RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Snakebite in the Brazilian Amazon: epidemiological surveillance and Primary Health Care as cornerstones of the SUS's response capacity to environmental changes (2020–2025)

Snakebites in the Brazilian Amazon: Epidemiological Surveillance and Primary Health Care as Axes of the SUS Response Capacity to Environmental Changes (2020–2025)

Larissa Queiroz Costa Carneiro - lari.queiroz1991@gmail.com

Summary

Snakebite accidents are a serious public health problem in the Amazon, influenced by socio-environmental factors and inequalities in access to healthcare. This study analyzed the epidemiological profile of these accidents in the Northern Region between 2020 and 2025, from the perspective of surveillance and Primary Health Care (PHC). An ecological and descriptive study was conducted using data from SINAN (National System of Notifiable Diseases), encompassing demographic, clinical, and temporal variables (preliminary 2025 data). The results indicate spatial heterogeneity, with a higher concentration of cases in Pará, Amazonas, and Tocantins. The genus *Bothrops* predominated, followed by *Crotalus, Micrurus ,* and *Lachesis.* A predominance of male victims and an increase in notifications until 2023 were noted. It was identified that extreme climate changes, such as the historic droughts of 2023-2024, altered the local ecological dynamics, intensifying synanthropic processes. The degradation of natural habitats and water stress have forced snakes to move to anthropogenic areas in search of refuge, increasing the risk of human exposure. Although primary health care and the strengthening of the cold chain have optimized response time, logistical bottlenecks in remote areas persist, aggravated by the low navigability of rivers during critical periods. It is concluded that snakebite in the Amazon is a structural problem exacerbated by the climate crisis, demanding resilient surveillance strategies that integrate environmental conservation with the response capacity of the Brazilian Unified Health System (SUS) to mitigate territorial inequalities and ensure timely assistance.

Keywords: Snakebite; Climate; Epidemiology; Primary Health Care; Brazilian Unified Health System (SUS); Amazon.

Abstract:

Snakebites represent a severe public health challenge in the Amazon, influenced by socio-environmental factors and inequalities in healthcare access. This study analyzed the epidemiological profile of these injuries in the Northern Region of Brazil between 2020 and 2025, from the perspective of surveillance and Primary Health Care (PHC). An ecological and descriptive study was conducted using SINAN data, covering demographic, clinical, and temporal variables (2025 data are preliminary). Results indicate spatial heterogeneity, with a higher concentration of cases in the states of Pará, Amazonas, and Tocantins. The genus *Bothrops* predominated, followed by *Crotalus, Micrurus,* and *Lachesis.* There was a predominance of male victims and an increase in notifications until 2023. It was identified that extreme climate changes, such as the historic droughts of 2023–

2024, altered local ecological dynamics, intensifying synanthropy processes. Natural habitat degradation and water stress forced the displacement of snakes toward anthropogenic areas in search of refuge, increasing the risk of human exposure. Although PHC and the strengthening of the Cold Chain have optimized response times, logistical bottlenecks in remote areas persist, worsened by low river navigability during critical periods. In conclusion, snake poisoning in the Amazon is a structural health issue exacerbated by the climate crisis, demanding resilient surveillance strategies that integrate environmental conservation with the SUS response capacity to mitigate territorial inequalities and ensure timely assistance.

Keywords: Snakebites; Climate; Epidemiological surveillance; Primary Health Care; Unified Health System; Amazon.

1. Introduction

Snakebite accidents constitute a significant public health problem in regions.

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

tropical diseases, being internationally recognized as a neglected tropical disease because of its high burden of morbidity and mortality and its association with contexts of social vulnerability, environmental and territorial (WHO, 2023). In Brazil, the Amazon stands out as the area of greatest The occurrence of these accidents is due to its extensive forest cover and diversity. Herpetofaunal characteristics and the predominance of productive activities carried out in natural environments.

Historically, snakebite in the Northern Region has a strong relationship with activities. agricultural, extractive, forestry and riverside activities, affecting mostly men of an age... economically active and residing in rural areas. Previous studies have shown that factors such as distance from health services, transportation difficulties, and late access to treatment. They directly influence the clinical prognosis of affected patients (CARNEIRO et al., 2020).

In recent years, the intensification of environmental changes, including deforestation, Forest fragmentation and extreme weather events have been identified as factors capable of... to alter the ecological dynamics of snakes and expand the interaction between humans and animals. venomous. Although these transformations do not act in isolation, they add up to historical territorial inequalities in the Amazon, impacting risk exposure and the response capacity of health systems (FEITOSA et al., 2022; GUTIÉRREZ et al., 2021).

In parallel, the Unified Health System has been undergoing processes of strengthening... epidemiological surveillance and improvement of Primary Health Care, especially in vulnerable territories. Primary health care assumes a strategic role as the gateway to the system, being responsible for the early recognition of cases, timely referral and

The articulation of the care network is a fundamental element for the resilience of the Brazilian Unified Health System (SUS) in the face of health problems. acute in complex environmental contexts.

