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Epidemiology of snake bites and envenomations in the Bofidji Group – West, Equateur Province, Democratic Republic of the Congo

Mokekola, B. E.[1,2,3], Ngbolua, K. N.[3,4], Ilumbe, G. B.[3], Assumani, I. Z.[2], Mulonda, A.[2], Mawunu, M.[5], Engomba, G. M.[1], Masengo, C. A.[4,6], & Ekamba, G. L.[6]

[1]*Department of Biology, Faculty of Sciences, Institut Supérieur Pédagogique, Mbandaka, Democratic Republic of Congo*
[2]*Department of Biology, Faculty of Science, National Pedagogical University, Kinshasa, Democratic Republic of Congo*
[3]*Department of Biology, Faculty of Science and Technology, University of Kinshasa, Kinshasa, Democratic Republic of Congo*
[4]*Center for Research in Pharmacopoeia and Traditional Medicine, Higher Institute of Medical Techniques, Kinshasa, Democratic Republic of the Congo*
[5]*Agronomy Department & Botanical Garden of the Polytechnic Institute of the University Kimpa Vita, Angola*
[6]*Researcher and Head of Research Department on Biodiversity, Bomongo Territory, Province of Equateur, Democratic Republic of the Congo*

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Correspondence to:
Prof. Koto-Te-Nyiwa Ngbolua
ngboluajpngbolua@unikin.ac.cd

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ABSTRACT

Introduction

Snakebites are a major public health concern in the Democratic Republic of the Congo (DRC) and tropical Africa, causing thousands of deaths and disabilities annually. Limited access to antivenom and modern healthcare forces rural communities to rely on traditional remedies. The high frequency of snakebites, particularly in rural areas like the West Bofidji cluster in Equator Province, highlights the urgent need for epidemiological data to enhance prevention and treatment strategies.

Purpose

This study aimed to assess the prevalence of snakebites, identify affected groups, evaluate treatment methods, and analyse clinical outcomes in the West Bofidji cluster. The findings aim to inform healthcare strategies to reduce snakebite incidence and improve health outcomes.

Methods

A retrospective analysis of snakebite cases from 2019 to 2020 in Bofidji West was conducted. Data sources included medical records, community surveys, and health centre records, focusing on 329 affected individuals. A preliminary survey identified local herbalists and traditional healers as key participants.

Results

Snakebites were most prevalent among working-age adults, with women being disproportionately affected. The highest incidence occurred between January and July. Of the 329 individuals, 249 recovered, 37 experienced long-term effects, and 43 showed no recovery. Traditional treatments yielded mixed outcomes, with complications arising due to limited access to modern healthcare.

Conclusion

This study underscores the need for improved healthcare infrastructure and preventive strategies to effectively manage snakebites. While traditional treatments have value, their limitations highlight the importance of integrating modern healthcare practices and educating rural populations on prevention measures.

INTRODUCTION

Snakebites and their envenomations represent a significant public health problem in many tropical and subtropical regions, particularly in rural areas across Africa (Musah et al., 2019; Ngbolua et al., 2021; Abdulbaki et al., 2024; Mokekkola et al., 2024a, 2024b), Asia (Hao et al., 2024), Latin America (Baudou et al., 2021), and dry savannah zones (Kasturiratne et al., 2008; Zarambaud et al., 2022). In the Democratic Republic of the Congo (DRC), a floristic hotspot with limited access to healthcare, snakebites pose a major risk to local populations, especially in rural areas (Bhaumik et al., 2023).

These regions are home to a variety of venomous snakes, and local populations, particularly those in rural and agricultural areas, are at high risk of interaction with these animals, leading to severe tissue damage, neurological complications, long-term disability, or mortality (Gutiérrez et al., 2020; Ngbolua et al., 2021). The World Health Organization (WHO) has declared snakebite envenomation a neglected tropical disease, affecting millions of people worldwide annually, with significant morbidity and mortality (Kasturiratne et al., 2008; Kumar et al., 2012).

