

A Profile of Snake Bites in Brazil, 2001 to 2012

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Abstract

Snake bite incidents are on rise in Brazil. The present study updates the current state of knowledge about snake poisoning in Brazil, following a descriptive and retrospective method. The study is based on the information on 329,180 cases registered at the Brazilian Information System on Diseases of Compulsory Declaration (Sistema de Informação de Agravos de Notificação - SINAN), for a period of 12 years starting from 2001 to 2012.

The variables selected were spatial (Brazilian state) and temporal (month and year). Factors like poisoning due to genus of snake, time elapsed between the poisoning and the first emergency treatment, the age and the sex of the victim, seriousness and evolution of the poisoning etc are crucial elements that play a role in the recovery process. Poisoning incidents based on the relative risks (RR) in terms of age group for all geographic regions of the country were calculated using the Northern region as an index. The study observed an annual increase in the number of cases with seasonal variations. It exhibited a sizeable difference between the minimum and maximum monthly rates of incidents throughout the study period. As per the study, the highest number of cases occurred in the state of Pará with the greatest number of cases (5,317). The state of Tocantins witnessed the highest incidence (79.4/100,000 inhabitants) and the percentage of affected children and adolescents between 10 and 19 years of age are high in the North region (23.2%; CI_{95%}=22.9-23.4%). Seasonal, regional and local factors must be taken into account when training the teams responsible for treating victims and in the planning of the production and distribution of stocks of antivenom serum.

Keywords: Snake; Poisoning; Information systems; Epidemiology; Epidemiological surveillance

Introduction

Snakebites are amongst the neglected health issues in the world [1]. Gutierrez et al. estimated an annual occurrence of 2.5 million bites, of which 250,000 victims are left with complications and 85,000 died in 2010 [2].

According to the Ministry of Health, an average of 26,000 cases is reported annually in Brazil [3]. When the snake is identified, the genus *Bothrops*, wide spread throughout all regions of Brazil, is responsible for 90% of the poisoning. The genus *Crotalus*, present mostly in open areas of fields, savannah and semi-arid scrub forest is responsible for 7% of cases, while the genera *Lachesis*, *Micrurus* and *Leptomicrurus* are responsible for the remaining 3% of cases registered in Brazil [4,5].

Brazilian medical aid for snakebite victims is available only at public health clinics or other clinics affiliated with the National Health System (SUS). These are the only establishments which stock antivenom and they are widespread throughout the country with the aim of making the antivenom available to the patients within few hours of snake bite. This serves as the best model for the countries in African that frequently affected with an increasing number of snake

bites [6]. Health clinics are also responsible for reporting incidents of snakebite to the Ministry of Health's Information System on Diseases Compulsory Declaration (Sistema de Informação de Agravos de Notificação - SINAN) [7]. The data are collected using two types of records: the Individual Declaration Record (Ficha Individual de Notificação - FIN), used for all health issues, which contains basic information of the patient, and the Individual Investigation Record (Ficha Individual de Investigação - FII) with specific reporting of incidents involving poisonous animal bites. Starting from the year 2006, SINAN began to offer online access to the data of all cases reported since 2001 [8].

The continental dimensions of Brazil and its constantly changing demographics, socio-economic and environmental diversity pose great challenges to the effective monitoring of snakebite poisoning in the country. It is difficult therefore to project a nationwide picture [5, 9]. In addition, non-Brazilian researchers that are new to this diversity and complexity may often produce biased estimates by treating Brazil as a single, homogenous territory. They by and large confine to the data collected from few states or municipalities and attribute the outcome to the entire nation [10].

The objective of this work therefore is to update the profile of snake poisoning in Brazil in general, with a special focus on its geographical regions during the first twelve years of the 21st century.

Materials and Methods

The study was conducted following descriptive and retrospective analysis of the online data base available at SINAN of the Brazilian health services on snakebite incidents in the country. The data was based on the snakebite incidents registered at the Brazilian health services between 2001 and 2012 [8].

