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ORIGINAL ARTICLE

Epidemiology of clinical complications of accidents caused by venomous animals in Brazil

Epidemiologia das complicações clínicas de acidentes provocados por animais peçonhentos no Brasil

Epidemiología de las complicaciones clínicas de accidentes causados por animales venenosos en Brasil

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ABSTRACT

Background and objectives: Accidents caused by venomous animals, included in the set of Neglected Tropical Diseases, often evolve to local and systemic clinical complications related to increased morbidity and mortality and saturation of health care resources. This study aimed to analyze the epidemiological profile, spatial distribution and temporal trend of clinical complications caused by accidents with venomous animals in Brazil. **Methods**: This is a quantitative, cross-sectional, observational, epidemiological study of the clinical complications of accidents caused by venomous animals reported to the Notifiable Diseases Information System from 2007 to 2019. **Results**: Of the 2,164,645 evaluated notifications, 38,934 cases (1.8%) showed complications. We observed a higher proportion of clinical complications (per 1,000 total cases) among men, Indigenous individuals, illiterates, and victims who received care 24 hours after their accidents, and snakebites. We also found a higher proportion of clinical complications among severe cases (198.8), cases treated with serum therapy (45.7), and those that resulted in death (41.8). The annual incidence of complicated cases increased, especially in the Brazilian Southeast region (+67.2%). The proportion of clinical complications is more worrying in the states of Amazonas, Rondônia, Amapá, and Pará. **Conclusion**: This study found a higher proportion of clinical complications among men, Indigenous people, illiterates, residents of rural areas, victims of snake bites, those who received late medical and hospital care, those who needed serum therapy, and individuals who had death as their outcome. We found a more severe spatial distribution of the annual incidence of complicated cases in the states of Amazonas, Rondônia, Amapá, and Pará, and that the tendency of the annual incidence of clinical complications increased more sharply in the Brazilian Southeast region.

Keywords: *Animals Poisonous. Epidemiology. Health Information Systems. Public Health Surveillance.*

RESUMO

Justificativa e objetivos: Os acidentes causados por animais peçonhentos, incluídos no conjunto de Doenças Tropicais Negligenciadas, predispõem a evolução de complicações clínicas locais e sistêmicas, relacionadas ao aumento da morbimortalidade e a saturação dos recursos assistenciais em saúde. Têm-se como objetivo analisar o perfil epidemiológico, a distribuição espacial e a tendência temporal das complicações clínicas causadas dos acidentes por animais peçonhentos no Brasil. **Métodos:** Estudo epidemiológico observacional transversal quantitativo das complicações clínicas dos acidentes causados por animais peçonhentos notificadas ao Sistema de Informação de Agravos de Notificação entre 2007-2019. **Resultados:** De 2.164.645 notificações, 38.934 casos (1,8%) apresentaram complicações. Observou-se maior proporção de complicações clínica (por 1.000 casos totais) em indivíduos do sexo masculino, indígenas, analfabetos, atendimentos realizados após 24h e vítimas de ofidismo. Ainda, a proporção de complicações clínicas foi maior entre os casos graves (198,8), os receptores de soroterapia (45,7) e os óbitos (41,8). A incidência anual de casos complicados ascende principalmente na Região Sudeste (+67,2%). A proporção de complicação clínica é mais preocupante nos estados do Amazonas, Rondônia, Amapá e Pará. **Conclusão:** O presente estudo identificou maior proporção de complicações clínicas entre pessoas do sexo masculino, indígenas, analfabetos e moradores de zona rural, cujo acidente ocorreu por picada de serpentes, que tiveram atendimento médico-hospitalar retardado, que necessitaram de soroterapia e que tiveram o óbito como desfecho. A distribuição espacial da incidência anual de casos complicados assevera-se nos estados do Amazonas, Rondônia, Amapá e Pará e a tendência da incidência anual de complicações clínicas ascende mais na Região Sudeste.