Thus, this study aimed to analyze snakebite accidents that occurred in the Brazilian Amazon. between 2020 and 2025, considering epidemiological surveillance, recent climate changes and their Synanthropic impacts and Primary Health Care as cornerstones of the Unified Health System's response capacity in the environmental and territorial context of the region.

In this context, it becomes relevant to update the analysis of snakebites in the Brazilian Amazon in light of from the recent period, considering not only the epidemiological description of the cases, but also the institutional response capacity of the health system. Thus, this study proposes to analyze the Snakebite accidents that occurred in the Brazilian Amazon between 2020 and 2025, emphasizing surveillance. Epidemiological analysis and Primary Health Care as central pillars of the SUS's response to... environmental and territorial transformations in the region.

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

2. Theoretical Framework / Results

2.1 Snakebite as a Neglected Tropical Disease and Structural Aggravation

Snakebite accidents are classified by the World Health Organization (WHO, 2023) such as Neglected Tropical Diseases (NTDs). In the Amazon, this condition ceases to be a major event. It goes from being purely biological to becoming a structural problem, conditioned by social determinants. and economic (Gutiérrez et al., 2021). The predominance of accidents caused by the *Bothrops* genus reflects the vast ecological distribution of these snakes and their adaptation to transitional areas, where the Occupational activity in agro-extractive activities increases the risk of human exposure (Feitosa et al., 2022; Brazil, 2025).

2.2 Epidemiological Surveillance and Primary Health Care (PHC)

The State's ability to respond to snakebites is mediated by the efficiency of the System. Information on Notifiable Diseases (SINAN) and the capillarity of Primary Health Care. According to Carneiro et al. (2020), primary health care acts as the organizing axis of care, being crucial for welcoming Early and timely administration of antivenom. Modernization of the Cold Chain, especially in vulnerable territories like the Yanomami, it represents progress in Decentralization of care, aiming to break down the geographical barriers that have historically prevented... treatment within the therapeutic "window of opportunity" (Brazil, 2024).

2.3 Climate Change and the Ecology of Fear in the Amazon

Anthropogenic climate change has altered rainfall patterns and temperatures in the region. Amazon, making extreme droughts like the one in 2023 more frequent and severe events (WWA, 2024; Clarke, 2024). These thermal and hydrological anomalies destabilize the hydrological cycle of rivers, such as observed in the Rio Negro (Andrade, 2024), impacting not only aquatic biodiversity, but all terrestrial fauna (Fleischmann et al., 2025). Prolonged environmental stress reduces resilience. of ecosystems and alters animal movement patterns.

2.4. Synanthropy and the Health-Climate Nexus

The concept of synanthropy is fundamental to understanding the increased risk of snakebites in certain scenarios. of the climate crisis. Habitat degradation and water scarcity are forcing snakes to

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

migrating to anthropic areas — villages, backyards, and the interiors of residences — in search of microclimates humid and prey (rodents) that also approach humans (Ministry of Health, 2024; Waldez & Vogt, 2024).

This phenomenon creates a "double burden" effect: while extreme drought isolates communities and This makes river transport for rescue unfeasible (Costa, 2024), and synanthropy increases the probability of encounters between humans and snakes. Thus, the climate acts as a risk multiplier, where The physical barrier of nature becomes a direct determinant of morbidity and mortality from snakebites.

2. Material and Method

This is an ecological, analytical, and retrospective study with a quantitative approach. developed from the analysis of snakebite accidents reported in the Brazilian Amazon region between 2020 and 2024. Secondary, aggregated, and publicly available data were used. from the Notifiable Diseases Information System (SINAN), accessed through the TabNet/DATASUS, supplemented by epidemiological bulletins and institutional documents from Ministry of Health and information from the Integrated Health Surveillance Platform (IVIS). The area The study encompassed the states of the Northern Region of Brazil.

All confirmed cases of snakebite accidents reported during the period were included. regardless of sex or age group. The variables analyzed included characteristics Sociodemographic data, event information, and the time elapsed between the accident and healthcare assistance are used as indirect indicators of the response capacity of the Unified Health System. The data analysis was performed using descriptive statistics, with an evaluation of the distribution. temporal and spatial aspects of the cases.

The interpretation of the results considered the role of epidemiological surveillance and care. Primary Health Care in the environmental and territorial context of the region. Because the data are public and aggregated, the study did not require review by a Research Ethics Committee. An analysis was performed. temporal analysis of cases throughout the study period, as well as a comparison of the results obtained with The findings of the original study, covering the period from 2009 to 2019, allow for the identification of trends. Continuities and possible changes in the epidemiological pattern of snakebite accidents in the region.

