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ORIGINAL ARTICLE

Temporal trend in the incidence rate and spatial distribution of spider bite accidents in Santa Catarina from 2011 to 2021

Tendência temporal da taxa de incidência e distribuição espacial dos acidentes por picadas de aranhas em Santa Catarina de 2011 a 2021

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KEYWORDS
Animals Poisonous
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Temporal Distribution
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ABSTRACT

Objective: To analyze temporal trends in the incidence and spatial distribution of spider bites in Santa Catarina. **Methods:** This was a mixed ecological study, with a descriptive approach involving multiple groups and a temporal trend analysis, of spider bite notifications recorded in the Information System for Notifiable Diseases from 1 Jan 2011 to 31 Dec 2021. **Result:** There were 62,671 reported cases, corresponding to an average annual rate of 83.27 per 100,000 population. The linear regression indicated an annual decline rate of 2.94 per 100,000 population. **Conclusion:** There was a high incidence of spider bites, higher than the national average, with a declining trend during the study period. The occurrences were concentrated in the Western and Northern regions of the state, in urban areas. Most victims were young adults. The lethality and mortality rates were low, and most patients had favorable outcomes.

PALAVRAS-CHAVE
Animais Venenosos
Venenos de Aranha
Distribuição Temporal
Epidemiologia

RESUMO

Objetivo: analisar a tendência temporal da taxa de incidência e distribuição espacial de picadas de aranha em Santa Catarina. **Método:** Estudo ecológico misto, descritivo, de múltiplos grupos, e com análise de tendência temporal, das notificações de picada de aranha registradas no Sistema de Informação de Agravos de Notificação, entre 1º de janeiro de 2011 e 31 de dezembro de 2021. **Resultado:** Houve 62.671 casos notificados, o que corresponde a taxa média anual de 83,27 casos/100.000 hab. A regressão linear indicou taxa de queda anual de 2,94 casos/100.000 hab. **Conclusão:** Houve elevada taxa de incidência de picadas de aranhas, superior à média nacional, com tendência de queda no período. As ocorrências se concentraram na Região Oeste e Norte do estado, em áreas urbanas. As vítimas, na maioria, são adultos jovens. A taxa de letalidade e mortalidade foi considerada baixa, e a grande maioria dos casos teve evolução favorável.

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INTRODUCTION

Accidents involving venomous animals represent a significant public health issue in Brazil. Data from the National System of Toxic-Pharmacological Information (SINITOX) have shown that venomous animals are the second leading cause of human poisoning in the country, second only to medication poisoning[1]. These incidents, particularly those caused by the Arachnida class, are global medical concerns and continue to be neglected, particularly in tropical countries. This is due to factors such as irregular deforestation, urban expansion, and population migration, where there is an increasing overlap of spaces shared by humans and venomous animals[2].

Venomous animals are defined as those that possess mechanisms capable of injecting venom or other toxic substances into their prey or predators[3]. The genera of spiders most involved in accidents in Brazil are *Phoneutria*, *Latrodectus*, and *Loxosceles*, which include armed spiders, black widows, and brown spiders, respectively[4].

Spider bites have distinct symptoms, depending on the genus of the animal. Loxoscelism is the most severe type of arachnidism. The bite of a brown spider is almost always imperceptible. The clinical presentation of poisoning appears in two forms: cutaneous or hemolytic, and the complications are divided into local (scarring and secondary infection) or systemic (acute renal failure)[5]. Accidents involving *Phoneutria* rarely lead to complications, and the condition is usually not severe, as the manifestations are predominantly local (pain, edema, and erythema). Finally, an attack by *Latrodectus* presents with local symptoms (pain and burning) or systemic symptoms (motor, cardiovascular, digestive, genitourinary, and ocular)[4].

Due to the widespread distribution of spiders around the world, especially in urban centers, and the high rates of morbidity and mortality from poisoning, healthcare professionals must recognize the specific signs and symptoms of these incidents[6]. It is also necessary to be familiar with the most prevalent species in each region to properly diagnose and treat victims of poisoning[7].

To avoid adverse outcomes, rapid intervention with a patient-specific approach according to the severity of the condition is necessary[8]. Treatment is based on three lines of care: support for vital signs, symptomatic treatment, and specific treatment with antivenom[9]. Therefore, the assessment of poisoning cases is crucial to promote preventive and therapeutic measures, including the provision of sufficient quantities of antivenoms in the locations where they are most needed, aiming to reduce the number of cases and their complications[10].

