta, ptose palpebral, turvação visual	SAEL	10
ESCORPIONISMO	**Escorpiônico** *escorpião*	Leve: dor, eritema e parestesia local	SAEsc ou SAA	---
		Moderado: sudorese, náuseas, vômitos ocasionais, taquicardia, agitação e hipertensão arterial leve		2 - 3
		Grave: vômitos profusos e incoercíveis, sudorese profusa, prostração, bradicardia, edema pulmonar agudo e choque		4 - 6
ARANEÍSMO	**Loxoscélico** *aranha-marrom*	Leve: lesão incaracterística sem aranha identificada	SAA ou SALox	---
		Moderado: lesão sugestiva com equimose, palidez, eritema e edema endurado local, cefaléia, febre, exantema		5
		Grave: lesão característica, hemólise intravascular		10
	Foneutrismo *aranha-armadeira aranha-da-banana*	Leve: dor local	SAA	---
		Moderado: sudorese ocasional, vômitos ocasionais, agitação, hipertensão arterial		2 - 4
		Grave: sudorese profusa, vômitos freqüentes, priapismo, edema pulmonar agudo, hipotensão arterial		5 - 10
LONOMIA	*taturana oruga*	Leve: dor, eritema, adenomegalia regional, coagulação normal, sem hemorragia	SALon	---
		Moderado: alteração na coagulação, hemorragia em pele e/ou mucosas		5
		Grave: alteração na coagulação, hemorragia em vísceras, insuficiência renal		10

Informações complementares e observações

Anotar todas as informações consideradas importantes e que não estão na ficha (ex: outros dados clínicos, dados laboratoriais, laudos de outros exames e necrópsia, etc.)

Investigador

Município/Unidade de Saúde | Cód. da Unid. de Saúde

Nome | Função | Assinatura

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S.2 - VARIABLES INCLUDED IN THE STATISTICAL ANALYSES

DESCRIPTIVE STATISTICS (ABSOLUTE NUMBER AND PERCENTAGE):

Sociodemographic characteristics

- **Year of occurrence**
  - 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017

- **Month of occurrence**
  - 01 - January (Jan)
  - 02 - February (Feb),
  - 03 - March (Mar),
  - 04 - April (Apr),
  - 05 - May (May),
  - 06 - June (Jun),
  - 07 - July (Jul),
  - 08 - August (Aug),
  - 09 - September (Sep),
  - 10 - October (Oct),
  - 11 - November (Nov),
  - 12 - December (Dec)

- **Age range**
  The patient's age was calculated from the date of birth and the date of the accident, generating a continuous variable that was categorized into age groups.
  - < 1-year-old to 4-years-old
  - 5- to 9-years-old
  - 10- to 14-years-old
  - 15- to 19-years-old
  - 20- to 29-years-old
  - 30- to 39-years-old
  - 40- to 49-years-old
  - 50- to 59-years-old
  - 60- to 69-years-old
  - 70- to 79-years-old
  - 80-years-old or more

- **Accident zone**
  - Urban
  - Peri-urban
  - Rural

- **Skin color/Ethnicity**
  - White
  - Black
  - Asian (yellow – East Asians)
  - Multiracial ("pardo" - mixed ethnic ancestries)
  - Indigenous (Amerindians)

- **Education level**
  Based in the law and guidelines and bases of Brazilian national education in force during the study period (available at http://www.planalto.gov.br/ccivil_03/Leis/L9394.htm)

  - Unlettered
  - Uncomplete primary school
    - 1st grade (complete or incomplete),
    - 2nd grade (complete or incomplete),
    - 3rd grade (complete or incomplete),
    - 4th grade (incomplete)
  - Complete primary school
    - 4th grade (complete)
  - Uncomplete elementary school
    - 5th grade (complete or incomplete),
    - 6th grade (complete or incomplete),
    - 7th grade (complete or incomplete),
    - 8th grade (incomplete)
  - Complete elementary school
    - 8th grade (complete)
  - Uncomplete high school
    - 10th grade (complete or incomplete)
    - 11th grade (complete or incomplete)
    - 12th grade (incomplete)
  - Complete high school
    - 12th grade (complete)
  - Uncomplete higher education
  - Complete higher education
  - Not applicable
  - Ignored/Omitted

Clinical characteristics

- **Severity**
  - Mild - pain, erythema and local paresthesia
  - Moderate - sweating, nausea, occasional vomiting, tachycardia, agitation and mild arterial hypertension
  - Severe - profuse and incoercible vomiting, profuse sweating, prostration, bradycardia, acute pulmonary edema and shock

- **Sting location**
  - Head
  - Arm
  - Forearm
  - Hand
  - Finger
  - Torso
  - Leg
  - Thigh
  - Foot
  - Toe

- **Occurrence of local manifestations**
  Yes or No

- **Occurrence of systemic manifestations**
  Yes or No

- **Serotherapy**
  Yes or No

- **Time between the sting and the medical care**
  - < 1 hour
  - 1 to 3 hours
  - 3 to 6 hours
  - 6 to 12 hours
  - 12 to 24 hours
  - 24 hours

S.3 STATISTICAL TESTS:

1) Student T-test (unpaired samples):

- **Gender (Female vs. Male cases per year)** – p-value: < 0.0001

2) One-way ANOVA (Tukey's multiple comparisons test – post hoc test):

- **Month of occurrence** – p-value: 0.4977

3) Part of a whole - Observed distribution with expected cases comparison:

The expected percentage for the population of Alagoas (Brazil) was obtained from 2010 Brazilian Census.