The Individual Declaration Record used by SINAN up to 2006 contained 54 variables, of which 16 are available on the Internet. The revised record since 2007 allows 64 variables, with 21 available on-line [11].

Of the various variables mentioned in the data base, only few variables like Type of Case or Type of Animal, spatial (Brazilian state) and temporal (month and year) distribution of the poisonings, genus of snake, time elapsed between the poisoning and first emergency treatment, and age and sex of the victim, as well the seriousness and evolution of the poisoning alone are considered for this study.

Keeping the unique and the distinct nature of the Brazilian geographic conditions, the study has decided to consider the geographic location where the incident took place. This was especially meant to reflect the socio, economic, and the environmental realities of the site where the snake bite incident took place.

Several changes to the variables listed in the database took place in the year 2007. The variable 'Evolution of the case' was altered and the

category 'Death' was classified as 'Death due to snake bite' and 'Death due to other reasons'. The category 'Healing with sequel' was removed.

The Individual Investigation Record (FII) does not allow the researchers to distinguishing between the genera *Micrurus* and *Leptomicrurus*, both of which are referred to as *Micrurus*.

The Year 2010 is considered as index as the last national census took place in that year [12] for the calculation of the snakebite incidents in the Brazilian state. The distribution of these incidents was analyzed using a box-plot graphic [13]. In addition to this, state wise maps marking the distribution of incidents and cases by state for the year 2010 were created. The Northern region was considered as the reference standard for determining the relative risks (CI_{95%}) for the occurrence of snakebites by age group for all regions.

Results

Between 2001 and 2012, 329,180 cases of snakebite were reported in Brazil. The average snakebite incidents for the past twelve years were around 27,000, indicating an average annual increase of 4.1% per year. More than 30,000 cases had been registered for treatment during the year 2009, 2010 and 2011. The 2012 data are subject to revision.

The data reveals the number of snakebite incidents over the years. It can be seen that there occurred an increase in the number of cases reported in all regions of Brazil (Figure 1).

