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TRENDS IN OCCURRENCES OF ACCIDENTS BY VENOMOUS ANIMALS IN BRAZIL: ANALYSIS OF NOTIFICATIONS FROM 2007 TO 2021

Tendências na ocorrência de acidentes por animais peçonhentos no brasil: análise das notificações de 2007 a 2021

Tendencias en las ocurrencias de accidentes por animales venenosos en Brasil: análisis de las notificaciones de 2007 a 2021

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RESUMO

Introdução: os acidentes por animais peçonhentos são um problema de saúde pública que apresenta elevado número de casos anuais no Brasil. **Objetivo**: descrever e analisar as ocorrências de acidentes por animais peçonhentos no Brasil e suas tendências entre 2007 e 2021. **Metodologia:** o estudo utilizou dados do Sistema de Informação de Agravos de Notificação e do Sistema de Informação sobre Mortalidade. A população do estudo foi analisada segundo sexo, faixa etária e região de residência. A análise de tendência da série histórica foi realizada por regressão linear generalizada usando a estimação de Prais-Winsten. **Resultados:** as taxas de ocorrência padronizadas dobraram no período estudado (53,8/100.000 hab. em 2007 para 111,2/100.000 hab. em 2021). A região Nordeste apresentou a maior taxa de ocorrência padronizada (105,5/100.000 hab.). As regiões Nordeste, Sudeste e Centro-Oeste apresentaram maior taxa bruta de acidentes por escorpiões (75,8, 48,7 e 32,8 acidentes/100.000 hab., respectivamente), enquanto a região Norte por serpentes (54,2 acidentes/100.000 hab.) e a Região Sul por aranhas (60,3 acidentes/100.000 hab.). A taxa de mortalidade observada no período de 2007 a 2020 foi de 1,3 óbitos/1 milhão de hab. Entre as mortes registradas, 39,6% foram por picada de cobra. **Conclusões:** as tendências no Brasil foram ascendentes para ambos os sexos e para todas as faixas etárias. Apenas as regiões Norte e Sul apresentaram algumas categorias com tendências estacionárias. A análise dos dados epidemiológicos possibilita a identificação de populações-alvo e a elaboração de políticas públicas a fim de prevenir novos acidentes, bem como aprimorar o atendimento às pessoas acometidas por meio do planejamento da distribuição de soros antiofídicos.

Palavras-Chave: animais venenosos; mordidas e picadas; sistemas de informação.

ABSTRACT

Introduction: accidents by venomous animals is a public health problem that presents a high number of annual cases in Brazil. **Objective**: to describe and analyze the occurrences of accidents by venomous animals in Brazil and their trends between 2007 and 2021. **Methodology:** the study used Notifiable Diseases Information System and Mortality Information System data. The study population was analyzed according to sex, age group, and region of residence. Trend analysis of the historical series was performed by generalized linear regression using Prais-Winsten estimation. **Results:** the standardized occurrence rates doubled during the studied period (53.8/100,000 inhab. in 2007 to 111.2/100,000 inhab. in 2021). The Northeast region had the highest standardized occurrence rate (105.5/100,000 inhab.). The Northeast, Southeast, and Midwest regions had a higher crude rate of accidents caused by scorpions (75.8, 48.7 and 32.8 accidents/100,000 inhab., respectively), while the North region by snakes (54.2 accidents/100,000 inhab.), and the South region by spiders (60.3 accidents/100,000 inhab.). Death rate observed in the period from 2007 to 2020 was 1.3 deaths/1 million inhab. Among the deaths registered, 39.6% were from snakebite. **Conclusions:** trends in Brazil were ascendant for both sexes and for all age groups. Only the North and South regions showed some categories with stationary trends. The analysis of epidemiological data makes it possible the identification of target

populations and elaborations of public policies in order to prevent new accidents, as well as the improvement of care for affected people by planning the distribution of antivenom serums.

Keywords: poisonous animals; bites and stings.; information systems.

RESUMEN

Introducción: los accidentes por animales venenosos son un problema de salud pública que presenta un elevado número de casos anuales en Brasil. **Objetivo:** describir y analizar las ocurrencias de accidentes por animales venenosos en Brasil y sus tendencias entre 2007 y 2021. **Metodología:** el estudio utilizó datos del sistema de información de enfermedades de declaración obligatoria (SINAN, según su sigla en portugués) y del sistema de información de mortalidad. La población del estudio se analizó según sexo, grupo de edad y región de residencia. El análisis de tendencia de la serie histórica se realizó mediante regresión lineal generalizada utilizando la estimación de Prais-Winsten. **Resultados:** las tasas de ocurrencia estandarizadas se duplicaron durante el período estudiado (de 53,8/100 000 hab. en 2007 a 111,2/100 000 hab. en 2021). La región Nordeste presentó la mayor tasa de ocurrencia estandarizada (105,5/100 000 hab.). Las regiones Nordeste, Sudeste y Medio Oeste presentaron la mayor tasa bruta de accidentes por alacranes (75,8, 48,7 y 32,8 accidentes/100 000 hab., respectivamente), mientras que la región Norte por serpientes (54,2 accidentes/100 000 hab.), y la Región Sur por arañas (60,3 accidentes/100 000 hab.). La tasa de mortalidad observada en el período de 2007 a 2020 fue de 1,3 muertes/1 millón de hab. Entre las muertes registradas, el 39,6 % fueron por mordedura de serpiente. **Conclusiones:** las tendencias en Brasil fueron ascendentes para ambos sexos y para todos los grupos de edad. Solo las regiones Norte y Sur presentaron algunas categorías con tendencias estacionarias. El análisis de datos epidemiológicos posibilita la identificación de poblaciones objetivo y la elaboración de políticas públicas para la prevención de nuevos accidentes, así como la mejora de la atención a las personas afectadas mediante la planificación de la distribución de sueros antiofídicos**.**

Palabras clave: animales venenosos; mordeduras y picaduras; sistemas de información.

