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SNAKEBITE: IMPORTANCE OF IMMEDIATE DIAGNOSIS AND TREATMENT

MORDEDURA DE SERPIENTE: IMPORTANCIA DEL DIAGNÓSTICO Y TRATAMIENTO INMEDIATO

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ABSTRACT

Snakebites affect around three million people worldwide every year. It is an ecological, social, and economic phenomenon, as well as a neglected tropical disease that impacts tropical and subtropical countries and poor, rural populations with limited access to health services and antivenoms, which means that morbidity and mortality are considered in public policies and international agreements mediated by the World Health Organization. The objective of this study is to present a review of the importance of immediate diagnosis and treatment of snakebites. The lack of attention to this public health problem and crises in antivenom production have left millions of people vulnerable, with less chance of treatment. Underreporting, few epidemiological studies, production inefficiencies, little incentive for innovation or investment in new technological processes, inadequate market demand, low manufacturing volumes, storage limitations, distribution problems, and inadequate financing for acquisitions, as well as poor training of health professionals, reflect the risk of collapse in many parts of the world. It is necessary to encourage investment in public policies to serve vulnerable populations, promote continuing education for health professionals and vulnerable communities, and direct attention to this disease.

Keywords: Antivenom. Neglected Tropical Disease. Epidemiology. Vulnerability. Envenoming.

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RESUMO
Picadas de cobra afetam cerca de três milhões de pessoas por ano no mundo. É um fenômeno ecológico, social, econômico, e uma doença tropical negligenciada que impacta países tropicais e subtropicais, populações pobres, rurais, com acesso limitado à serviços de saúde e antivenenos, o que faz com que a morbidade e mortalidade sejam consideradas nas políticas públicas e acordos internacionais mediados pela Organização Mundial de Saúde. O objetivo deste estudo é apresentar uma revisão sobre a importância do diagnóstico e tratamento imediatos da picada de cobra. A falta de atenção a esse problema de saúde pública e as crises na produção de antivenenos têm deixado milhões de pessoas vulneráveis, com menor chance de tratamento. A subnotificação, poucos estudos epidemiológicos, ineficiências de produção, pouco incentivo para inovação ou investimento em novos processos tecnológicos, demanda de mercado inadequada, baixos volumes de fabricação, limitações de armazenamento, problemas na distribuição e financiamento inadequado para aquisições, treinamento deficiente dos profissionais de saúde que reflete no risco de colapso em muitas partes do mundo. É necessário incentivar investimentos em políticas públicas para atender populações vulneráveis, promover educação continuada de profissionais de saúde e comunidades vulneráveis, direcionando atenção a esse agravo.

Palavras-chave: Antiveneno. Doença Tropical Negligenciada. Epidemiologia. Vulnerabilidade. Envenenamento.

RESUMEN
Las mordeduras de serpiente afectan a unos tres millones de personas al año en todo el mundo. Se trata de un fenómeno ecológico, social y económico, y una enfermedad tropical desatendida que afecta a los países tropicales y subtropicales, a las poblaciones pobres y rurales, con acceso limitado a los servicios de salud y antídotos, lo que hace que la morbilidad y la mortalidad se tengan en cuenta en las políticas públicas y los acuerdos internacionales mediados por la Organización Mundial de la Salud. El objetivo de este estudio es presentar una revisión sobre la importancia del diagnóstico y el tratamiento inmediatos de las mordeduras de serpiente. La falta de atención a este problema de salud pública y las crisis en la producción de antídotos han dejado a millones de personas vulnerables, con menos posibilidades de recibir tratamiento. La subnotificación, la escasez de estudios epidemiológicos, las ineficiencias en la producción, los escasos incentivos para la innovación o la inversión en nuevos procesos tecnológicos, la demanda inadecuada del mercado, los bajos volúmenes de fabricación, las limitaciones de almacenamiento, los problemas de distribución y la financiación inadecuada para las adquisiciones, así como la formación deficiente de los profesionales de la salud, se reflejan en el riesgo de colapso en muchas partes del mundo. Es necesario fomentar las inversiones en políticas públicas para atender a las poblaciones vulnerables, promover la formación continua de los profesionales sanitarios y las comunidades vulnerables, prestando especial atención a esta enfermedad.

Palabras clave: Antídoto. Enfermedad Tropical Desatendida. Epidemiología. Vulnerabilidad. Envenenamiento.

1 INTRODUCTION

Snakebites have long been associated with mystical meanings in popular imagination. Humans and snakes have always interacted, and chance encounters usually end badly for one of the parties, either with the human injuring or killing the snake, or vice versa [1].

Snakebites have been a global public health problem for many years, affecting all continents, especially poor countries with traditional agricultural and extractive practices, difficulties in accessing efficient health care systems and antivenoms, widespread underreporting, and public health systems with little or no incentive for research and educational production in health or environmental areas [2–6]. It is estimated that around 2.7 million people worldwide suffer snake bites each year [7–9]. And that approximately 100,000 to 138,000 people die each year, and another 400,000 are disabled [10–13].