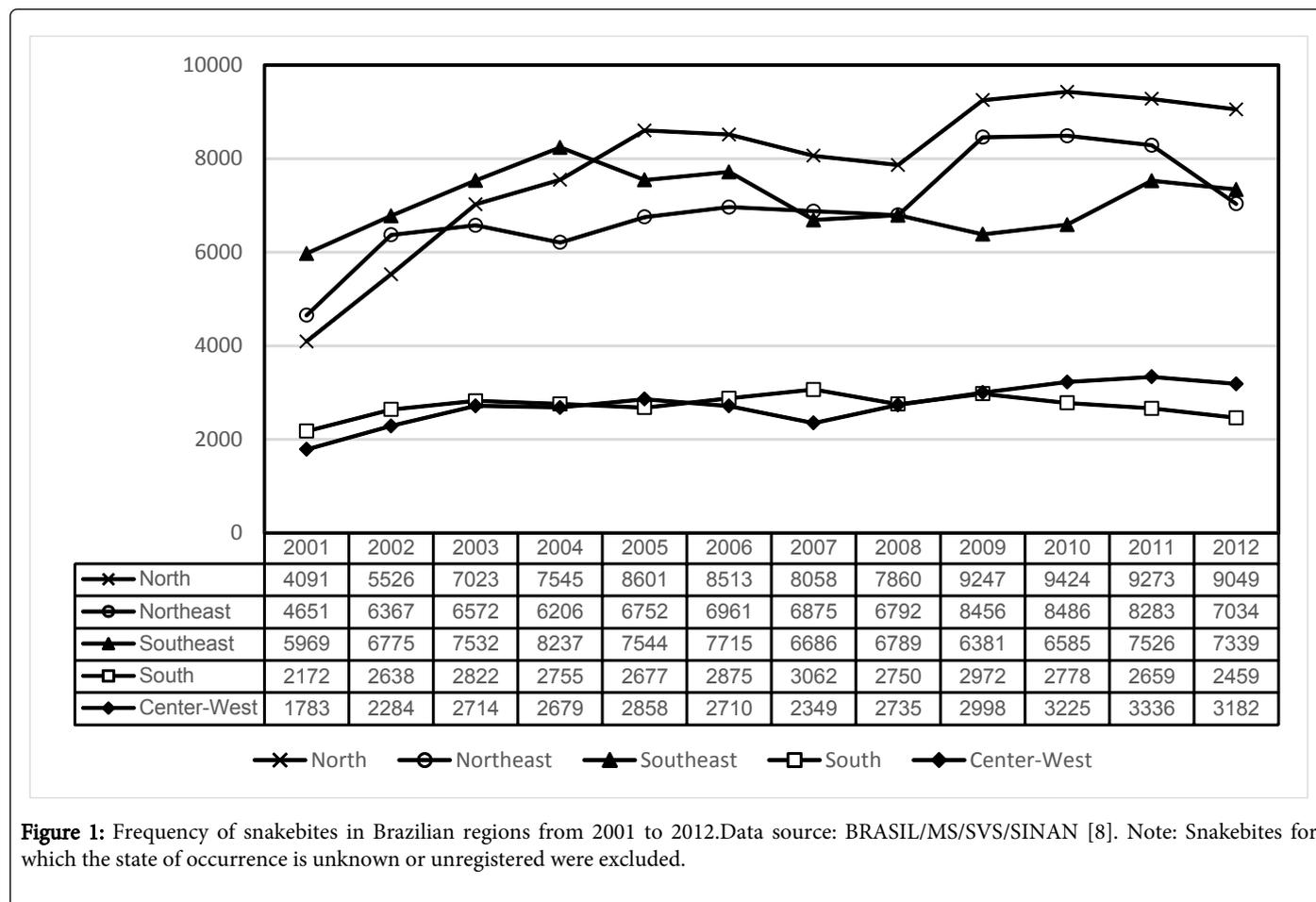


Figure 1: Frequency of snakebites in Brazilian regions from 2001 to 2012. Data source: BRASIL/MS/SVS/SINAN [8]. Note: Snakebites for which the state of occurrence is unknown or unregistered were excluded.

When we look at the region wise snakebite incidents, the Northern region (7.5%) lead the number of cases registered followed by the Center-West (5.4%), Northeast (3.8%) and Southeast (1.9%) regions. The South region showed the lowest average annual of increase, 1.1%

The highest number of incidents were observed during 2010 in the North, (59.4/100,000 inhabitants), followed by the Center-West, (22.9/100,000 inhabitants), and the Northeast, (16.0/100,000 inhabitants). In the South and Southeast regions the incidence rates remained below the national average (16.0/100,000 inhabitants), at 10.1/100,000 inhabitants and 8.2/100,000 inhabitants, respectively.

Figure 2 presents the geographic distribution of cases within the Brazilian state. Incidences (Figure 2a) and cases (Figure 2b), referring to snakebites which took place in 2010. It also contains the box-plot graphics to support the manual construction of the class intervals used to color the map. This application of box-plot deserves attention, as it aggregates information relevant to the map.