3. Results and Discussion

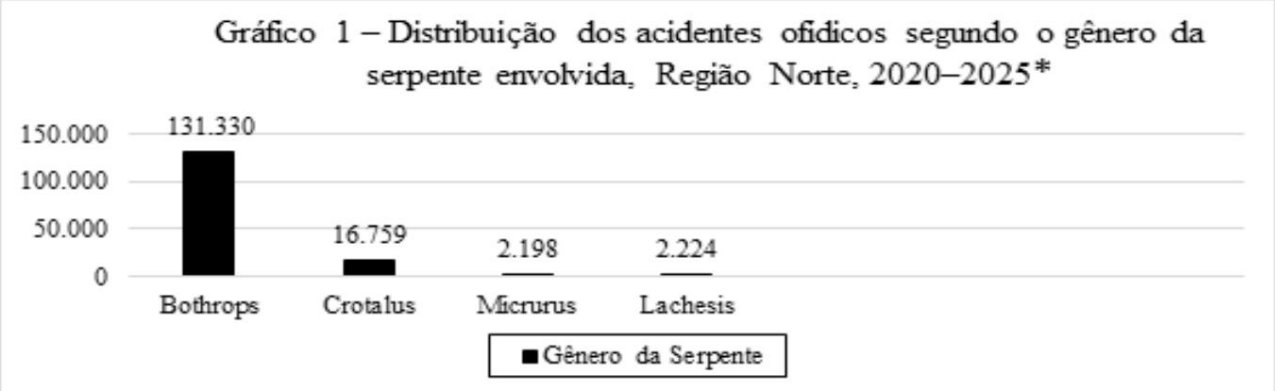
In the Northern Region of Brazil, accidents caused by venomous animals remain as a significant public health problem, strongly associated with environmental and occupational characteristics. from the Amazon. Recent data from the Notifiable Diseases Information System indicate that, in

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

In the most recent period, accidents involving venomous animals related to work continue.
concentrated among agricultural, forestry and fishing workers, a group that accounts for the largest share.
The proportion of notifications of this health problem reflects a pattern consistent with the reality of the Amazon region.
(Brazil, 2025).

Identifying the genus of the snake involved in snakebite accidents is an essential element.
central to understanding the clinical profile of cases and to appropriate therapeutic management, a
This guides the indication of the specific antivenom serum. Graph 1 shows the distribution of
Snakebite accidents reported in the Northern Region according to the genus of snake involved, during the period
From 2020 to 2025:



Source: Ministry of Health/SVSA - Notifiable Diseases Information System - Sinan Net

The data above show a significant predominance of accidents caused by snakes.
of the *Bothrops* genus , which accounted for the majority of notifications during the analyzed period,
totaling 131,330 cases. In a significantly smaller proportion, accidents attributed to
The genus *Crotalus* totaled 16,759 records, while the genera *Micrurus* and *Lachesis* presented...
considerably lower numbers, with 2,198 and 2,224 cases, respectively.

This distribution demonstrates that, in the Northern Region, snakebite accidents maintain a pattern.
strongly associated with the presence and wide ecological distribution of snakes of the genus *Bothrops.*
The relatively low frequency of accidents involving *Micrurus* and *Lachesis* indicates occurrence
Sporadic occurrences of these genera in the analyzed records, although their clinical relevance remains.
significant due to the potential severity associated with these types of poisoning.

Just as the analysis of the temporal distribution of snakebite accidents reveals the variation
annual notifications during the study period, allowing for the observation of trends, fluctuations, and possible
reflections of improved epidemiological surveillance. Graph 2 shows the annual evolution of
Cases reported in the Northern Region between 2020 and 2025:

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Source: Ministry of Health/SVSA - Notifiable Diseases Information System - Sinan Net