Gender

Gender	Observed cases	Expected (IBGE, 2010)
Male	10,693	48.45%
Female	17,295	51.55%

- **Test:** Binomial Test
- **p-value**: < 0.0001
- **Conclusion**: The discrepancy is significant

Age Range

Age Range	Observed cases	Expected (IBGE, 2010)
1- to 4-years-old	2,236	8.72%
5- to 9-years-old	2,399	9.62%
10- to 14-years-old	2,290	10.84%
15- to 19-years-old	2,357	10.03%
20- to 29-years-old	4,742	18.01%
30- to 39-years-old	4,156	14.69%
40- to 49-years-old	3,614	11.37%
50- to 59-years-old	2,882	7.86%
60- to 69-years-old	1,973	5.02%
70- to 79-years-old	986	2.63%
80-years-old or more	353	1.23%

- **Test:** Chi-square for goodness of fit
- **Chi-square test:** 908.5
- **Degrees of freedom:** 10
- **p-value**: < 0.0001
- **Conclusion**: The discrepancy is significant

Accident Zone

Accident zone	Observed cases	Expected (IBGE, 2010)
Urban	26,494	73.60%
Peri-urban or Rural	489	26.40%

Ignored/Omitted: 1,005 cases

- **Test:** Binomial Test
- **p-value**: < 0.0001
- **Conclusion**: The discrepancy is significant

Skin color/Ethnicity

Skin color/ Ethnicity	Observed cases	Expected (IBGE, 2010)
White	1,426	31.61%
Black	1,243	6.57%
Asian	16	1.18%
Multiracial	24,858	60.18%
Indigenous	25	0.46%

- **Test:** Chi-square for goodness of fit
- **Chi-square test:** 10770
- **Degrees of freedom:** 4
- **p-value**: < 0.0001
- **Conclusion**: The discrepancy is significant

4) Chi-square test for independence:

Systemic manifestations vs:

Not Included (Variables whose expected count value of one fifth of categories was less than 5):

- Skin color/Ethnicity - 20% of expected counts were < 5
- Accident zone - 16,7% of expected counts were < 5
- Evolution - 66.7% of expected counts were < 5

Included

No association with the occurrence of systemic manifestations (p-value > 0.05)

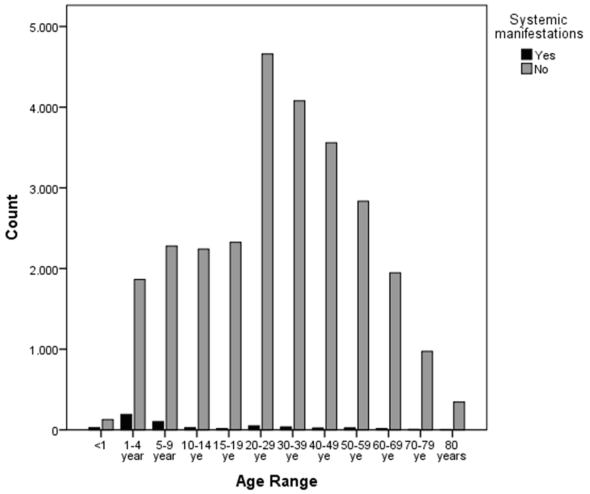
- **Sting location:**
  - $\chi^2 = 15.480$
  - Degrees of freedom: 9
  - p-value = 0.079

- **Gender:**
  - $\chi^2 = 0.053$
  - Degrees of freedom: 1
  - p-value = 0.819

Association with systemic manifestations:

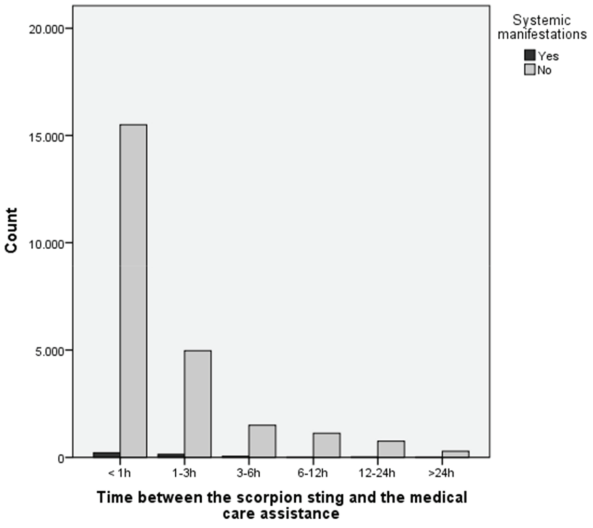
Age range (years):

- $\chi^2 = 1007.956$
- Degrees of freedom: 11
- p-value < 0.0001



Time between the sting and the medical care:

- $\chi^2 = 98.832$
- Degrees of freedom: 5
- p < 0.0001



Association of Severity with Age Range

- $\chi^2 = 1328.604$
- Degrees of freedom: 22
- p < 0.0001