

Snakebite frequencies and envenomation case management in primary health centers of the Bobo-Dioulasso health district (Burkina Faso) from 2014 to 2018

Rabila Bamogo^{a,b,c}, Massamba Thiam^c, Achille Sindimbasba Nikiéma^a, Fabrice Anyirekun Somé^a, Youssouph Mané^d, Simon Péguédwindé Sawadogo^a, Bazoumana Sow^a, Abdoulaye Diabaté^a, Youssouph Diatta^c, and Roch Kounbobr Dabiré^{a,*}

^aInstitut de Recherche en Sciences de la Santé (IRSS), Direction Régionale de l'Ouest, BP 545 Bobo Dioulasso 01, Burkina Faso;

^bUniversité Cheikh Anta Diop, Ecole Doctorale en Sciences de la Vie, de la Santé et de l'Environnement, Faculté des Sciences et Techniques BP : 5005, Dakar, Sénégal; ^cUniversité Cheikh Anta Diop, Institut Fondamental d'Afrique Noire (IFAN), Laboratoire de Zoologie et des Vertébrés terrestres de Dakar, BP 206, Dakar, Sénégal; ^dInstitut de Recherche pour le Développement (IRD) de Dakar, BP 1386 CP 18524, Dakar, Sénégal

*Corresponding author: Tel: 226 70 73 90 69; E-mail: dabireroch@gmail.com

Received 29 March 2021; revised 25 June 2021; accepted 9 September 2021

Background: Snakebite envenomation is a significant public health problem in Burkina Faso. Our study describes the epidemiological and therapeutic aspects of snakebite cases at primary health centers in Houet Province, which is located in the western area of Burkina Faso.

Methods: We conducted a retrospective study of 664 snakebite cases occurring at 10 primary health centers in Houet Province from January 2014 to December 2018. Data were collected from the patient consultation recording database registry system.

Results: Affected individuals had a male/female ratio of 1.31. The lowest annual incidences (0.02 [95% CI – 0.01 to 0.05] and 0.24 [95% CI 0.05 to 0.43]) were observed in the urban primary health centers of Bolomakoté and Sarfalao, respectively. Rural primary health centers in Nasso in 2016 and in Soumouso in 2014 had the highest annual incidence (13.80 [95% CI 7.59 to 20.00] and 3.92 [95% CI 2.99 to 4.86], respectively). Of the 664 registered snakebite victims, none received antivenom immunotherapy treatment.

Conclusion: Our study shows that snakebite envenomation incidents are common at the 10 primary health centers in Houet Province. Furthermore, despite the lack of antivenom and often inadequate treatment at these primary health centers, they remain the first point of care for snakebite victims.

Keywords: envenomation, epidemiology, frequencies, Hauts-Bassins, snakebites

Introduction

Snakebite envenomation is a significant problem affecting all the continents of the world, in particular Africa, where it represents a major public health problem. Moreover, it is a problem often neglected by scientists, donors and international agencies as those affected are largely 'people without a voice'. For example, in March 2017 at its 10th meeting, a subcommittee of the WHO Strategic and Technical Advisory Group on Neglected Tropical Diseases recommended that snakebite envenomation must be considered a neglected tropical disease.^{1,2} In West Africa, 16 low- and middle-income

countries have 3500–5350 deaths from snakebite envenomation annually, or approximately 1.2 deaths per 100 000 individuals per year.³

In Burkina Faso, a landlocked country in West Africa, approximately 114 126 snakebites were reported during the 5 y from 2010 to 2014.⁴ This corresponds to >20 000 snakebite cases each year with a 3% case-fatality rate, as reported by the Ministry of Health. All sub-Saharan Africa countries are confronted with this problem, both in urban and rural areas.⁵ In Burkina Faso, snakebites are the fifth most common reason for admittance to Burkina Faso basic health facilities.⁶ Human-snake contact occurs mainly during field activities in high grass or