In sub-Saharan Africa, including the DRC, the situation is particularly concerning for rural children, who are at a higher risk of severe envenomation due to their small body volume and the high vascularity of commonly affected areas such as the hands (Alcoba et al., 2020). In these areas, the high incidence of snakebites contrasts sharply with the limited availability of epidemiological data and healthcare resources. Access to modern medical care and antivenoms remains scarce, compounded by a reliance on traditional herbal remedies, which, though widely used, often lack the efficacy of modern medical treatments (Habib et al., 2018; Williams et al., 2019; Gutiérrez et al., 2020; Ngbolua et al., 2021; Yalcouyé et al., 2021; Potet et al., 2021; Moos et al., 2021; Mokekkola et al., 2024a, 2024b).

Regions such as the Equateur Province in the DRC, characterized by unique geographical features that increase the risk of snakebites, face insufficient health infrastructure and a lack of trained medical personnel. In these remote rural areas, the risk of poisoning is heightened, with many individuals resorting to traditional treatments due to the inaccessibility of antivenom (Felix-Silva, 2017; Ayékotchami & Adandé, 2021; Ndinga et al., 2021; Inkoto et al., 2021).

Snakebite envenomation, while common in agricultural and forested regions, is often poorly documented. A comprehensive study is necessary to understand its frequency, risk groups, treatment practices, and the role of traditional medicine in managing the condition. The ultimate objective of these surveys is to establish a care system tailored to local conditions, alongside continuous training for healthcare personnel and traditional healers. Additionally, the study aims to raise awareness among rural populations through mass education campaigns to reduce the mortality rate. Enhancing the use of indigenous knowledge and leveraging the region's abundant floristic and zoological resources are key aspects of improving snakebite management (Felix-Silva, 2017; Ayékotchami & Adandé, 2021).

The study in West Bofidji, a rural region of the DRC, focuses on understanding the epidemiology of snakebites and their clinical outcomes, particularly the effectiveness of traditional versus modern treatments.

Specific objectives include:

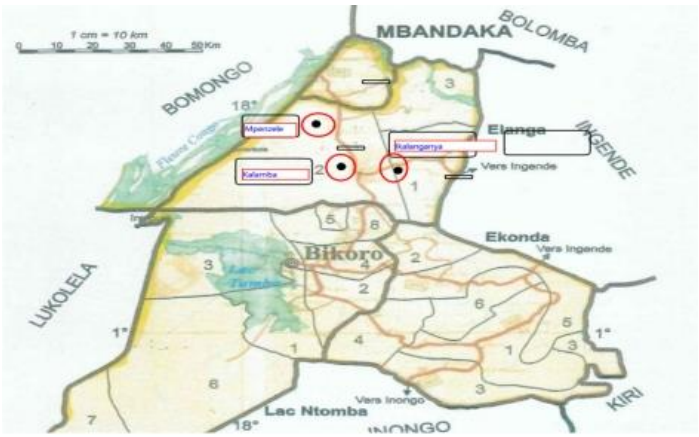
- Assessing the distribution of snakebites by demographics such as sex, age, and occupation.
- Analyzing cure rates, sequelae, and mortality based on access to traditional or modern care.
- Identifying periods of peak incidence and high-risk groups.
- Comparing the effectiveness of ethnobotanical treatments and modern medical care.
- Providing recommendations to improve snakebite management in the region.

The choice of West Bofidji is due to its rural setting, with forests and wetlands that provide a natural habitat for venomous snakes. Limited access to modern healthcare makes it a critical area for researching the role of traditional medicine and improving clinical outcomes for snakebite victims.

METHODS

Study Site

Figure 1:
Map showing location of study area



***Source**: Image taken from the atlas of Leon DE Saint-Moulin*

The Bofidji-Ouest groupment, located along the R8 public road, is a rural area within the Bikoro district in the Equateur province of the Democratic Republic of Congo (DRC) (Ndinga et al., 2021). It is characterised by significant biodiversity, including various species of snakes and other venomous creatures. This area, situated on the outskirts of Mbandaka, is known for its long-standing traditional health practices and limited access to modern healthcare services. The environmental and social conditions of Bofidji-Ouest provide an ideal setting for studying the impact of snakebites and envenomations, as well as the use of medicinal plants in local healthcare practices.