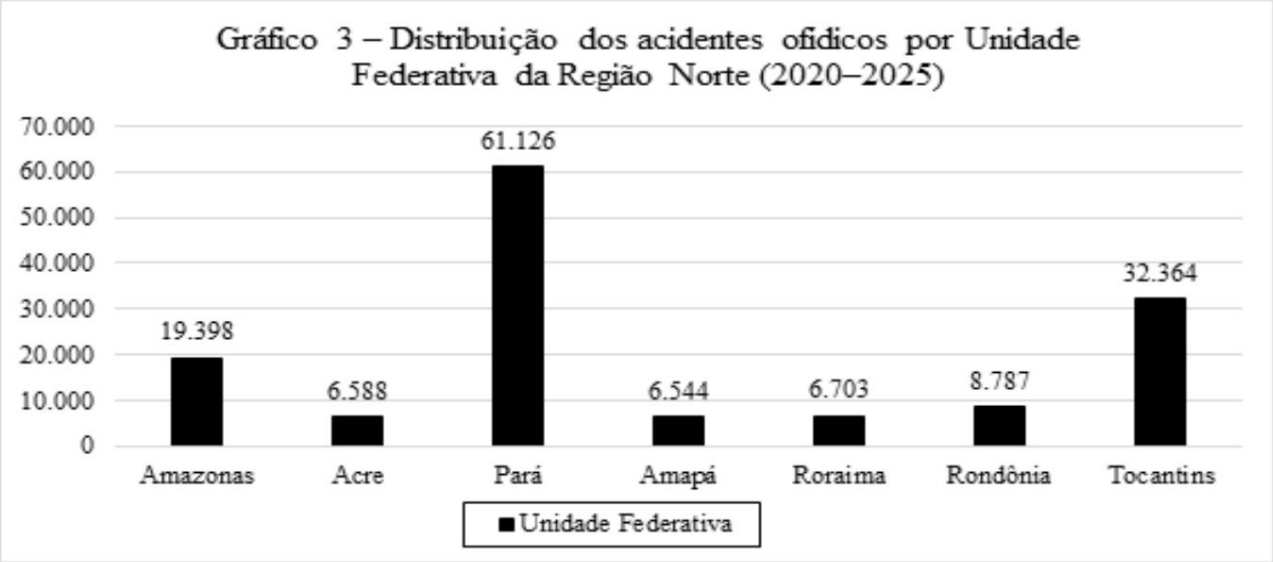
It is also observed that, between 2020 and 2025, there was progress in registration capacity and monitoring of these events, associated with the consolidation of universal mandatory reporting and Integration between the SINAN and e-SUS Health Surveillance systems. This system improvement. The lack of information tends to broaden the capture of cases, which may produce an apparent increase in... notifications do not necessarily represent a proportional increase in the actual incidence. (Brazil, 2025).

In 2024, the Brazilian Ministry of Health promoted a historic modernization of the Network of Cold weather from the National Immunization Program (PNI), with the goal of improving access and conservation of antivenom in remote and hard-to-reach areas, such as the Yanomami territory, in the north of the country (BRAZIL, 2024) This initiative included the acquisition and distribution of equipment appropriate refrigeration systems for local conditions, such as electric and solar refrigerated chambers, in addition to of thermal boxes of different capacities, capable of maintaining the cold chain even without stable electricity. In the context of the Yanomami Indigenous Special Health District (DSEI), by For example, solar and electric cameras and hundreds of thermal boxes were delivered, expanding the providing storage points and facilitating the availability of antivenoms in health centers. local (BRAZIL, 2024).

The spatial distribution of snakebite accidents reveals heterogeneity among the states of The Northern Region reflects territorial, environmental, and productive differences. Graph 3 presents the... Absolute distribution of reported cases by federative unit during the analyzed period.

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025



Source: Ministry of Health/SVSA - Notifiable Diseases Information System - Sinan Net

The distribution of snakebite accidents by federative unit in the Northern Region, during the period The analysis reveals marked heterogeneity among the states. It is observed that Pará concentrated... the largest absolute number of cases (61,126), followed by Tocantins (32,364) and Amazonas (19,398), establishing themselves as the main centers of occurrence of the disease in the region. In contrast, States such as Acre (6,588), Amapá (6,544) and Roraima (6,703) presented quantities significantly lower, while Rondônia recorded an intermediate volume (8,787 cases).

This profile highlights the persistence of the territorial and occupational nature of the accidents. venomous animals in the region, marked by productive activities developed in rural, forest and transition zone between natural and anthropogenic environments. The widespread exposure of workers in areas of Forests and peri-urban areas contribute to maintaining vulnerability to the disease, especially in contexts where access to health services is difficult.

This distribution reveals striking differences in the relative prevalence of snakebites among the states of Northern Region, indicating that the problem is not homogeneous across the Amazonian territory. The concentration of cases in certain federative units reflects distinct spatial patterns. possibly related to territorial extension, population density, productive activities predominant and specific environmental characteristics of each state, as evidenced by Graph 3.

Furthermore, the modernization of the Cold Chain in the context of vaccination and distribution of Immunobiologicals was described as a milestone in supply chain logistics, requiring assurance of Thermal stability in accordance with manufacturers' recommendations and the technical qualifications of the teams. health guidelines for the management of these supplies (BRAZIL, 2024). This change represents a unprecedented decentralization of the antivenom network, with a view to reducing response times and chances of death or lasting damage from accidents involving venomous animals, considering geographical barriers. which historically hinder access to treatment in indigenous regions and isolated areas of

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Amazonia (Brazil, 2024).