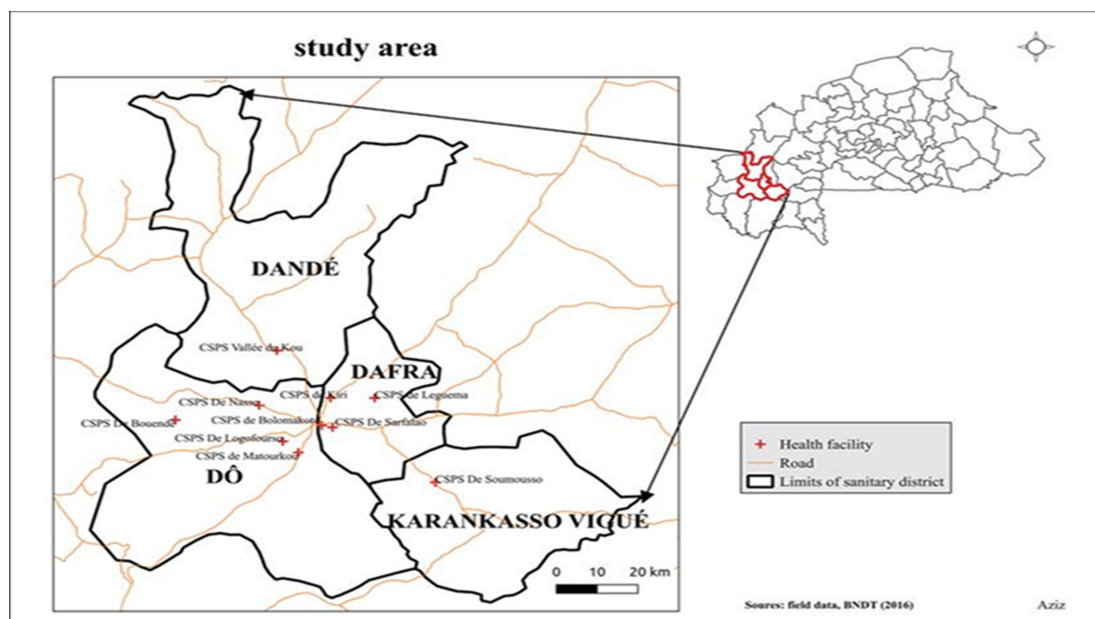


Figure 1. Survey site location in the health district of Bobo-Dioulasso (Hauts-Bassins). The red crosses represent the exact locations of each study site. The black bars represent the boundaries of each health district.

during forest walks. However, human-snake contact can also occur around or in houses in regions with a high density of snakes, typically farming regions where grain attracts rodents, which, in turn, attract snakes.⁷ In Burkina Faso, snake species belong to six different families, of which *Elapidae* and *Viperidae* are the most venomous.⁸ Over the last 10 y, snakebite envenomation has gained more attention from health leaders and scientists, with decisions being made to improve snakebite envenomation management. Indeed, recent epidemiological studies have estimated snakebite incidence, and a system of data collection for tracking snakebite envenomation throughout the territory was established in 2010.^{4,5,9}

In the health system of Burkina Faso, primary health center facilities are the first point of care for patients. It is at this primary level that patient care is first administered and decisions for potential referral to a higher level facility are made. Since 2015, the Ministry of Health has subsidized antivenom serums and made them available at public care centers for treating snakebite envenomation.⁴

The objective of the current study was to determine the frequency of snakebites in primary healthcare facilities and to identify the snake species responsible by conducting a prospective survey.

Methods

This study was conducted in Houet Province, located in the Hauts-Bassins administrative region of Bobo-Dioulasso (11°11'00"N; 4°17'00"W). This region is located in the western part of Burkina Faso, approximately 360 km from Ouagadougou, the capital city (Figure 1). Houet Province covers a total area of 25,479 km² (9.4% of the national territory). The population of Ouagadougou

is approximately 1.7 million inhabitants. Climate is a Sudan climatic type and is characterized by a rainy season from May to October with relatively abundant rainfalls (the annual rainfall ranges from 1000 to 1200 mm) and a dry season from November to April. The annual average temperature is approximately 28°C. Many individuals live in rural settings, where their access to healthcare depends on their proximity to the city Bobo-Dioulasso, where >80% of health services are located.

Ten primary health centers were selected for surveying: Bolmakoté, Bouende, Kiri, Leguema, Logofourouso, Matourkou, Nasso, Sarfalao, Soumouso and Vallée du Kou (Figure 1). The main criteria justifying health center selection was a transect from the city to a rural setting that included a rice-growing area to a gallery forest. These criteria are representative of the ecological features of the region. The eco-climatic conditions of this region are suitable for snakes and human-snake contact seemed likely.

A retrospective survey was conducted, with data collected from the patient consultation recording database at primary health centers. These data included all patients referred for snakebite envenomation at the 10 primary health centers from January 2014 to December 2018. We used a survey card with a guide, a grid and a questionnaire. Annual incidence data were calculated using true population counts, with the total number of individuals in the village as the denominator, and are expressed with 95% CIs. Data were collected from patient health information and epidemiological surveillance centers in each district. Statistical analyses were performed using R 3.5. χ^2 tests were used to compare differences between categories at a statistical significance of 5%.