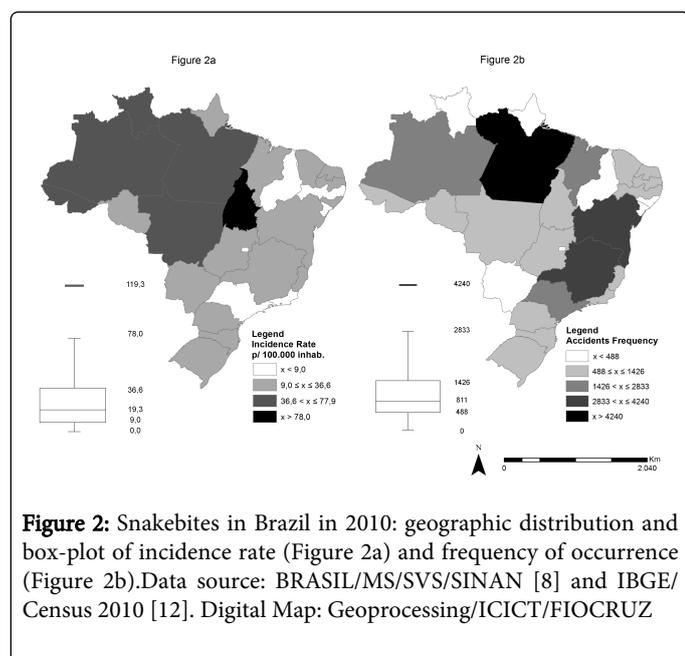


Figure 2: Snakebites in Brazil in 2010: geographic distribution and box-plot of incidence rate (Figure 2a) and frequency of occurrence (Figure 2b).Data source: BRASIL/MS/SVS/SINAN [8] and IBGE/Census 2010 [12]. Digital Map: Geoprocessing/ICICT/FIOCRUZ

Figure 2a shows that the state of Tocantins leads all other states with 79.4 cases per 100,000 inhabitants, exceeding national average (78.0) shown in the box-plot graphic. The lowest number of cases is registered at Federal District (3.5) and in Rio de Janeiro (3.7). The state with the highest number of cases in 2010 was Pará (5,317), while Tocantins, the state with the highest incidence rate, reported 1,099 cases (Figure 2b).

Of all the snakebite incidents recorded in Brazil between 2001 and 2012, Bothropic bites were predominant in all the regions and were responsible for 70.5% cases followed by *Crotalus* 7.5%, *Lachesis* 2.8% and *Micrurus* 0.6%. The genus of the snake was unknown or not recorded in 15.3% of the cases and no traces of poisoning was found in 3.3% incidents. Other genera that were responsible for snakebites mentioned in national snakebite statistics varies widely from region to region.

Except in the Northern region, where *Lachesis* was responsible for 8.7% cases, snakes of the genus *Crotalus* constitute the second major cause of snakebite in all other regions, while *Micrurus* and *Lachesis*

were responsible for less than 1.5% of cases. The proportion of incidents in which the genus of the snake was unknown dropped in the whole country from 19.3% in 2001 to 12.1% in 2012.

The month wise incidents of snakebites during 2001-2012 demonstrated seasonal variations in all regions (Figure 3). With the exception of the Southeast and South that witnessed growth in the frequency, substantial fluctuations were noted related to the number of incidents between the months of greatest and least frequency of cases. The highest number of bite was marked repeatedly during certain months over the years in the Southeast in 2004. While 1,023 incidents occurred in January and almost one third of this number, 344 cases took place in August. The smallest fluctuation took place in the Center-West in 2002, with a maximum of 263 incidents in February and 115 in June. Seasonal variations occurred simultaneously with the growth in the frequency of incidents.