Temporal trend analyses of accidents involving venomous animals are excellent strategies for analyzing how these phenomena fluctuate in nature, allowing us to verify whether their incidence is decreasing, increasing, or stationary at each location[11]. This study is based on an overview of spider bite accidents in the state of Santa Catarina, Brazil, and the limited knowledge about the temporal trend of its incidence and distribution in the state.Therefore, the objective of this study was to evaluate the temporal trend of the incidence and geographic distribution of spider bite accidents in Santa Catarina from 2011 to 2021.

METHODS

Study design

This is a mixed descriptive ecological study, with multiple groups and temporal trend analysis. Data on spider bites reported in the state of Santa Catarina, Brazil, were recorded in the Notifiable Diseases Information System (SINAN) and analyzed based on the census of all notifications from 1 Jan 2011 to 31 Dec 2021.

Context

The study location was the state of Santa Catarina in the southern region of Brazil, which is divided into six mesoregions: *Grande Florianópolis, Norte Catarinense, Oeste Catarinense, Serra Catarinense, Sul Catarinense, and Vale do Itajaí*, comprising a total of 295 municipalities. The state has a territorial area of 95,730.690 km^2 and a humid subtropical climate. Santa Catarina ranks second nationally in the number of reported spider bite incidents, second only to the state of Paraná.

Participants

All individuals affected by spider bite incidents reported in the 295 municipalities grouped into the nine macroregions of the state of Santa Catarina and recorded in SINAN between 2011 and 2021 were analyzed. The data were extracted from the TABNET Information System via the website of the State Epidemiological Surveillance Directorate of Santa Catarina. Using the SINAN[12] - venomous accidents were selected with filters applied to register the variables of interest, selecting only spider accidents.

Variables

Among the variables of interest for the study, the following stand out Sociodemographic Data: Age, Gender (Male / Female / Unknown), Pregnancy (1st Trimester / 2nd Trimester / 3rd Trimester / Gestational Age Unknown / No / Not Applicable / Unknown), Race/Ethnicity (White / Black / Yellow / Brown / Indigenous / Unknown), Education Level (Illiterate / Incomplete Primary School / Complete Primary School / Incomplete Secondary School / Complete Secondary School / Incomplete Higher Education / Complete Higher Education / Unknown / Not Applicable), Occupation; Accident Data: Investigation Date, Accident Date, Season (Summer / Winter / Spring / Autumn), Municipality of Occurrence, Zone (Urban / Rural / Periurban / Unknown), Time Elapsed from Bite/Medical Attention (0 to 1 hour / 1 to 3 hours / 3 to 6 hours / 6 to 12 hours / 12 to 24 hours / 24 hours or more / Unknown), Bite Location (Head / Arm / Forearm / Hand / Finger / Trunk / Thigh / Leg / Foot / Toe / Unknown), Local Manifestations (Yes / No / Unknown), if local manifestations present (Pain / Edema / Bruising / Necrosis / Other), Systemic Manifestations (Yes / No / Unknown), if systemic manifestations present (Neuroparalytic / Hemorrhagic / Vagal / Hemolytic / Renal / Other), Type of Accident (Phoneutria Bite / Loxoscelism / Latrodectism / Other Spider / Unknown) and Outcome.

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Data sources and measurements

The data were obtained directly or indirectly through the analysis of mandatory notification forms. They were organized and analyzed using Microsoft Excel (Microsoft Corporation, Redmond, Washington). Qualitative variables were described using absolute and percentage frequencies. For temporal trend analysis, the Pearson linear correlation test was applied. The significance level adopted was 5%.

To calculate the incidence rate, the total population of Santa Catarina for each year during the study period was used, as provided by the Brazilian Institute of Geography and Statistics (IBGE) and population estimates from the Department of Informatics of the Unified Health System (DATASUS). The calculations used in this study are described below:

Incidence Rate of Spider Bites:

$$I = \frac{total\ number\ of\ reported\ cases}{total\ population\ of\ the\ state} \times 100,000 \quad (1)$$

Mortality Rate from Spider Bites:

$$I = \frac{total\ number\ of\ deaths}{total\ population\ of\ the\ state} \times 100,000 \quad (2)$$

Case Fatality Rate for Spider Bites (Percentage %):

$$I = \frac{total\ number\ of\ deaths}{total\ population\ of\ reported\ cases} \times 100 \quad (3)$$

For mapping the analyzed phenomenon, the GIS (Geographic Information System) software Quantum GIS – QGIS (QGIS Development Team) and Microsoft Excel were used, with data tabulated on spider bite accidents according to the year of notification and the municipality of residence of the victim. Tables were created to summarize the cases by year and municipality.

