
EPIDEMIOLOGY OF SNAKEBITES IN THE CATALÃO MICROREGION, GOIÁS, BRAZIL

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ABSTRACT

Snakebites represent a major public health problem, especially in tropical countries such as Brazil. This study analyzed the epidemiology of snakebites in the geographical microregion of Catalão, Goiás, from 2017 to 2023. This is a descriptive, quantitative, and retrospective analysis based on data collection from the Ministry of Health's Notifiable Diseases Information System (SINAN). A total of 273 cases of snakebites were reported, 62.3% of which were bothropic. There was a higher incidence among males (81.3%) and those aged 40-59 years (39.9%). It is noteworthy that 75% of the accidents were non-occupational. Approximately half of the cases were classified as mild (50.4%). The anatomical region of the foot and leg was the most affected. Most victims received medical care within three hours (89.1%), underwent serum therapy (89.2%) and were cured. The municipality of Três Ranchos had the highest incidence of cases (73.26/100,000 inhabitants), while Catalão had the highest annual average (17.4) and the highest percentage of occurrence (35.8%). Our study shows that *Bothrops* bites predominate, affecting working-age men, care occurs within three hours, the lower limbs are common, cases are mild with recovery, and accidents are nonoccupational.

KEY WORDS: Snake envenoming; bothropic; public health.

INTRODUCTION

Snakebites represent a global public health problem, particularly in tropical and subtropical regions of Africa, Asia, and Latin America. Considered a neglected tropical disease by the World Health Organization, snakebite affects economically disadvantaged populations in rural, periurban, and urban areas

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(Kasturiratne et al., 2008; WHO, 2019; Freitas et al., 2025). Globally, about 5.4 million people are bitten by snakes each year, with 1.8 to 2.7 million cases of envenomation and approximately 81,410 to 137,880 deaths, in addition to numerous amputations and other permanent disabilities caused by snakebites (WHO, 2019).

In Brazil, more than 27,000 snakebite cases are reported per year, with an annual average of approximately 100 deaths. This corresponds to a national incidence rate of approximately 13 cases per 100,000 inhabitants (Schneider et al., 2021), although the risk of snakebites varies considerably between regions of the country (Schneider et al., 2021). The most recent epidemiological bulletin confirms this trend, recording 32,595 cases in 2023, with an incidence of 15.28/100,000 inhabitants and 143 deaths resulting from snakebites. The North and Northeast regions were responsible for almost two-thirds of all cases in the country. The highest incidence rates for snakebite occurred in Roraima (81.81/100,000 inhabitants), Pará (59.63/100,000 inhabitants), and Acre (51.83/100,000 inhabitants). The Central-West region recorded 3,217 cases of snakebite accidents in 2023, with the State of Goiás reporting the highest number of notifications and deaths in the region: 1,451 cases and 13 deaths, respectively (Brasil, 2024a).

Snakes are reptiles of the order Squamata, which includes 22 families and approximately 4,038 species (Uetz et al., 2020). In Brazil, the snakes that cause poisoning of medical importance include two families: Viperidae and Elapidae, with 34 and 38 species, respectively. The Viperidae family includes three main genus: *Bothrops*, *Crotalus*, and *Lachesis*, while the genus *Micrurus* belongs to the family Elapidae (Guedes et al., 2023; Brasil, 2024b).

The genus *Bothrops* is found throughout Brazil, with 30 species already catalogued in the country. In Brazil, more than 70% of snakebite accidents are caused by these snakes (Brasil, 2024b). In contrast, the genus *Crotalus* comprises only one species in the country (*Crotalus durissus*), which accounts for the second most common cause of envenomation cases. Geographically, they are found in the South, Southeast, Central-West, Northeast, and part of the North Region (Guerra et al., 2023; Brasil, 2024b).

Snakes of the *Lachesis* genus inhabit forested areas, such as the Amazon Rainforest and the Atlantic Forest. These snakes are the largest representatives of the Viperidae family and rank as the third-leading cause of snakebites in Brazil. In contrast, *Micrurus* species cause fewer accidents due to their fossorial behavior and are generally less aggressive toward humans. Nevertheless, envenomation by this genus is typically severe (Bucarety et al., 2016; Strauch et al., 2018; Brasil, 2024b).