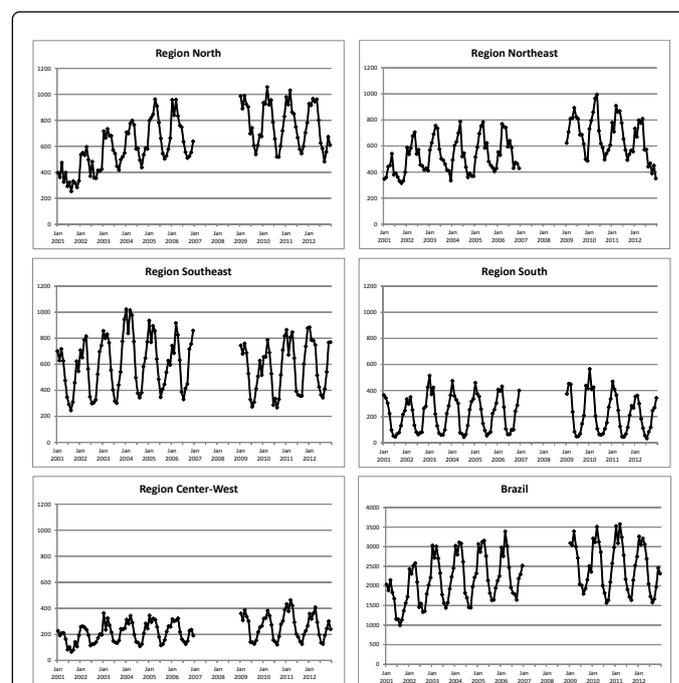


Figure 3: Monthly frequency of snakebites, distributed by Brazilian region, in the period from 2001 to 2012.Data source: BRASIL/MS/SVS/SINAN [8]. Note: The monthly for 2007 and 2008 were not available.

Table 1 shows that 63% of Brazilian snakebite victims were in the age group of 20-59 years. The sum percentages of the children and adolescents between 10 and 19 in the North region (23.2%; CI_{95%} =22.9-23.4%) is statistically higher than those observed in other regions, as its confidence interval does not intersect with the others: Northeast (21.0%; CI_{95%}=20.7-21.3%), Southeast (16.7%; CI_{95%}=16.5-17.0%), South (17.8%; CI_{95%}=17.4-18.2%) and Center-West (17.1%; CI_{95%}=16.7-17.5%). In 2010, the relative risk (RR) for the occurrence of snakebite between 10 and 19 years was varied over the country's five regions. The North demonstrated a RR of 3.08 (CI_{95%}: 2.79-3.39) compared to the Center-West; 3.80 (CI_{95%}:3.57-4.05) compared to the Northeast; 6.58 (CI_{95%}:5.94-7.29) compared to the South and 8.85 (CI_{95%}:8.19-9.56) compared to the Southeast. In the

country as a whole, 53% of victims received medical attention within three hours of the incident, with the exception of the North, at 42%. This statistic remains the same, even when cases are stratified by seriousness.

Region	North		Northeast		Southeast		South		Center-West	
	No	%	No	%	No	%	No	%	No	%
Age group										
<1	957	1.0	883	1.1	843	1.0	231	0.7	258	0.8
1-4	1,817	1.9	1,817	2.2	1,521	1.8	629	1.9	757	2.3
5-9	6,191	6.6	4,541	5.4	3,816	4.5	1,510	4.6	1,709	5.2
10-14	10,270	10.9	7,764	9.3	6,152	7.2	2,738	8.4	2,595	7.9
15-19	11,583	12.3	9,780	11.7	8,092	9.5	3,068	9.4	3,035	9.2
20-39	36,702	38.9	30,380	36.4	30,915	36.3	10,790	33.0	12,217	37.1
40-59	20,706	21.9	20,561	24.6	25,235	29.6	10,193	31.2	9,324	28.3
60-64	2,631	2.8	2,979	3.6	3,487	4.1	1,480	4.5	1,266	3.8
65-69	1,680	1.8	2,102	2.5	2,362	2.8	950	2.9	819	2.5
70-79	1,449	1.5	2,046	2.4	2,283	2.7	910	2.8	740	2.2
≥ 80	355	0.4	686	0.8	511	0.6	177	0.5	168	0.5
Ignored	13	0.0	20	0.0	17	0.0	4	0.0	4	0.0
Sex										
Male	74,739	79.2	63,238	75.7	65,521	76.9	24,470	74.9	25,443	77.4
Female	19,590	20.8	20,273	24.3	19,661	23.1	8,194	25.1	7,431	22.6
Ignored	25	0.0	48	0.1	52	0.1	16	0.0	18	0.1
Classification										
Mild	44,174	46.8	44,444	53.2	42,608	50.0	16,701	51.1	15,098	45.9
Moderate	36,978	39.2	26,172	31.3	30,328	35.6	12,154	37.2	12,349	37.5
Severe	5,921	6.3	5,401	6.5	6,791	8.0	2,618	8.0	3,371	10.2
Ignored	7,281	7.7	7,542	9.0	5,507	6.5	1,207	3.7	2,074	6.3
Time										
0 to 1 hour	12,719	13.5	14,899	17.8	31,055	36.4	14,921	45.7	9,820	29.9
1 to 3 hours	26,411	28.0	29,240	35.0	31,432	36.9	11,204	34.3	12,096	36.8
3 to 6 hours	21,719	23.0	16,541	19.8	9,137	10.7	2,622	8.0	4,855	14.8
6 to 12 hours	13,134	13.9	6,967	8.3	3,169	3.7	970	3.0	1,844	5.6
12 and over	13,523	14.3	6,977	8.3	3,455	4.1	1,380	4.2	1,896	5.8
Ignored	6,848	7.3	8,935	10.7	6,986	8.2	1,583	4.8	2,381	7.2
Evolution										
Healing	79,189	83.9	71,706	85.8	75,214	88.2	30,228	92.5	28,638	87.1
Healing with the sequel ¹	934	1.0	559	0.7	645	0.8	247	0.8	265	0.8
Death ²	484	0.5	483	0.6	243	0.3	66	0.2	189	0.6