Snakebites are a priority disease in the tropics [13,14] classified as a neglected tropical disease (NTD) by the World Health Organization (WHO) [5,9,15,16], which reinforces the importance of investments in the sector and innovations in public policies to serve vulnerable populations, for the continuing education of health professionals, and the training of new professionals who can pay closer attention to this condition that affects so many people around the world [6].

There are many challenges to reducing the impact of this disease on vulnerable populations. The WHO has developed strategies and recommendations to reduce mortality and disability from snakebite poisoning by up to 50% by 2030 [10,11,13,15,17,18]. This strategy requires the involvement of member countries, investments in health and access to health services, diagnosis and treatment with specific and appropriate antivenoms, production and distribution of new, reliable antivenoms, and continuing education for health teams and the communities involved. In addition, better quality epidemiological information is also necessary [2,19–22].

Knowledge about the epidemiology of accidents, their incidence rates, morbidity, lethality, distribution patterns, as well as their physiological and behavioral characteristics, is fundamental for the prevention and adequate treatment of snakebites, so that any potential change in any of these items is a cause for concern for the control of this disease. A change in the distribution of these species may lead to a change in the way the specific serum is currently distributed, as well as to possible risk areas that require greater attention from public authorities [23].

The objective of this study is to address the importance of diagnosing snake bite poisoning and providing immediate and specific treatment.

2 METHODOLOGY

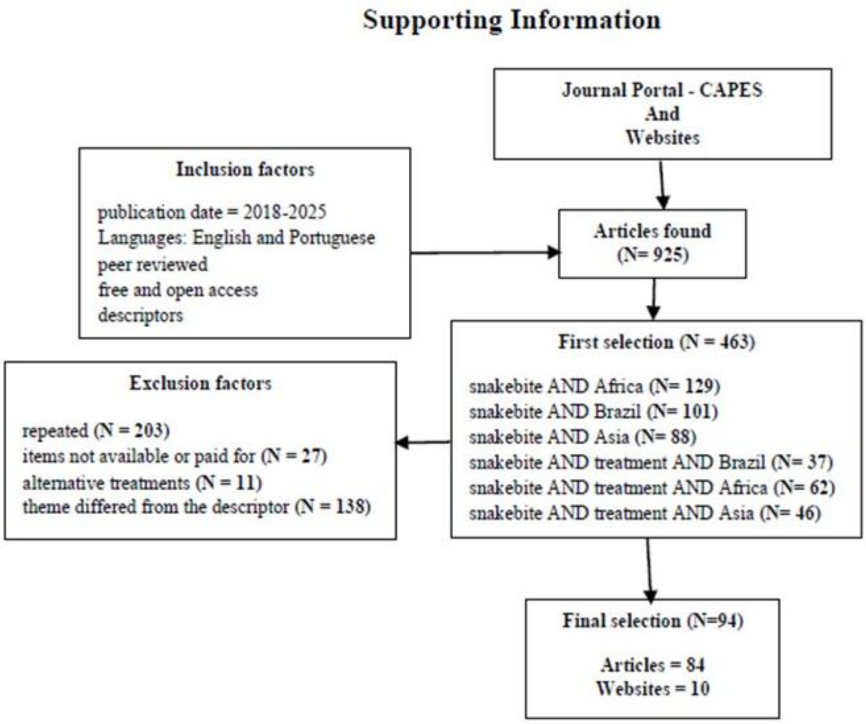
This manuscript was produced based on a review of the bibliography of articles indexed on the journal portal platform of the Coordination for the Improvement of Higher Education Personnel Foundation. [24], on the diagnosis and treatment of snake bites. This portal is a virtual library of scientific information that hosts: 48,038 full-text journal titles; 130 reference and abstract databases; 41 statistical databases; 64 thesis and dissertation databases; 48 reference works, including specialized dictionaries, special library collections, compendiums, databases, and analysis tools; 15 audiovisual content databases; 14 open file databases and e-print networks; 12 patent databases; 2 technical standards databases; more than 275,000 documents, including proceedings, reports, books, yearbooks, guides, manuals, among others, and 274,730 books. It hosts manuscripts from Pubmed, Pubmed-NCBI, Scielo, Minerva Access, *Halsorbone Université,* Arca Fiocruz, *The Lancet, Spiral, and ScienceDirect*, among others. The following were also consulted: websites: Snakebite Envenoming – WHO [25]; Pan American Health Organization - PAHO/WHO [26]; Brazilian Ministry of Health [27]; Vital Brazil Institute [28]; Butantan Institute [29]; African Snakebite Institute [30].

The following descriptors were chosen: snakebite, Brazil, Asia, Africa, diagnosis, and treatment combined with the Boolean operator “and”. The inclusion criteria were: publications between 2018 and 2025, English and Portuguese languages, full-text articles with free access and peer-reviewed. The exclusion criteria were repetition of articles in the databases, conflicting abstracts, or abstracts not relevant to the topic. For the analysis of the selected scientific production information, no characteristic quantitative or qualitative techniques were used, but rather the analysis of each article and its relationship to the objectives of this study. After the initial search, 925 articles were found. The selection was made in two stages, the first applying the inclusion criteria and the second applying the exclusion criteria. In the end, after using all the filters, we selected 84 articles to be used in this manuscript (Figure 1).

