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ORIGINAL ARTICLE

Snakebites envenoming in the State of Minas Gerais between 2017 and 2022: an epidemiological analysis

Acidentes ofídicos em Minas Gerais: uma avaliação epidemiológica entre 2017 e 2022

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ABSTRACT

Introduction: Snakebites are life-threatening injuries that need quick intensive care. Minas Gerais has one of the highest incidences of Snakebites in Brazil. The main problems related to snakebites are underreporting and treatment delay. **Objective:** This study aims to analyze epidemiological data from 2017 to 2022 about snakebites in Minas Gerais. **Methods:** Data were taken from the "Sistema de Informação de Agravos de Notificação" (SINAN) linked to "DATASUS" about SB in MG. Chi-Square and Mann-Whitney tests were used to conduct the statistical analysis. **Results:** There were 19395 cases of snakebites in Minas Gerais between 2017 and 2022, with an average of 3333 accidents per year, with an incidence of 15.60 cases for every 100000 inhabitants per year, and a lethality rate of 0.33%. Men (74.89%) and Brown (53.18%) were the most attacked sex and race, respectively. The total number of deaths was 64, with an average of 9.5 per year. There was a correlation between the genus and the outcome of the accident (p=0.002), with *Bothrops* being the most frequent. Additionally, there was a greater incidence between October and March (p=0.045). Time to medical attention greater than 6 hours had an odds ratio (OR) of 6.10. **Conclusion:** Snakebites in Minas Gerais shows some stability during the analyzed time frame, with increasing numbers until 2020 and a drop afterwards. There was no clear trend related to the deaths reported, but time between SB and treatment showed a positive correlation on the case outcome.

Keywords: Snakebites; Tropical medicine; Epidemiology, Descriptive.

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RESUMO

Introdução: Acidentes ofídicos são ferimentos potencialmente fatais que exigem cuidados imediatos. Minas Gerais apresenta uma das maiores incidências de acidentes ofídicos no Brasil. Os principais problemas relacionados a essas ocorrências incluem a subnotificação e o atraso no tratamento. **Objetivo:** Este estudo visa analisar dados epidemiológicos de 2017 a 2022 sobre acidentes ofídicos em Minas Gerais. Métodos: Os dados foram extraídos do "Sistema de Informação de Agravos de Notificação" (SINAN) vinculado ao "DATASUS" sobre acidentes ofídicos em MG. Os testes qui-quadrado e Mann-Whitney foram utilizados para a análise estatística. **Resultados:** Foram registrados 19.395 casos de ofidismo em Minas Gerais entre 2017 e 2022, com uma média de 3.333 acidentes por ano, uma incidência de 15,60 casos para cada 100.000 habitantes por ano e uma taxa de letalidade de 0,33%. Homens (74,89%) e pardos (53,18%) foram o sexo e a raça mais atacados, respectivamente. O número total de óbitos foi 64, com uma média de 9,5 por ano. Houve correlação entre o gênero da serpente e o desfecho do acidente (p=0,002), sendo Bothrops o mais frequente. Além disso, houve uma maior incidência entre outubro e março (p=0,045). O tempo para atendimento médico superior a 6 horas apresentou uma razão de chances (OR) de 6,10. **Conclusão:** Os acidentes ofídicos em Minas Gerais mostraram certa estabilidade durante o período analisado, com números crescentes até 2020 e uma queda posterior. Não houve uma tendência relacionada aos óbitos relatados, mas o tempo entre o acidente e o tratamento mostrou uma correlação positiva no desfecho dos casos.

Palavras-chave: Mordedura de serpente; Medicina tropical; Epidemiologia, Descritiva.

Introduction

Snakebite accidents (SB) are characterized by poisoning caused by the inoculation of toxins, through the snakes' fangs, which can cause local and systemic impact, and represent a public health problem worldwide, especially in tropical and subtropical countries, such as Brazil. Minas Gerais (MG) has one of the highest incidences of accidents with venomous animals, including venomous snakes. According to the *Sistema de Informação de Notificação de Doenças*[1] (Information System of Notifiable Diseases - SINAN), in 2019 more than 3,000 cases of SB were registered in the state. Additionally, in 2016, 26,000 SB cases were reported, with 109 fatalities in Brazil[2]. This represents a concern for health services and the general population.