Introduction

The heterogeneity of habitats found in Latin American countries enables the presence of different species of venomous animals of sanitary relevance in these places. This scenario causes accidents by venomous animals (AVA) to be a significant public health problem in the region, capable of presenting a high number of annual cases, which can evolve to serious and fatal outcomes. This type of poisoning is of interest to different fields of scientific production and public policy, and considered

part of the group of neglected tropical diseases[1]. Accidents by venomous animals result from the contact of humans with venomous animals – usually due to the overlapping use of the environmental space by both –; normal biological activity and behavior of venomous species in the environment, and also from the type of activity carried out by the victim at the time of the accident, such as rural work, site cleaning, and ecotourism[2].

The presence of various species of venomous animals in Latin American countries, due to the heterogeneity of habitats, contributes to the significant public health problem of accidents caused by venomous animals in the region. These accidents can result in a high number of cases annually, with potential for severe or fatal outcomes. AVA are of interest to multiple scientific fields and public policy, and are classified as neglected tropical diseases[1]. They occur when humans come into contact with venomous animals, often due to the shared use of environmental space. The accidents can be influenced by the normal biological activity and behavior of venomous species, as well as the activities undertaken by the victims at the time of the incident, such as rural work, site cleaning, and ecotourism[2].

In Brazil, according to data from the Notifiable Diseases Information System (SINAN), an average of 148,000 AVA occur annually, with fatal outcome of about 0.2% cases each year. Most accidents in Brazil involve scorpions – accounting for 47.3% cases –, followed by accidents caused by snakes, spiders, bees, and caterpillars. Deaths occur mainly from snakes and scorpions[2]. Although they have a low death rate, AVA are a significant cause of morbidity and emergency outpatient/hospital admission in Brazil, especially when considering the length of hospital stay required to deal with accidents, the sequelae resulting from more severe cases, and the avoidable characteristic of the health status worsening.

Most Brazilian studies on AVA present accident clinical and epidemiological profiles based on local data, of regional, state and municipal coverage, and hospital data from reference health establishments[3,4]. Currently, there are no nationwide studies on the occurrence of AVA that use SINAN data to observe temporal trends.

Robust descriptive analysis of occurrence of AVA is important to characterize the distribution of these events over time and stimulate the use of SINAN data, at the same time promoting data quality improvement and the occurrence monitoring, thus allowing effective planning of measures for preventing new cases and adequate treatment of cases occurred. In this context, the objective of this study was to describe and analyze the occurrence of AVA in Brazil and their trends, according to epidemiological variables of interest, in the period between 2007 and 2021.

Methods

This is a descriptive ecological time series study on the notifications of occurrences of AVA in Brazil during the period from 2007 to 2021. The selection of the time period was carried out based on the availability of the data. The analysis was performed according to the variables of interest sex (male and female) and age group (0-4 years, 5-9 years, 10-19 years, 20-39 years, 40-59 years and 60 years and over), considering the Brazilian regions (North, Northeast, Midwest, Southeast and South) and their Federative Units (FUs) of residence.

Accidents by venomous animals data were obtained from TABNET, considering SINAN notifications with the field "Epidemiological and morbidity" "Notifiable diseases and conditions from 2007 onwards (SINAN)(https://datasus.saude.gov.br/informacoes-de-saude-tabnet/)". There was inclusion of all notifications with the X20 to X29 code (X20 - Contact with snakes and poisonous lizards; X21 - Contact with poisonous spiders; X22 - Contact with scorpions; X23 - Contact with bees, wasps and hornets; X24 - Contact with (tropical) centipedes and myriapods; X25 - Contact with other poisonous arthropods; X26 - Contact with poisonous marine animals and plants; X27 - Contact with other specified poisonous animals, and X29 - Contact with unspecified poisonous animals or plants) of the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10). Additionally, data from the Center for Information and Toxicological Assistance (CIATox-ES) of the Health State Department of Espírito Santo were also accessed.

For data related to deaths, the "vital statistics" module was accessed; "mortality – since 1996 by ICD-10" also on TABNET. Data on the number of inhabitants came from inter-census estimates from 2007 to 2012, from the 2010 census and from 2013 to 2021 population projections made available by the Brazilian Institute of Geography and Statistics (IBGE).

Crude accident rates were calculated by dividing the number of events that occurred in the study population by the number of inhabitants corresponding to the period, multiplied by the population base of 100,000 inhabitants. As the crude rates are greatly influenced by age structure and distribution per sex of populations in different regions and between different years, the calculated rates were standardized by the direct method, using the world population suggested by the World Health Organization (WHO) as a standard)[5], so that there is no interference in the estimation of trends and data comparison. Death rates were multiplied by 1 million inhabitants because the number of occurrences was lower.