The cartographic data used were shapefiles from the official Brazilian cartographic system, based on official data provided by IBGE. Additionally, annual population data from the same institute, published in the respective Official Diary of the Union (*Diário Oficial da União*), were also utilized.

Using QGIS, tables summarizing cases and annual population by municipality were linked based on municipal codes. Subsequently, incidence rates per 100,000 inhabitants were calculated within the same GIS environment. These incidence rates were thematically mapped using the "Natural Breaks (Jenks)" classification. The Natural Breaks (Jenks) statistical method creates a defined set of thematic classes based on natural groupings in the data, grouping similar values to maximize the differences between classes. This method divides features into classes where there are relatively large differences in data values, minimizing the variance within each class (a clustering method). It is suitable for mapping values that are not evenly distributed, as in the phenomenon studied in this work.

Statistical analysis

The analysis of temporal trends was performed using a simple regression model. In this context, the dependent variable corresponded to the incidence of bites from different types of spiders, while the independent variable represented the year of observation. The equation of the regression line was obtained using established statistical methods, providing an elucidative capability regarding the nature and intensity of the inter-variable relationships. The significance of the regression coefficients and intercepts was assessed using ANOVA hypothesis tests, with p-values serving as indicators. The regression coefficient was interpreted as the average annual variation in spider bite incidences, while the model intercept allowed for the estimation of occurrences in the base year. To measure the effectiveness of the regression model in explaining data fluctuations, the coefficient of determination (R^2) was calculated. This metric reflected the proportion of variance in spider bites that the models were able to clarify. A significance level of $\alpha = 0.05$ was defined for the statistical tests. Microsoft Excel 365 was used for statistical analysis.

Ethical approval

This study was approved by the Research Ethics Committee of the University of Southern Santa Catarina (UNISUL) under opinion number 5.829.201, CAAE 65992422.8.0000.0261, on December 20, 2022.

RESULTS

A total of 62,671 reported cases of spider bites in the state of Santa Catarina between 2011 and 2021 were analyzed, corresponding to an average annual rate of 83.27 incidents per 100,000 inhabitants. The year with the highest incidence was 2011, with 97.35 cases per 100,000 inhabitants. Conversely, 2021 had the lowest incidence, with 58.59 cases per 100,000 inhabitants. The annual incidence of spider bite accidents is presented in Figure 1. The linear regression model was applicable as it was statistically significant ($p < 0.05$) and indicated that, on average, each year, the incidence decreased by 2.94 cases per 100,000 inhabitants. When analyzed by spider genus, Phoneutria showed a significant decreasing trend over the period ($p = 0.003$), as did *Loxosceles* ($p = 0.005$) and other spiders, including the genus *Latrodectus* ($p = 0.015$).

Table 1 shows the distribution of cases according to sociodemographic characteristics. Of the total, 602 (0.93%) pregnant women were bitten by spiders. The frequency of bites according to occupation was highest among workers engaged in agricultural activities (9,372; 14.95%), followed by housewives (6,293; 10.04%), students (6,187; 9.87%), and retirees/pensioners (4,481; 7.15%).

Table 2 presents the clinical events related to the accidents. There was a higher incidence of bites on the lower limbs (30,159; 48.12%), with the foot being the most common area, accounting for 16.23% of the reported cases.

Fourteen deaths were reported, with a case fatality rate of 0.02% and a mortality rate of 0.19 per 100,000 inhabitants. Among the types of accidents with

Table 1 – Sociodemographic Characteristics of Spider Bite Victims in Santa Catarina, 2011-2021.

