SNAKEBITE ACCIDENTS IN THE AMAZON AND THEIR LOCAL COMPLICATIONS: TISSUE NECROSIS ASSOCIATED WITH PREDOMINANT SPECIES IN THE STATE OF AMAZONAS

ACIDENTES OFÍDICOS NA AMAZÔNIA E SUAS COMPLICAÇÕES LOCAIS: NECROSE TECIDUAL ASSOCIADA ÀS ESPÉCIES PREDOMINANTES NO AMAZONAS

ACCIDENTES OFÍDICOS EN LA AMAZONÍA Y SUS COMPLICACIONES LOCALES: NECROSIS TISULAR ASOCIADA A LAS ESPECIES PREDOMINANTES EN EL ESTADO DE AMAZONAS

https://doi.org/10.56238/sevened2026.019-005

Thaís da Costa Dias[1], Caty Esbelana Urrego Ditta[2], Laisa Divina Vieira Lavor[3], Kezia de Souza Nunes[4], Kessia Cibele Machado Ferreira[5], Paula Cristine da Silva Freitas[6], Walter Oliveira da Costa[7], Dimas Melo Gonçalves[8]

ABSTRACT

Snakebite accidents represent a significant public health issue, particularly in the Amazon region, where environmental and occupational factors, along with high biodiversity, increase human exposure to venomous snakes. In this context, the genus Bothrops stands out as the main cause of envenomation, often associated with severe local complications such as tissue necrosis. This study aimed to analyze snakebite accidents in the Amazon and their local complications, with emphasis on tissue necrosis associated with predominant species in the state of Amazonas. This is a qualitative, exploratory, and descriptive study conducted through a literature review of scientific articles published between 2021 and 2026, selected from relevant health science databases. The findings indicate that Bothrops atrox is the primary species involved in snakebite cases in the region, responsible for intense local clinical manifestations such as edema, pain, hemorrhage, and tissue necrosis. Furthermore, the severity of complications is directly related to the time to medical care and the amount of venom injected, potentially leading to permanent sequelae and significant impacts on patients' quality of life. It is concluded that snakebite accidents in the Amazon constitute a complex phenomenon with important clinical and social implications, highlighting the need for effective strategies for prevention, early diagnosis, and appropriate treatment.

Keywords: Amazon. Bothrops Atrox. Envenomation. Snakebite Accidents. Tissue Necrosis.

[1] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: sobreirac.thais@gmail.com
[2] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: catyditafaculdade@outlook.com
[3] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: laisalavor92@gmail.com
[4] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: kezia.dsn@gmail.com
[5] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: kessia-querida@hotmail.com
[6] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: paulafreitas2001@yahoo.com.br
[7] Medical Student. Faculdade Santa Teresa - Manaus. E-mail: walteroli8@yahoo.com.br
[8] Master's degree in Process Engineering. Faculdade Santa Teresa - Manaus.
E-mail: dimasmelogoncalves@gmail.com

RESUMO

Os acidentes ofídicos representam um importante problema de saúde pública, especialmente na região amazônica, onde fatores ambientais, ocupacionais e a elevada biodiversidade favorecem o contato entre humanos e serpentes peçonhentas. Nesse contexto, destaca-se o gênero Bothrops, responsável pela maioria dos envenenamentos na região, frequentemente associado a complicações locais graves, como a necrose tecidual. O presente estudo teve como objetivo analisar os acidentes ofídicos na Amazônia e suas complicações locais, com ênfase na necrose tecidual associada às espécies predominantes no estado do Amazonas. Trata-se de uma pesquisa de natureza qualitativa, com caráter exploratório e descritivo, desenvolvida por meio de revisão bibliográfica de artigos científicos publicados entre 2021 e 2026, selecionados em bases de dados relevantes da área da saúde. Os resultados evidenciam que Bothrops atrox é a principal espécie envolvida nos acidentes na região, sendo responsável por manifestações clínicas locais intensas, como edema, dor, hemorragia e necrose tecidual. Observou-se ainda que a gravidade das complicações está diretamente relacionada ao tempo de atendimento e à quantidade de veneno inoculado, podendo resultar em sequelas permanentes e impacto significativo na qualidade de vida dos indivíduos afetados. Conclui-se que os acidentes ofídicos na Amazônia constituem um fenômeno complexo, com importantes implicações clínicas e sociais, reforçando a necessidade de estratégias eficazes de prevenção, diagnóstico precoce e tratamento adequado.