Descritores: *Animais Peçonhentos. Epidemiologia. Sistemas de Informação em Saúde. Vigilância em Saúde Pública.*

RESUMEN

Justificación y objetivos: Los accidentes causados por animales venenosos, incluidos en el conjunto de Enfermedades Tropicales Desatendidas, predisponen a la evolución de complicaciones clínicas locales y sistémicas, relacionadas con el aumento de la morbimortalidad y la saturación de los recursos asistenciales. El objetivo es analizar el perfil epidemiológico, la distribución espacial y la tendencia temporal de las complicaciones clínicas causadas por accidentes con animales venenosos en Brasil. **Métodos**: Estudio epidemiológico, observacional, transversal y cuantitativo de las complicaciones clínicas de los accidentes por animales venenosos notificados al Sistema de Información de Enfermedades de Declaración Obligatoria entre 2007-2019. **Resultados**: De 2.164.645 notificaciones, 38.934 casos (1,8%) presentaron complicaciones. Se observó una mayor proporción de complicaciones clínicas (por 1.000 casos totales) en varones, indígenas, analfabetos, cuidados posteriores a las 24 horas y en víctimas de mordeduras de serpientes. Además, la proporción de complicaciones clínicas fue mayor entre los casos graves (198,8), los receptores de sueroterapia (45,7) y las muertes (41,8). La incidencia anual de casos complicados aumentó principalmente en la región Sudeste (+67,2%). La proporción de complicaciones clínicas es más preocupante en los estados de Amazonas, Rondônia, Amapá y Pará. **Conclusión:** Este estudio identificó una mayor proporción de complicaciones clínicas entre varones, indígenas, analfabetos y residentes de zonas rurales, que tuvieron el accidente a causa de mordeduras de serpientes, que tuvieron retrasada la atención médica y hospitalaria, que necesitaban sueroterapia y que tenían la muerte como resultado. La distribución espacial de la incidencia anual de casos complicados se afirma en los estados de Amazonas, Rondônia, Amapá y Pará, y la tendencia de la incidencia anual de complicaciones clínicas se eleva más en la región Sudeste.

Palabras clave: *Animales Venenosos. Epidemiología. Sistemas de Información em Salud. Vigilancia de la Salud Pública.*

INTRODUCTION

The Brazilian Notifiable Diseases Information System (SINAN)[1] recorded 2,691,447 accidents by venomous animals between 2007 and 2022. Such incidents kill more than 500,000 people and cause disabilities in many more every year worldwide.[2]

These accidents violate third-generation human rights as they stem from a compromised environment and the rupture of the ideal of solidarity and socioeconomic equality. Thus, they are included in Neglected Tropical Diseases.[3] Global public health authorities argue that this problem is associated with poverty, precarious public services, health vulnerability, and the hot and humid climate of tropical countries.[4, 5]

This led to the inclusion of these accidents in Brazilian List of Compulsory Notification, in accordance with Ordinance No. 2,472 of August 31, 2010, later updated by the Ministry of Health Ordinance No. 264 of February 17, 2020.[6] SINAN, an important ecological, medical, and economic device since it aggregates public health data,[6] began reporting these occurrences to the Ministry of Health.

Venomous animals have glands that produce toxic substances and mostly enzymatic solutions for defense and hunting,[7] using their teeth, chelicerae, and stingers or by contact.[8, 9] Case courses vary, and they often evolve to local and/or systemic clinical complications.

Out of the diversity of the Brazilian fauna, some venomous animals stand out for the frequency and severity

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of the accidents they cause, such as *Lonomia* caterpillars, which may cause hemorrhagic syndrome; *Bothrops, Crotalus, Lachesis*, and *Elapidae* snakes, which may then evolve to acute renal failure, paralysis, neuroparalysis, and hemorrhage; *Tityus serrulatus* (Lutz & Melo, 1922), *Tityus bahiensis* (Perty, 1833), and *Tityus stigmurus* (Thorell, 1876), whose venom can cause seizures, pulmonary edema, cardiogenic shock, and heart failure; and *Loxosceles* spiders, which can cause cardiac arrhythmias and shock.[9]

Accidents are classified according to their severity, i.e., if they offer clinical conditions with self-limited transient symptoms, prolonged ones, or the risk of death.[10] Thus, victims have several prognoses, including permanent or temporary morbidities and death.

Further evaluating these events is essential to delineate and strengthen strategies to rationalize the distribution of immunobiologicals to affected areas according to their vulnerability – proportional to the qualitative analysis of reports, as per Ordinance No. 1.138/GM/MS of May 23, 2014, and Information Note No. 74/2016 - CGPNI/DEVIT/SVS/MS.[11, 12]

As we recognize its social relevance as a public health problem, this study aimed to analyze the epidemiological profile, spatial distribution, and temporal trend of complications due to accidents by venomous animals in Brazil.

METHODS

This is an individual, quantitative, observational, cross-sectional, and epidemiological study whose assessed population was composed of all reported accidents due to venomous animals in Brazil between 2007 and 2019. Data from the Brazilian Ministry of Health Surveillance Secretariat were collected via SINAN.