Sociodemographic Characteristics	Notifications	
	n	%
Sex		
Female	31,972	51.01
Male	30,697	48.98
Unknown	2	0.01
Age		
0-9	6,280	10.02
10-19	6,569	10.48
20-34	15,079	24.06
35-49	14,709	23.47
50-64	13,360	21.32
65-79	5,852	9.34
≥80	821	1.31
Race		
White	57,278	91.40
Black	812	1.30
Yellow	247	0.39
Brown	2837	4.52
Indigenous	287	0.46
Unknown	1210	1.93
Education		
No education	580	0.93
Incomplete Elementary School	22,985	36.68
Complete Elementary School	4,967	7.92
Incomplete High School	4,563	7.29
Complete High School	10,657	17.00
Incomplete Higher Education	1,321	2.10
Complete Higher Education	2,435	3.89
Unknown	10,163	16.21
Not Applicable	5,000	7.98
Location of Occurrence		-
Urban	35,245	56.23
Rural	26,025	41.52
Periurban	604	0.97
Unknown	797	1.28
Season		
Summer	21,503	34.31
Autumn	12,278	19.59
Winter	10,341	16.50
Spring	18,549	29.60

Source: DIVE Santa Catarina.

Table 2 – Clinical Events Related to Spider Bite Incidents in Santa Catarina, 2011-2021.

Clinical Events	Notifications	
	n	%
Time to healthcare assistance (hours)		
0-1	14,901	23.78
1-3	12,024	19.19
3-6	5,358	8.54
6-12	2,991	4.77
12-24	6,351	10.13
>24	18,442	29.43
Unknown	2,604	4.16
Location of the bite		
Head	3,211	5.12
Trunk	6,042	9.64
Upper limb	22,631	36.11
Lower limb	30,159	48.12
Unknown	628	1.01
Local manifestations		
Yes	60,214	96.08
No	1,904	3.04
Unknown	553	0.88
Manly local manifestations		
Pain	56,190	89.65
Edema	43,750	69.80
Ecchymosis	11,514	18.37
Necrosis	4,218	6.73
Other	12,715	20.28
Systemic manifestations		
Yes	3,685	5.88
No	57,709	92.08
Unknown	1,277	2.04
Main systemic manifestations		
Vagais	1,262	2.01
Myolytic	486	0.77
Neuroparalytic	475	0.75
Renal	224	0.35
Other	2,238	3.56
Type of accident		
Phoneutriism	9,700	15.48
Loxoscelism	19,771	31.55
Latrodectism	110	0.17
Another spider	25,112	40.07
Unknown	7,978	12.73
Outcome		
Cure	60,503	96.54
Death	14	0.02
Unknown	2,154	2.26

Source: DIVE Santa Catarina.

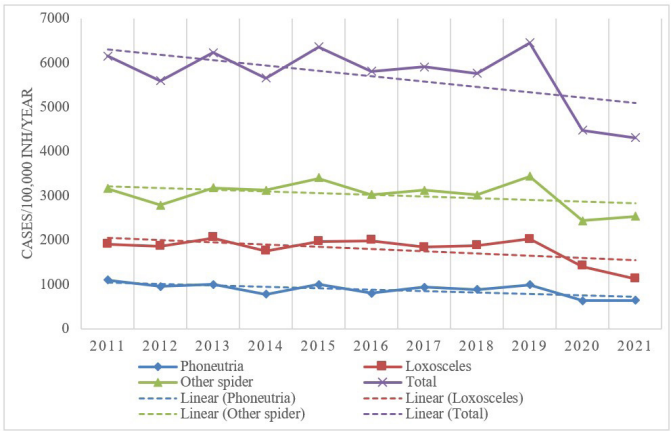

Figure 1 – Temporal trends in spider bite incidence rates in Santa Catarina State, 2011-2021. The solid lines indicate the absolute incidence rates of cases per year. The dotted lines represent the temporal trend based on the regression model and are accompanied by the regression equations.
Source: DIVE Santa Catarina.