We also use artificial intelligence resources to create some figures.

Figure 1

Flowchart of literature review, inclusion and exclusion criteria used in this study, with the number of manuscripts selected in each stage



Source: produced by the authors, 2025.

3 RESULTS AND DISCUSSION

3.1 SNAKES AROUND THE WORLD

Snakes are a group of vertebrates that have been highly successful in evolutionary terms, inhabiting almost every continent except Antarctica. They are found in a wide variety of habitats, including the ground, trees, rivers, lakes, and oceans. They are the second largest group in terms of diversity among reptiles, with more than 3,700 known species worldwide, of which 15% are considered venomous. Brazil, due to its climatic heterogeneity and different biomes, is the South American country with the greatest diversity of snakes and the richest in terms of the number of species described [31–34].

The WHO has recorded 373 venomous snakes worldwide [35] and classified them into two groups based on their level of medical importance to guide antivenom production: Category 1, of major medical importance, and Category 2, of secondary medical importance. To achieve the global goal of halving the burden of snakebite accidents by 2030, which is the WHO's objective, it is important to understand the global situation of these accidents [10,35,36].

In the Middle East, North Africa, and sub-Saharan Africa, the snakes responsible for most bites and associated with severe or potentially fatal envenomations are viperids: *Echis spp*., African vipers: *Bitis spp.,* cytotoxic or neurotoxic snakes: *Naja spp*., and mambas: *Dendroaspis spp.* [22,37,38].

The impact of snakebites is relatively high in several Asian countries, such as the Philippines, Thailand, Vietnam, Laos, Cambodia, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka, and India, where poisonings occur mainly from *Naja naja, kraits, Daboia russelli, Daboia siamensis, Echis carinatus, Calloselasma rhodostoma, Hypnale hypnale,* and green vipers (*Trimeresurus spp*.). In Japan, Korea, Hong Kong, Taiwan, and Indonesia, most poisonings are caused by vipers (subfamily: *Crotalinae*) [37–39], *Naja atra*, *Bungarus multicinctus*, *Protobothrops mucrosquamatus*, *Trimeresurus stejnegeri*, *Deinagkistrodon acutus,* and *Daboia siamensis* [40].

Epidemiological data on snakebites in Central, Western, and Northern Asia, including Russia and China, are limited [37–39]. India is home to 52 species of venomous snakes and has more deaths from snake bites per year than any other country in the world [37].

WHO has also cataloged several species of medical importance in Oceania [25], including *Oxyuranus scutellatus* [41], *Pseudechis porphyriacus, Notechis scutatus* and *Hoplocephalus stephensii* [42].

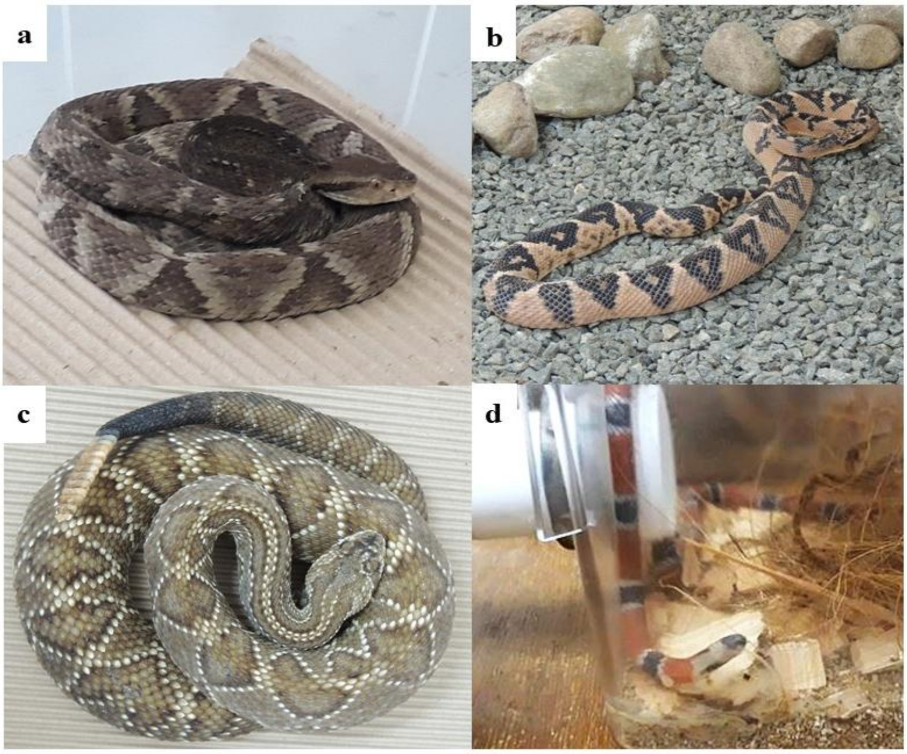
In Europe, snakebites are a rare occurrence. All venomous snakes belong to the Viperinae subfamily, which is responsible for the highest proportion of serious accidents: *Vipera berus*, *Vipera aspis* [37], *Vipera ursinii* and *Vipera latastei* [25].