Palavras-chave: Acidentes Ofídicos. Amazônia. Bothrops Atrox. Envenenamento. Necrose Tecidual.

RESUMEN

Los accidentes ofídicos representan un importante problema de salud pública, especialmente en la región amazónica, donde factores ambientales, ocupacionales y la alta biodiversidad favorecen el contacto entre humanos y serpientes venenosas. En este contexto, el género Bothrops se destaca como el principal responsable de los envenenamientos, frecuentemente asociado a complicaciones locales graves, como la necrosis tisular. El presente estudio tuvo como objetivo analizar los accidentes ofídicos en la Amazonía y sus complicaciones locales, con énfasis en la necrosis tisular asociada a las especies predominantes en el estado de Amazonas. Se trata de una investigación de naturaleza cualitativa, con carácter exploratorio y descriptivo, desarrollada mediante revisión bibliográfica de artículos científicos publicados entre 2021 y 2026, seleccionados en bases de datos relevantes del área de la salud. Los resultados evidencian que Bothrops atrox es la principal especie involucrada en los accidentes en la región, siendo responsable de manifestaciones clínicas locales intensas como edema, dolor, hemorragia y necrosis tisular. Asimismo, se observó que la gravedad de las complicaciones está directamente relacionada con el tiempo de atención médica y la cantidad de veneno inoculado, pudiendo resultar en secuelas permanentes y un impacto significativo en la calidad de vida de los individuos afectados. Se concluye que los accidentes ofídicos en la Amazonía constituyen un fenómeno complejo, con importantes implicaciones clínicas y sociales, lo que refuerza la necesidad de estrategias eficaces de prevención, diagnóstico precoz y tratamiento adecuado.

Palabras clave: Accidentes Ofídicos. Amazonía. Bothrops Atrox. Envenenamiento. Necrosis Tisular.

1 INTRODUCTION

Snakebites are a relevant public health problem in several tropical regions of the world, especially in countries with great biodiversity and extensive natural areas, such as Brazil. In the Amazon region, this scenario becomes even more expressive due to the intense interaction between human populations and the forest environment, which favors contact with venomous snakes. According to Scheliga (2024), the epidemiology of snakebite accidents in Brazil is more concentrated in the North region, highlighting the need for studies focused on the environmental and social specificities of the Amazon.

In this context, the genus Bothrops stands out as the main responsible for snakebite accidents in the country, and the species Bothrops atrox is widely associated with the cases registered in the Amazon region. This predominance is related both to the wide geographical distribution of these snakes and to their adaptive behavior in environments close to human activity. As Silva (2023) points out, botroscopic accidents represent the majority of cases of snake envenomation in Brazil, especially in tropical forest areas, where there is greater occupational and environmental exposure.

From a clinical point of view, accidents caused by snakes of the genus Bothrops have local and systemic manifestations that can evolve into severe conditions when not treated properly. Among the most relevant local complications, tissue necrosis stands out, characterized by the progressive destruction of tissues at the site of the bite, which may result in permanent sequelae. According to Nascimento (2024), tissue damage resulting from bothrops envenomation often requires prolonged hospital follow-up, especially in cases where there is significant muscle involvement.

In addition to the clinical aspects, snakebites also have important social and economic impacts, since they affect, for the most part, individuals of working age, especially rural workers and populations that depend directly on the natural environment for their subsistence. In this sense, Fernández (2025) highlights that the sequelae resulting from tissue necrosis can compromise the functional capacity of individuals, directly impacting their quality of life and work activities.

In view of this scenario, it is essential to understand the factors involved in the occurrence of snakebites in the Amazon, as well as the local complications associated with envenomation, with emphasis on tissue necrosis. The analysis of these elements allows not only to expand scientific knowledge on the subject, but also to contribute to the development of more effective prevention, diagnosis, and treatment strategies.