All accidents by venomous snakes, scorpions, spiders, caterpillars, and bees in all national federative units were included. The evaluated period was chosen by inserting accidents by venomous animals as neglected diseases from 2007 to 2019 (given the available of data on SINAN). Cases without occurrence site and year and/or showed less than 80% of the chosen analysis variables were excluded.

Analysis variables were divided into a) sociodemographic data (gender, skin color, and educational attainment); b) accident circumstances (geographical area, time elapsed until care administration, attacked anatomical region, accident type, case classification, serotherapy, amount of used immunobiological ampoules, relation with victims' work, and case evolution); and c) occurrence measures (incidence and prevalence of total and complicated cases and the proportion of clinical complications).

The total number of reported cases was individually analyzed and the occurrences that met our inclusion criteria composed a database on Statistical Package for the Social Sciences (SPSS), version 21, by IBM.[13] The consistency and normality of its variable distribution was evaluated by the Kolmogorov-Smirnov test. Variables were then descriptively and statistically analyzed and absolute and relative frequencies and central tendency and dispersion, distributed. The proportion of clinical complications was obtained by multiplying the ratio between the number of complicated cases and the total number of cases by 1,000.

Temporal trend analysis was performed using polynomial regression, which was tested for linear, quadratic, cubic, and exponential models. Our final model depended on statistical significance, the highest coefficient of determination (r^2), and final adequacy in relation to how notifications tended to behave graphically over time. Thus, models whose probability of type-I error (alpha) remained below 5% were considered statistically significant.

Spatial analysis was carried out using TABWIN, version 4.15, maps of Brazil, and adopting Brazilian federative units and municipalities as reference units. This study dispensed with approval from a Research Ethics Committee as it is based on secondary public records which omit personally identifiable information.

RESULTS

Brazil recorded 2,164,645 accidents by venomous animals from 2007 to 2019, of which 38,934 showed some type of clinical complication, totaling 17.9 complications per 1,000 cases.

Illiterates (30.0), Indigenous individuals (48.5), men (21.0), and rural inhabitants (26.6) showed a higher proportion of clinical complications per 1,000 cases. We found more severe complications if victims received care 24 hours or more after the accident (70.5) (Table 1).

Injured legs and *Lachesis* accidents showed complications more often. Our sample highlighted severe cases, those which required serotherapy, and deaths due to accidents with venomous animals.

The temporal trend for the annual incidence of total cases (AITC) decreased in the Brazilian Northeast (-63.36), Southeast (-44.83), and Midwest (-58.18) regions, increasing in the North (+55.78) and South (+16.81) (Table 2 and Figure 1). The annual incidence of complicated cases (AICC) decreased in the North, but increased in the Southeast. We should also highlight the increase in the AICC in Northeast (+9.30%) and Midwest (+56.48%) regions, although we found no statistical significance in the tested models, which showed $p>0.05$, as shown in table 2.

Note that the states of Alagoas, Tocantins, Minas Gerais, and Paraná showed a higher prevalence of total cases, and Amazonas, Rondônia, Amapá, and Pará, the highest proportion of clinical complications (Figure 2).

The percentage of the average use of all immunobiological types to manage cases increased due to case complications, as with anti-*Lachesis* serum (900%) (Table 3).

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Table 1. Distribution of the total number of cases and the proportion of clinical complications in accidents by venomous animals in Brazil between 2007 and 2019 according to sociodemographic and clinical, epidemiological aspects. Brazil, 2022.