In North America, in the US, the *Micrurus spp, Crotalus spp*., *Agkistrodon spp*. and *Sistrurus spp*. are the main genera involved in bites [37]. In Central America, we have the following species of medical importance: *Agkistrodon spp*., *Atropoides spp*., *Bothriechis spp*., *Cerrophidion spp*., and *Porthidium spp*. [37]. *Bothrops lanceolatus* is the only venomous snake in Martinique [43]. In South America, the most important snakes belong to the genera *Bothrops spp.* [22,43], *Lachesis muta, Crotalus spp.,* and *Micrurus spp.* [44] distributed among the families Viperidae and Elapidae [32,45]. In the family Viperidae, the genera *Bothrops, Crotalus*, and *Lachesis*, commonly known as jararacas, rattlesnakes, and surucucus, respectively, have solenoglyphous dentition, specialized for injecting venom [13,32,46]. The most prominent genres are *Bothrops spp*. and *Crotalus spp*. because they are responsible for more than 95% of reported accidents. Species of Bothrops are abundant, with a wide geographical distribution, since they have successfully colonized most of the southern part of the American territory, and are responsible for most accidents in Brazil, around 85% [44,47].

In Brazil, reporting snakebites is mandatory. Approximately 29,000 cases are reported annually to the Ministry of Health's National System of Notifiable Diseases (acronym in Portuguese, SINAN) [48], involving the four genera of snakes of public health interest [8,13,32,45,46,49–51]. There are 405 known species of snakes, 66 of which are venomous, divided into 4 genera. (**Figure 2**) [52].

Figure 2

Snakes of medical importance in Brazil

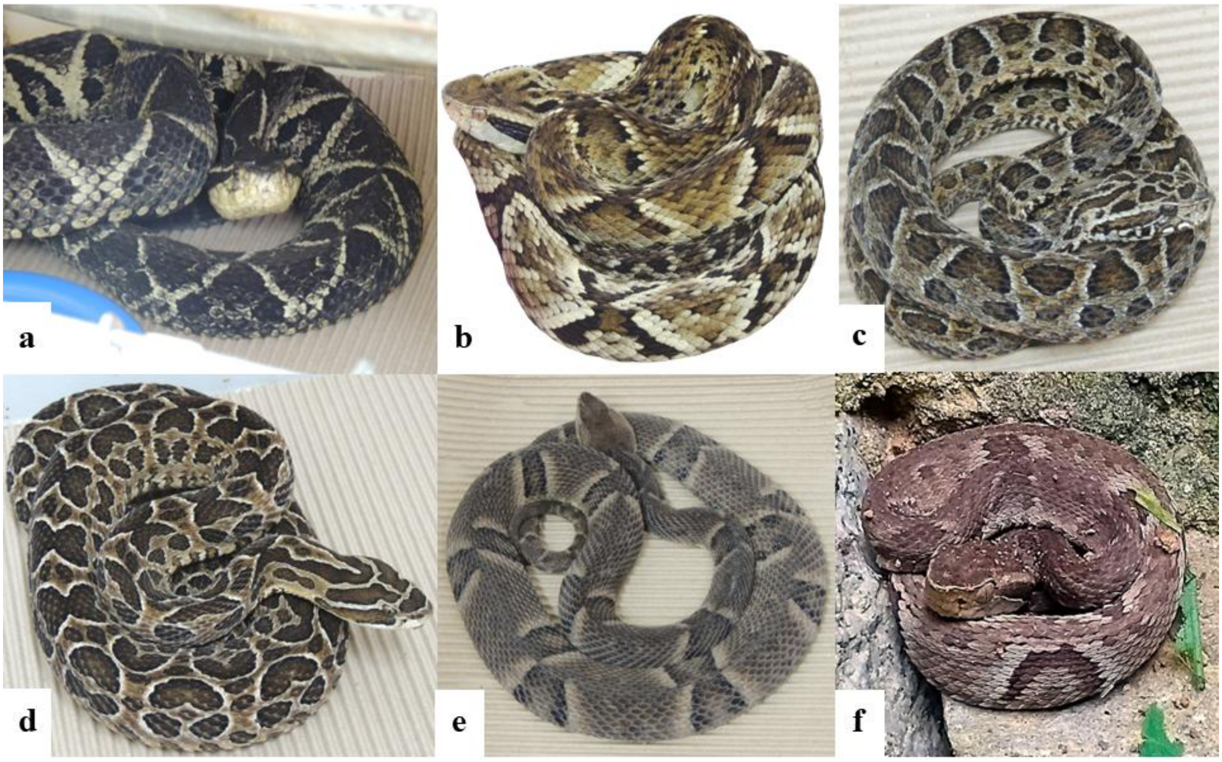


a) *Bothrops*; **b)** *Lachesis*; **c)** *Crotalus*; **d)** *Micrurus*. Source: Prepared by the authors, 2025. Photos: Ana Paula Amorim (a, d); Moana Ferreira (b, c).