Regardless of the type of accident, medical management is guided by the severity of clinical manifestations and the presence of complications. This initial stratification will determine the number of antivenom vials to administer. It is crucial to note that treatment in Brazil is also species-specific,

as different types of antivenom are indicated according to the snake genus involved (*Bothrops*, *Crotalus*, *Lachesis*, or *Micrurus*) (Brasil, 2001; Bucarechi et al., 2016). Therefore, due to the public health and clinical importance, this study investigated the epidemiological profile of snakebite accidents in the microregion of Catalão, Goiás, with the aim of understanding the extent of the problem and providing data for planning health education, surveillance, and prevention programs.

MATERIAL AND METHODS

Study area

The geographical micro-region of Catalão, Goiás, covers an area of 15,209 km² and is made up of 11 municipalities: Anhanguera, Campo Alegre de Goiás, Catalão, Corumbaíba, Cumari, Davinópolis, Goiandira, Ipameri, Nova Aurora, Ouvidor, and Três Ranchos. According to the last demographic census 2022 (IBGE, 2022), the population of this micro-region was 179,509 (Figure 1).

Data collection

Data on snakebite accidents in the geographical micro-region of Catalão, for the period 2017 to 2023, were collected from the Notifiable Diseases Information System (*Sistema de Informação de Agravos de Notificação*, SINAN) of the Brazilian Ministry of Health. The following information was obtained for the study: snake genus (*Bothrops*, *Crotalus*, *Micrurus*, and *Lachesis*), municipalities where the accidents were notified and occurred, sex (male and female), age group (<1 year; 1–4; 5–9; 10–14; 15–19; 20–39; 40–59; 60–64; 65–69; 70–79; and ≥80 years), classification (mild, moderate, severe and ignored), time elapsed between the accident and medical attention (0-1h, 1-3h, 3-6h, 6-12h, 12-24h, >24h), site of the bite, whether the accident was work-related, serotherapy and case outcome (cure, death due to the snakebite, or death from other causes). Only records of snakebite accidents involving venomous snakes from the four genera of greatest public health importance, reported in SINAN between 2017 and 2023, were included. Accidents involving nonvenomous snakes and records outside this period were excluded.

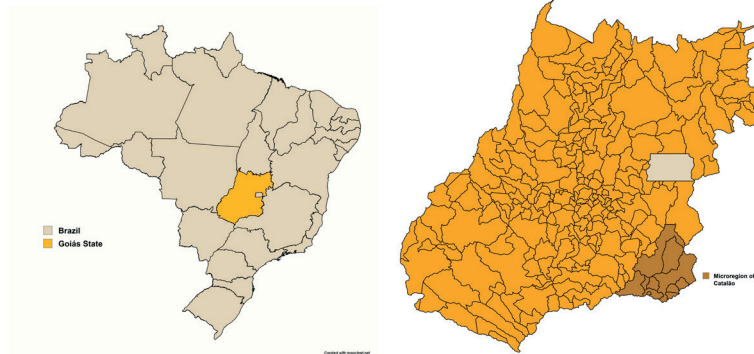


Figure 1. Geographical map of the State of Goiás, Brazil, highlighting the microregion of Catalão.

Data analysis

Statistical analysis was performed using GraphPad Prism software version 5.0. Simple linear regression was used to analyze the distribution of the number of snakebite accidents over the years. The Kruskal-Wallis test with Dunn’s post-test was used to test associations between the variables “time elapsed between the snakebite accident and medical attention” and between the “site of the bite” and the severity of the condition. All tests were carried out at a confidence level of 95% ($p < 0.05$). For each municipality, the incidence rate was calculated based on the municipality of occurrence. It represents the average annual number of cases per 100,000 inhabitants over the study period.

RESULTS

Between 2017 and 2023, SINAN recorded 340 snakebite accidents that occurred in the municipalities of Catalão microregion (Table 1). However, only 273 cases were notified in this region, 62.3% of which were caused by the *Bothrops* genus, followed by *Crotalus* (21.3%) and *Micrurus* (1.5%) (Table 2). There were no reported cases of accidents involving *Lachesis* in the studied region.

Table 1. Snakebite accident by municipality where the accidents occurred between 2017 and 2023: number of cases (*n*), percentage (%), annual average, incidence and work-related cases.