Ignored	13,747	14.6	10,811	12.9	9,132	10.7	2,139	6.5	3,800	11.6
Total	94,354	100.0	83,559	100.0	85,234	100.0	32,680	100.0	32,892	100.0

Data source: BRASIL/MS/SVS/SINAN [8]
 Note: ¹Available data from 2001 to 2006. ²For the years from 2007 to 2012 deaths by snakebite are added with injury deaths from other collateral causes.

Table 1: Number and percentage of snakebites distributed by Brazilian region, age group and sex of the victim, severity classification, time elapsed between snakebite and administration of medical care and case evolution. Brazil: from 2001 to 2012.

Genus of the serpent	Classification	Time elapsed between snakebite and administration of medical care					Total
		0 to 1	1 to 3	3 to 6	6 to 12	12 and over	
<i>Bothrops</i>	Mild	52.2	49.3	44.9	42.1	39.9	47.8
	Moderate	36.2	38.7	41.7	42.7	41.3	39.2
	Severe	6.3	6.4	7.3	8.7	12.6	7.3
	Ignored	5.3	5.6	6.0	6.5	6.1	5.7
	Total	100.0	100.0	100.0	100.0	100.0	100.0
<i>Crotalus</i>	Mild	46.8	41.7	35.7	31.9	29.2	40.7
	Moderate	38.7	40.5	41.4	38.2	35.1	39.5
	Severe	8.8	12.5	17.3	24.2	30.3	14.3
	Ignored	5.7	5.3	5.5	5.8	5.4	5.5
	Total	100.0	100.0	100.0	100.0	100.0	100.0
<i>Micrurus</i>	Mild	46.6	42.8	45.1	47.7	50.4	45.4
	Moderate	22.4	27.9	24.4	30.0	26.8	25.4
	Severe	23.6	21.7	24.9	14.6	18.1	22.2
	Ignored	7.4	7.6	5.6	7.7	4.7	7.0
	Total	100.0	100.0	100.0	100.0	100.0	100.0
<i>Lachesis</i>	Mild	45.4	38.2	37.1	35.7	34.5	37.9
	Moderate	41.0	48.2	48.6	47.7	47.8	47.2
	Severe	6.1	6.7	6.5	10.1	10.4	7.8
	Ignored	7.5	6.9	7.8	6.6	7.3	7.2
	Total	100.0	100.0	100.0	100.0	100.0	100.0
Nonvenomous	Mild	91.0	91.6	91.1	87.9	87.9	90.8
	Moderate	3.1	3.5	3.7	3.1	5.2	3.5
	Severe	0.3	0.2	0.2	1.3	1.1	0.4
	Ignored	5.6	4.7	5.0	7.8	5.7	5.3
	Total	100.0	100.0	100.0	100.0	100.0	100.0

Data source: BRASIL/MS/SVS/SINAN [8]

Table 2: Percentage distribution of snakebite severity, showing genus of snake and time elapsed between the occurrence and administration of medical care in Brazil, from 2001 to 2012.