In the map referenced **(Figure 1)**, the three survey sites—Mpenzele, Kalamba, and Ikalanganya—are marked with red circles, each with a black dot in the centre, along with the names of these sites. The area is socio-economically vulnerable (Ndinga et al., 2021). The main sources of animal protein in the region are hunting (game), fishing, and caterpillars. People frequently gather firewood, the primary source of domestic energy, widely used for cooking and heating by almost the entire population of Bofidji-Ouest. These activities expose the local populations to the risk of snakebites at various times of the year.

The main ethnic groups in this region are the Ntomba, Ekonda, Ngele'a'ntando (Bantu), and Twa (indigenous pygmy population) (Ndinga et al., 2021). These groups include farmers, fishermen, traders, and professionals (e.g., government employees and workers in various organisations). The lifestyle of these ethnic groups varies, particularly between the Bantu and indigenous populations, which may explain the specific heterogeneity within the local population.

Study Design

This study is a retrospective review that involved the collection and analysis of data concerning snakebite cases that occurred in Bofidji-Ouest during 2019 and 2020. Data were gathered from local clinical records, community surveys of victims and traditional practitioners, and local health centre records from three distinct sites in the Bofidji-Ouest groupment.

Target Population and Sampling

The study population comprised residents of Bofidji-Ouest who had experienced snakebites over the defined study period. Subgroups of interest were categorised by sex, age, professional status, and marital status. Data were obtained from health centres, traditional medicine practitioners, and household surveys.

Preliminary surveys identified male and female tradiphytotherapists, male and female botanists (25 subjects: 9 females and 16 males), and others who had been victims of snakebites or caregivers for victims in 2019 and 2020 (113 subjects in total). Participants were selected using a combination of non-random and criterion-based sampling methods. This approach ensured representation of key demographic and socio-economic groups relevant to the study's goals.

Sampling Methods

- **Stratified Sampling**: Participants were grouped into strata based on age, occupation, marital status, gender, and ethnicity. This stratification enabled a detailed examination of subgroups within the population.
- **Criterion-Based Selection**: Participants were included based on predefined criteria, such as their involvement in community health practices or exposure to particular health risks. This method ensured the relevance of participants to the study's focus on ethnomedical practices and healthcare.

Data Collection

Data collection occurred in two stages:

1. **Epidemiological Stage**: Data regarding snakebite victims were collected from clinical records and family interviews. This included demographic details (e.g., sex, age, marital status, and occupation) and clinical outcomes, forming the basis for epidemiological analysis.
2. **Ethnobotanical Stage**: Information on the plants used to treat bites, preparation methods, and perceptions of traditional healers was obtained through semi-structured interviews with local health professionals and healers. This ethnobotanical data is presented in a separate publication (Mokekola et al., 2024b).

Data Analysis

The collected data were analysed using Microsoft Excel, and the results were presented visually through diagrams for clarity.

Ethical Considerations

- **Informed Consent**: Participants were fully informed about the study's objectives, their voluntary participation, and their right to withdraw at any time without consequences.
- **Confidentiality**: Participants' identities and responses were anonymised and stored securely to ensure confidentiality.
- **Cultural Sensitivity**: The study was conducted with respect for the cultural and health practices of the local community to ensure accurate and culturally appropriate data collection.
- **Approval**: Ethical clearance was obtained from the Department of Biology Ethics Committee, Faculty of Science and Technology, University of Kinshasa.

RESULTS

Sociodemographic Data

Age Distribution:

Figure 2:
Survey Population Age Groups

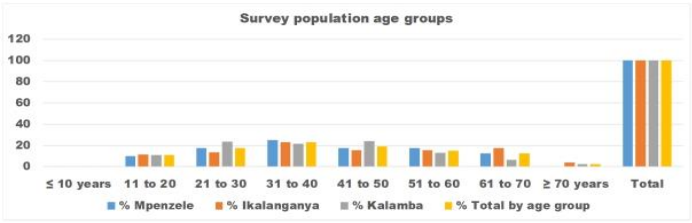


Figure 2 illustrates the age distribution of the surveyed population, excluding individuals in the nearly ten-year age group. The most represented age group is between 31 and 40 years, emphasising the focus on middle-aged adults, a significant demographic for health-related research.