And based on consolidated data from the Notifiable Diseases Information System (SINAN Net), Table 1 presents the volume of notifications related to the male sex among the years 2020 and 2025. For analysis purposes, data covering the period from 15 to 59 years old, as this is the system parameterization that most closely approximates the age range of interest for this [study/reference]. Research (ages 18 to 60):

Table 1: Notifications: Male Sex (2020-2025):

Year	15-19 years old	20-39 years old	40-59 years old	Total
2020	10.275	46.097	39.214	95,586
2021	10.607	*46.097*	*39.214*	95,918
2022	*11,499*	*52,569*	*47.038*	111.106
2023	*13.077*	*60.258*	*54,870*	128.205
2024	*12,751*	*58,814*	*53,150*	124,715
2025	*12,600*	*56,966*	*51,405*	120,971

Source: Ministry of Health/SVSA - Notifiable Diseases Information System - Sinan Net

Analysis of notifications registered between 2020 and 2025 reveals a trend of sharp growth in the historical series for the male population, starting from a total of 95,586. records in the 15 to 59 age range at the beginning of the period. It is observed that the volume of Notifications showed a continuous upward trajectory until reaching their peak in 2023. with 128,205 documented cases. In the final two-year period (2024-2025), although the numbers demonstrate a subtle retraction from the recorded peak, they remain at significantly higher levels. higher than those observed in the initial years of the series, demonstrating the persistence of the phenomenon in adult male audience.

Based on data extracted from the Notifiable Diseases Information System (SINAN). Net), Table 2 presents the profile of notifications related to the female sex between the years 2020 and 2025. As with the analysis of the male group, the data were filtered to understand the age ranges from 15 to 59 years, aiming for the closest possible approximation to the 18 to 60 age range. years delimited within the scope of this research.

Table 2: Notifications: Female Sex (2020-2025):

Year	15-19 years old	20-39 years old	40-59 years old	Total
2020	8.335	35.029	31,385	74,749
2021	8,487	*36,637*	*32,536*	77,660
2022	*9.779*	*40.819*	*38.037*	88.635
2023	*11.315*	*48,589*	*44,793*	104,697
2024	*11.135*	*47,896*	*44,294*	103.325

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

2025	*11.115*	*47,471*	*43,549*	102.135

Source: Ministry of Health/SVSA - Notifiable Diseases Information System - Sinan Net

Analysis of female historical data shows that, although the total volume of notifications is...
Lower than that recorded among men, there is a significant proportional growth trend.
throughout the period. The group shows a continuous upward trajectory, starting from 74,749
notifications in 2020 and exceeding the mark of 100,000 annual registrations from 2023 onwards. This
The increase suggests a intensification in the occurrence or in the ability to detect notifications for
This audience, with particular emphasis on the stability of the high numbers in the years 2024 and 2025.

Considering the time interval between the occurrence of the venomous accident
and the start of medical care is a critical prognostic determinant for reducing
morbidity, mortality, and functional sequelae. In this sense, Table 3 systematizes the notifications.
recorded in the Northern Region between the years 2020 and 2025, categorized according to latency time.
care, allowing observation of the efficiency of the referral flow and the response capacity.
from local health networks:

Table 3 – Notifications by Time Between Bite/Treatment (2020-2025):

Year 0 to 1 hours 1 to 3 hours		3 to 6 hours	6 to 12 hours 12 to 24 hours	
2020 6,456	5,893	3.151	1.386	833
2021 6,876	6.351	3.456	1,513	1.021
2022 7,826	6.903	3,681	1,521	1.006
2023 8,792	7.245	3,526	1,511	1.117
2024 8.986	7.167	3.504	1,454	1.031
2025 9.020	6,842	3.299	1,443	1.205

Source: Ministry of Health/SVSA - Notifiable Diseases Information System - Sinan Net

The data above demonstrates a positive evolution in the speed of initial service, with
The time interval from '0 to 1 hour' showed the highest volume of records in all the years analyzed.
It is observed that this indicator of immediate response jumped from 6,456 notifications in 2020 to 9,020.
in 2025, which represents an increase of approximately 39.7% in the system's capacity in
To provide early support to victims.

On the other hand, although the vast majority of appointments take place within 6 hours, it is noted that
Persistence of cases with waiting times exceeding 12 hours. In the year 2025, for example, the
The number of patients who waited between 12 and 24 hours reached its peak in the historical series, with
1,205 notifications, highlighting that a significant portion of the population still faces bottlenecks.
critical factors for access to serum therapy treatment.

However, understanding this precariousness in care cannot be dissociated from
Extreme environmental dynamics are reshaping the Amazonian territory, where the barriers

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Physical forces imposed by nature began to act as direct determinants of sanitary isolation.

Analysis of recent climate events reveals that the extreme drought recorded in the Amazon... The impact of climate change in 2023 was primarily driven by anthropogenic climate change. According to... World Weather Attribution [WWA] (2024), these changes made the event thirty times more more likely than if there were only the isolated influence of the El Niño phenomenon.

This scenario was aggravated by the simultaneous anomalous warming of the Pacific Ocean and the The North Tropical Atlantic, which profoundly altered atmospheric circulation, inhibiting the formation of of clouds and reducing the volume of rainfall essential for maintaining the hydrographic basin (Senna, 2024).

Furthermore, it is projected that the combination of greenhouse gas emissions and the increase evapotranspiration could make events of this magnitude recurrent every thirteen years, if the global warming reaches the 2°C threshold (Clarke, 2024).