A prospective survey of victims and their families was conducted from September 2018 to February 2019. The prospective survey aimed to better understand the circumstances of

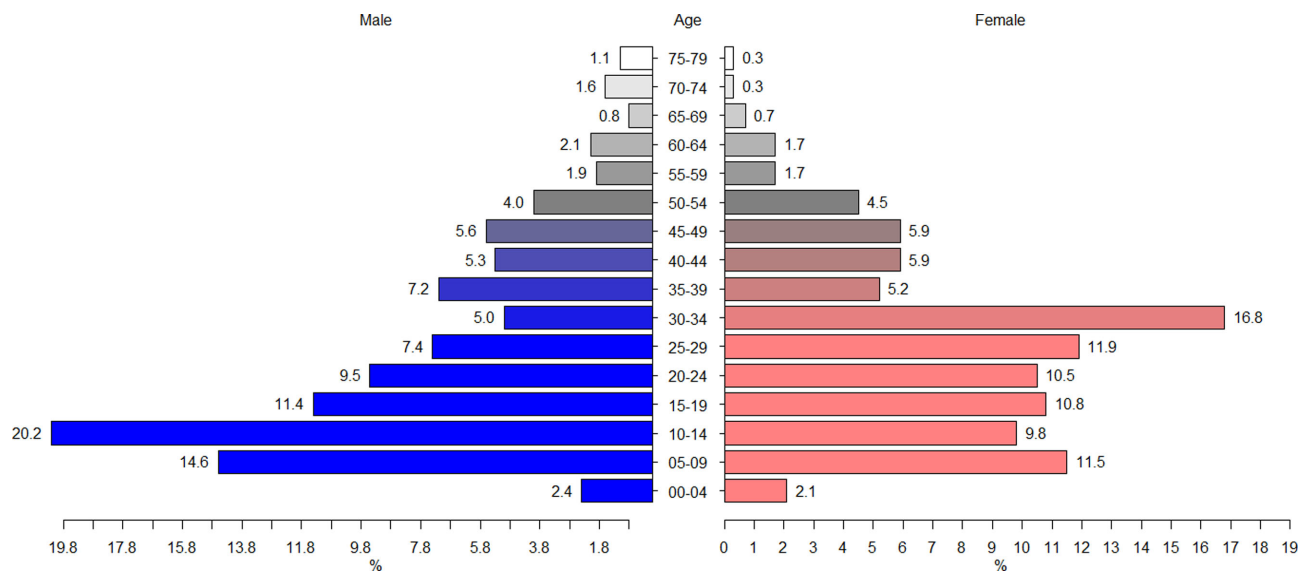


Figure 2. Pyramid of the ages of males and females of the population affected by snakebites. On the right is the frequency of snakebites for females by age group. On the left is the frequency of snakebites for males by age group.

each snakebite and the fate of the patient bitten following care in a primary health center. Additionally, the survey also attempted to identify the snake responsible for the bite and to list the incriminated species in the list of snakebites occurring in the Hauts-Bassins region. For snake identification we relied on either the snake being physically brought to us, described by the victim or through species identification using photographs.¹⁰

A questionnaire was used to collect information about the nature and circumstances of each snakebite. This information is not typically collected by health centers. We also carried out focus group discussions to gain additional information from patients about their snakebites and the treatment they underwent.

Results

Population characteristics of those affected by snakebites

A total of 664 snakebite cases were recorded from January 2014 to December 2018 in 10 primary health centers in the Hauts-Bassins region. Affected individuals had a male/female ratio of 1.31 (Figure 2). Male patients aged 10–14 y were the most affected group, representing 20.2% of all male cases (Figure 2). In females, those aged 30–34 y were the most affected group, representing 16.8% of all female cases.

Incidence of snakebites in the Hauts-Bassins region during 2014–2018

The incidence of snakebites varied from 0.00 to 13.80 per 1000 individuals. The lowest annual incidences (0.02 [95% CI –0.01 to 0.05] and 0.24 [95% CI 0.05 to 0.43]) were observed in the urban

primary health centers of Bolomakoté and Sarfalao, respectively (Table 1). The rural primary health centers of Nasso in 2016 and Soumoussou in 2014 had the highest annual incidence (3.92 [95% CI 2.99 to 4.86] and 13.80 [95% CI 7.59 to 20.00], respectively). Of the 664 surveyed individuals, 639 were from rural primary health centers. The mean bite rate (0.03) in urban primary health centers was significantly different to that in rural primary health centers (0.96; $\chi^2=1135.5$, $df=1$; $p<0.0001$). Over the entire 5-y period, peak snakebite incidence occurred during the rainy season. Rainy season incidents (448) occurred at approximately twice the rate of dry season incidents (216), a statistically significant difference ($\chi^2=24.821$, $df=1$; $p>0.0001$).

Changes in annual incidence

The primary health center in Nasso, a village of wooded savannah and dense forest, had an annual incidence of 13.80 per 1000 individuals in 2016. Similarly, the primary health center in Soumoussou had an annual incidence of 1.96 per 1000 individuals in 2016. Interestingly, in 2018, both of these villages experienced significant decreases in incidence of 1.02 and 1.43, respectively (Figure 3). The two urban primary health centers of Bobo-Dioulasso, Bolomakoté and Sarfalao, had very low annual snakebite incidence, ranging from 0 to 0.24 per 1000 individuals.

Envenomation management

Of the 664 snakebite victims, none received antivenom treatment in any of the 10 primary health centers surveyed from 2014 to 2018. Treatments were therefore symptomatic or prophylactic and consisted almost exclusively of metronidazole (59.1%) and paracetamol (55.9%). Amoxicillin was also administered in some cases (47.8%) (Figure 4).