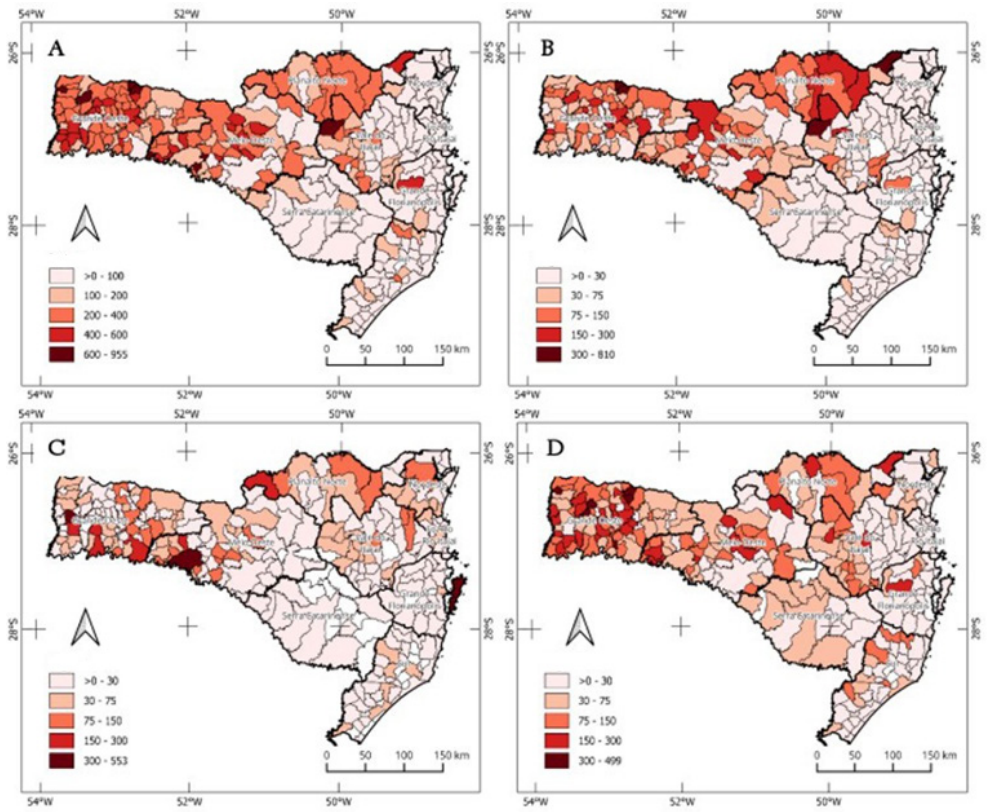

Figure 2 – Choropleth map showing the distribution of the incidence rate of arachnism cases per 100,000 inhabitants, by location of occurrence, in the cities of the State of Santa Catarina – A) General; B) Loxosceles (brown recluse spider); C) Phoneutria (armed spider); D) Others, including Latrodectus (black widow).
Source: DIVE Santa Catarina.

the identified spider genus, the highest incidence of deaths was associated with loxoscelism, with 6 fatalities.

Figure 2 presents the processing of spider bite accident cases in Santa Catarina using choropleth maps. The Northern and Western regions of Santa Catarina had the highest total incidence. The cities with the highest number of accidents were Rio do Campo, located in the Vale do Itajaí region, with an incidence of 955 cases per 100,000 inhabitants,

followed by Galvão and Jupiá, both situated in the Grande Oeste region of the state, with incidences of 860 and 778 cases per 100,000 inhabitants, respectively.

When examining the maps segmented by genus, a similarity was observed in the distribution pattern of accidents caused by *Loxosceles* compared to the total number of occurrences. The most affected cities were Rio do Campo, with an incidence of 809 cases per 100,000 inhabitants, followed by Jupiá and Galvão, with incidences of 569 and 347 cases per 100,000 inhabitants, respectively. Regarding the incidence pattern related to the genus *Phoneutria*, the most affected locations are Lindóia do Sul, Lacerdópolis, and Peritiba, with occurrence rates of 351, 312, and 310 cases per 100,000 inhabitants, respectively. It is worth noting that all these cities are located in the Meio Oeste region of the state. Finally, unidentified accidents or those resulting from *Latrodectus* bites were mainly observed in the Grande Oeste region of the state, with notable cities including Planalto Alegre, Santa Terezinha do Progresso, and Princesa, with incidence rates of 498, 468, and 454 cases per 100,000 inhabitants, respectively.

DISCUSSION

This study found a high frequency of spider bites in Santa Catarina. Although 2021 was characterized as a period of lower incidence from 2011 to 2021, with a rate of 58.59 cases per 100,000 inhabitants, this number still exceeds the incidence rates observed in other Brazilian states. According to the report "Panorama of Spider Bites in Brazil, 2017-2021," the Northeast, Central-West, North, and Southeast regions had lower incidences than the South Region, with a national average of 13.56 cases per 100,000 inhabitants[13]. The high incidence in the South Region may be attributed to a higher number of diagnoses (notifications) or the presence of venomous spider species in the local fauna.