Regarding hydrological indicators, the 2023-2024 biennium has consolidated itself as a period... of an unprecedented water crisis. Satellite monitoring indicated a loss of 3.3 million hectares of water surface in 2023, a deficit that extended into 2024 with the additional loss of 2.2 million hectares by the month of September (Ferreira; Brandão; Souza Jr., 2025). Specifically In Manaus, the severity of the phenomenon was evidenced by the Rio Negro, which reached its minimum level. A historic 12.70 meters, surpassing all records since measurements began in 1902. (Andrade, 2024).

The persistence of this situation in 2024 characterizes a scenario of "drought upon drought," given that... Low rainfall at the end of 2023 prevented the full recovery of the rivers during the rainy season. flood, culminating in new record low water levels in the following year (Costa, 2024).

Alongside water stress, environmental changes have forced changes in The behavior of the local fauna intensifies synanthropic processes. Water scarcity and The degradation of natural habitats has driven wild animals, including snakes, to seek out refuge in remaining wetlands located within anthropogenic perimeters (Change Guide) Climate and Health, 2024).

This displacement, coupled with the migration of prey such as rodents to residential areas, increased the risk of snakebites, since the geographic isolation caused by the low The navigability of the rivers simultaneously hampered access to treatment for the affected populations. serum therapy (Costa, 2024; FVS-RCP, 2025).

The predominance of accidents caused by snakes of the genus *Bothrops* in the Northern Region This is consistent with recurring findings in the literature, which point to this genre as the main one. responsible for snakebites in Brazil, especially in tropical forest areas and environments of transition between natural and anthropogenic zones (Chippaux, 2021; Brazil, 2024). The high incidence of

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Bothrops is related to its wide geographic distribution, high population density and More aggressive behavior in situations involving contact with humans, factors that are widely present in the Amazonian territory.

On the other hand, the lower participation of the genera *Crotalus, Micrurus ,* and *Lachesis* in the records. This should not be interpreted as epidemiologically irrelevant. Accidents caused by these snakes, Although less frequent, they are associated with potentially more severe clinical conditions and greater risk. therapeutic challenges, requiring prompt identification and timely access to specific antivenom.

In this context, Primary Health Care plays a strategic role in identification. Early detection of cases, initial patient stabilization, and appropriate referral within the care network reinforce the importance of the organization of the Unified Health System (SUS) to respond to these needs. an effective way to address the specificities of snakebites in the Amazon.

The overwhelming prevalence of accidents caused by snakes of the genus *Bothrops,* As shown in Graph 4, this has direct implications for the organization of serum logistics. antivenoms in the Northern Region. Considering that antivenom serum is the most demanded in In the Amazonian territory, the high concentration of these accidents reinforces the need for maintenance. of regular and decentralized stocks of this immunobiological product, especially in rural municipalities, peri-urban areas and indigenous territories. The appropriate match between the epidemiological profile The location and availability of the specific antivenom are central elements of the Unified Health System's capacity to respond to snakebites.

It is important to consider that the modernization of the Cold Chain Network initiated by the Ministry of Health from 2024 onwards represents a strategic advance to guarantee conservation and Timely availability of antivenom serums in hard-to-reach areas. The incorporation of chambers Solar-powered refrigerators, high-performance thermal boxes, and the expansion of storage points. In Special Indigenous Health Districts and remote municipalities, greater alignment is possible. between the distribution of different types of serum and the actual pattern of accident occurrence. This This strategy helps to reduce delays in starting serum therapy, minimize clinical complications, and

Brazilian Amazon.

The results reinforce findings previously described in the literature, which point to Pará and the Amazonas is one of the states historically most affected by snakebite accidents in the Amazon. Brazil, due to its extensive forest cover, intense agro-extractive activity and large population contingent exposed to natural environments (Chippaux, 2021; Brazil, 2024). In the case of Tocantins, the high absolute number of cases, even with a smaller territorial extension compared to other Amazonian states, suggests the influence of productive factors, such as the expansion of agriculture and livestock farming. and the occupation of transition areas between cerrado and forest.

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

On the other hand, the lowest numbers were observed in states such as Acre, Amapá, and Roraima. They should not be interpreted solely as lower risk, but also in light of the barriers. geographical factors, population dispersion, and historical limitations in access to health services and to the notification systems. The significant presence of cases in Rondônia and Roraima, especially in indigenous territories and remote rural areas, it highlights the importance of Primary Health Care and the regional organization of the healthcare network as central elements of the response capacity of The Unified Health System (SUS) in the face of snakebite, particularly in contexts of territorial inequality. and environmental.

The evolution of the data presented in Tables 1 and 2 reflects not only the dynamics epidemiological aspects of the health problems, but also the strategic role played by Primary Care. to Health in identifying and referring cases. As the preferred entry point to the Unified Health System (SUS), strengthening the primary care network has been crucial for the reach of surveillance.