2 THEORETICAL FRAMEWORK

Snakebites represent an important public health problem in tropical regions, especially in areas of the Brazilian Amazon, where the interaction between human populations and natural environments favors the occurrence of snake envenomation. Recent studies indicate that Brazil registers thousands of cases annually, with the North region responsible for a significant portion of these records. In this context, the high biodiversity of snakes and the presence of rural, extractive and forestry activities increase the risk of exposure of the population to snakebites. As demonstrated by Scheliga (2024), the epidemiology of snake accidents in Brazil is strongly concentrated in Amazonian areas, which highlights the need for studies directed to the ecological and clinical particularities of this region.

Among the snakes responsible for accidents in the Amazon, the genus *Bothrops* stands out, whose geographic distribution and behavior contribute to the high incidence of envenomation. The species *Bothrops atrox* is considered the main responsible for snakebites in the Amazon region, and is often associated with severe clinical manifestations. According to Silva (2023), botroscopic accidents represent most of the cases recorded in the country, especially in tropical forest regions, where environmental conditions favor the abundance of these snakes. In addition, Amaral (2024) observes that the diversity of species involved in tropical snakebites reinforces the epidemiological complexity of the problem, requiring specific regional approaches to understand the dynamics of these events.

In the clinical context, accidents caused by snakes of the genus *Bothrops* are characterized by systemic and local manifestations resulting from the action of the venom. Among the most relevant local complications are edema, hemorrhage, severe pain, and tissue necrosis, conditions that can evolve into permanent sequelae when treatment is not carried out quickly and adequately. According to Nascimento (2026), envenomation by *Bothrops atrox* can trigger serious complications, such as compartment syndrome, as a result of the intense inflammatory response and vascular impairment caused by the toxins present in the venom. These local effects represent one of the main causes of morbidity associated with snakebite accidents in the Amazon.

The pathophysiology of tissue necrosis associated with botroscopic accidents is directly related to the action of proteolytic enzymes, metalloproteinases and phospholipases present in snake venom. These substances promote cell destruction, vascular changes, and inflammatory processes that lead to tissue degradation at the bite site. Nascimento (2024) highlights that local damage caused by bothrops envenomation may require prolonged hospital care, especially when there is significant muscle and skin involvement. In this sense, understanding the pathophysiological mechanisms involved in tissue necrosis becomes

essential for the development of more effective therapeutic strategies and for reducing the sequelae resulting from these accidents.

In addition to local pathophysiological changes, snakebites caused by snakes of the genus *Bothrops* can also have long-term functional consequences. Complications from tissue necrosis often result in permanent physical limitations, especially when there is a delay in medical care or when treatment is not carried out properly. In this sense, Fernández (2025) highlights that victims of botropic accidents in the Amazon can present lasting sensory and motor sequelae, compromising the quality of life and work capacity of affected individuals. These consequences show that the impact of snakebite accidents goes beyond the acute phase of envenomation, configuring itself as a public health problem that also involves social and economic aspects.

The epidemiological analysis of snakebite accidents in Brazil shows that certain population groups are more vulnerable to this type of occurrence. In general, rural workers, farmers, fishermen and populations living in areas close to forest environments are more exposed to the risk of contact with snakes. According to Silva (2023), accidents by snakes of the genus *Bothrops* predominantly affect male individuals of productive age, reflecting the association between work activities and environmental exposure. This epidemiological profile reinforces the importance of preventive strategies aimed at populations living or working in regions at higher risk.

Another relevant aspect refers to the diversity of species responsible for snakebite accidents in the Amazon, which contributes to the variability of the clinical manifestations observed in patients. Although *Bothrops atrox* is the main species involved in envenomations in the region, other representatives of the genus may also be associated with accidents with similar clinical manifestations. In this context, Oliveira Pardal (2023) reports records of envenomation by *Bothrops brazili* in the Brazilian Amazon, showing that different species can cause complex clinical conditions and require an appropriate therapeutic approach. The correct identification of the species involved in the accident is, therefore, a relevant element for the clinical and epidemiological management of cases.

In addition to the diversity of species, environmental and ecological factors also influence the occurrence of snakebites in the Amazon region. The proximity between urbanized areas and natural environments favors increased contact between humans and snakes, especially in regions where agricultural and extractive activities are predominant. Siqueira (2025) observes that the spatial distribution of snakebites in the North region is directly related to local environmental characteristics, such as vegetation cover, rainfall and the presence of rural areas. Thus, understanding the ecological dynamics of snakes becomes

essential for the planning of public policies aimed at preventing and controlling these accidents.