Trend analysis of the historical series was performed by generalized linear regression using Prais-Winsten estimation[6], with correction for the first-order autocorrelation effect, using Stata 16 software. The average annual percentage change (APC) was calculated using the following formula:

$$APC = [-1 + 10b1] * 100\%$$

The trend was considered stationary when $p > 0.05$; declining when $p < 0.05$ and negative APC, or ascending when $p < 0.05$ and positive APC.

This study was carried out with secondary data, produced in the routine of health services and widely available in an anonymized manner on the official pages of the Ministry of Health, and therefore, without the need for evaluation by Research Ethics Committees.

Results

During the period from 2007 to 2021, 2,693,706 accidents involving venomous animals were registered in Brazil, that is, around 178,677 accidents per year, with an incidence of 88.9 accidents/100,000 inhab. in the country throughout the period.

Accidents doubled during the period studied, going from 53.8 accidents/100,000 inhab. in 2007 to 111.2 accidents/100,000 inhab. in 2021. All Federal Units (FUs) experienced higher occurrence frequency; the state of Alagoas presented the highest standardized occurrence rate (253.5 accidents/100,000 inhab.), and the state of Rio de Janeiro had the lowest one (9.5 accidents/100,000 inhab.). Considering the Brazilian regions, the Northeast region had the highest standardized occurrence rate for the period (105.5 accidents/100,000 inhab.), followed by the South (98.3/100,000 inhab.), North (95.7 /100,000 inhab), Southeast (75.8/100,000 inhab), and Midwest (64.3/100,000 inhab.) regions.

Crude accident rates were higher for males than females in Brazil (101.0 vs. 77.1 accidents/100,000 inhab.), in their regions and for most FUs (77.8%). Higher rates were observed in females only in some Northeastern states: Alagoas, Ceará, Paraíba, Pernambuco, Sergipe, and Rio Grande do Norte (Table 1). The analysis per age group showed a higher occurrence in individuals aged 40 to 59 years (101/100,000 inhab.) and 60 and over (102.2/100,000 inhab.), and this pattern was observed in all FUs (Table 2).

Table 1 – Cases and crude rates of occurrence (per 100,000 inhab.) of accidents with venomous animals, by sex. Brazil, regions and Federative Units, 2007-2021. Florianópolis/SC, 2023.

	Cases	Male	Female	Both
Brazil	**2,693,706**	**101.0**	**77.1**	**88.9**
North	**240,855**	**134.6**	**53.1**	**95.7**
Acre	12,781	145.3	71.4	108.6
Amapá	8,859	119.5	39.6	79.8
Amazonas	36,487	93.6	33.4	63.7
Pará	114,291	142.0	46.9	95.0
Rondônia	15,044	82.9	33.9	58.9
Roraima	9,738	171.4	92.2	132.9
Tocantins	43,655	249.6	144.5	197.8
Northeast	**885,482**	**107.9**	**104.5**	**106.2**
Alagoas	124,562	228.3	277.2	253.5
Bahia	255,188	125.9	102.8	114.2
Ceará	72,373	52.5	57.1	54.8
Maranhão	44,306	60.0	27.4	43.5
Paraíba	62,965	99.6	114.3	107.2
Pernambuco	192,970	133.6	145.8	139.9
Piauí	36,069	87.1	64.6	75.6
Rio Grande do Norte	75,164	139.8	157.8	149.0
Sergipe	21,885	66.4	66.7	66.5

Midwest	**149,827**	**79.6**	**52.8**	**66.1**
Distrito Federal	17,137	44.7	35.9	40.1
Goiás	65,912	80.0	56.2	68.1
Mato Grosso	32,829	92.2	43.0	68.2
Mato Grosso do Sul	33,949	99.0	75.7	87.4
Southeast	**988,257**	**92.6**	**64.0**	**78.0**
Espírito Santo	71,581	169.3	81.5	125.1
Minas Gerais	482,196	177.1	135.7	156.2
Rio de Janeiro	23,369	13.0	6.2	9.5
São Paulo	411,111	75.0	51.1	62.8
South	**429,285**	**107.6**	**91.3**	**99.3**
Paraná	223,782	144.0	127.3	135.5
Rio Grande do Sul	80,303	55.5	41.0	48.1
Santa Catarina	125,200	133.4	116.6	125.0

*Sources: Brazilian Institute of Geography and Statistics (IBGE); Notifiable Diseases Information System (SINAN); Center for Information and Toxicological Assistance (CIATox-ES) – Secretary of State for Health of Espírito Santo.

Table 2 – Gross occurrence rates (per 100,000 inhab.) of accidents with venomous animals, by age group. Brazil, regions and Federative Units, 2007-2021. Florianópolis/SC, 2023.