The analysis of SB accidents in Brazil demonstrates a trend that has remained stable over the past century[3]. Such incidents are more frequent at the beginning and end of the year. They predominantly affect male individuals aged between 15 and 49 years who are engaged in rural activities[1]. The lower extremities are most commonly affected[4]. Notably, approximately 85% of notifications of SB accidents reported to the Ministry of Health are associated with the *Bothrops* genus, while only 8,9% are attributed to the *Crotalus* genus[5]. However, in the northern and central regions of the state of São Paulo, the proportion of accidents caused by *Crotalus* snakes increases to 20%, the highest rate in the country[3].

SB have a higher prevalence in poorer populations living in rural areas, mainly men who work in the field and fishermen[6]. These areas are usually distant from qualified health centers, which makes it difficult to attend and treat victims, as well as to notify the health system about these cases[2]. It is important to highlight that delays of 6 hours or more in medical care are directly related to a worse prognosis for patients[7], which makes the preparation and organization of the health system to attend to the affected population essential.

It is important to highlight that SB are considered a neglected tropical disease[8]. The World Health Organization (WHO) created some strategies in order to reduce the number of deaths and disabilities due to these accidents by 2030[9]. Therefore, periodic analyses of the current scenario at both the national and state levels are needed to determine if current policies are effectively achieving the WHO goal. The objective of this study is to verify the epidemiology of the occurrence of SB in MG and identify patterns and trends in the accident rate data.

Methods

In this cross-sectional and ecological study, data were collected using the *Sistema de Informação de Notificação de*

Doenças (Information System of Notifiable Diseases) (SINAN-NET)[1] linked to DATASUS for all snakebite accidents between 2017 and 2022. Demographic data were obtained from the Brazilian Institute of Geography and Statistics (IBGE)[10] and used were used to calculate incidence coefficients. The data studied in relation to accidents occurring in the state of MG included seasonality (epidemiological variables); ethnicity and sex (social variables); and the time between the bite and medical care. The accidents investigated include those involving *Bothrops, Crotalus*, *Micrurus*, and *Lachesis* separately, as well as the unidentified and non-venomous snakes. Data regarding the presence or absence of serum therapy, its relationship with work accidents, and case outcomes (clinical variables) were also collected.

Statistical analysis

Statistical analysis was performed using the calculators on the Social Science Statistics website[11]. The Chi-Square test was used to examine the association between the categorical variables, namely the social variables, the clinical variables and the time between the bite and medical care. The *p*-value used was 0.05. If an association was found, the *Odds Ratio* (OR) was calculated using a *p*-value of 0.05. The OR is a measure of the strength of association between an event and exposure. The Mann-Whitney test was used to analyze the seasonality of the accidents, dividing the cases between the months of October to December and April to September. The Mann-Whitney test compares the means between two independent groups with the assumption that the data is not in a normal distribution. The null hypothesis consists of: there is no association between the tested variables. The alternative hypothesis consists of: there is an association between the variables.

Results

General overview

The total number of SB between 2017 and 2022 was 19,395. The incidence rate calculated taking into account the partial data from Instituto Brasileiro de Geografia e Estatística (IBGE)[12] in 2022 was 94 cases for every 100,000 inhabitants from 2017 to 2022, or 15.60 cases for every 100,000 inhabitants per year. Among the cases, there were 64 deaths, making up a lethality rate of 0.33%. The remaining 19,331 cases were distributed as follows: 17,592 were cured; 1,732 were ignored or left in blank; and 7 died of other causes.

A higher number of cases was observed in the period from October to March (60.88%) compared to the period from April to September (39.12%), with a positive association by the Mann-Whitney test (p=0.045).