	Total cases (%)[a]	Complicated cases (%)[a]	Proportion of clinical complications (per 1,000 cases)
Gender			
Man	1,216,328 (56.2%)	25,602 (65.8%)	21.0
Woman	948,317 (43.8%)	13,332 (34.2%)	14.0
Total	2,164,645 (100%)	38,934 (100%)	-
Skin color			
White	792,628 (42.7%)	16,163 (44.7%)	20.3
Black	118,660 (6.4%)	2,218 (6.1%)	18.6
Asian	16,357 (0.9%)	326 (0.9%)	19.9
Mixed-race	906,137 (48.9%)	16,401 (45.4%)	18.0
Indigenous	20,828 (1.1%)	1,012 (2.8%)	48.5
Total	1,854,610 (100%)	36,120 (100%)	-
Educational attainment			
Illiterate	49,579 (3.6%)	1,492 (5.4%)	30.0
Incomplete 1st to 4th grades	249,899 (18.2%)	6,439 (23.1%)	25.7
Complete 4th grade	127,514 (9.3%)	2,923 (10.5%)	22.9
Incomplete 5th to 7th grades	251,287 (18.3%)	5,227 (18.8%)	20.8
Complete elementary school	111,902 (8.2%)	2,116 (7.6%)	18.9
Incomplete Middle School	116,766 (8.5%)	2,010 (7.2%)	17.2
Complete Middle School	211,528 (15.4%)	3,141 (11.3%)	14.8
Incomplete higher education	23,656 (1.7%)	412 (1.5%)	17.4
Complete Higher Education	42,144 (3.1%)	762 (2.7%)	18.0
Not applicable	186,185 (13.6%)	3,331 (12%)	17.8
Total	1,370,460 (100%)	27,853 (100%)	-
Place of occurrence			
Urban	1,152,485 (55.8%)	13,635 (35.9%)	11.8
Rural	889,237 (43.0%)	23,714 (62.4%)	26.6
Periurban	23,993 (1.2%)	627 (1.7%)	26.1
Total	2,065,715 (100%)	37,976 (100%)	-
Time between accident and care			
0 – 1 hours	923,725 (43.8%)	7,359 (19.3%)	7.9
1 – 3 hours	520,389 (24.7%)	7,318 (19.2%)	14.0
3 – 6 hours	184,675 (8.8%)	4,317 (11.3%)	23.3
6 – 12 hours	85,990 (4.1%)	2,809 (7.4%)	32.6
12 – 24 hours	93,855 (4.4%)	3,636 (9.5%)	38.7
24 or more hours	146,986 (7.0%)	10,374 (27.2%)	70.5
Ignored	153,718 (7.3%)	2,306 (6.0%)	15.0
Total	2,109,338 (100%)	38,119 (100%)	-
Accident site			
Head	126,963 (6.1%)	1,736 (4.5%)	13.6
Arm	117,194 (5.7%)	1,905 (5.0%)	16.2
Forearm	65,638 (3.2%)	1,198 (3.1%)	18.2
Hand	342,096 (16.5%)	4,624 (12.1%)	13.5
Finger	339,605 (16.4%)	3,468 (9.1%)	10.2
Torso	110,528 (5.3%)	2,054 (5.4%)	18.5
Thigh	87,494 (4.2%)	2,710 (7.1%)	30.9
Leg	191,439 (9.3%)	7,195 (18.8%)	37.5
Foot	526,498 (25.4%)	11,222 (29.4%)	21.3
Toe	161,995 (7.8%)	2,109 (5.5%)	13.0
Total	2,069,450 (100%)	38,221 (100%)	-
Cause of accident			
Snakes	366,968 (17.4%)	16,197 (42.9%)	44.1
Spiders	366,510 (17.3%)	11,446 (30.3%)	31.2
Scorpions	1,082,607 (51.2%)	6,128 (16.2%)	5.6
Caterpillars	54,811 (2.6%)	488 (1.3%)	8.9

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Bees	155,868 (7.4%)	1,692 (4.5%)	10.8
Other	87,891 (4.2%)	1,840 (4.9%)	20.9
Total	2,114,655 (100%)	37,791 (100%)	-
Snake genus			
Bothrops	263,473 (81.3%)	12,466 (83.0%)	47.3
Crotalus	28,439 (8.8%)	1,441 (9.6%)	50.6
Lachesis	2,977 (0.9%)	89 (0.6%)	29.8
Elapidae	10,021 (3.1%)	887 (5.9%)	88.5
Other (Non-venomous)	19,015 (5.9%)	132 (0.9%)	6.9
Total	323,925 (100%)	15,015 (100%)	-
Case classification			
Mild	1,724,368 (83.6%)	11,839 (31.7%)	6.8
Moderate	297,334 (14.4%)	17,248 (46.2%)	58.0
Severe	41,669 (2.0%)	8,285 (22.2%)	198.8
Total	2,063,371 (100%)	37,372 (100%)	-
Serotherapy			
Yes	477,532 (23.4%)	21,867 (58.3%)	45.7
No	1,566,791 (76.6%)	15,614 (41.7%)	9.9
Total	2,044,323 (100%)	37,481 (100%)	-
Work-related accident			
Yes	286,061 (15.1%)	10,459 (28.8%)	3.6
No	1,605,809 (84.9%)	25,821 (71.2%)	1.6
Total	1,891,870 (100%)	36,280 (100%)	-
Case evolution			
Cure	1,986,941 (99.8%)	33,195 (95.4%)	1.6
Death	3,426 (0.2%)	1,435 (4.1%)	41.8
Death from other causes	408 (0.0%)	172 (0.5%)	42.1
Total	1,990,775 (100%)	34,802 (100%)	-

a: valid cases.
Source: Information System for Notifiable Diseases, 2022

Table 2. Temporal trend of the annual incidence of total and complicated cases. 2007 to 2019. Brazil, 2022.