Another relevant aspect in the theoretical framework on snakebite accidents in the Amazon refers to the clinical complications resulting from envenomation, especially those associated with local tissue involvement. The toxins present in the venom of snakes of the genus *Bothrops* have strong proteolytic and hemotoxic activity, which contributes to the progressive destruction of tissues at the bite site. This process can result in extensive necrosis, often accompanied by severe edema and local hemorrhage. In this sense, studies indicate that the intensity of these manifestations is directly related to the amount of venom inoculated and the time elapsed until the start of treatment. Amaral (2024) points out that the complexity of the toxins present in bothrops venom contributes to the diversity of clinical manifestations observed in patients, which makes the clinical management of these accidents a constant challenge in health services.

Tissue necrosis resulting from botroscopic accidents represents one of the main causes of morbidity associated with snake envenomation in the Amazon region. This condition can progress to secondary infections, loss of muscle tissue, and, in more severe cases, the need for surgical procedures or amputations. Nascimento (2024) highlights that patients affected by *Bothrops atrox* envenomation often require prolonged hospital follow-up due to the severity of local lesions and complications resulting from the inflammatory process triggered by the venom. This scenario highlights the importance of early diagnosis and proper administration of antivenom as fundamental measures to reduce tissue damage.

In addition to the immediate clinical manifestations, snakebites can have lasting impacts on the health of affected individuals. The physical sequelae resulting from tissue necrosis can significantly compromise the functionality of the affected limbs, limiting daily and professional activities. Fernández (2025) observes that individuals who are victims of botropes in the Amazon often have persistent sensory and motor limitations, as a result of the tissue destruction caused by the venom. These consequences demonstrate that snakebites should not only be analyzed from an acute clinical perspective, but also considering the long-term effects on the quality of life of exposed populations.

Another important element in understanding the complications associated with snakebites concerns the therapeutic strategies employed in the treatment of these envenomations. Antivenom continues to be the main therapeutic resource used in the clinical management of these cases, acting to neutralize the toxins present in the venom. However, the effectiveness of the treatment is directly related to the time of administration and the clinical conditions of the patient at the time of care. Teixeira (2024) points out that the search

for complementary therapeutic alternatives has been the subject of scientific investigation, especially with regard to the control of local complications, such as necrosis and tissue inflammation. Thus, the expansion of knowledge about the mechanisms of action of the venom and about the forms of therapeutic intervention is an essential step towards improving the clinical management of snakebites.

3 METHODOLOGY

The present research is characterized as a qualitative study of exploratory and descriptive character, developed through a literature review. This type of approach allows a critical analysis of the scientific knowledge already produced about a given phenomenon, making it possible to understand the main theoretical perspectives, scientific advances, and gaps in the literature. The choice of this methodological design is justified by the need to gather and analyze recent scientific evidence on snakebites in the Amazon and their local complications, especially those related to tissue necrosis associated with the predominant species in the state of Amazonas.

The universe of the research consisted of scientific articles published in national and international academic journals that address snakebites, envenomation by snakes of the genus *Bothrops*, clinical complications associated with envenomation and epidemiological aspects of these accidents in the Amazon region. The sample consisted of ten scientific articles published in the last five years, selected for their thematic relevance and scientific contribution to the understanding of the clinical manifestations and local complications resulting from snake envenomation.

Data collection was carried out through a systematic search in scientific databases widely used in the area of health and biological sciences, including academic indexing platforms and repositories of scientific journals. Descriptors related to the research theme were used, such as snakebite, *snakebite*, tissue necrosis, *Bothrops atrox*, bothrops envenomation and Amazonia. These descriptors were strategically combined to expand the scope of the search and identify relevant scientific studies published in the period delimited for the investigation.

After the initial identification of the publications, a screening stage of the studies was carried out based on previously defined inclusion and exclusion criteria. Scientific articles published between 2021 and 2026, available in full format, and that had a direct relationship with snakebites, pathophysiology of envenomation, clinical manifestations, or complications associated with tissue necrosis were included. Studies that did not have a direct relationship with the topic investigated, duplicate publications, or studies that did not provide access to

the full text were excluded.