	0-4 years	5-9 years	10 a 19 years	20 a 39 Years	40 a 59 Years	60 years and over
Brazil	**75.8**	**68.3**	**78.1**	**88.8**	**101.0**	**102.2**
North	**48.8**	**57.6**	**90.5**	**103.0**	**120.6**	**106.0**
Acre	63.1	72.4	103.9	124.4	135.6	106.4
Amapá	34.9	47.2	75.8	87.7	110.6	99.5
Amazonas	28.4	38.2	66.7	68.2	80.3	81.9
Pará	40.9	52.7	94.2	106.5	122.4	100.8
Rondônia	37.5	37.4	49.8	61.9	76.4	63.8
Roraima	81.4	104.2	138.3	140.3	155.3	143.7
Tocantins	155.8	145.4	164.8	208.2	248.4	211.8
Northeast	**94.8**	**84.5**	**90.7**	**105.1**	**123.6**	**128.1**
Alagoas	209.6	199.5	219.6	254.6	297.9	323.2
Bahia	99.2	91.8	103.9	108.2	131.7	142.6
Ceará	46.7	35.2	40.5	57.9	67.7	65.9
Maranhão	22.0	24.2	38.2	47.0	60.6	54.8
Paraíba	107.5	84.3	86.4	105.5	123.7	129.2
Pernambuco	159.2	144.1	130.0	134.7	142.6	149.5
Piauí	68.9	46.3	51.3	76.6	97.5	102.8
Rio Grande do Norte	122.5	106.1	115.7	159.4	173.5	170.7
Sergipe	51.5	48.8	53.7	68.7	82.1	78.5
Midwest	**49.5**	**47.7**	**55.7**	**65.5**	**79.6**	**81.3**
Distrito Federal	33.1	38.0	36.9	40.4	44.1	41.4
Goiás	50.0	45.5	52.5	65.7	84.6	93.0
Mato Grosso	37.0	41.2	57.9	69.7	89.1	81.3
Mato Grosso do Sul	81.3	70.6	80.3	90.5	94.4	91.0
Southeast	**63.9**	**60.2**	**68.9**	**76.4**	**86.8**	**92.4**
Espírito Santo	80.3	76.8	99.7	126.7	159.1	142.7
Minas Gerais	134.6	125.9	140.4	148.2	174.0	190.2
Rio de Janeiro	6.2	5.7	7.8	10.0	11.6	9.4
São Paulo	49.2	46.7	53.3	62.1	70.1	77.2

South	106.2	76.4	81.5	100.2	112.0	102.5
Paraná	145.1	112.1	116.4	140.6	147.8	131.2
Rio Grande do Sul	40.8	30.8	35.0	47.1	57.4	57.6
Santa Catarina	141.8	87.5	96.4	117.5	147.3	148.5

*Sources: Brazilian Institute of Geography and Statistics (IBGE); Notifiable Diseases Information System (SINAN); Center for Information and Toxicological Assistance (CIATox-ES) – Secretary of State for Health of Espírito Santo.

By observing the types of accidents, it is possible to note that more than half of the notifications during the studied period were due to accidents involving scorpions (52.4%), followed by accidents involving snakes (16.0%), spiders (15.9%), bees (7.2%), and caterpillars (2.4%). Gross occurrence rates in the period per 100,000 inhab. were 46.6 involving scorpions, 14.2 involving snakes, 14.1 involving spiders, 6.4 involving bees and 2.1 involving caterpillars. Accidents by scorpions showed a large increase during the study period, rising from 19.7 in 2007 to 69.9 in 2021 (Figure 1). The Northeast, Southeast, and Midwest regions had a higher crude rate of accidents caused by scorpions than by other types (75.8, 48.7 and 32.8 accidents/100,000 inhab., respectively), while the North region presented more accidents with snakes (54.2 accidents/100,000 inhab.), and the South region with spiders (60.3 accidents/100,000 inhab.).
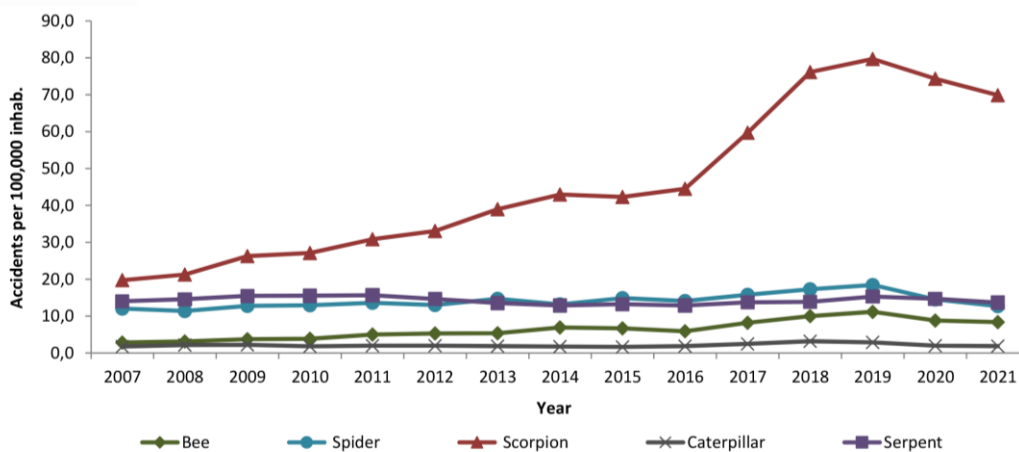