Macroregion	Variable	PPV (%)	Model	Trend
North	AITC	55.78	$Y=8.949-0.030X+0.012X2+0.010X^3$	Increasing
			$R^2=0.907$	p<0.001
	AICC	-28.17	$Y=4.734-0.315X+0.009X2+0.005X^3$	Decreasing
			$R^2=0.902$	p<0.001
Northeast	AITC	-63.36	$Y=8.299-0.695X+0.063X^2$	Decreasing
			$R^2=0.942$	p<0.001
	AICC[a]	9.3	NA[b]	NA[b]
			NA[b]	NA[b]
South	AITC	16.81	$Y=9.566+0.154X+0.033X^2$	Increasing
			$R^2=0.703$	p<0.001
	AICC[a]	-14.89	NA[b]	NA[b]
			NA[b]	NA[b]
Southeast	AITC	-44.83	$Y=10.585-0.561X+0.035X^2$	Decreasing
			$R^2=0.875$	p<0.001
	AICC	67.21	$Y=0.712+0.035X+0.002X^2$	Increasing
			$R^2=0.768$	p<0.001
Midwest	AITC	-58.18	$Y=30.530-1.500X-0.120X^2$	Decreasing
			$R^2=0.682$	p<0.001
	AICC[a]	56.48	NA[b]	NA[b]
			NA[b]	NA[b]

Other comparisons showed no statistical significance.
b: not applicable.
PPV: percentage of proportional variation.
IACT: annual incidence of total cases.
AICC: annual incidence of total cases.
Source: Information System for Notifiable Diseases, 2022

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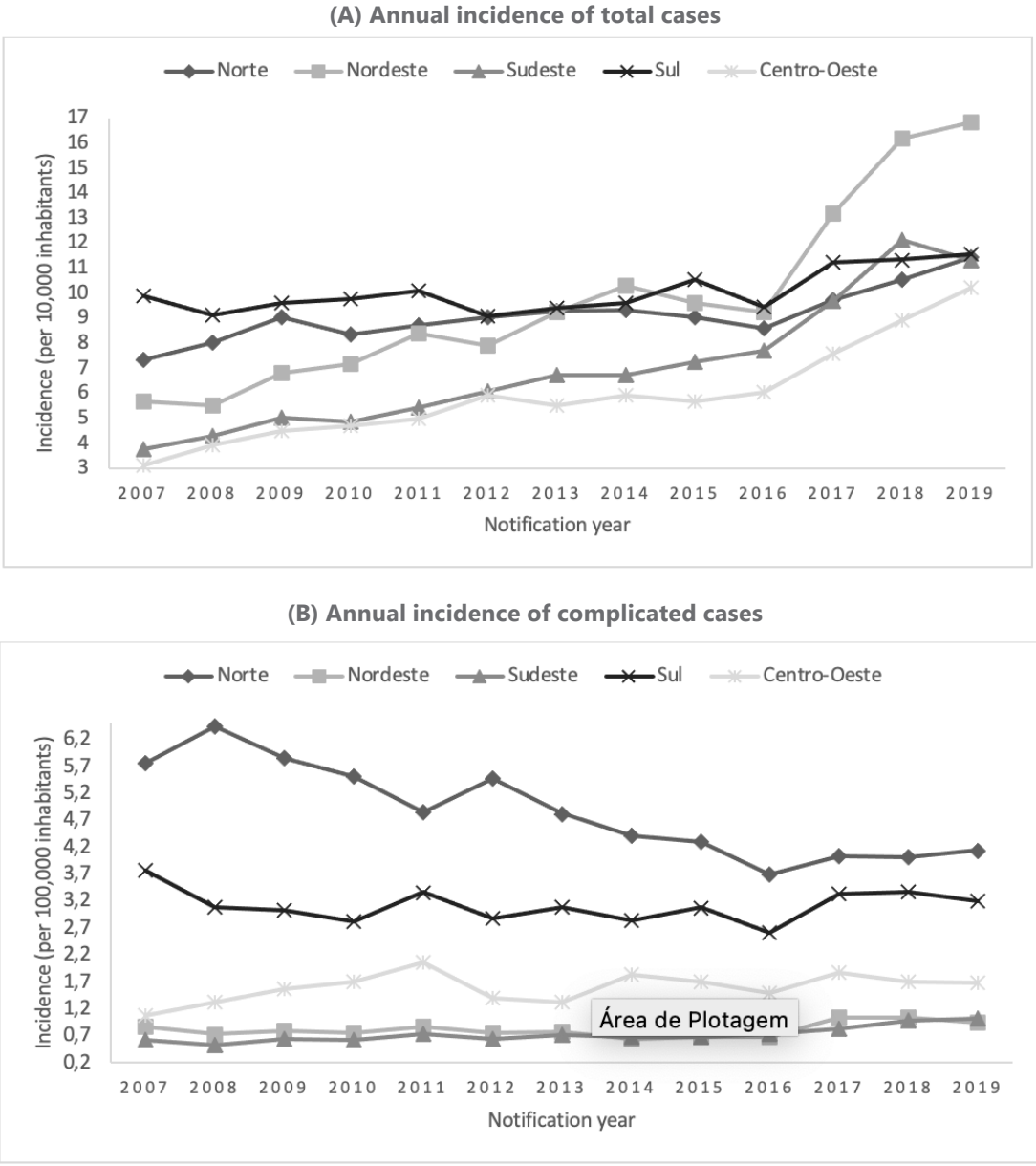