Occupation:

Figure 3:
Professional Status of Respondents

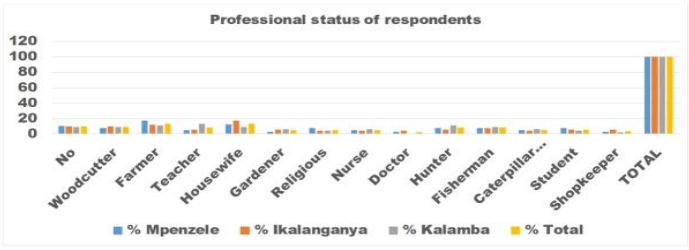


Figure 3 presents the distribution of respondents by occupation. The largest groups were housewives and farmers, accounting for 13.04% of the total. Other notable groups included the unemployed (9.42%) and lumberjacks (8.69%). This occupational diversity provides valuable insights into risk factors for health issues, recovery, mortality rates, and access to healthcare resources within the community.

Marital Status:

Figure 4:
Marital Status of Respondents

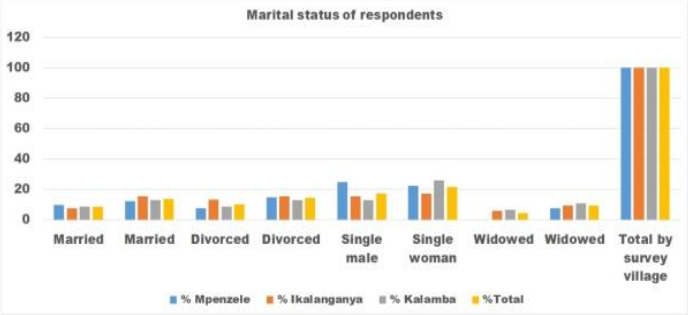


Figure 4 details the marital status of respondents. Single women constituted the largest group (21.74%), followed by single men (17.39%). Married men were the least represented, which may reflect social and cultural factors influencing survey participation.

Gender Representation:

Figure 5:
Status of Respondents by Gender

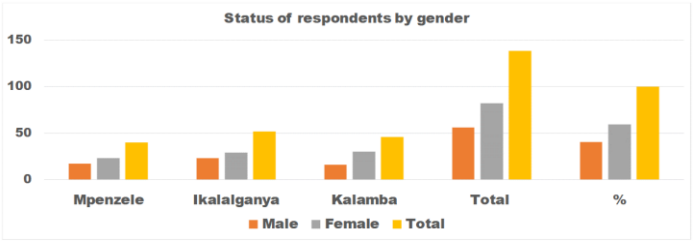


Figure 5 illustrates the gender distribution among respondents, showing a higher participation rate among women (59.42%) compared to men (40.58%). This indicates that women in the community may be more engaged with surveys and healthcare-related issues.

Ethnic Groups:

Figure 6:
Distribution of Respondents by Ethnic Group in Groupement Bofidji-Ouest

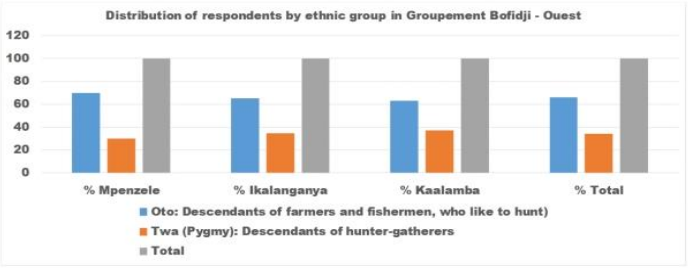


Figure 6 presents the ethnic composition of the respondents from the Bofidji-Ouest Groupement. The Oto ethnic group had the highest representation, with 91 respondents (65.94%), while the Twa group accounted for 47 respondents (34.06%). This distribution highlights the significant involvement of these communities in preserving their social practices and contributing to the study.