Municipality of occurrence	<i>n</i>	%	Annual average	Population ^a	Incidence rate ^b	Work-related cases	
						Yes	No
Anhanguera	0	0	0	924	0	0	0
Campo Alegre de Goiás	35	10.3	5	7,422	67.4	12	20
Catalão	122	35.8	17.4	114,427	15.2	19	92
Corumbaitaba	35	10.3	5	9,164	54.6	5	29
Cumari	7	2.1	1	2,927	34.2	0	7
Davinópolis	9	2.6	1.2	1,902	67.6	1	6
Goandira	8	2.4	1.1	4,973	23.0	0	7
Ipameri	87	25.6	12.4	25,548	48.6	14	64
Nova Aurora	4	1.2	0.5	2,101	27.2	0	3
Ouvidor	18	5.3	2.5	7,200	35.7	3	14
Três Ranchos	15	4.4	2.1	2,921	73.3	1	13
TOTAL	340	100	48.2	179,509		55* (16.2%)	255* (75%)

Source: Ministry of Health/SVS - *Notifiable Diseases Information System - SINAN Net*. a: calculated using population data based on the Brazilian Institute of Geography and Statistics from the year 2022; b: cases per 100,000 inhabitants. *The remaining 30 notified cases were Blank/Ignored regarding work-related accidents.

A variation in the number of occurrences and notification of cases is justified by the distinction between “municipality of occurrence” and “municipality of notification”, available in the SINAN records. Records indicate that some accidents occurred in the microregion of Catalão, but were notified in a location outside the microregion. Among the municipalities in the microregion, Três Ranchos has the highest incidence of cases (73.3/100,000 inhabitants). Catalão showed the highest absolute number of cases (122; 35.8%), with a mean of 17.4 cases per year. In contrast, Anhanguera municipality recorded no cases. Furthermore, the majority of accidents were not work-related (75%) (Table 1). It was observed that only 46 cases involved agricultural workers. The years 2017 and 2020 showed the highest number of notifications. The statistical analysis did not show sufficient evidence to conclude that there was a downward or upward trend in the number of snakebite accidents over the years ($p>0.05$).

Table 2. Snakebite accidents annually reported from 2017 to 2023 in the Catalão microregion, Goiás, Brazil, classified by snake genus.

Accident year	Ignored/blank	<i>Bothrops</i>	<i>Crotalus</i>	<i>Micrurus</i>	Total
2017	5	42	11	0	58
2018	6	17	10	0	33
2019	3	22	8	2	35
2020	9	22	10	2	43
2021	9	18	8	0	35
2022	5	22	9	0	36
2023	4	27	2	0	33
TOTAL	41 (15.0%)	170 (62.3%) $p = 0.464$	58 (21.3%) $p = 0.0869$	4 (1.5%) $p = 0.7349$	273 (100%)

Source: Ministry of Health/SVS - *Notifiable Diseases Information System - SINAN Net.*

The majority of reported cases occurred in males (81.3%), with the age group between 40 and 59 years (39.9%) being the most affected in both genders. As for the classification of snakebite accidents, 117 (50.4%) cases were considered mild, 88 (37.9%) moderate, and 18 (7.8%) severe (Table 3). The proportion of serious cases involving snakes of the *Micrurus* genus was 0.25 (25%), while that associated with the *Bothrops* and *Crotalus* genera was approximately 0.076 (7.7%) and 0.069 (6.9%), respectively.

Table 3. Classification of snakebite accidents reported between 2017 and 2023 in the Catalão Microregion, Goiás, Brazil by snake genus and clinical severity.

Snake genus	Blank/ Ignored	Classification			Total
		Mild	Moderate	Severe	
<i>Bothrops</i>	5	86 (50.6%)	66 (38.8%)	13 (7.6%)	170 (62.3%)
<i>Crotalus</i>	4	29 (50%)	21 (36.2%)	4 (6.9%)	58 (21.3%)
<i>Micrurus</i>	0	2 (50%)	1(25%)	1 (25%)	4 (1.5%)
TOTAL	9 (3.9%)	117 (50.4%)	88 (37.9%)	18 (7.8%)	232* (100%)

Source: The Ministry of Health/SVS - *Notifiable Diseases Information System - SINAN Net*. * The remaining 41 notified cases were Blank/Ignored regarding the snake genus involved, as described in the Table 1.