Table 1. Incidence of snakebites in the 10 primary health centers in the Hauts-Bassins region during 2014–2018

Village	Year									
	2014		2015		2016		2017		2018	
	Number of cases of snakebite Number of the population by year	Incidence rate per 1000 95% CI	Number of cases of snakebite Number of the population by year	Incidence rate per 1000 95% CI	Number of cases of snakebite Number of the population by year	Incidence rate per 1000 95% CI	Number of cases of snakebite Number of the population by year	Incidence rate per 1000 95% CI	Number of cases of Snakebite Number of the population by year	Incidence rate per 1000 95% CI
Bolomakoté	0 22 025	0 [0.00–0.00]	0 22 752	0 [0.00–0.00]	7 23 504	0.30 [0.08–0.52]	6 24 258	0.25 [0.05–0.45]	6 25 036	0.24 [0.05–0.43]
Bouendé	1 4096	0.24 [–0.23–0.72]	8 4251	1.88 [0.58–3.19]	4 4369	0.92 [0.02–1.81]	9 4511	2.00 [0.69–3.30]	12 4804	2.50 [1.08–3.91]
Kiri	5 6649	0.75 [0.09–1.41]	4 6868	0.58 [0.01–1.15]	15 7093	2.11 [1.04–3.18]	3 7323	0.41 [–0.05–0.87]	10 7558	1.32 [0.50–2.14]
Leguema	12 7653	1.57 [0.68–2.46]	0 7906	0 [0.00–0.00]	3 8164	0.37 [–0.05–0.78]	11 8428	1.31 [0.53–2.08]	4 8698	0.46 [0.01–0.91]
Logofouroussou	0 4852	0 [0.00–0.00]	0 5 013	0 [0.00–0.00]	7 5177	1.35 [0.35–2.35]	12 5344	2.25 [0.98–3.52]	5 5516	0.91 [0.11–1.70]
Matourkou	8 9858	0.81 [0.25–1.37]	11 10 183	1.08 [0.44–1.72]	13 10 516	1.24 [0.56–1.91]	24 10 857	2.21 [1.33–3.09]	8 11 205	0.71 [0.22–1.21]
Nasso	9 12 914	0.70 [0.24–1.15]	30 13 363	2.25 [1.44–3.05]	19 13 777	13.80 [7.59–20.00]	33 14 223	2.32 [1.53–3.11]	15 14 680	1.02 [0.50–1.54]
Sarfallao	0 56 865	0 [0.00–0.00]	0 60 442	0 [0.00–0.00]	1 64 693	0.02 [–0.01–0.05]	3 66 789	0.04 [–0.01–0.10]	2 68 932	0.03 [–0.01–0.07]
Soumoussou	68 17 332	3.92 [2.99–4.86]	60 17 751	3.38 [2.52–4.24]	36 18 332	1.96 [1.32–2.61]	22 18 926	1.16 [0.68–1.65]	28 19 533	1.43 [0.90–1.96]
Vallé du Kou	26 24 656	1.05 [0.65–1.46]	26 25 469	1.02 [0.63–1.41]	27 26 303	1.03 [0.64–1.41]	23 27 154	0.85 [0.50–1.19]	28 28 025	1.00 [0.63–1.37]
Overall incidence	129 166 900	0.77 [0.64–0.91]	139 173 998	0.80 [0.67–0.93]	132 181 928	0.73 [0.61–0.87]	146 187 813	0.78 [0.65–0.90]	118 193 987	0.61 [0.50–0.72]

Identification of snake species involved in biting incidents

In our study, we received nine photographs and identified three large snake families (*Viperidae*, *Lamprophiidae* and *Colubridae*). From these three families we identified nine species: seven species of *Echis ocellatus* (*Viperidae*; Figure 5A,B), one species of *Atractaspis watsoni* (*Lamprophiidae*; Figure 5C) and one species of *Lycophidion semicinctum* (*Colubridae*; Figure 5D).

Discussion

Characteristics of snakebite victims

The higher proportion of men involved in snakebite incidents may be explained by the larger number of men involved in

agricultural and ranching activities that may expose them to more snakes. Similarly, women aged 30–34 y were the most affected age group of females (Figure 2), possibly due to snake exposure during typical activities of shea nut picking, consumable shea caterpillar collection, cooking, wood cutting and farming activities. This may be especially true for housewives, who both cultivate and carry out housework. Boys aged 10–14 y were the most affected age group of males. This may be explained by the fact that these children still walk to school barefoot and often engage in risky behaviors such as reptile hunting, making them more vulnerable to snakebites. In addition, during the rainy season children typically work in the fields, helping their parents with cultivation or housing animals in barns. These activities may also increase their exposure to snakes.