The primary species responsible for the accidents was the *Bothrops* jararaca, with 11,929 cases, representing 61.51% of the total. In second place, the *Crotalus* genus had 3,688 accidents, with 19.02%. Accidents with non-venomous snakes had 1,246 cases, representing 6.42% of the total. The other accidents were caused by snakes of the *Micrurus* genus (168) and *Lachesis* (22), adding up to less than 1%. Cases marked as ignored or left blank accounted for 2,342 of the total.

The main sex affected was Male, with 74.89% of the total. Regarding race, Brown-skinned individuals (53.18%) and White individuals (31.06%) race were the most prevalent. This data is summarized in Table 1.

Table 1. General overview of cases and deaths from snakebites in Minas Gerais from 2017 to 2022.

Variables	Accidents		Deaths	
Accidents' Overview	N	%	N	%
Total	19,395	100%	64	100%
2017	3,328	17.16%	6	9.37%
2018	3,337	17.21%	7	10.94%
2019	3,400	17.53%	15	23.44%
2020	3,472	17.90%	8	12.50%
2021	3,011	15.52%	17	26.56%
2022	2,847	14.68%	11	17.19%
Deaths	64	0.33%	64	100%
Tratament				
Medical attention <6 hours	17,060	87.96%	37	57.81%
Serum Therapy	14,323	73.85%	20	31.25%
Type of snakes				
Bothrops	11,929	61.51%	34	53.13%
Crotalus	3,688	19.02%	23	35.94%
Non-venomous	1,246	6.42%	1	1.56%
Others	180	0,98%	0	0.00%
Overview of the population				
Man	14,524	74.89%	48	75.00%
Race				
Brown	10,315	53.18%	38	59.38%
White	6,025	31.06%	22	34.38%
Black	1,809	9.33%	3	4.69%
Others	292	1.51%	1	1.56%

Results are presented in absolute numbers (N) and percentage values (%).

Deaths

As summarized in Table 1, the overview of the deaths was not much different. There were a total of 64 deaths between 2017 and 2022. Despite the consistency in the number of cases per year, the number of deaths showed a peak in 2019 (15 deaths) and in 2021 (17 deaths).

The main snake involved was of the *Bothrops* genus, with 34 cases, representing 53.13%. In second place, the *Crotalus* genus participated in 23 cases, representing 35.94%. It is also observed that 37 individuals (57.81%) received medical attention within 6 hours, 53 patients (82.81%) received serum therapy, and only 11 cases (17.19%) were work-related accidents.

Analyzing the social variables, the Male sex was the most affected, with 48 deaths, representing 75.00% of the total. The most prevalent race was Brown, with 38 deaths, representing 59.38%, followed by the White race, with 22 deaths, representing 34.38%, and the Black race, with 3 deaths, representing 4.69%.

Association of variables

As shown in Table 2, the results showed revealed an association between the time it took to receive medical attention after the SB and case the outcome (p<0.001), but not between the presence or absence of serum therapy and outcome (p=0.295). For medical attention after 3 hours, the OR was 3.849 (95% Confidence Interval (CI) = 2.287 to 6.478 and p<0.001), taking medical attention in less than 3 hours as a reference. In comparison, for medical attention after 6 hours, the OR was 6.10 (95% CI = 3.560 to 10.4419 and p<0,001), taking medical attention in less than 6 hours as a reference.

After excluding cases and deaths caused by non-venomous snakes, the association between the time from SB to medical care and case outcome remained significant (p<0.001), whereas the lack of association between serotherapy and case outcome also persisted (p=0.637).

The number of cases and deaths in the years before the COVID-19 Pandemic (2017, 2018, 2019) was compared with the data during the pandemic (2020, 2021, 2022). There was no statistical association between the Pandemic and the case outcome (p=0.188).