Data analysis was conducted through analytical and interpretative reading of the selected studies, seeking to identify convergences, divergences and relevant contributions to the understanding of the investigated phenomenon. In this process, aspects such as the objectives of the research, the methods used, the main results found and the clinical and epidemiological implications of snakebites described in the analyzed studies were examined. From this analysis, it was possible to systematize the existing knowledge about the occurrence of these accidents in the Amazon and about the local complications resulting from poisoning.

Like all research based on literature review, the present study has some methodological limitations. Among them, the dependence on the availability of published studies on the subject stands out, as well as possible methodological differences between the studies analyzed. Even so, the use of recent scientific articles from recognized journals contributes to strengthen the consistency of the information analyzed and to expand the scientific understanding of snakebites and their local complications in the Amazon region.

The literature review carried out in this research allowed the identification of recent studies that address epidemiological, clinical and pathophysiological aspects of snakebites, with emphasis on the predominant species in the Amazon and the local complications resulting from envenomation.

The selected studies contribute to understanding the dynamics of these accidents, the mechanisms of action of the venom and the associated clinical impacts, especially with regard to tissue necrosis and the sequelae resulting from bothrops envenomation. The following table presents the main authors used in the construction of the theoretical framework, as well as the titles of the works and the respective years of publication.

Table 1

Authors used in the research

Author	***Title***	***Year***
Amaral	*Snakes involved in snakebites in tropical regions of Brazil*	*2024*
Fernández	*Physical and sensory long-term disabilities from Bothrops snakebites in the western Brazilian Amazon*	*2025*
Birth	*Acute compartment syndrome in Bothrops atrox snakebites*	*2026*
Birth	*Long-term hospital care needs after Bothrops atrox envenomation*	*2024*

Author	Title	Year
Oliveira Pardal	First record of envenomation by Bothrops brazili in the Brazilian Amazon	2023
Scheliga	Exploring snakebite epidemiology and outcomes in Brazil	2024
Siqueira	Epidemiology and clinical characteristics of snakebite accidents in the Northern region of Brazil	2025
Silva	Who are the most affected by Bothrops snakebite envenoming in Brazil	2023
Souza	Botroscopic accidents in Brazil, a brief review	2024
Teixeira	Therapeutic alternatives for the treatment of snakebites	2024

Source: The authors.

From the studies presented in the table, it is observed that the recent scientific literature has directed significant attention to the epidemiological, clinical and therapeutic aspects of snakebites, especially those related to snakes of the genus *Bothrops*, predominant in the Amazon.

The analyzed studies show the relevance of the theme for public health, highlighting both the pathophysiological mechanisms of envenomation and local complications, such as tissue necrosis, in addition to the functional and social consequences resulting from these accidents. Thus, the joint analysis of these studies contributes to theoretically support the investigation proposed in this study.

4 RESULTS AND DISCUSSIONS

The analysis of the selected studies allowed us to identify that snakebite accidents continue to represent a relevant public health problem in Brazil, especially in the Amazon region, where environmental, social and occupational factors contribute to the higher incidence of these events. The results found in the literature show that snakes of the genus *Bothrops* are responsible for most of the accidents recorded in the Amazon, with *Bothrops atrox* being the species most frequently associated with cases of human envenomation. In this context, epidemiological studies show that the distribution of these accidents is strongly related to the proximity between human populations and natural environments, in addition to the performance of work activities in rural or forest areas. Scheliga (2024) highlights that the epidemiological pattern of snakebite accidents in Brazil is strongly concentrated in tropical regions, particularly in the Amazon, where the diversity of snakes and environmental characteristics favor increased contact between humans and these animals.

In addition to the high incidence of these accidents in the Amazon region, the results

analyzed indicate that certain populations are more vulnerable to snake envenomation. In general, the individuals most affected are rural workers, farmers, fishermen and populations living in areas close to the forest. According to Silva (2023), accidents caused by snakes of the genus *Bothrops* predominantly affect male individuals of economically active age, which highlights the direct relationship between occupational activities and risk of exposure to envenomation. This epidemiological profile also reinforces the need for public policies aimed at preventing these accidents, including educational actions and health surveillance strategies in regions considered to be at higher risk.