The Viperidae family has three genera: jararacas (*Bothrops spp*.), which are widely distributed throughout the country and can be found in forests and anthropized environments such as plantations and even urban centers. They are responsible for most snakebites in Brazil (Figure 3). Rattlesnakes (*Crotalus spp*.) are mainly distributed in dry areas of the country. Surucucu (*Lachesis spp*.) are mainly distributed in the Amazon. The Elapidae family has about 39 species of true coral snakes (*Micrurus spp*.), which are distributed throughout Brazil and adapt very well to anthropized areas, and can also be found in cities [13,32,34,52–54].

Figure 3

Some representatives of the genus Bothrops spp distributed throughout Brazil



a) *B. jararacuçu*; **b)** *B. newvied*; **c)** *B. mattogrossensis*; **d)** *B. alternatus*; **e)** *B. moojeni*; **f)** *B. jararaca*. Photos: Moana Ferreira

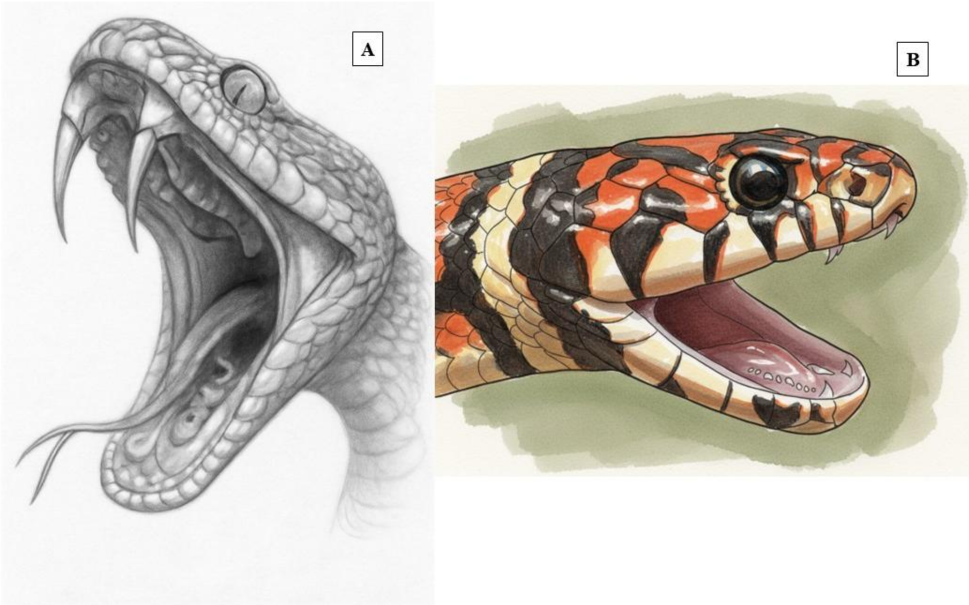
3.2 SNAKEBITES

Snakebites are an ecological phenomenon [32], social, economic, cultural, and political [7]. Snakes will bite to defend themselves from a predator or to secure a meal. Snake bites on humans are mostly defensive or mistaken, and therefore accidental [51,55]. Snake bites occur when a complex cocktail of toxins is injected into the victim's body through the animal's fangs. These fangs are of the solenoglyphous type in Viperidae, which are long and mobile and function as an efficient inoculation device that injects venom deep into the victim, and protoglyphous in Elapidae, which are smaller and fixed (Figure 4). The introduction of these toxins leads to changes at the bite site and can cause systemic effects in the victim's body, depending on the type and amount of venom injected [5,55–59]. There may be a seasonal pattern to these snakebites, as the onset and end of the rainy seasons have been associated with an increase in the number and frequency of cases [13,31,60,61].

Doctors have long witnessed the tragedy of injuries, disabilities, and deaths caused by snakebites, which are commonplace in many parts of Africa, Asia, and Latin America. For many people living in these regions, snakebites are an ever-present occupational and environmental hazard, an additional penalty of poverty [13,64].

Figura 4

Venom inoculation device for venomous snakes



A) Viperids – Solenoglyphic Dentition*;* **B)** Elapides – Proteroglyphic Dentition*.* Created by artificial intelligence*.* A- Perplexity [62]; B – Lovart [63]. Adapted by the authors, 2025.

It is believed that this uneven distribution of the impacts of poisoning results from occupational practices such as low-cost, non-mechanized agriculture, poorly constructed houses, and limited access to protective clothing, such as closed shoes and appropriate pants, in addition to living in lower socioeconomic rural contexts [65].