There was an association between the type of snake and the case outcome. A positive association was found between the *Crotalus* genus and the case outcome, with OR = 7.81 (95% CI 1.054 to 57.916 and p=0.044) compared to accidents involving non-venomous snakes. Compared to accidents with *Bothrops* genus, the OR was 2.196 (95% CI: 1.292 to 3.732 and p=0.004).

Finally, an association was observed between the administration of antivenom and the amount of time that elapsed between the bite and receiving medical care. Patients who received treatment within the first six hours after the incident had an odds ratio of 0.83 for receiving antivenom, compared to those who were treated after this period.

There was no correlation between sex or race and case outcome (p=0.902 and p=0.385 respectively).

Discussion

The profile of SB in MG in the time frame studied is similar to that found in Brazil, where most cases occur with Male and Brown individuals, and the incidence rate is 15.60 cases per 100,000 people per year in MG and 14.70 cases per 100,000 people per year in Brazil[6]. The majority of the cases received medical attention in less than 6 hours, which probably impacted the high percentage of favorable outcomes.

The SB distribution is also similar. *Bothrops* was responsible for most of the accidents, followed by *Crotalus*. *Micrurus* and *Lachesis* were responsible for fewer than 2% of the cases in MG and in Brazil. Nevertheless, MG showed a lower prevalence of *Bothrops* genus, 61.51% in MG compared to 70.89% in Brazil, and a higher prevalence of the *Crotalus* genus, 19,02% in MG compared to 8.04% in Brazil[6]. There was also a much lower *Lachesis* prevalence (0.11% in MG compared to 1.10% in Brazil), probably due to the nature of the snake, given that it lives in areas with higher forest areas[13].

This scenario is likely explained by the fact that the *Bothrops* genus is one of the most abundant in the country and in MG, and also by the predominance fact of Male and Brown population, which contributes to the numbers observed[5,14]. However, there is still a significant portion of cases without recorded information, which may indicate the need for improvements in the registration and monitoring of these accidents[14].

The lethality rates found were lower than the Brazilian average. While Brazil has an overall lethality rate of 0.44%, MG has a lethality rate of 0.33%. That can also

Table 2. Overview of cases divided by time needed for medical attention and statistical analysis.

Medical attention	N of accidents	N of deaths	OR (95% CI)	*p*-value
6 hours cut-off analysis				
<6 hours	17,060	37	1.00	p<0,001
>6 hours	1,609	21	6.10 (3.56 to 10.44)	p<0,001
3 hours cut-off analysis				
<3 hours	14,723	28	1	p<0,001
>3 hours	3,983	29	3.85 (2.29 to 6.48)	p<0,001

Results are presented in absolute numbers and percentage values. Caption: N = Total number; OR = *Odds ratio*; CI = Confidence interval.

be said for the overall lethality rates of *Bothrops* (0.41% in Brazil vs 0.29% in MG) and *Crotalus* (1.03% in Brazil vs 0.62% in MG)[6]. However, the OR for *Crotalus* was significantly higher than for *Bothrops* in both analyses.

A significant increase in the number of SB is observed between October and March. This phenomenon can be attributed to the prevalence of rainy and warm months during this period, in contrast to the period from April to September. As ectothermic beings, snakes show greater activity in conditions of heat and humidity[15]. Besides that, the seasonality of agricultural activities, which are more intense during the months of October to March, also contributes to the increase in cases[16]. Therefore, the combination of these factors results in a higher number of SB during this time of year.

There was no significant difference in the number of deaths and the race of those affected. Although the 2010 census pointed to a higher predominance of the White race (45.4%), followed by Brown (44.3%) and Black (9.2%)[10], there is a much lower prevalence of accidents in the white population, even though it is an expressive population in the total population of the state. The 2022 census does not have information on race distribution by states[12]. Nevertheless, there is a higher number of cases and a higher number of deaths in patients of the Brown race, followed by White and Black, but interestingly this did not translate into a higher lethality rate.

There is a certain consistency in the number of cases per year with an increase in the number of cases from 2017 to 2020, and a subsequent drop in 2021 and 2022. This decline may reflect a significant decrease during the COVID-19 pandemic. A similar phenomenon was observed with dengue, for which cases were markedly underreported during that time[17].