Another relevant aspect identified in the analyzed studies refers to the clinical manifestations associated with bothrops envenomation, especially with regard to local complications resulting from the action of the venom. The data indicate that envenomation by *Bothrops atrox* is often associated with intense local manifestations, such as pain, edema, hemorrhage, and tissue necrosis. Nascimento (2026) observes that the action of the toxins present in the venom of these snakes can cause significant vascular and inflammatory damage, leading to the development of serious complications, such as compartment syndrome. This clinical picture results from increased pressure in the muscle compartments, caused by intense edema and vascular involvement, which can lead to permanent damage to the affected tissues.

The results also show that tissue necrosis represents one of the main local complications associated with botroscopic accidents in the Amazon. This process occurs as a result of the action of enzymes present in the venom, which promote degradation of structural proteins and compromise local microcirculation. Amaral (2024) points out that the diversity of toxins present in the venom of snakes of the genus *Bothrops* contributes to the complexity of the clinical manifestations observed in patients, especially with regard to tissue lesions and intense inflammatory processes at the bite site. In this sense, the studies analyzed indicate that tissue necrosis can evolve rapidly when there is no adequate therapeutic intervention, increasing the risk of severe complications and permanent sequelae.

Another relevant result identified in the literature concerns the functional and social impact resulting from complications associated with snakebites. Tissue injuries caused by envenomation can result in long-term physical disabilities, significantly compromising the quality of life of affected individuals. Fernández (2025) points out that victims of botroscopic accidents in the Amazon often have persistent motor and sensory sequelae, resulting from the destruction of muscle and nerve tissues caused by the toxins in the venom. These consequences show that snakebites should not be analyzed only from the perspective of the

acute phase of envenomation, but also considering the lasting effects that can impact the social and economic life of the affected populations.

The results presented in this stage demonstrate that snakebites in the Amazon involve a complex set of epidemiological, environmental and clinical factors, which contribute to the occurrence of severe local complications, such as tissue necrosis. The analysis of the selected studies reinforces the importance of understanding the dynamics of these accidents and the pathophysiological mechanisms involved in bothrops envenoming, in order to expand scientific knowledge on the subject and contribute to the improvement of strategies for the prevention, diagnosis, and treatment of these diseases.

The discussion of these results continues in the next section, in which other scientific evidence related to clinical complications and therapeutic approaches used in the management of snakebite events will be analyzed.

The analysis of the selected studies also highlighted the importance of identifying the species involved in snakebites for an adequate understanding of the clinical manifestations and complications associated with envenomation. Although *Bothrops atrox* is recognized as the main species responsible for accidents in the Amazon, other representatives of the genus may also be associated with relevant clinical cases in the region. In this context, Oliveira Pardal (2023) records the occurrence of envenomation by *Bothrops brazili* in the Brazilian Amazon, highlighting that different species may present variations in the composition of the venom and, consequently, in the clinical manifestations observed in patients. This biological diversity contributes to the complexity of the clinical diagnosis and reinforces the need for greater knowledge about the regional snakebite.

Another relevant result identified in the analyzed studies refers to the time of medical care as a determining factor for the clinical evolution of patients who are victims of snakebites. The literature indicates that the speed of administration of antivenom plays a fundamental role in reducing the local and systemic complications of envenomation. Nascimento (2024) highlights that patients who receive late care are more likely to develop extensive tissue lesions and complications that require prolonged hospital follow-up. Thus, the availability of health services in remote areas of the Amazon is an essential element for reducing the morbidity associated with snake accidents.

In addition, the results indicate that tissue necrosis resulting from bothrops envenomation has a significant impact on the clinical evolution of patients, and may result in permanent functional loss of the affected limbs. Amaral (2024) points out that the toxins present in the venom of snakes of the genus *Bothrops* have a high capacity to cause cell destruction and local inflammation, favoring the development of extensive lesions in the

affected tissues. This pathological process can progress to severe conditions when there is no adequate therapeutic intervention or when treatment is carried out late, increasing the risk of irreversible sequelae.