Table 2 shows that snakes of the genus *Micrurus* are responsible for the greatest proportion of serious cases, independently of time elapsed until medical attention arrives. For the genus *Crotalus*, there was a high correlation observed between incidents classified as serious and delays in receiving medical attention ($R^2=0,9957$).

Discussion

Despite the fact that the data for the years 2011 and 2012 are constantly undergoing revisions and updates within the Information System on Diseases Compulsory Declaration (SINAN), the available data allows a deep, unprecedented and wide-ranging analysis.

The observed annual average rate of incidents makes it possible to affirm that the most recent estimate of the Ministry of Health quoting only 26,000 cases of snakebite for the year 2010 [3] is an underestimation by at least 4,000.

The observed growth in the number of incidents in all the regions between 2001 and 2004 can be attributed not only to a greater occurrence of snakebites, but also to improvements in the Brazilian health information system that tried to document the incidents while providing improved access to health services for victims.

The distinct reduction in the frequency of incidents in the Southeast region in the period from 2005 to 2009 does not appear to be as a result of any preventive measures. It merits a study to determine if there was a reduction in access to health services (which could have reduced the number of victims recorded by the information system) and/or environmental changes, which might have reduced the snake population as a consequence. There was a curve inversion with a growth trend after 2010.

In some states, snakebites represent a significant noticeable health issue for medical services. It is the third most reported medical issue in Tocantins, after dengue and leprosy, and the second most reported in Pará, exceeded only by dengue [14].

Waldez & Vogt [15] report that the highest incidences of snakebites for the Center-West region (33/100,000 inhabitants), followed by the North (24/100,000 inhabitants). The data analyzed in the present study allows for an inversion in the order of these two regions. The states bordering the Amazon Forest and the Pantanal (Acre, Amazonas, Pará, Roraima and Tocantins in the North region and Mato Grosso in the Center-West region) are those, which showed the highest frequency of cases in 2010. The low rates observed in the states of São Paulo and Rio de Janeiro (Southeast region), Paraná (South region), Piauí, Pernambuco and Sergipe (Northeast region) and the Federal District (Center-West region) demonstrate that, an analysis which contains a breakdown by region is important, but it is insufficient to fully explain the phenomenon of snakebite. Urbanization leading to concentration of significant human population reduces the risk of exposure to the snakebite. It is an important factor to note that mechanization of agriculture is also reducing the exposure of rural workers from snakes. Both these factors may contribute to an explanation of the low rates in the Southeast and Southern regions of the country. This logic, however, is not adequate in the case of several states of the Northeast regions. It is likely that difficulties in accessing health services and problems in reporting might have contributed to underreporting.

The high rate of Bothropic incidents may be explained by the enormous capacity of these snakes to adapt to a range of environments, allowing them to equally inhabit in forested areas or

those which have been cleared and occupied by humans. Urbanization in Brazil has led to increased physical closeness of the Bothropic group of snakes to areas densely populated by humans. The precarious nature of the infrastructure in these new urban areas has contributed to proliferation of rodents and other pests which are the preferred prey of these snakes [16]. Urban centers, whether in substandard settlements on the peripheries of cities, or in more affluent neighborhoods alongside areas of natural preservation, offer shelter for snakes. It may be said that parallel to the traditional rural snakebite issue, the conditions have been nurtured for a phenomenon called "urbanization of snakebites".