3.3 POISON DIAGNOSIS

It is essential to obtain a complete patient history, targeted examination, and appropriate laboratory investigations. Information about the circumstances of the bite is also relevant, such as: geography; time of the incident; activity and number of bites; details of the snake, if possible; initial clinical manifestations of poisoning; whether first aid was administered; and past medical history, e.g., allergies, previous snake bites, relevant medications, and pre-existing medical conditions [37,66].

At the site of injury, there may be tissue damage, ecchymosis, blistering, tissue necrosis, dermonecrosis, and myonecrosis. The patient may present with generalized weakness, ptosis, and ophthalmoplegia, facial muscle paralysis, and eventually, respiratory failure due to diaphragmatic paralysis. Bleeding at the site—from the puncture, epistaxis, or spontaneous bleeding—may indicate a hemotoxic effect. Some patients may show signs of shock secondary to venom-induced vasodilation, hypovolemia, or even anaphylaxis. Elapid bites are generally associated with minimal local tissue damage and present a systemic neurotoxic syndrome. Viperid bites, on the other hand, are associated with deep local tissue damage, present a hemotoxic syndrome with systemic toxicity, and can affect the cardiovascular system. Symptoms of the systemic effects of poisoning include nausea, vomiting, abdominal pain, lethargy, muscle weakness, and severe headache. It is important to recognize the symptoms to immediately begin administering the specific antivenom [66,67].

In addition, the wound site should be monitored for edema, blistering, or compartment syndrome. If compartment syndrome becomes a clinical concern, a definitive diagnosis is possible by obtaining direct compartment pressure. If it is greater than 30 mmHg, it is consistent with the initial development of compartment syndrome [68].

There are several biochemical methods for identifying snakebites, such as polymerase chain reaction, agglutination assay, biosensor assay, mass spectrometry, and immunological methods. However, these are generally used in hospitals, requiring a long analysis time and personal skills [69]. In general, laboratory investigations may include an assessment of the blood coagulation profile to screen for coagulation disorders. This can be performed as a 20-minute whole blood coagulation test (20WBCT). If more sophisticated equipment is available, repeated tests of International Normalized Ratio (INR), blood coagulation, activated partial thromboplastin time (aPTT), D-dimer, and/or fibrinogen degradation products (FDP) can be performed, supplemented by complete blood counts and electrocardiograms. Acute drops in hemoglobin and hematocrit values may indicate internal bleeding, and a drop in fibrinogen levels may be indicative of coagulopathy. Blood samples are also examined for creatine kinase (CK), electrolytes, urea, nitrogen/creatinine levels, which, together with urine tests, can be used to assess venom-induced rhabdomyolysis and associated complications such as myoglobinuric renal failure or polyuria, oliguria, or anuria [37,70].

These laboratory tests may include a complete blood count, prothrombin time, partial thromboplastin time, fibrinogen in cases of suspected hemotoxin, and creatinine kinase, basic electrolytes, and urinalysis for possible development of hematuria or proteinuria. For cases of neurotoxicity, the patient requires monitoring of expired CO2 or serial arterial blood gas analysis to assess the development of respiratory acidosis. They should also undergo frequent neurological examinations to monitor the evolution of toxicity [68].

Snakebite victims present with a variety of clinical manifestations, and complications are related to factors such as age and physiological conditions, as well as the species of snake involved and the amount of venom injected [22,71,72].

3.4 TREATMENT

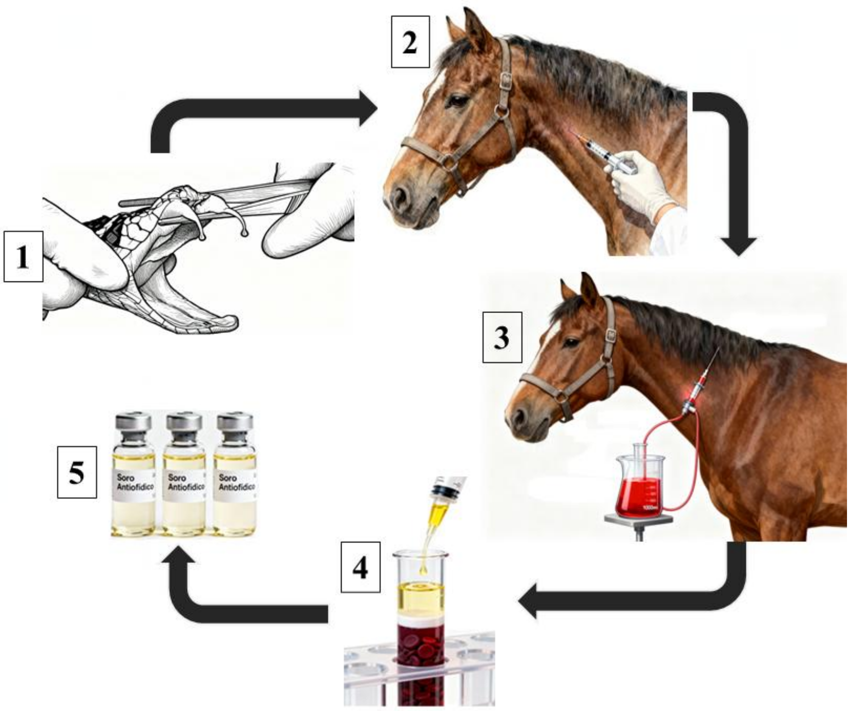
Antivenom is the ideal and recommended treatment for snakebites [12,70,73,74]. Ideally, it should be administered within 3 to 6 hours after poisoning to offer better results and lower risk of surgical interventions, myotoxicity, neurotoxicity, disability, and death. They are specific, and to be effective, they must be administered according to the type of accident and the severity of the case [22,75,76]. Victims who seek medical attention within the first few hours after being bitten have significantly lower morbidity and mortality rates [68]. Their production protocols have remained essentially unchanged since 1800: purification of immunoglobulins (IgG) from horses or sheep hyperimmunized with sublethal and subtropical doses of snake venom. The effectiveness of conventional antivenom is limited to the immunogenic potential of the venoms used in its manufacture [56,70,77]. Research efforts have been made to overcome problems in the production of antivenoms [32].