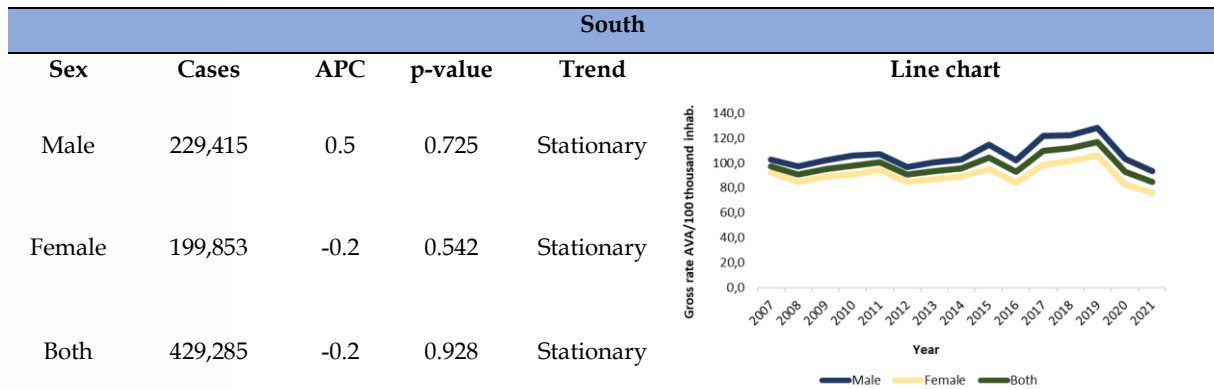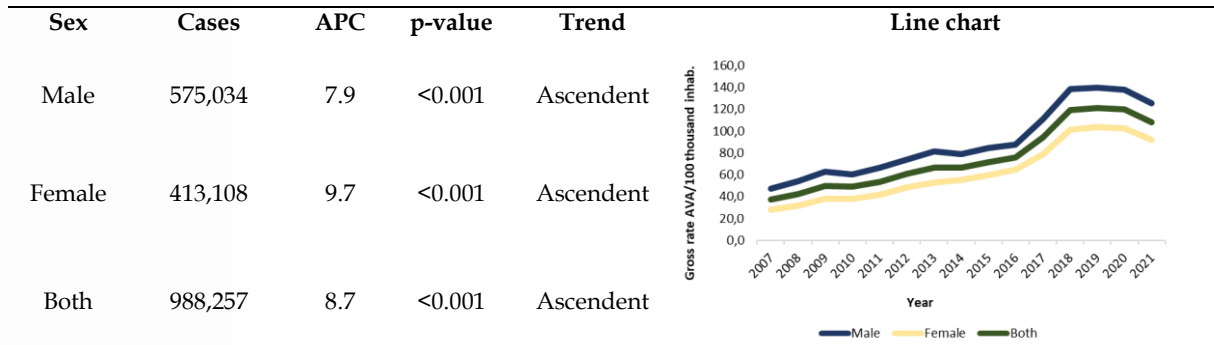Figure 1 – Historical series of accident rates by venomous animals. Brazil and regions, 2007-2021.
*Sources: Brazilian Institute of Geography and Statistics (IBGE); Notifiable Diseases Information System (SINAN); Center for Information and Toxicological Assistance (CIATox-ES) – Secretary of State for Health of Espírito Santo.
Note: APC: Annual Percent Change; AVA: accidents by venomous animals.

There were reports of 3,506 deaths from AVA between 2007 and 2020, which corresponds to an average of 250 deaths per year, with a case fatality rate of 0.1% and a death rate of 1.3/1 million inhabitants. Among the registered deaths, 39.6% were caused by accidents with snakes, 29.1% with bees, and 13.7% with scorpions. Deaths by other venomous animals totaled 17.6%. The North region had the highest death rate (3.3 deaths/1 million inhab.), and the Southeast region presented with the lowest one (0.7 deaths/1 million inhab.). Northeast, Midwest, and South regions had 1.5, 1.7 and 0.9 deaths/1 million inhabitants, respectively. In addition, the North, Midwest, and Northeast regions had more deaths from accidents with snakes than from other types of animals (40.6%, 46.4%m and 40.6%, respectively), while the South and Southeast regions had more deaths from accidents with bees (51.3% and 32.5% respectively).