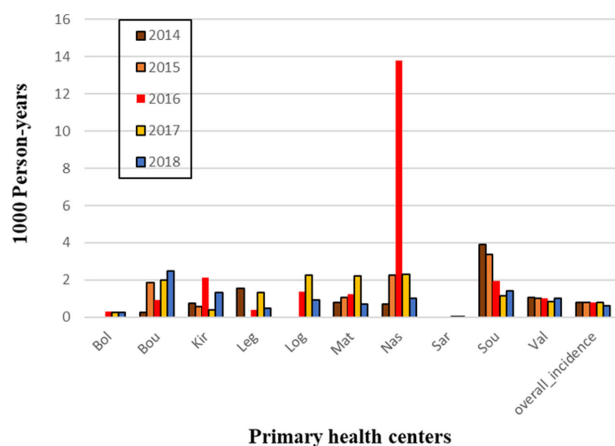


Figure 3. The evolution of the annual incidence by period and by primary health center. The x-axis represents the annual incidence by primary health center. The y-axis represents the change in incidence over time in years per 1000 persons. Bol, Bolomaké; Bou, Bouendé; Kir, Kiri; Leg, Leguema; Log, Logofourouso; Mat, Matourkou; Nas, Nasso; Sar, Sarfalao; Sou, Soumouso; Val, Vallée du Kou.

Increased awareness about snakes as well as personal protective equipment, such as shoes, may help to reduce the frequency of snakebites in this age group. Rural areas and rice-growing zones are still conducive to snake proliferation and the risk of human-snake contact is much higher in these areas. Indeed, several studies have shown that rural populations are more vulnerable to snakebites than urban populations.^{11–16}

These rural conditions may also explain the increased frequency of lower limb bites compared with upper limb bites. Regardless of the primary health center or village, 390 of the 556 individuals surveyed (70%) were bitten on their feet. Conversely, only 2% (11/556) and 0.17% (1/556) were bitten on the arm or forearm. This high proportion of leg bites may be due to a lack of agricultural personal protective equipment in low-income rural areas. Providing personal protective equipment to farmers and rural women could help to reduce the risk of snakebite exposure. We also encourage Burkina Faso and other countries to adopt agricultural policies that promote mechanization, as this may help to reduce manual farming and potential snakebite exposure.

The annual incidence of snakebites found in our study of the Hauts-Bassins region of Burkina Faso was higher in rural health centers than in urban health centers per 1000 individuals per year. This incidence in the current study is very low compared with that found in the same country by other authors in previous years, who reported an average of 100 snakebites per 100 000 individuals per year.⁴ We found that rural primary health centers typically observe at least one snakebite incident per 1000 individuals. A number of factors likely explains the differences between these two geographic health centers, as well as the overall low incidence in the urban primary health centers of Bolomakoté and Sarfalao. Poverty is one of the main risk factors for snakebites and the socioeconomic level in rural health center regions remains lower than the wealthier populations in urban cities.¹⁷ In addition, our case fatality rate (0.9%) was lower than those previously reported by Somé et al.¹⁸ and Gampini et al.⁴

We suspect destruction of natural snake habitats for housing or agriculture may explain the lower annual incidence observed from 2017 to 2018 in the villages of Nasso and Soumouso (Figure 3), as these are semi-urban villages located approximately 10 to 25 km from the city of Bobo-Dioulasso. These practices have likely contributed to reducing accidental human-snake contact. Indeed, some ophidian species have ecological requirements that keep them away from ecosystems heavily modified by humans.¹⁹

Envenom management in primary health centers

Antivenom immunotherapy is the only specific treatment for ophidian envenomation. Burkina Faso is the only sub-Saharan country where government subsidies allow for patients to receive a dose of antivenom (African Internal Standard Snake Antivenom Serum) at only 5% of the original price (<3US\$).^{4,20} However, despite its low cost, antivenom is still not available in Burkina Faso health centers, with very few snakebite victims receiving antivenom immunotherapy. This is likely due to the continued use of traditional medicines and difficulties in distributing antivenom to rural health centers. This lack of antivenom immunotherapy in health centers, especially in outlying rural areas, likely increases the risk of death for snakebite victims. In our study we recorded 6 deaths from the 664 victims (0.9%). However, this may not be representative of the true case-fatality rate, as snakebite victims may have died before arriving at the treatment site. Of note among the six cases of death observed during our study, a young 21-y-old mother died following viper (*Echis ocellatus*) envenomization after being referred to a health center that had no antivenom available.

We recommend that the National Program for the Control of Neglected Tropical Diseases take the necessary steps to make antivenom immunotherapy available and accessible in Burkina Faso hospitals, as well as in primary health centers. We believe increased antivenom availability will significantly reduce case-fatality rates.