Most snakebite victims (89.1%) obtained medical care within three hours post-bite (Table 4). The statistical association showed that the time of medical attention influenced the final classification of the severity of the snakebite accident ($p = 0.0286$ in the Kruskal-Wallis test), however it was not possible to confirm the time interval in which this relationship was most evident ($p > 0.05$ in Dunn's post-test). When calculating the proportion of serious cases according to the time between bite and medical attention, we found 0.39 (39%) within the first hour, 0.5 (50%) between one and three hours, 0.05 (5.5%) between 12 and 24 hours, and 0.055 (5.5%) for 24 hours or more than 24 hours.

Table 4. Snakebite accidents reported from 2017 to 2023 in Catalão Microregion, Goiás, Brazil, by time elapsed between the accident and healthcare, and the clinical severity.

Classification	Time (hours)						Total
	<1	1-3	3-6	6-12	12-24	24 or more	
Blank/ Ignored	2	3	2	1	0	1	9
Mild	72	33	7	2	2	1	117
Moderate	44	32	5	2	5	0	88
Severe	7	9	0	0	1	1	18
TOTAL	125 (53.9%)	77 (33.2%)	14 (6.0%)	5 (2.2%)	8 (3.5%)	3 (1.3%)	232* (100%)

Source: Ministry of Health/SVS - *Notifiable Diseases Information System – SINAN Net*. *The remaining 41 notified cases were Blank/Ignored regarding the snake genus involved, as described in Table 1.

As for the bite location, the anatomical regions most affected were the foot (39.7%) and leg (24.1%), which together accounted for 63.8% of all cases, followed by the hand (9.4%) and fingers (12.3%) (Table 5). Statistical analysis showed no significant association between bite site location and final severity for all snake genus ($p = 0.1571$).

As for serotherapy, 207 (89.2%) reported cases received antiophidic serum, 17 (7.3%) did not receive it, and 8 (3.5%) cases were unknown or blank. Of the total number of snakebite cases, 242 (88.6%) progressed to a cure, with only one death reported, and another from an unrelated cause. In addition, the Catalão microregion had a lethality rate of 0.4% among reported cases.

Table 5. Classification of snakebite accidents reported from 2017 and 2023 in the Catalão Microregion, Goiás, Brazil, by bite site and severity.

Bite site	Classification				Total
	Blank/ Ignored	Mild	Moderate	Severe	
Blank/ Ignored	0	1	0	0	1 (0.4%)
Toes	2	8	6	2	18 (7.8%)
Foot	2	46	37	7	95 (39.7%)
Leg	1	30	21	4	57 (24.1%)
Thigh	0	0	1	0	1 (0.4%)
Trunk	0	0	1	0	1 (0.4%)
Finger	0	14	10	2	22 (9.4%)
Hand	4	15	9	3	29 (12.3%)
Forearm	0	1	1	0	2 (0.9%)
Arm	0	2	1	0	2 (0.9%)
Head	0	0	1	0	1 (0.4%)
TOTAL	9 (5.1%)	117 (51.9%)	88 (37.0%)	18 (6.8%)	232* (100%)

Source: The Ministry of Health/SVS - *Notifiable Diseases Information System - SINAN Net*. * The remaining 41 notified cases were Blank/Ignored regarding the snake genus involved, as described in Table 1.

DISCUSSION

The incidence of snakebite cases varies between countries and between regions within a country, influenced by several factors, such as climate, ecological parameters, biodiversity, and distribution of snakes, population density of snakes, population density, as well as economic activities and types of housing (Otero-Patino et al., 2009). In the geographical microregion of Catalão, there were 340 snakebite accidents between 2017 and 2023, of which 273 were notified in this region. A concrete factor influencing this patient flow is the availability of healthcare services and the distribution of antivenom stocks. Although Catalão serves as a reference hub, other municipalities within the microregion, such as Corumbaíba and Ipameri, also maintain antivenom supplies (Ciatox, 2025). Consequently, victims often seek care at these closer facilities. However, cases requiring more complex care or originating in areas without local stocks may have been transferred and notified in larger centers outside the microregion, reflecting the operational dynamics of the regional healthcare network. The patient flow pattern, influenced by the geographical availability of antivenom, is a documented challenge in the Brazilian healthcare system, where studies indicate that the unequal distribution of antivenoms and access barriers in remote areas may distort reporting and affect the clinical management of cases (Cristino et al., 2021; Isaacson et al., 2023).