Another relevant point identified in the literature analysis refers to the epidemiological characteristics of snakebite accidents in the northern region of Brazil. Siqueira (2025) observes that the occurrence of these accidents is often associated with rural areas and forest regions, where activities such as agriculture, extractivism, and fishing expose populations to contact with snakes. This epidemiological pattern shows that snakebites are not random events, but rather phenomena strongly influenced by environmental and socioeconomic factors present in the Amazon region.

The studies analyzed also point to the need for the development and improvement of therapeutic strategies capable of reducing the complications associated with snake envenomation. Although antivenom continues to be the main therapeutic resource used in the treatment of these accidents, recent research indicates the importance of complementary approaches aimed at controlling local complications.

Teixeira (2024) highlights that new therapeutic alternatives have been investigated with the aim of minimizing tissue damage and improving the prognosis of patients who are victims of snakebites. These findings reinforce the relevance of expanding scientific knowledge about the mechanisms of action of the venom and about the treatment strategies capable of reducing the sequelae resulting from these accidents.

The discussion of the results also shows that snakebites have impacts that go beyond the immediate clinical dimension, configuring themselves as a problem that involves social, economic and structural aspects, especially in regions of difficult access such as the Amazon. The studies analyzed indicate that the occurrence of these accidents is often associated with rural communities and forest areas, where access to health services may be limited. In this sense, Scheliga (2024) observes that the geographical distribution of snakebite accidents in Brazil reveals a higher incidence in tropical regions, in which environmental and socioeconomic factors directly influence the risk of exposure to snakes.

Another important aspect identified in the studies refers to the functional consequences resulting from the lesions caused by bothrops envenomation. Tissue necrosis, often seen in these cases, can result in loss of muscle mass, impairment of nerve structures, and permanent limitations of the affected limbs. Fernández (2025) points out that the sequelae associated with accidents by snakes of the genus *Bothrops* can generate long-lasting physical disabilities, compromising the victims' work capacity and quality of life. These results demonstrate that snakebites should be analyzed not only from a clinical perspective,

but also considering their social and economic effects on the affected populations.

The integrated analysis of the selected studies also allows us to observe that the complexity of bothrops envenomation is related to the diversity of toxins present in the venom of these snakes. Amaral (2024) points out that the biochemical composition of the venom can vary between species and even between populations of the same species, influencing the intensity of the clinical manifestations observed in patients. This variability contributes to the diversity of clinical conditions recorded in snakebite accidents and reinforces the need for further research on the pathophysiology of envenomation and its local complications.

In addition, the results discussed indicate that epidemiological knowledge about snakebites is an essential tool for planning strategies for the prevention and control of these diseases. Studies such as those by Silva (2023) and Siqueira (2025) show that the identification of the population groups most exposed to the risk of accidents allows for the direction of public policies and educational actions aimed at reducing the incidence of these events. Thus, prevention measures, training of health professionals and expansion of access to appropriate treatment become essential to reduce the impacts of snakebite accidents in the Amazon region.

In general, the analysis of the selected studies demonstrates that snakebites in the Amazon represent a complex phenomenon, influenced by biological, environmental and social factors. The high incidence of these accidents, associated with local complications such as tissue necrosis, highlights the need to expand scientific knowledge on the subject and strengthen prevention and treatment strategies. In this context, the integration between scientific research, public health policies, and health education actions is essential to reduce the morbidity associated with snake envenomation and improve the quality of life of populations exposed to this risk.

The systematized analysis of the selected studies allowed the identification of different methodological approaches and scientific objectives aimed at understanding snakebites, especially those associated with snakes of the genus *Bothrops* in the Amazon. The studies analyzed range from epidemiological and clinical aspects to discussions on local complications and therapeutic strategies used in the management of envenomation.

The organization of this information in a table allows us to visualize in a comparative way the contributions of each study to the understanding of the investigated phenomenon. Thus, the following table presents the main authors used in the research, as well as the objectives, methods used and the main results found in each study.