Symptomatic treatment often consists of analgesics, anti-inflammatory drugs and antibiotics. Chippaux demonstrated the importance of symptomatic treatments following snakebite envenomation.²¹ Patients experiencing fever, hypothermia or unexplained aggravation often receive a combination of penicillin G and an antibiotic (metronidazole or amoxicillin) administered in the face. These episodes are often related to nosocomial infections. Analgesics such as paracetamol are sometimes used to relieve pain. All treatments involved merely treating patient symptoms. Additionally, some patients (8.2%) benefit from black stone treatment; however, following a failure of this treatment, all patients end up going to the closest primary health center. The antibiotics used are either for prophylaxis or to treat secondary infections (Figure 4). Other therapies such as coagulation factors, labile blood products and artificial respiration are sometimes used during symptomatic treatment; however, we did not observe any of these treatments in the current study. We did observe empirical treatments such as black stone treatment, which are of limited interest and likely add no clinical value, and may even cause harm. However, despite the controversial ineffectiveness of black stone treatment,²² it is still used in Burkina Faso communities for ophidian envenomation.

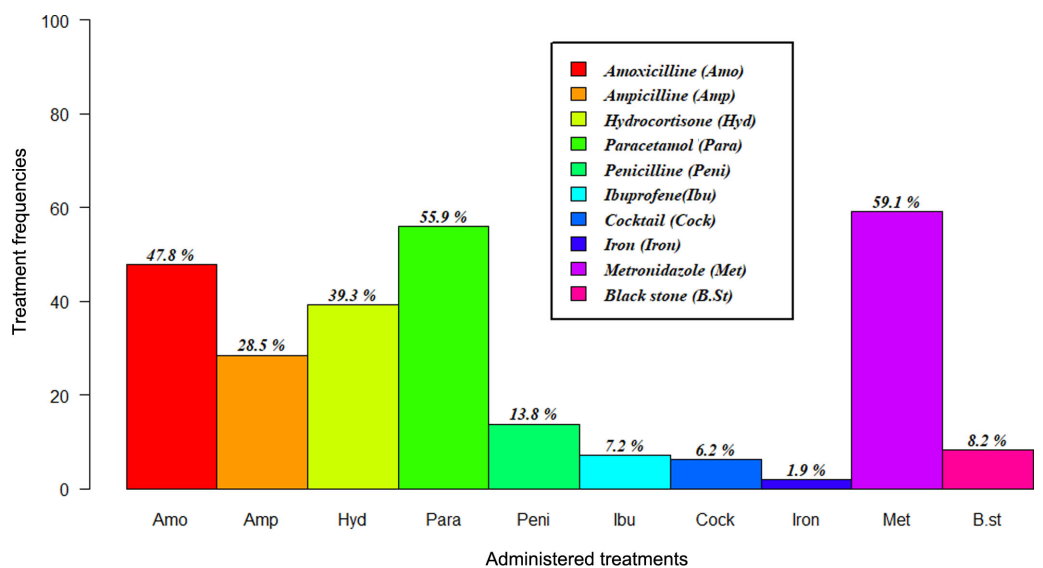


Figure 4. The proportions of drugs administered to patients bitten by snakes during their treatment.