The comparative analysis between the sexes, consolidated in the period from 2020 to 2025, shows that The epidemiological profile of the reported cases is predominantly male, although both groups have shown significant growth up to the peak recorded in 2023. In males, Notifications jumped from 95,586 in 2020 to 128,205 in 2023. Meanwhile, the female group... It demonstrated a similar upward trajectory, surpassing the mark of 100,000 annual registrations in same period. This increase in both genders highlights the strategic importance of Attention. Primary Health Care in identifying and referring cases, functioning as the vital link between The occurrence of the illness and timely treatment.

The predominance of care provided within the first hour after the event highlights the role Strategic primary health care as a fundamental pillar of surveillance and assistance. Strengthening the units. basic health care and the reach of family health teams in the Northern Region, especially in areas Remote methods have been crucial for the rapid identification of cases and the establishment of protocols. more agile referral systems, ensuring that the patient accesses the emergency network within the 'window of 'Therapeutic opportunity'.

However, maintaining records with a delay of more than 12 hours reflects the challenges. geographical factors intrinsic to the Amazon, where territorial distances and logistical barriers of Transportation hinders the full operation of primary health care. Thus, the discussion of the data suggests that, although Primary Care has made progress in improving surveillance and referral capabilities Even in its early stages, overcoming territorial determinants still requires investments in infrastructure and in Strategic decentralization of serum therapy centers to mitigate the impact of long distances. in the clinical outcome of accidents.

The convergence between anthropogenic climate change and oceanic phenomena

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

The extreme events in 2023 and 2024 established a new vulnerability paradigm for the region. Amazonian region. The data reveals that the intensification of the drought is no longer an isolated event, but a A direct reflection of global warming, which alters the hydrological cycle and compromises the resilience of the ecosystem, which imposes continuous pressure on biodiversity and on the dynamics of Human occupation is exacerbating contact between species in search of scarce resources.

In this context, the displacement of snakes and their prey to anthropic areas is motivated Due to habitat degradation and the search for moisture, the domestic environment is transformed into a new A high-risk area for snakebites. This forced adaptation process breaks with seasonality. traditional accident prevention suggests that health surveillance strategies need to be... recalibrated to respond not only to floods, but also to the concentration of animals in areas residential areas during periods of extreme drought.

Finally, the gravity of the situation is amplified by the geographical isolation inherent in the logistics. Amazonian river system. The record low river levels in 2023 and 2024 not only increased the The probability of encounters between humans and snakes has decreased, but they have also erected almost physical barriers. insurmountable obstacles to accessing treatment. The peak of patients waiting more than 12 hours for This is a direct result of the impossibility of navigation, highlighting that the climate crisis acts as... a risk multiplier that paralyzes the health system's response and worsens the prognosis of victims in remote communities.

Analysis of the data reveals that, although accidents involving venomous animals persist Despite being a structural public health problem in the region, there have been significant advances in epidemiological surveillance and the response capacity of the Unified Health System (SUS). This progress is inseparable from strengthening Primary Health Care (PHC), which acts as the organizing axis. of assistance and gateway for the timely identification and management of these health problems.

However, the improvement in the quality of notifications in the current period, driven by The capillarity of family health teams allows for a more precise understanding of the magnitude of The problem, although critical challenges related to underreporting in remote territories persist. from the Amazon.

Thus, it can be observed that institutional strengthening and the strategic role of primary health care in Early detection has not yet been accompanied by substantial changes in the determinants. territorial aspects of the disease. This scenario explains the maintenance of notification rates at certain levels. The figures were high in 2024 and 2025, demonstrating the efficiency of the health network in registering and treating patients. The cases coexist with the persistence of environmental and social risk factors characteristic of region.

Final Considerations

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Analysis of epidemiological data between 2020 and 2025 confirms that snakebite persists.
as a structural public health challenge in the Amazon, intrinsically linked to the dynamics
territorial and productive aspects of the region. Although there has been significant progress in the capacity to
surveillance and registration, driven by the capillarity of Primary Health Care and by
Modernization of the Cold Chain Network, the stabilization of notifications at high levels reveals that the
The efficiency of the Brazilian public health system (SUS) in treating cases coexists with the worsening of environmental risk factors.

In this scenario, climate change emerges as a critical determinant and
Multiplier of vulnerabilities. The historic droughts of 2023 and 2024 not only imposed barriers.
severe logistical challenges to river navigation, delaying access to antivenom in remote areas, but
They also profoundly altered the behavior of the local fauna. Water stress and degradation
The loss of natural habitats has intensified the process of snake displacement to perimeters.
Humans seeking refuge and food. This phenomenon alters the seasonal predictability of
accidents, transforming residential areas into zones of immediate risk and exposing populations to accidents.
vulnerable to more frequent accidental encounters.