When administered to victims of snakebite poisoning, it neutralizes the toxins in the venom [56]. But the quality and safety of some antivenoms are still bad. Production inefficiencies, inadequate market demand, low manufacturing volumes, storage limitations, and distribution problems have all combined with not enough money for buying them and poor training for health workers to cause treatment problems in many parts of the world [39,75,78].

Antivenoms for snakebites are specific immunoglobulins produced by fractionating animal plasma, mainly from horses (Figure 4) [56]. The survival rate after a snakebite is considerably improved by prompt medical attention and the administration of antivenom to neutralize the venom. This requires knowledge of local venomous species, specific first-aid measures, local hospitals with experienced physicians, and appropriate and readily available medications [65]. The time that elapses between the bite and the administration of antivenom serum is decisive in the evolution of the victim's health condition [1,13,22,79]. Otherwise, delays in treatment increase the risk of injury and acute renal failure, as well as the severity of poisoning, especially in victims of bites in Brazil [37]. Once at the hospital, further evaluation, additional resources, and treatment options may be offered [70]. However, the lack of attention to this public health problem and crises in antivenom production worldwide have left millions of people vulnerable, with less chance of treatment for poisoning and of reducing the likelihood of death and occupational disability [46,65,78].

Figure 5

Diagram of antivenom production



1. Extraction of snake venom, which is transformed into an antigen; **2.** Horses receive the antigen in small doses to produce antibodies against the venom **3.** Blood tests to check if there are enough antibodies in the animal's body. When this occurs, blood is collected and separated from the plasma, which is the part where the antibodies are found **4.** The plasma undergoes industrial purification and formulation processing **5.** The serum is ready. Source: Butantan Institute[29]. Graphic figure, Created by artificial intelligence. Lovart [63]. Adapted by the authors, 2025.

They can be produced for a single species (monospecific), which is much more efficient, or for multiple species (polyspecific), and have proven to be effective in preventing many lethal and harmful effects of poisoning, reversing the main effects, such as anti-hemostasis, neurotoxicity, and hypotension [56,80].

Access to safe, effective, and quality-assured antivenoms tailored to endemic species of venomous snakes is crucial to coordinated efforts to reduce the global burden of snakebite envenomation. Many access challenges can affect the journey of antivenoms from manufacturers to accident victims [81].

The weaknesses found in the market attempt to explain why antivenom production has been dominated by public health laboratories, even with difficulties in keeping up with modern pharmaceutical manufacturing technologies. And although private manufacturers have played an increasingly important role over the past four decades, especially in Asia and Africa, the nature of the market limits their capacity in terms of resources, infrastructure, and innovation. As a result, there is little incentive for innovation or investment in new technological processes [78,80].

In Africa, for example, despite the high number of snakebites, there has been a decline in production and loss of confidence in antivenom products, as good quality ones made by proven and long-established manufacturers have become inaccessible to all victims [82]. When we talk about security of supply, it is important to remember that dependence on imports of antidotes puts African countries at permanent risk of supply shortages [19,83]. Also, some African countries have registered antivenoms that are epidemiologically inappropriate due to the most prevalent snake species [84].

In India, polyvalent and monovalent antivenoms are available, but they do not cover all venomous species. There is a need for a standardized quality control process for the manufacture of antivenoms to ensure their efficacy and safety [37]. The fact is that care for accident victims remains very poor in both public and private healthcare systems in India [85].

Geographic accessibility is part of the broader, more diverse, and complex concept of access to healthcare. Assessing the quality of access to care involves not only geographic accessibility to healthcare services, but also their availability, the feasibility of obtaining them, and the acceptability of such care. Factors such as spatial distribution of the population, road network, location of health centers and hospitals, and travel time must be considered when accessing facilities that provide antivenom. As with many other types of health care, travel time and costs make access to antivenom difficult [17,86].