During the period analyzed, the epidemiological profile of the Catalão microregion indicated a predominance of accidents caused by bothropic snakes (62.3%), followed by those linked to crotalic snakes (21.3%). Males were the most affected (81.3%), similar to what happens in other regions of the country (Pinho et al., 2004; Ceron et al., 2019; Brasil, 2024a). A previous study on snakebites in the municipality of Catalão, carried out between 2007 and 2016, found similar results. The study reported 213 cases, with the majority of victims male (78.4%), and accidents involving snakes of the *Bothrops* genus were most frequent (37.3%), followed by *Crotalus* (15.0%) (Silva et al., 2020). In comparison, the case distribution pattern between the studies remained the same, but our data showed a greater number of notifications over a shorter period (2017-2023), which reflects the increase in snakebite cases and/or notifications.

The higher rate of snakebite accidents involving snakes of the *Bothrops* genus compared to other species is probably due to the abundance of species, wide geographical distribution, aggressive behavior, and the ability of these animals to adapt to different environments (Da Silva et al., 2008; Bernarde, 2014). The higher incidence in males is related to work activities in the countryside that expose them to these accidents, which men predominantly perform (Lima et al., 2009; Chippaux et al., 2017b; Ciarlino, 2021). In addition, outdoor activities such as fishing, hunting, and extractive activities make certain populations more susceptible to envenomation cases (Costa et al., 2019).

In our study, the number of notifications ranged from 33 to 58 cases per year, with a slight increase in the number of records in 2017 and 2020. However, based on the statistical analysis, we observed that snakebite cases in the region remained without significant variation over the period, with an average of 48 accidents per year. Among the variables that can influence the occurrence of snakebite accidents are climatic conditions, such as humidity and temperature (Costa et al., 2019). There is a significant proportion of cases in the hot and rainy months, which coincides with greater agricultural activity during these periods (Bernarde, 2014; Tavares et al., 2017) where snakes are more active, and prey is more abundant (São Pedro & Pires, 2009).

Concerning the incidence of snakebites per municipality, our study reveals a higher number of cases per 100,000 inhabitants in cities with smaller populations, as observed in the municipality of Três Ranchos, which had the highest incidence of snakebite accidents among municipalities in the Catalão microregion. The municipality of Três Ranchos is primarily a tourism destination, although much of the land is used for farming (Três Ranchos, 2013; Feitosa et al., 2019). Thus, the incidence of snakebite accidents in this municipality is associated with tourism, which may also be influenced by the large number of country houses in the region, as most accidents occurred outside the workplace. Other studies have shown that municipalities with low population density tend to have higher incidence coefficients as they are close to native vegetation (Chippaux, 2017a,b). In Brazil, this ecological risk is confirmed by surveillance data, which identifies the Amazon, Cerrado, and Caatinga biomes as areas with the highest persistent risk of snakebite (Schneider et al., 2021).

As observed in Três Ranchos, other municipalities in Catalão's microregion similarly lacked this direct relationship between snakebite accidents and work activities in the countryside, unlike epidemiological data from other regions, which show higher prevalence among rural workers (Matos & Ignotti, 2020; Ciarlini, 2021). Studies in Amapá and Rio Grande do Norte likewise found no such association (De Brito & Barbosa, 2012; Firmino et al., 2024). Studies show that outdoor activities such as hunting, fishing, and hiking also contribute to these cases (Ciarlini, 2021). Although 48 cases were linked to agricultural work in the Catalão microregion, this number represents a small proportion of the total number of accidents reported. Environmental and socio-economic variables significantly increase the risk of accidents. Proximity to native vegetation and deforestation favors snake presence in inhabited areas (Bastos et al., 2005; Matos & Ignotti, 2020).

In our study, the most affected age group was aged 40 to 59 years. This data shows that snakebite accidents predominate among people aged 20-59, although geographical region and socio-economic characteristics may have an influence (São Pedro & Pires, 2009). In a study in Rio Grande do Norte and Paraíba, victims between the ages of 10-19 were more likely to

be affected, possibly explained by greater participation of people in this age group in agricultural work to contribute to family income, which reflects the socio-economic conditions of these regions (Oliveira et al., 2013; Tavares et al., 2017).