In the trend analysis, the occurrence of AVA in Brazil were ascending for females (APC=6.9), males (APC=5.5), and total cases (APC=6.1) during the period studied. The analysis per regions shows most of them also with an upward trend for both sexes, with only the North region presenting a stationary trend for males, and the South region stationary trends for females, males and in the analysis that covered both sexes (Figure 2). When observed per age groups, the trends maintained the same pattern of analysis per sex, all ascending, with the following differences: the North region showed stationary trends for individuals aged 40-59, and the South region stationary trends for all age groups (Figure 3). However, it is important to note that even though it had no impact on the trend analysis, there was a decrease in the notification of occurrence of AVA from 2020 onwards in all regions (Figures 2 and 3).
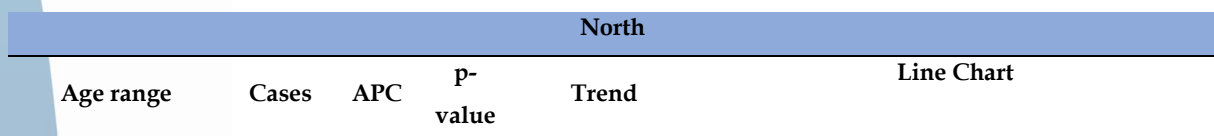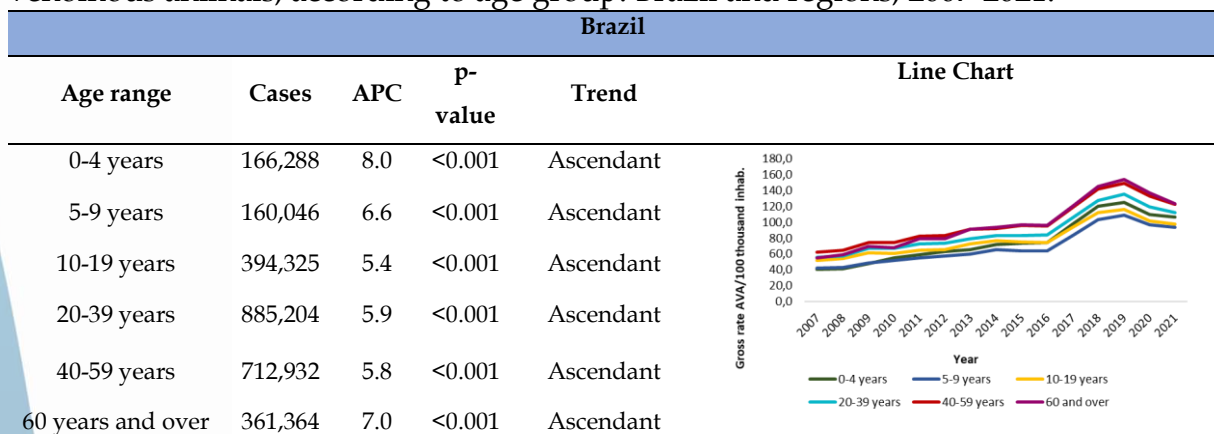
Figure 2 – Cases, annual percent change and trend in the occurrence of accidents by venomous animals, by sex. Brazil and regions, 2007-2021. Florianópolis/SC, 2023.

Brazil					
Sex	**Cases**	**APC**	**p-value**	**Trend**	**Line chart**
Male	1,499,425	5.5	<0.001	Ascendent	
Female	1,180,490	6.9	<0.001	Ascendent	
Both	2,680,159	6.1	<0.001	Ascendent	

North					
Sex	**Cases**	**APC**	**p-value**	**Trend**	**Line chart**
Male	173,908	1.6	0.009	Stationary	
Female	66,942	4.3	<0.001	Ascendent	
Both	240,855	2.3	0.001	Ascendent	

Northeast					
Sex	**Cases**	**APC**	**p-value**	**Trend**	**Line chart**
Male	440,407	7.5	<0.001	Ascendent	
Female	44,980	8.6	<0.001	Ascendent	
Both	885,482	8.1	<0.001	Ascendent	

Midwest					
Sex	**Cases**	**APC**	**p-value**	**Trend**	**Line chart**
Male	89,632	6.5	<0.001	Ascendent	
Female	60,183	10.6	<0.001	Ascendent	
Both	149,827	8.1	<0.001	Ascendent	

Southeast					

Sex	Cases	APC	p-value	Trend	Line chart
Male	575,034	7.9	<0.001	Ascendent	
Female	413,108	9.7	<0.001	Ascendent	
Both	988,257	8.7	<0.001	Ascendent	

South					
Sex	Cases	APC	p-value	Trend	Line chart
Male	229,415	0.5	0.725	Stationary	
Female	199,853	-0.2	0.542	Stationary	
Both	429,285	-0.2	0.928	Stationary	

*Sources: Brazilian Institute of Geography and Statistics (IBGE); Notifiable Diseases Information System (SINAN); Center for Information and Toxicological Assistance (CIATox-ES) – Secretary of State for Health of Espírito Santo.
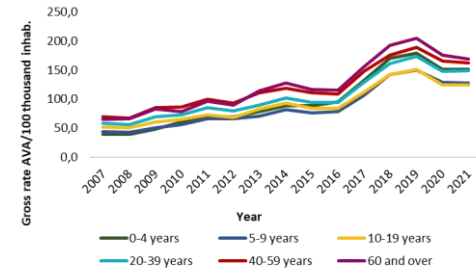Note: APC: Annual Percent Change; AVA: accidents by venomous animals.

Figure 3 - Cases, annual percent change and trend in the occurrence of accidents by venomous animals, according to age group. Brazil and regions, 2007-2021.
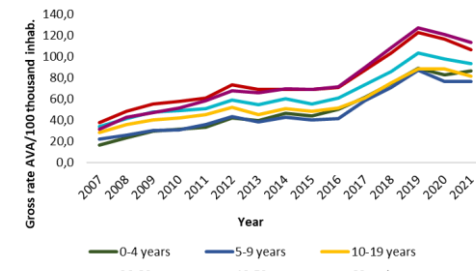
Brazil					
Age range	Cases	APC	p-value	Trend	Line Chart
0-4 years	166,288	8.0	<0.001	Ascendant	
5-9 years	160,046	6.6	<0.001	Ascendant	
10-19 years	394,325	5.4	<0.001	Ascendant	
20-39 years	885,204	5.9	<0.001	Ascendant	
40-59 years	712,932	5.8	<0.001	Ascendant	
60 years and over	361,364	7.0	<0.001	Ascendant	