Figure 1. Annual incidence of total and complicated cases due to accidents by venomous animals in Brazil per region and notification year. Brasil 2022.
Source: Information System for Notifiable Diseases, 2022

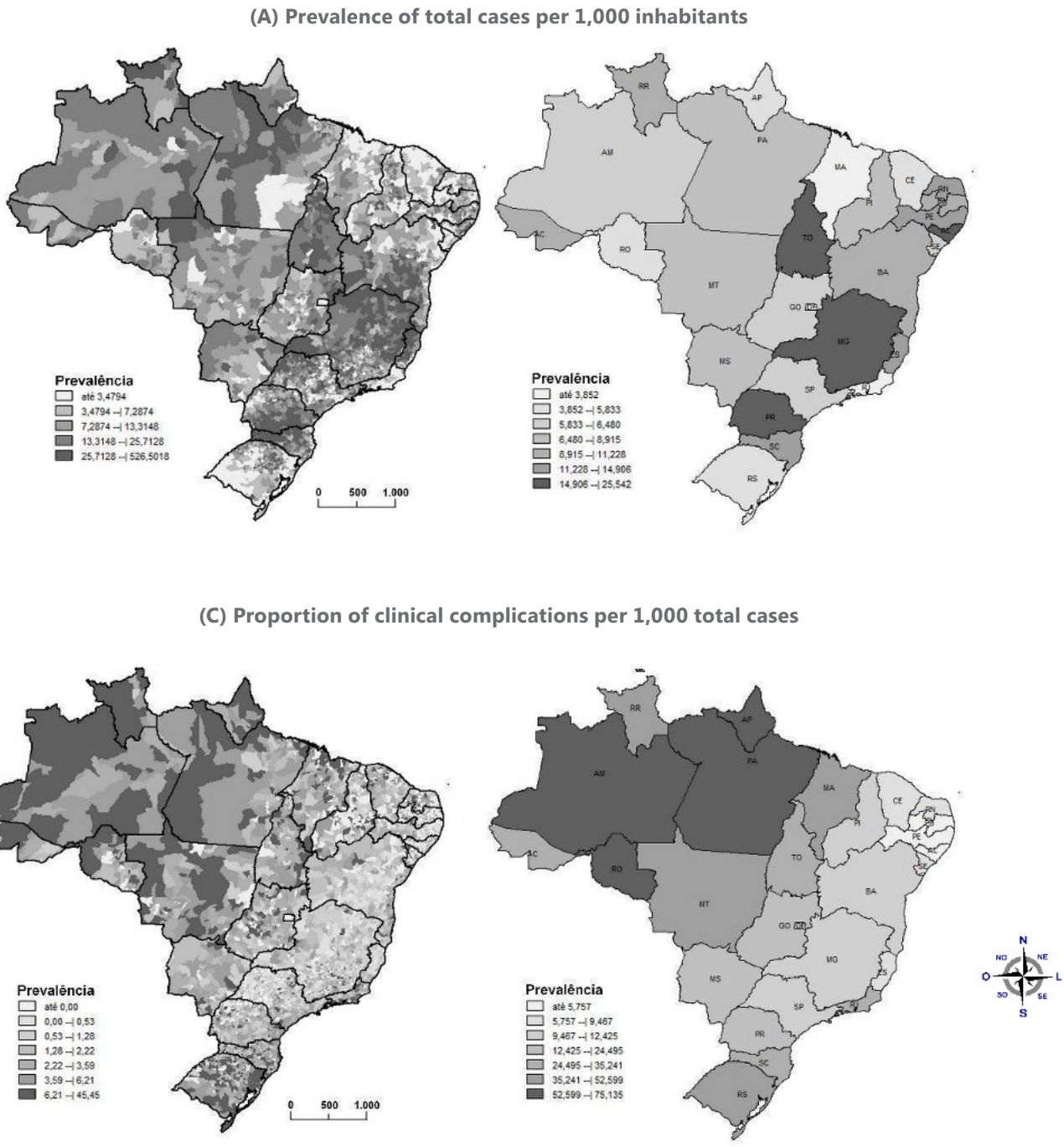

Figure 2. Spatialization of the prevalence of total and complicated cases and the proportion of clinical complications due to accidents by venomous animals in Brazil by municipality and federative unit. Brasil 2022.
Source: Information System for Notifiable Diseases, 2022

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Table 3. Mean immunobiological ampoules used per patient due to clinical complications. Brazil, 2022.

Immunobiological agent	Average per patient without complications	Average per patient with complications	Percentage increase (%)
Anti-*Bothrops*	0.61	2.27	272
Anti-*Crotalus*	0.08	0.39	387
Anti-*Arachnid*	0.04	0.19	375
Anti-*Bothrops-Lachesis*	0.05	0.32	540
Anti-*Elapidae*	0.01	0.02	100
Anti-*Lachesis*	0.01	0.1	900
Anti-*Bothrops-Crotalus*	0.04	0.16	300
Anti-scorpion	0.16	0.4	150
Antilonomic	0.01	0.03	200

Source: Information System for Notifiable Diseases, 2022

DISCUSSION

Our epidemiological data showed a higher proportion of clinical complications due to accidents by venomous animals in Brazil among illiterates, Indigenous individuals, men, and rural inhabitants, findings which corroborate a study conducted in inner Minas Gerais in 2017, showing the predominance of cases involving economically active males, especially during agricultural activities and cattle production.[14] Thus, health actions and services aimed at ensuring sanitary equity must consider these populations' greater vulnerability.

Most studies evaluated the social and demographic profile of general cases of accidents by venomous animals, ignoring their clinical complications. A study conducted in northeastern Brazil found a prevalence of accidents involving scorpions, women, and mixed-race individuals.[15] Thus, victims of venomous animals differ from those who developed clinical complications due to them. Thus, healthcare management and professionals must pay especial attention to the differences among these populations.

In another perspective, a study conducted in inner Amazonas on ophidian accidents showed the greater expressiveness of clinical complications if inoculation occurred in victims' lower feet and legs, which agrees with the numbers in this study[16] However, research based on the medical records of children admitted to a hospital in the municipality of Montes Claros-MG discussed the greater prevalence of complicated cases due to scorpions inoculating victims' hands, arms, and forearms.[17] Thus, although the relation between inoculated anatomical areas and case complications suffers influence from the venomous animal and victims' characteristics, limbs configure the topographic regions most involved in clinical complications.