As for the time between the snakebite and medical attention, our data corroborate studies in which victims received medical attention within three hours (Oliveira et al., 2013; Ceron et al., 2019). This proportion of cases treated promptly may reflect the proximity of health services, well-established emergency care protocols, the availability of anti-snakebite serum (Citeli et al., 2018), and the presence of the reference hospital in the region (*Unidade de Pronto Atendimento Dr. Jamil Sebba*) in Catalão, Goiás.

Early care and treatment with antivenom are essential to avoid complications and greater severity (Williams et al., 2019). In our study, the statistical analysis shows an influence between the time of treatment and the severity of the snakebite accident, which is confirmed by other studies (Cardoso et al., 2003). A delay in medical treatment of more than six hours is a consistent risk factor for greater severity and mortality (Feitosa et al., 2015). This risk is quantifiable and increases with time: data show that victims treated between six and 12 hours face a risk 1.4 times higher, and those treated between 12 and 24 hours face a risk nearly 3.8 times higher than victims treated within the first three hours (Tavares et al., 2017). Thus, early treatment and antivenom therapy within three hours, increases the likelihood of cases leading to recovery.

As noted in the study by Tavares et al. (2017), the time taken to receive care is crucial and influences the clinical outcome classification, but a longer time taken to receive care does not necessarily indicate severity. Our data show that most severe cases received medical care within three hours after the bite, likely because the early onset and recognition of severe clinical manifestations prompted faster healthcare seeking. In addition, the administration of the appropriate dose is fundamental to the effectiveness of the treatment (Oliveira et al., 2013).

The majority of snakebite accidents were classified as mild or moderate, with a small percentage of severe cases, as has also been observed in other studies. The statistical association between the snake genus and the severity of clinical condition did not reach statistical significance in our study, but other studies have reported this association, with bothropic and crotalic accidents being more associated with moderate cases, while the lachesic accident manifests itself with high and moderate severity (Tavares et al., 2017). In addition, it is important to consider the implications of the properties of each snake's venom on severity, since the variety of toxins present in venom can trigger different and variable clinical pictures, depending on each species and influenced by factors to which each animal is exposed, such as diet, age, sex of the snake, geographical distribution and seasonality (Moura da Silva et al., 2020; De Godoy et al., 2024).

In addition, it was observed that the majority of reported snakebite accidents in the Catalão microregion occurred in the lower limbs, especially in the foot and leg, as observed in other studies (Lima et al., 2009; Bernarde et al., 2012; Tavares et al., 2017; Citeli et al., 2018). This finding suggests insufficient or inadequate use of personal protective equipment (PPE) and thus highlights the need for basic protective measures such as the use of footwear and gloves in rural activities or ecotourism, as well as educational campaigns to reinforce the importance of preventive care (Brandão et al., 2020; Vasconcelos et al., 2022).

Of the reported cases, the majority of victims received antivenom therapy (89.2%), with favorable outcome (88.6%), and only one death as a result of snake envenomation recorded in the period. The national lethality rate in 2023 was 0.4%, with 0.5% in the Midwest region and 0.9% in the State of Goiás (Brasil, 2023). In comparison, the lethality rate in the Catalão microregion was 0.4%, lower than the state, regional, and national averages, which reflects adequate access to antivenom, public awareness, and preparation of healthcare services in dealing with this health problem. Early health care, raising awareness among rural workers and the general population about prophylactic and therapeutic measures, increasing access to and availability of medical treatment, as well as the proper administration of antivenom, are fundamental factors in reducing the lethality of snakebites (Ceron et al., 2019). The best way to avoid snakebite accidents is through preventive measures and appropriate treatment (Bernarde et al., 2018).

Our study thus reveals an epidemiological profile similar to that of other studies in the Midwest and nationwide. The majority of snakebite accidents involve snakes of the genus *Bothrops*, affecting men in their working years. The victims received medical assistance within three hours, with the lower limbs most affected, and the majority of cases were classified as mild and resulted in recovery. Conversely, it became evident that in all the municipalities evaluated, the majority of accidents were not related to work activities, a finding that requires further studies into environmental and socio-economic variables in order to be explained. Thus, these data represent a public health problem, demonstrating the need to implement care measures, planning, surveillance, and health education actions, with the promotion of preventive measures to reduce the morbidity and mortality of this health problem.

CONFLICT OF INTEREST

There are no conflicts of interest to disclose.

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