North					
Age range	Cases	APC	p-value	Trend	Line Chart

Age range	Cases	APC	p-value	Trend	
0-4 years	11,816	6.0	<0.001	Ascendant	
5-9 years	14,731	3.5	<0.001	Ascendant	
10-19 years	46,895	1.9	0.005	Ascendant	
20-39 years	90,149	2.0	0.003	Ascendant	
40-59 years	57,745	1.8	0.007	Stationary	
60 years and over	19,519	3.1	<0.001	Ascendant	
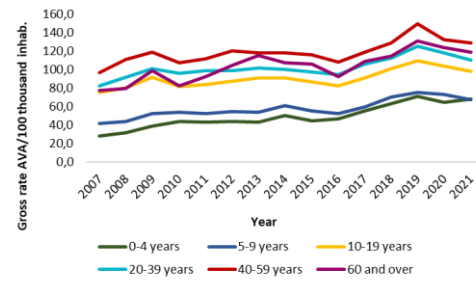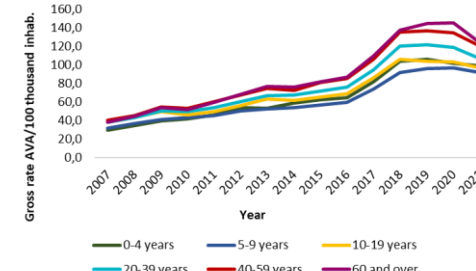
Northeast					
Age range	**Cases**	**APC**	**p-value**	**Trend**	**Line Chart**
0-4 years	64,174	11.2	<0.001	Ascendant	
5-9 years	61,175	9.1	<0.001	Ascendant	
10-19 years	138,587	7.6	<0.001	Ascendant	
20-39 years	193,426	7.9	<0.001	Ascendant	
40-59 years	216,650	7.2	<0.001	Ascendant	
60 years and over	111,470	8.3	<0.001	Ascendant	

Midwest					
Age range	**Cases**	**APC**	**p-value**	**Trend**	**Line Chart**
0-4 years	8,385	11.7	<0.001	Ascendant	
5-9 years	8,401	9.4	<0.001	Ascendant	
10-19 years	21,270	7.6	<0.001	Ascendant	
20-39 years	51,603	7.3	<0.001	Ascendant	
40-59 years	42,084	7.5	<0.001	Ascendant	
60 years and over	18,084	9.3	<0.001	Ascendant	

Southeast					
Age range	**Cases**	**APC**	**p-value**	**Trend**	**Line Chart**
0-4 years	53,051	9.5	<0.001	Ascendant	
5-9 years	53,409	8.3	<0.001	Ascendant	
10-19 years	134,173	7.5	<0.001	Ascendant	
20-39 years	315,615	8.4	<0.001	Ascendant	
40-59 years	277,539	9.1	<0.001	Ascendant	
60 years and over	154,470	9.8	<0.001	Ascendant	

South					
Age range	**Cases**	**APC**	**p-value**	**Trend**	**Line Chart**

0-4 years	29,400	0.8	0.492	Stationary	
5-9 years	22,988	0.2	0.90	Stationary	
10-19 years	54,990	0.9	0.158	Stationary	
20-39 years	138,657	0.2	0.989	Stationary	
40-59 years	123,219	0.1	0.817	Stationary	
60 years and over	60,031	1.0	0.425	Stationary	
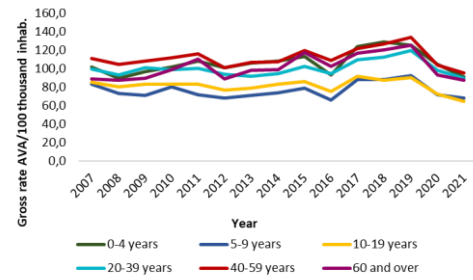
*Sources: Brazilian Institute of Geography and Statistics (IBGE); Notifiable Diseases Information System (SINAN); Center for Information and Toxicological Assistance (CIATox-ES) – Secretary of State for Health of Espírito Santo. Note: APC: annual percent change; AVA: accidents by venomous animals.

Discussion

Brazil experienced a significant increase of AVA during the studied period, with the annual rate doubling between 2007 and 2021. The occurrence rates were comparable to or higher than those of other tropical countries, as demonstrated in Chippaux's study in the Americas[7]. Brazil had the highest absolute number of snakebite incidents and an annual incidence greater than countries like Argentina, Bolivia, Colombia, Paraguay, Uruguay, and Peru. However, snakebite incidences in the Americas were lower compared to Asia and Africa, although this comparison depends on specific locations. Certain areas in the Amazon region stand out for their high snakebite rates.

For instance, a study in Kenya reported significantly fewer occurrences than those observed in Brazil during the same period[8]. Similar trends were observed in research conducted using data from the Turkish National Center for Toxicological Information[9]. The data from Turkey showed considerably fewer spider[10] and scorpion-related accidents compared to Brazil[11]. Studies that encompassed all types of accidents, without distinguishing between animal types, also reported lower annual occurrence rates than those observed in Brazil, as seen in examples from Argentina[12] and Colombia[13].

The increasing occurrence of AVA in Brazil, as indicated by this study, is attributed to various factors. These factors can be both positive and negative. Positive factors include improvements in compulsory notification practices over time and expanded healthcare coverage in the country.

Negative factors include climate changes, conversion of natural habitats for agriculture, excessive use of pesticides, elimination of natural predators of venomous animals, deforestation and anthropization of natural environments, which forces animals to leave their habitats and increases their contact with humans. Disorganized urbanization also contributes to the establishment of synanthropic relationships between animals and humans, creating environments conducive to accidents places with accumulation of garbage and lack of sanitation[2].