Clinical complications in upper and lower limbs are associated with victims' reduced income and greater public spending in social assistance, social security, and health as they can cause amputation and permanent limitation and/or disability, compromising individuals' autonomy and capacity for work, especially in family agriculture and manufacturing.[18]

Reducing the time between accidents and care administration is a fundamental measure to prevent case complications since estimates suggest that a lethality rate around 4.1% for care given 12 hours after accidents.[17, 19] This explains our findings as it shows that the proportion of clinical complications was almost nine times higher among users who received care 24 hours after the accident than among those who received care in the first hour, showing the need for a functioning and articulated health network and well implemented policies (especially the national Workers' s Health Policy), in which healthcare providers receive training to offer quick, effective, and direct care and monitor such injuries.

This study also found a higher proportion of clinical complications among Indigenous people. In areas far from reference health services, such as Indigenous communities and *quilombolas*, popular knowledge often becomes the only way to cope with diseases and injuries - configuring a legitimate and efficient informal health system. However, as formal health care practices lack complementarity, inappropriate conducts may worsen clinical cases and delay medical care administration. Thus, the lack of articulation between traditional and scientific knowledge marginalizes traditional groups and perpetuates the inappropriate use of tourniquets, herbs and other substances at injury sites, and the oral suction of the inoculated venom.[20]

Snakes stood out in our analysis of the proportion of clinical complications according to venomous animal, especially those of *Lachesis* genus, as they inflict greater harm to humans, causing nausea, vomiting, abdominal cramps, diarrhea, compartment syndrome, abscesses, necrosis, hypotension, and shock[16,21] even though studies conducted in the Amazon on the clinical repercussions and victims' factors show that *Bothrops* snakes cause about 80-90% of all ophidian accidents. We also observed the epidemiological relevance of accidents involving spiders and scorpions, which, although not the most prevalent regarding animal types, evolve significantly to clinical complications.