No trend was observed in terms of a decrease or increase in the number of deaths over the years. In addition, as found in the results, no association was observed between the number of deaths and the pandemic years in the statistical analysis.

The only variable that had a significant positive correlation with the case outcome was the time between the bite and the medical attention. Excluding the ignored cases, the p value was less than 0.001. This analysis is in agreement with other records in the literature, which shows the importance of quick medical support for the severity of the cases and patient survival[7,18].

Besides that, it was found that the longer the time to receive medical care, the higher the lethality. For care in less than 3 hours, lethality was 0.19%. The other lethality rates were increasingly higher, up to 2.22% for care over 24 hours. This further reinforces the importance of early care for the best prognosis for the patient. The importance of care before 6 hours is highlighted to maximize the patient's prognosis, since the OR after 6 hours is greater than 6, much higher in comparison with the OR for care before 6 hours.

This cut-off value of 6 hours is also used in other literature. Feitosa et al. (2015)[19] found an odds ratio of 1.73 for severity for patients treated after 6 hours of the bite, in addition to an odds ratio of 2.01 for death. In addition, Souza et al. (2018)[20] analyzed cases of SB in the Amazon, from 2007 to 2015, and also identified a higher risk for death and case severity after 6 hours, increasing even more after 24 hours. In this study, the OR for care after 3 hours was 3.85 and for care after 6 hours was 6.10. These numbers might be higher due to the profile of the cases reported, with a higher prevalence of *Crotalus* and more severe cases. It is also noteworthy that the lower frequency of antivenom administration among patients treated within the first 6 hours after the accident, compared to those receiving care after this period, highlights the importance of early medical intervention for an accurate clinical assessment. A plausible explanation for this finding is that continuous monitoring from the time of the incident enables healthcare professionals to achieve a more precise understanding of the patient's clinical status and prognosis, thus supporting more appropriate therapeutic decisions regarding antivenom use. In contrast, delayed medical care may hinder this initial evaluation, potentially leading to unnecessary antivenom administration.

It is crucial to invest in the training of health professionals so they can correctly identify cases of SB and make accurate notifications. This includes training for species identification and symptomatic recognition, as well as specific training on the importance of notification, classification criteria, and appropriate ways of filling out forms, which are essential to ensure the quality of the collected data, since the epidemiological surveillance system of SB is paramount to identify care failures, correct problems, and improve the quality of reported data. The training in the correct identification of the snake's genus should also be extended to the general population, through educational programs and advertisement.

The analysis of epidemiological indicators and the conduct of internal audits contribute to the improvement of surveillance and care, and can help structuring specific public policies for each area of operation. The focus should be on improving epidemiological surveillance and the flow of care in SB, especially in areas where these accidents are more common. The data analysis also highlighted a direct relationship between care time and case lethality, emphasizing the need for quick and effective intervention to improve patient survival.

However, it is essential to recognize the limitations of the study, such as the underreporting of cases and the great amount

of information ignored or left in blank in the SINAN database, which can mask the true extent of the problem and hinder the association of socioeconomic and demographic variables. Besides that, the total number of cases and deaths is still small to conduct a really strong statistical analysis.

Based on the analysis of the epidemiological data of SB in MG between 2017 and 2022, it was possible to identify significant patterns and trends. The significant positive correlation between the time between SB and medical attention and the case outcome highlights the relevance of response time in the patient prognosis. The direct relationship between time to care and case lethality of the cases underscores the importance of agility in providing adequate medical care, highlighting the need for effective strategies to reduce waiting time and improve the survival of patients affected by SB.

Authors' Contributions:

We describe contributions to the papers using the taxanomy (CRediT) provide above:

Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization & Writing – original draft, review & editing: SCVBK de Salles; LMR de Oliveira. *Project administration, Supervision, Visualization & Writing – original draft, review and editing*: AO Silva; ACA de Azevedo.

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