Brazil is a self-sufficient manufacturer of snake antivenom. Under current policies, most antivenom is distributed free of charge to various hospitals through the Unified Health System (UHS) [54,87,88]. But even though Brazil has a nationalized healthcare system, many municipalities in the country do not have easy access to emergency care services [79]. There is an association between population distribution, routes, and health facilities that can provide serum. More populous parts of the country have more widely distributed facilities and more significant route availability. The Amazon region, in the north of the country, has a spatially concentrated distribution of facilities and more complex circulation or transportation, since in many cases the only means available are waterways [17]. When the victim is indigenous, they receive antivenom through the Indigenous Health Care Subsystem, under the UHS. It should be noted that the indigenous population, especially in northern Brazil, is extremely vulnerable to accidents and has a mortality rate 3.5% higher than the white population in the same region. This is mainly due to the centralization of antivenom in more populous regions [54,89–91].

The high costs of antivenoms result from the cost of the various stages of production, such as: maintenance of the snake farm; venoms; breeding of animals such as horses; immunization of these animals for 15 to 18 months; purification of IgG; digestion of IgG; quality control tests, preferably on rats, carried out at each stage of production and for each batch produced; bottling; sometimes freeze-drying; distribution and clinical studies. As it is a product that expires quickly, if it is not sold or made available, its final value ends up increasing even more [19].

Socioeconomic and cultural factors also influence behaviors related to seeking alternative treatment and unconventional traditional practices to the detriment of hospital care [65]. A lack of money or transportation, or distrust of Western medicine, can influence the decision to go to the hospital. Compounding this lack of confidence, staff at many health centers are not sufficiently trained to treat snake bites, and even if medication is available, it can be too expensive for many victims [19,92]. People often turn to traditional therapies and treatments instead of the medical system and health centers, which leads to higher rates of death and amputation. This behavior is especially common in African countries [17]. Furthermore, many antivenoms need to be kept refrigerated to remain stable and effective. In resource-poor settings with frequent power outages, even in cities, keeping them cold can be nearly impossible [65].

Despite the importance of basic knowledge and awareness about snakebite poisoning, several studies have found that many health professionals in endemic regions have little general knowledge about the subject. A study of medical care in Nigeria showed little knowledge of first aid, treatment, and prevention of snakebites. Similar gaps in initial knowledge and treatment confidence regarding the treatment of snakebite patients were found among physicians in Hong Kong, Laos, Nepal, and West Bengal [65,82,92].

As for follow-up after hospital discharge, once the acute effects have resolved and patients are discharged from the hospital, they rarely have any further contact with the healthcare system in relation to the poisoning. Due to the lack of clinical follow-up and clinical research studies, the long-term effects of snake venom poisoning are poorly defined. In addition, some psychological effects are likely to have a delayed onset. Long-term sequelae that may be observed include local necrosis resulting in amputation, chronic ulcers, chronic local pain and swelling, blindness due to the primary effects of the venom, chronic kidney disease, neuromuscular paralysis, neurological effects secondary to hypoxic or ischemic events, neurological effects after intracranial hemorrhage, reduced parasympathetic activity, anosmia and taste changes, hypopituitarism, and psychological effects [93,94].

4 CONCLUSION

Accidents involving venomous snakes are a global public health problem, affecting poor countries, with traditional agricultural and extractive practices, difficult access to health systems and effective antivenoms, high underreporting, and low incentives for research and education in health and the environment. These factors consolidate the character of Neglected Tropical Disease, reinforcing the need for investments and public policies aimed at vulnerable populations, continuing education for health professionals, and the training of new specialists who pay greater attention to this condition. Encouraging research on snake poisoning from ecological and public health perspectives is essential to improve estimates of the burden of this condition.

Improving the quality of information is also essential for epidemiological surveillance, supporting public health promotion and prevention strategies and policies. As with other neglected tropical diseases, the control of snakebite faces the limitation of poor epidemiological data and low investment in diagnosis, intervention, and analysis.

Strengthening health units and teams, especially in the most vulnerable regions, is essential. Community engagement through education about the ecology and behavior of snakes is also crucial, promoting preventive actions and the well-being of exposed populations. Knowledge about the epidemiology of accidents, incidence rates, morbidity, lethality, and the distribution and biological characteristics of species is essential for adequate prevention and treatment. Changes in the geographical distribution of snakes may require a review of the logistics of specific serums and a redefinition of priority risk areas for public authorities.

INSTITUTIONAL REVIEW BOARD STATEMENT

This doctoral project in the Postgraduate Program in Infectious and Parasitic Diseases at the School of Medicine of the Federal University of Rio de Janeiro, entitled “Epidemiological aspects of accidents by venomous snakes reported in the municipality of Rio de Janeiro between 2008 and 2017", was submitted, evaluated and approved by the Human Research Ethics Committee of the Clementino Fraga Filho University Hospital of the Federal University of Rio de Janeiro (CEP/HUCFF/FM/UFRJ), Brazil. It is registered under the protocol CAAE: 70667423.9.0000.5257.

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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