In short, the resilience of the Brazilian Unified Health System (SUS) in the Amazon region in the face of snakebites depends on maintaining...
Decentralized assistance strategies, such as the expansion of solar serum therapy centers and the
Strengthening primary health care. However, it is imperative that health surveillance integrates variables.
climate and ecological factors in their forecasting models. Only an approach that recognizes the
Synanthropy and extreme weather events as components of epidemiological dynamics will be
capable of mitigating territorial inequalities and ensuring a swift and timely response to new challenges.
environmental settings of the region.

References

ANDRADE, RO. **The drought that affected the Amazon in 2023 caused the largest drop in river levels ever recorded.** Jornal da Unesp, São Paulo, 2024. Available at: [Link to source]. Accessed on: Dec. 24, 2025.

BRAZIL. Ministry of Health. **Ministry of Health modernizes distribution of antivenom to Yanomami territory.** Brasília: Ministry of Health, April 29, 2024. Available at: https://www.gov.br/saude/pt-br/assuntos/noticias/2024/abril/ministerio-da-saude-moderniza-distribuicao-de-soro-antiofidico-para-territorio-yanomami . Accessed on: December 15, 2025.

BRAZIL. Ministry of Health. **Notifiable Diseases Information System (SINAN).** Accidents involving venomous animals. Brasília: Ministry of Health, 2025. Available at: https://datasus.saude.gov.br. Accessed on: December 2, 2025.

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

BRAZIL. Ministry of Health. Secretariat of Health and Environmental Surveillance. **Epidemiological Bulletin: Diseases and health problems related to work.** Brasília: Ministry of Health, v. 56, n. 19, 2024.

CARNEIRO, LQCC et al. Epidemiological profile of patients treated due to snakebite accidents in Northern Brazil, Amazon Region, from 2009 to 2019. **Multidisciplinary Scientific Journal Nucleus of Knowledge,** year 5, ed. 9, v. 3, p. 47–59, 2020.

CHIPPAUX, J.-P. Snakebite envenomation turns again into a neglected tropical disease! **Journal of Venomous Animals and Toxins including Tropical Diseases,** Botucatu, v. 27, e20210004, 2021.

CLARKE, B. **Climate change and the 2023 exceptional drought in the Amazon: attribution analysis.** World Weather Attribution, 2024.

COSTA, MA Dynamics of accidents caused by venomous animals in extreme weather events in the Amazon. **Brazilian Journal of Epidemiology,** v. 27, p. e240012, 2024.

FEITOSA, ESL et al. Snakebite envenomation in Brazil: epidemiology, challenges and perspectives. **Tropical Medicine and Infectious Disease,** Basel, vol. 7, no. 8, p. 1–15, 2022.

FERREIRA, BG; BRANDÃO, IM; SOUZA JR., CM Severe droughts in the Amazon in 2023 and 2024: detection and monitoring with satellite images. In: **Proceedings of the XXI Brazilian Symposium on Remote Sensing,** São José dos Campos: INPE, 2025.

FLEISCHMANN, AS et al. Extreme warming of Amazon waters in a changing climate. **Science,** vol. 390, n. 6721, p. 450-455, 2025.

AMAZONAS HEALTH SURVEILLANCE FOUNDATION (FVS-RCP). **Epidemiological Bulletin: Monitoring of Snakebite Accidents during Prolonged Drought Periods.**
Manaus: FVS-RCP, 2025.

GUTIÉRREZ, JM et al. Snakebite envenoming. **Nature Reviews Disease Primers,** London, vol. 7, no. 1, p. 1–21, 2021.

Ministry of Health. **Guide to Climate Change and Health: Impacts of the climate crisis on the proliferation of venomous animals.** Brasília: Ministry of Health, 2024.

SENNA, MCA. Oceanic thermal anomalies and the Amazonian water crisis of 2023. **Brazilian Journal of Meteorology,** v. 39, 2024.

WALDEZ, F.; VOGT, RC. Ecology of snakes and the risk of snakebites in riverside communities in the face of environmental changes. In: **Proceedings of the National Institute for Amazonian Research (INPA).**
Manaus: INPA, 2024.

WALDEZ, F.; VOGT, RC. Ecology of snakes and the risk of snakebites in riverside communities in the face of environmental changes. In: **Proceedings of the National Institute for Amazonian Research (INPA).**

Year V, v.2 2025 | Submission: 12/25/2025 | Accepted: 12/27/2025 | Publication: 12/29/2025

Manaus: INPA, 2024.

WORLD HEALTH ORGANIZATION (WHO). **Snakebite envenomation: a strategy for prevention and control (2023–2030).** Geneva: World Health Organization, 2023.

WORLD WEATHER ATTRIBUTION (WWA). **Climate change, not El Niño, was the main cause of the exceptional drought in the Amazon in 2023.** Technical Report, London, 2024.

WWF-Brazil. **Socio-environmental Impact Report: The historic drought in the Amazon in 2023.** Brasilia: WWF, 2023.