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Thus, *T. serrulatus*, *T. bahiensis,* and *T. stigmurus* cause the most scorpion-related accidents in Brazil. The first is found in the states of Bahia, Minas Gerais, São Paulo, Espírito Santo, Paraná, Rio de Janeiro, and Goiás; the second, in the Brazilian South and Southeast, and the third, in the Northeast.[22] Most incidents cause severe local pain, edemas, salivation, among other symptoms, but may evolve to cardiogenic shock. [21]

In turn, the spiders of the genera *Loxosceles, Phoneutria,* and *Latrodectus* cause most complicated cases as they tend to evolve to acute renal failure, disseminated intravascular coagulation, sepsis, and occasionally death. Although *Loxosceles* species are not aggressive, they can cause accidents if compressed, usually affecting people at their homes since, by seeking shelter from light, they find refuge in clothing, paintings, furniture, bricks, and other places.[21]

Although AITC decreased in the Southeast, AICC increased in the region, especially considering the prevalence of total cases in the state of Minas Gerais. These findings describe the environmental, social, and economic aspects predisposing individuals to attacks (irregular occupations, hydrographic networks, vegetation, land use, metalworks, railways, etc.) — especially regarding scorpion-related accidents — and the distribution of fauna in Brazil, regarding which we stress those by *T. serrulatus* in this state.[19,23] Biological, social, and environmental determinants influence populations' health conditions, as per the AITC and IACC data of each region.

Thus, both North and South regions showed ascending AITCs and descending IACCs not only due to their growing agriculture and unbridled urbanization — which leads to a greater exposure to accidents by venomous animals (especially due to inadequate housing conditions) — but also to how seasonality relate with the increasing number of notifications of accidents by snakes and scorpions (but not spiders[24]) in May and June, suggesting their increase during rainy and hot periods.

The recent growth of primary health care and health surveillance has contributed to increasing the number of notifications as it has expanded access to low complexity care to the target audience and better supplied information systems, although underreporting and accessibility remain problematic, hindering the further development of knowledge on accidents by venomous animals and their repercussions.[25]

Thus, aiming to minimize health care expenses by assisting these occurrences, the Ministry of Health released the Information Note No. 74/2016 - CGPNI/DEVIT/SVS/MS in 2016, aiming to rationalize the distribution of immunobiologicals and restrict their supply to strategic points under adequate infrastructure and professional training dependent on health information systems, i.e., supported by epidemiological data. This strategy tends to qualify the infrastructure of health services to care for accidents due to venomous animals.[12]

We also found that 45.7 cases in every 1,000 that underwent serotherapy evolved to clinical complications and 41.8 complicated cases in every 1,000, to death. In view of this, we stress that clinical management and the early infusion of immunobiologicals reduces mortality and morbidity as users receiving immediate treatment have shorter hospitalizations and evolve to systemic complications in a milder proportion than those who received serotherapy later.[17]

This study found a higher proportion of clinical complications among illiterates, Indigenous people, men, and rural population, users whose accidents stemmed from snakes, and those who had received late medical-hospital care. We also observed a higher proportion of clinical complications in severe cases, those which required serotherapy, and deaths. The annual incidence of complicated cases increases in the Southeast, as well as the proportion of clinical complications in the states of Amazonas, Rondônia, Amapá, and Pará.

Despite the reasonable scientific support for analysis of the notifications of total cases. few studies have specifically investigated secondary clinical complications, thus offering scarce findings for comparison, which represents a limitation in this study. We also consider underreporting and inadequate notifications as a limitation as they restrict analysis due to their varying completeness, consistency, and quality. We recommend the development of analytical research capable of inferring the associations among the variables described in this study, such as the social and economic impact of late medical care to victims of accidents by venomous animals.

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AUTHORS' CONTRIBUTIONS

Valentina Ribeiro Tomaz contributed to data analysis, interpretation, and writing of the first and subsequent drafts of this article. **Marcelo Luiz Medeiros Soares** contributed to the conception of this article, data analysis and interpretation, and writing the first and subsequent versions of this article. **Diego Bonfada** contributed to the conception of this article, data analysis and interpretation, writing the first and subsequent versions of this article, critical review, and final approval. All authors approved the final manuscript for submission and take responsibility for the integrity and accuracy of their work.