Table 2

Synthesis of the studies used in the research

Authors	***Objective***	***Method***	***Main results***
Amaral	*To analyze snake species involved in snakebite accidents in tropical regions*	*Literature review*	*He identified a predominance of snakes of the genus Bothrops in snakebites and highlighted the diversity of toxins present in the venom, associated with local complications such as tissue necrosis*
Fernández	*To investigate the physical and sensory sequelae resulting from botropic accidents in the Amazon*	*Observational study*	*Demonstrated that victims of Bothrops poisoning may have long-term motor and sensory limitations*
Birth (2026)	*To evaluate clinical complications associated with Bothrops atrox poisoning*	*Clinical study*	*It showed the occurrence of serious complications, such as compartment syndrome and tissue damage associated with the action of toxins*
Birth (2024)	*To analyze the need for long-term hospital care after bothrops poisoning*	*Clinical study and case analysis*	*It indicated that severe local injuries may require prolonged hospital treatment and medical follow-up*
Oliveira Pardal	*To record and analyze cases of envenomation by Bothrops brazili in the Amazon*	*Case report*	*It showed that different species of the genus Bothrops can cause complex clinical conditions*
Scheliga	*To investigate the epidemiological profile of snakebite accidents in Brazil*	*Epidemiological study*	*It identified a higher concentration of accidents in tropical regions and association with environmental factors*
Siqueira	*To analyze epidemiological characteristics of snakebite accidents in the North region*	*Epidemiological study*	*It demonstrated a relationship between snakebites, rural activities and forest environments*
Silva	*To identify the population groups most affected by botroscopic accidents in Brazil*	*Epidemiological study*	*It indicated a predominance of male victims of working age*
Souza	*To review the literature on botroscopic accidents in Brazil*	*Literature review*	*He highlighted the main clinical and epidemiological aspects of bothrops envenomation*
Teixeira	*To investigate therapeutic alternatives for the treatment of snakebites*	*Literature review*	*He indicated the importance of complementary therapies to antivenom to reduce local complications*

Source: The authors.

From the synthesis presented in the table, it is observed that the studies analyzed converge in pointing out the predominance of accidents caused by snakes of the genus *Bothrops* in the Amazon region, as well as the relevance of local complications associated with envenomation, especially tissue necrosis.

In general, the research highlights both the epidemiological aspects of these accidents and the clinical and functional implications resulting from the injuries caused by the venom, evidencing the importance of expanding scientific knowledge on the subject to support more effective prevention, diagnosis and treatment strategies.

5 CONCLUSION

The present study achieved the proposed objective by analyzing the application of the protection of sensitive personal data in the health area, evidencing the relevance of adapting to current regulations and the need for more rigorous practices in the treatment of this information. The investigation allowed us to understand that health data, due to its highly sensitive nature, requires not only legal compliance, but also an ethical commitment on the part of the institutions and professionals involved.

Despite the advances in the adoption of data protection measures, there are still important flaws, such as the lack of standardization of procedures, the need for greater training of professionals, and the insufficiency in monitoring compliance with the rules.

In addition, it was found that the adoption of good practices, such as the implementation of clear internal policies, investment in information security technologies and the awareness of the agents involved, contributes significantly to risk mitigation. In this sense, data protection in health should not be understood only as a legal obligation, but as an essential element for the quality of care and trust between patients and institutions.

The questions raised in the introduction were duly answered, demonstrating that the effective application of the rules depends on the integration between technical, legal and organizational aspects. The hypotheses initially considered can be classified as partially confirmed, since, despite the existence of adequate legal mechanisms, their practical application still faces relevant challenges.

Finally, the importance of continuing studies in the area is highlighted, especially in the face of constant technological transformations and the growing volume of data generated in the health sector. Future investigations can deepen the analysis of more effective implementation and monitoring strategies, contributing to the continuous improvement of the protection of sensitive personal data.

ACKNOWLEDGMENTS

The authors express their sincere gratitude to all researchers and science professionals, especially to our professor and advisor who, through their studies and investigations, contribute to the expansion of knowledge about snakebite accidents and their impacts on human health. The development of this work is also supported by the collective effort of researchers who dedicate their careers to understanding the scientific and social challenges present in the Amazon region.

In particular, the honor of being able to contribute to the dissemination of scientific knowledge produced from the reality of the Amazon is registered. The region is home to one of the greatest biodiversity on the planet and presents unique challenges for science and public health. Spreading this knowledge to the international scientific community represents not only an academic commitment, but also a way of valuing the environmental, social, and cultural richness of the Amazon, expanding the visibility of its issues and strengthening scientific dialogue with the world.

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