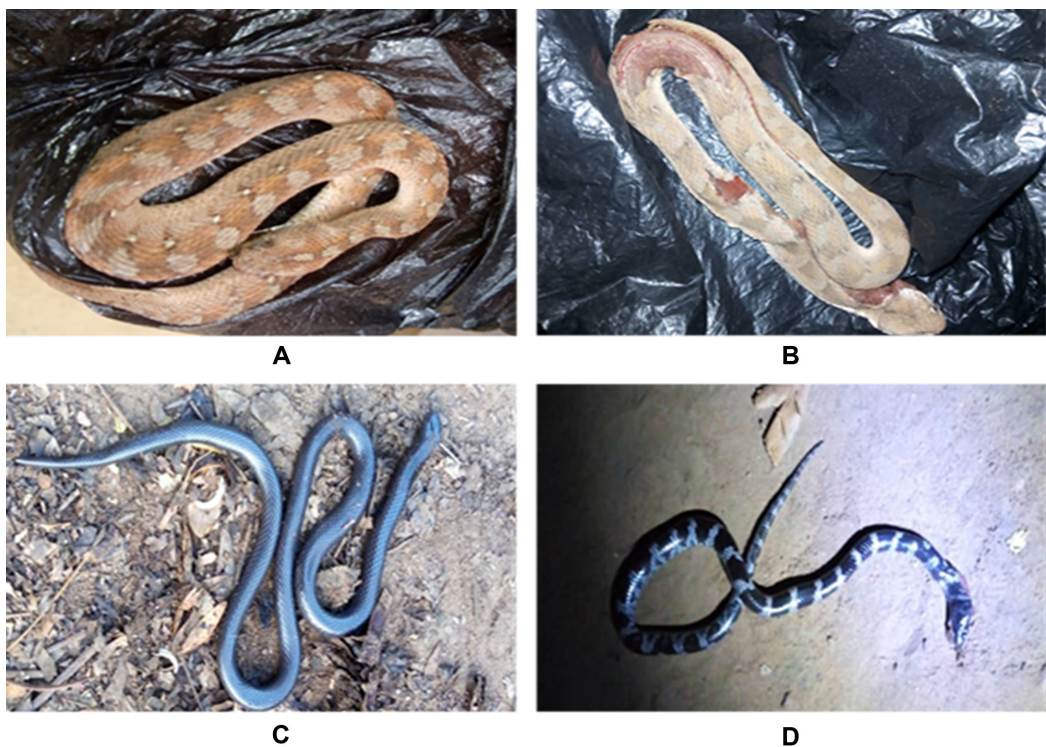


Figure 5. Distribution of the snake species involved in the biting cases recorded. (A) *Echis ocellatus* in the *Viperidae* family (village in Nasso); (B) *Echis ocellatus* in the *Viperidae* family (village in Matourkou); (C) *Atractaspis watsoni* in the *Lamprophiidae* family (village in Nasso); and (D) *Lycophidion semicinctum* in the *Colubridae* family (village in Nasso).

Our findings are consistent with the vicious cycle described by Chippaux in 2002.²³ Specifically, the lack of a protocol for managing envenomation cases in combination with the lack of available antivenom, as well as ignorance of its use by health professionals, leads to a shortage of antivenom. We believe this vicious circle could be broken through

financial support for antivenom distribution, particularly in rural areas, as well as the training of health workers on administering antivenom. These changes are undoubtedly a necessary condition for improving the snakebite management and reducing snakebite fatalities in Burkina Faso.

Snake species identification

Few patients spontaneously bring the culprit snake to health centers, reducing the quality of patient care. Moreover, most snakebite victims are unable to provide any description of the culprit snake and relatively few patients are able to identify snakes by their local names. Based on local knowledge, many communities give the most venomous and most dangerous snakes local names such as 'Fonfon-nii' in the Dioula language. In our study we received nine photographs of culprit snakes (Figure 5A,B). These photographs were taken by inexperienced personnel, justifying their poor quality. Although our snake picture sample size is insufficient, several authors have previously shown that vipers, notably *Echis ocellatus*, are a major contributor to snakebite envenomation in West Africa and particularly in Burkina Faso.^{5,8,18,20,23,24} We further encourage the National Program for the Control of Neglected Tropical Diseases to inform rural populations about the importance of bringing the killed culprit snake to the primary health center, as this will inform ophidian envenomation victim care.

Study limitations

Our retrospective study has limitations consistent with that of other retrospective studies.⁹ Victim recall bias was a potential limitation, similar to all cross-sectional studies utilizing questionnaires of past events. Furthermore, nursing consultation records were not sufficiently detailed for understanding the victim's symptoms and the symptomatic treatment administered. In addition, most victims were unable to describe the snake that attacked them. Lastly, the reported data did not always contain relevant and useful information for implementing strategies to prevent or manage snakebites.

Conclusion

Our study demonstrates that snakebite envenomation is relatively common in the 10 primary health centers of the Hauts-Bassins region and has a case fatality rate of 0.9% (6/664). Most snakebite cases were the result of a *Viperidae* family bite. Medical management of these snakebite victims was symptomatic and was dominated by metronidazole and paracetamol administration, which did constitute an adequate or recommended treatment regimen. Therefore, there is a critical need to develop and adopt snakebite management guidelines to sensitize vulnerable segments of the African population. Rural health centers would greatly benefit from making antivenom serum available to reduce the morbidity and mortality associated with snakebites. Furthermore, snakebite victims must be provided with immediate access to specific medical care, with a particular focus on antivenom therapy. Our current work enables future studies in other regions of Burkina Faso and Africa at large with similar ecological and environmental patterns. We hope these efforts will help improve snakebite epidemiological data and improve snake inhabitation maps, so as to reduce human-snake contact, accidental envenomation and death.

Authors' contributions: RKD and YD conceived the study; RKD, MT and RB designed the study protocol; RB, ASN, Fabrice Anyirekun Somé (FAS)

and SPS carried out the investigations; RB and BS analyzed the data; RB and YM identified the species; RKD, MT and RB drafted the manuscript; RKD, AD, YM and YD critically revised the manuscript for intellectual content. All authors read and approved the final manuscript. RKD and RB are guarantors of the paper.

Acknowledgements: The authors thank the people who participated in this study for their cooperation and the staff of the IRSS for their collaboration during the surveys. We would like to thank warmly the primary health centres' authorities in each village for facilitating access to the consultation files.

Funding: None.

Competing interests: The authors did not declare any conflict of interest.

Ethical approval: The study protocol was approved by the regional health authorities of Hauts-Bassins under No. 2018-0021/MS/RHBS/DRS and by the ethical committee retrospective approval under Ref. 34-2021/CEIRES.

Data availability: The data is available in the link below: <https://github.com/Rabila-Bamogo/Snake-data.git>.