The concentration of incidents involving snakes of the genus *Lachesis* in the North region is due to the fact that this type of snake lives predominantly in the tropical forests, thus favoring the higher frequency of cases in the region which contains the Amazon [17]. It should be noted that each species of snake is geographically distributed in a particular region and pose challenges to the health-care teams in the identification of the species by attending the victims at various regions of Brazil. Nevertheless, there is an observed tendency in the last few years of the period studied towards a reduction in the proportion of incidents reflecting an improvement in the capacity of healthcare personnel to identify the snake genus, either by mere description given by the victim, or based on the symptoms. Strategies have been developed to assist with identification, such as the establishment of protocols based on the manifested symptoms of the victim, which aid in identifying the type of poisoning and, consequently, in guaranteeing the administration of the appropriate anti-venom [5,18-19]. Another recent strategy is, taking advantage of the advancements of information technology, which provides direct access to snakebite specialists, so that the healthcare teams could attend the victims efficiently.

The monthly frequency of snakebite incidents throughout the period 2001-2012 shows the presence of seasonal variations in the temperature and rainfall in all regions, with the strong influence of periods of rain/dry weather in the North and Northeast regions and of temperature variations in other regions. The snakes are most active in the hot and humid months which correspond to the higher incidence of snakebites. Also to be taken into consideration is the degree of exposition implicit in human activities related to agriculture and ecotourism.

Although incidence rate is an important parameter in the analysis of snakebites, the total number of cases should not be neglected, since it informs policy concerning the production and distribution of antivenom in the country. Seasonal variations suggest the need for concern about the guarantee of antivenom supply, keeping the fluctuations in view related to the number of cases in each region. The production of sufficient serum to deal with the average annual number of cases need not necessarily guarantee its availability during the months when the majority of snakebites take place. Large fluctuations in the number of incidents could generate temporary shortages of serum which might not be detected in an analysis based on average values. A recent study by Machado [5,18] points to a high frequency of cases involving the genus *Crotalus*, but with the number of doses of serum used below that recommended by the Ministry of Health. One possible explanation for this may be the smaller number of doses available in certain periods, a hypothesis which demands further investigation.

The social and environmental variations between regions are reflected in the observed differences in the time elapsed before medical

attention is received for young people between 10 and 19 years of age, and in the evolution of the case. In the South and Southeast, 79.9% and 73.3% of the victims, respectively, received medical attention within three hours. These numbers reflect the better quality of transportation networks and health services in those regions. The higher relative risk to which young people in the North are exposed may be due to their entry at an early age into the rural job market, especially in extractive industries, which tend to exhibit the highest prevalence of snakebites [20-22].

Aspects like the species of the snake, the age of the victim, the site of the bite, and the time elapsed until medical attention is given, are determinants of seriousness and lethality.

Lethality in general is low, in the Northeast and Center and Western regions and a high percentage of them are curable with after-effects. This is due to variety of causes, such as better healthcare access, quality of care, information about the steps to be taken in the event of a snakebite, and the genus of the snake. It is worth noting that snakes of the genus *Micrurus* are not an aggressive species, and not possessing specialized teeth for venom delivery. The data related to states do not permit an estimation of the underreporting of snakebites which must inevitably take place, especially in the North, where low population density, precarious nature of transportation and huge distances to be traveled are acting as hurdles for victims in accessing health services. Nevertheless, the hypothesis should be raised that the growth in the number of reported incidents may be the result of both improvements in the access to the healthcare services, improving the quality of record keeping.

Current information systems have already produced a large quantity of data, which makes possible an updating of the profile of snakebite in Brazil. Despite this, information is lacking in all the areas as most of the fields are not properly filled and recorded for each snakebite incident so that it is not available on the SINAN site. Such information ought to be shared better and used to support the planning and decision-making process through the entire chain related to the production, storage and distribution of antivenom serum, as well as the education, training and maintenance of teams specialized in the treatment of snakebite. The differing patterns of snakebite presented by Brazil's various regions suggest that studies of snakebite should make use of disaggregated data, which will permit the incorporation of existing environmental and socio-economic peculiarities into analysis of this serious health issue.

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