The South region had the highest average accident rate, followed by the North, Northeast, Southeast, and Midwest regions. Different factors are associated with the occurrence and notification of AVA in certain places, such as the biology and natural behavior of animals, which have specific characteristics of geographic distribution, generally linked to climatic conditions and availability of habitats favorable to their shelter, feeding, and reproduction needs. In the South region, the municipalities are closer to each other and relative values of peri-urban and remote rural municipalities are the lowest when compared to other regions of the country. Those characteristics favor the search for care at the time of the accident; besides, there is the great availability of health services in the region that report cases, causing the South region to present an expressive notification of cases occurred[14].

Although the North, Northeast, and Midwest regions do not have the same attributes as the South region, their notifications are relevant because they are areas with a considerable portion of rural municipalities, where agriculture and extractivism activities are carried out, favoring the risk of contact between rural workers and venomous animals. In turn, in the Southeast region, the high demographic density collaborates with the occurrence of cases[14].

During the analysis of accident types, a significant number of scorpion-related accidents in the Southeast, Northeast, and Midwest regions were observed. Scorpions have a high adaptability to changes resulting from human activities in urban areas[14], which explains their prevalence in these regions. In the South region, there was a higher incidence of spider bites. Various studies have highlighted the increase in spider populations in large cities[15], primarily due to unregulated urban development

that creates suitable microhabitats. This demonstrates the growing synanthropy, or coexistence, established by spiders in recent years.

In Northern Brazil, the region boasts a diverse snake population, and snakebites are associated with local rainfall patterns[16]. During periods of human activity, such as extractive businesses, there is increased contact between snakes and humans during floods[17]. Additionally, snake activity rises during rainy periods when prey availability, such as amphibians, anurans, and lizards, increases, coinciding with the birth of snake offspring[7].

The majority of the population affected by AVA in Brazil is male, consistent with findings from both international[8-12] and national studies[14-16]. This can be explained by the fact that male individuals are more frequently engaged in rural activities, forestry, agriculture, and crop-related work, which increase their exposure to venomous animals compared to women[2,3]. Since the main venomous animals in the country are terrestrial, not wearing personal protective equipment (PPE) during rural activities puts male workers at a higher risk of being attacked. It is estimated that 50% to 75% of AVA cases could be prevented by using proper PPE[2].

The age groups most affected by AVA are those of working age[3,7]. In this study, individuals between 40-59 years and 60 years and older were the most affected. Another study conducted by Chippaux between 2001 and 2012 also observed increasing occurrences of AVA in individuals up to the age of 65, with a decline after that age, with peaks of accidents occurring in working-age individuals. This pattern reflects the prevalence of rural work among older individuals in Brazil, which has been highlighted in studies focusing on the vulnerabilities faced by this population[3,18].

Brazil has a relatively low death rate for AVA, which is consistent with other countries that also experience a significant number of accidents, including tropical regions[7,12,19]. Almost half of the reported deaths in Brazil are attributed to snakebites, while deaths from scorpion stings account for about a third of the fatalities. The occurrence pattern of snakebite accidents, which predominantly happen in forested or rural areas[7], often far from healthcare services, contributes to the severity or fatality of such cases. The delay between the bite and receiving medical care worsens the

prognosis. On the other hand, some published studies on AVA mortality rates, considering all types of accidents, indicate that bee stings are the primary cause of deaths, surpassing fatalities from snakebites and scorpion stings[12,19]. It is important to note that bee stings do not have specific treatments available.

The analysis by region reveals higher mortality rates in the North, Northeast, and Midwest regions, precisely where most snakebite-related deaths occur, often associated with rural activities and human presence in remote areas, as mentioned earlier. The Southeast and South regions have lower death rates, with most deaths attributed to scorpion stings and bee stings, respectively. As the occurrence pattern of these types of accidents is more urban in nature, victims are more likely to reach healthcare services promptly, leading to better prognoses.

The use of secondary SINAN data in this study subjects the observations found to some limitations, such as recording or typing errors, missing form data and underreporting, and underreporting is mainly related to logistical and geographic issues of access to health services or results from the care teams' unpreparedness regarding the precise problem identification[1]. Even so, SINAN data relevance is undeniable both for health surveillance activities and for epidemiological studies on AVA. This is the only information system in Brazil that allows detailed observation of the accident occurrence, including identifying the region where cases take place, which is essential for identification of risk areas, since AVA are intensely related to the environment conditions of the places where the accidents occurred. Finally, even if it had no impact on the trend analysis, it should be noted that, as a limitation, a reduction in notifications was observed from 2020 onwards, very likely related to the COVID-19 pandemic, which generated major impacts on reports of notifiable diseases, mandatory for epidemiological surveillance[20].

Conclusions

Annual rates of AVA have grown over time in Brazil, which presented almost twice as many accidents from 2007 to 2021. The South region had the highest occurrence rate and lowest death rate. Deaths were mainly related to accidents with

snakes and more frequent in the North region. Men of working age were the most affected by AVA. AVA trends in the country were ascending for both sexes and for all age groups. The findings of this study highlight the need for surveillance and monitoring of these accidents through epidemiological surveillance. Furthermore, further research is needed to advance the analysis of the impact and the necessity for qualification and interoperability of information systems for AVA monitoring.

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