References

- WHO. Charge mondiale de mortalité et de morbidité due aux morsures de serpents. 2018;2:1–7. Available at https://apps.who.int/iris/bitstream/handle/10665/276408/A71_17-fr.pdf [accessed 13 April 2018].
- Gutiérrez JM, Calvete JJ, Habib AG, et al. Snakebite envenoming. Nat Rev Dis Prim. 2017;3(1):17063.
- Williams SS, Wijesinghe CA, Jayamanne SF, et al. Delayed psychological morbidity associated with snakebite envenoming. PLoS Negl Trop Dis. 2011;5(8):1–6.
- Gampini S, Nassouri S, Chippaux JP, et al. Retrospective study on the incidence of envenomation and accessibility to antivenom in Burkina Faso. J Venom Anim Toxins Incl Trop Dis. 2016;22(1):1–5.
- Chippaux JP. Estimate of the burden of snakebites in sub-Saharan Africa: a meta-analytic approach. Toxicon. 2011;57(4):586–99.
- Kyelem CG, Yaméogo TM, Ouédraogo SM, et al. Snakebite in Bobo-Dioulasso, Burkina Faso: illustration of realities and challenges for care based on a clinical case. J Venom Anim Toxins Incl Trop Dis. 2012;18(4):483–5.
- Alcoba G, Chablot M, Eyong J, et al. Snakebite epidemiology and health-seeking behavior in Akonolinga health district, Cameroon: cross-sectional study. PLoS Negl Trop Dis. 2020;14(6):1–15.
- Chirio L. Inventaire des reptiles de la région de la Réserve de Biosphère Transfrontalière du W (Niger/Bénin/Burkina Faso: Afrique de l'Ouest). Bull la Société herpétologique Fr. 2009;132:13–41.
- Chippaux JP. Epidemiological investigation on envenomation: from theory to practice. J Venom Anim Toxins Incl Trop Dis. 2012;18(4):446–50.
- Trape JF, Mané Y. Guide des Serpents d'Afrique Occidentale, Savane et Désert. IRD Paris. 2006;39–51.
- Lam A, Camara B, Kane O, et al. Epidemiology of snakebites in Kédougou region (eastern Senegal): comparison of various methods for assessment of incidence and mortality. J Venom Anim Toxins Incl Trop Dis. 2016;22(1):1–6.

- 12 Mensah EK, Karikari K, Aikins M, et al. Secondary analysis of snake bite data in the Western Region of Ghana: 2006-2010. *Ghana Med J*. 2016;50(2):103-6.
- 13 Musah Y, Ameade EPK, Attuquayefio DK, et al. Epidemiology, ecology and human perceptions of snakebites in a savanna community of northern Ghana. *PLoS Negl Trop Dis*. 2019;13(8):1-20.
- 14 Longbottom J, Shearer FM, Devine M, et al. Vulnerability to snakebite envenoming: a global mapping of hotspots. *Lancet*. 2018;392(10148):673-84.
- 15 Habib AG. Public health aspects of snakebite care in West Africa: perspectives from Nigeria. *J Venom Anim Toxins Incl Trop Dis*. 2013;19(1):1.
- 16 Tchoffo D, Kamgno J, Kekeunou S, et al. High snakebite underreporting rate in the Centre Region of Cameroon: an observational study. *BMC Public Health*. 2019;19(1):1-7.
- 17 Harrison RA, Hargreaves A, Wagstaff SC, et al. Snake envenoming: a disease of poverty. *PLoS Negl Trop Dis*. 2009;3(12):1-7.
- 18 Somé N, Poda JN, Guissou IP. Épidémiologie et prise en charge des envenimations ophidiennes dans le district sanitaire de Dano, province du Ioba (Burkina Faso) de 1981 à 2000. *Bull la Soc Pathol Exot*. 2002;95(3):163-6.
- 19 Akaffou MH, Koué Bi MT, Yaokokore-Beïbro HK. Etude de quelques paramètres écologiques des Elapidae de six villes de Côte d'Ivoire. *Int J Biol Chem Sci*. 2019;13(1):237.
- 20 Hamza M, Idris MA, Maiyaki MB, et al. Cost-effectiveness of antivenoms for snakebite envenoming in 16 countries in West Africa. *PLoS Negl Trop Dis*. 2016;10(3):1-17.
- 21 Chippaux JP. Prise en charge des morsures de serpent en Afrique subsaharienne. *Med Sante Trop*. 2015;25(3):245-8.
- 22 Chippaux JP, Ramos-Cerrillo B, Stock RP. Study of the efficacy of the black stone on envenomation by snake bite in the murine model. *Toxicon*. 2007;49(5):717-20.
- 23 Chippaux JP. Snake bite epidemiology in Benin. *Bull Soc Pathol Exot*. 2002;95(3):172-4.
- 24 Ameh MP, Mamman M, Yusuf PO, et al. Overview of the venomous snakes in West Africa, clinical manifestation, diagnosis and treatment. *J Med Biol*. 2019;1(1):11-26.