Although the incidence rate remained high, there was a regression in the number of cases over the years, particularly in 2020 and 2021. This decrease may be attributed to the pandemic period when there was less demand for hospital care or cases of underreporting. This hypothesis is consistent with the results of Birkmeyer et al., who assessed the impact of the pandemic on hospital admissions in the United States[14].

It is valid to associate the findings with the occupational dimension and the gender of individuals, particularly regarding the occurrence of accidents caused by venomous animals. The predominance of spider bite accidents occurred primarily among young adults and economically active adults, with a slight predominance in females. A similar finding was observed in a study by Tavares et al., in which most spider bite cases occurred in individuals aged between 20 and 49 years old (51.7%), suggesting that the economically active population of the studied region is the most affected by these accidents[15]. Additionally, Cristiano et al. found a slight predominance of females among spider bite victims[16].

There was a higher prevalence of accidents among housewives and workers involved in agricultural activities, likely because the genera *Phoneutria* and *Latrodectus* are more commonly associated with agricultural activities. These spiders can take shelter in food and supply storage areas, where they can find small prey and hiding spaces[17].

The urban area had the highest incidence of cases possibly because of the greater availability of healthcare services in the region. In rural areas, there is likely a significant underreporting of cases due to the lack of access to these services by local population[16]. Another possible explanation for this phenomenon is related to changes such as urban expansion and consequent population decline in rural areas[18].

Regarding the season of the year, summer has approximately twice as many accidents as winter. The explanation for this higher number during the warmer and wetter months is that spiders tend to leave their hiding places in search of safer and more drier locations near residences. In this context, these animals can cause accidents when they escape or enter people's homes[13].

In relation to the time elapsed between the accident and medical treatment, approximately one-third of patients sought assistance only after 24 h. This delay may be associated with factors such as waiting for more severe symptoms to appear at the injury site and a lack of awareness regarding the importance of early medical care for this type of injury. These findings are consistent with research conducted by Braga et al.[19] in the Northeast region of the country, where, despite geographical and regional differences, a similar trend of delayed medical care after the accident was also observed. Local manifestations were the primary clinical events related to the accident, with the lower limbs, followed by the upper limbs, being the anatomical regions with the highest incidence of accidents. This distribution is likely related to more exposed areas during activities of daily living[17].

Although the southern region of Brazil has a higher prevalence of spider bite notifications, the accidents observed in this study exhibited a fatality rate lower than the national average. Notably, the state of Santa Catarina had the lowest fatality rate among all Brazilian states[13,20]. These results can be attributed to the rapid identification and appropriate treatment of bites, availability of antivenoms and medical resources, and possibly a more efficient notification system than those in other regions. This efficiency may lead to a higher number of recorded cases but less severity.

After conducting a thorough analysis of the choropleth maps, it was found that the Western Region of the state had the highest number of total recorded accident cases. This can be attributed to the region's economic base in terms of agricultural and livestock activities[21], which aligns with the results obtained in this study.

The frequency of accidents caused by *Loxosceles* was higher in the North Plateau region. This distribution may be associated with environmental characteristics, climatic conditions, and demographic distribution. Results from a study in Curitiba (PR) confirmed the presence of *Loxosceles* spiders in the municipality and suggest that these populations are found in built environments as they are more conducive to reproduction and development, due to reduced exposure to weather variations[22].

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This study has some limitations. Because this was an ecological study, it relied on secondary data from aggregated databases, which did not allow for a more detailed analysis of each individual case. The lack of direct access to compulsory notification forms may have also affected the quality of the data. Some variables of interest were not identified. Another issue concerns the potential underreporting of incidents involving venomous animals, which may affect the data presented. Despite these limitations, this study encompasses a large population over an extended observation period, illustrating the relatively unknown reality of spider bites in Brazil. This topic is still underexplored in scientific literature, making this research a valuable contribution to public health research.

CONCLUSION

The state of Santa Catarina, located in the Southern Region of Brazil, exhibited a high incidence of spider bites, exceeding the national average. The occurrences were concentrated mainly in the Western and Northern regions of the state, with a higher incidence in urban areas. Among the three evaluated genera, a variation in the geographic distribution of incidents was identified. Most victims were young adults and economically active, with lower and upper limbs being the most frequently affected sites. The fatality and mortality rates were low, and most patients had favorable outcomes.

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