Epidemiological Data

Mpenzele Site:

Figure 7:
Follow-Up of Care Admissions at Household Level in Mpenzele

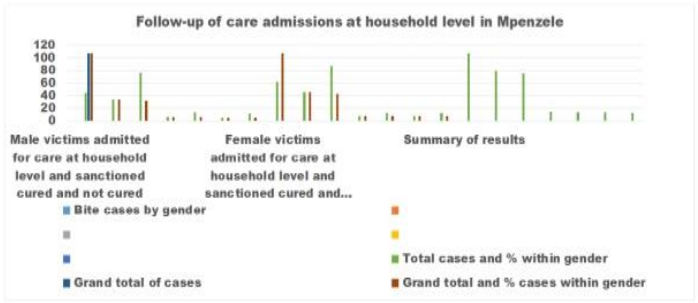


Figure 7 shows data from 107 individuals bitten by snakes between 2017 and 2021 at the Mpenzele site in the Bofidji-West Groupement. Of these, 80 recovered (74.77%), 14 experienced lasting effects (13.08%), and 13 did not recover (12.15%). Women were more frequently affected, with 62 cases (57.94%) compared to men with 45 cases (42.06%). Among those experiencing sequelae, women had 8 cases (12.90%), slightly fewer than the proportion of affected men (13.33%).

Ikalanganya Site:

Figure 8:
Follow-Up of Care Admissions at Household Level in Ikalanganya

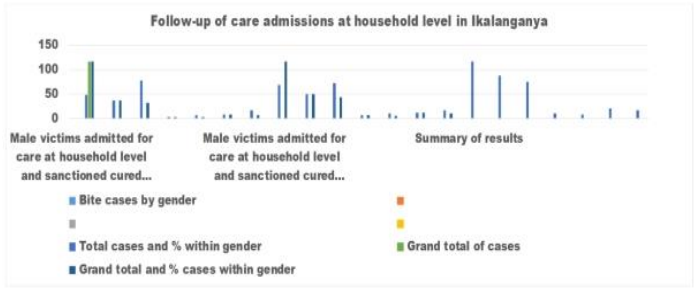


Figure 8 summarises data from 329 snakebite cases between 2017 and 2021 in Ikalanganya. Of these, 249 recovered (75.68%), 37 experienced lasting effects (11.25%), and 43 did not recover (13.07%). Women were more frequently affected (193 cases, 58.66%) compared to men (136 cases, 41.34%). Women also experienced more

lingering effects, with 23 cases (6.99%) versus 14 cases (4.25%) in men.

Kalamba Site:

Figure 9:
Follow-Up of Care Admissions at Household Level in Kalamba

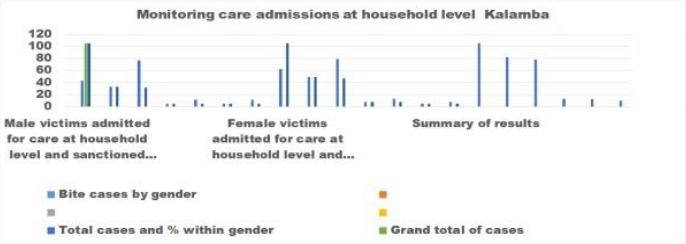
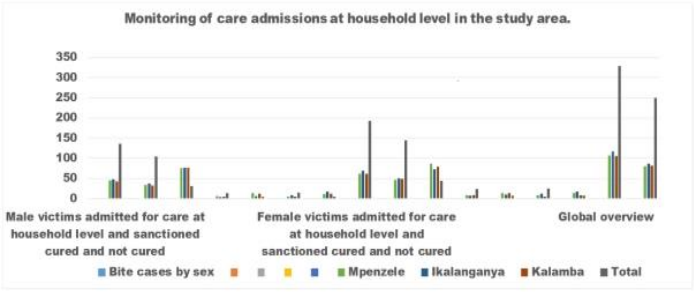


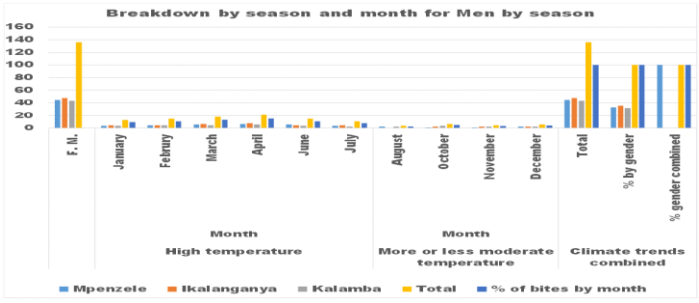
Figure 9 provides data from 329 snakebite cases between 2017 and 2021 in Kalamba. Of these, 249 recovered (75.68%), 37 experienced lingering effects (11.25%), and 43 did not recover (13.07%). Women accounted for 193 cases (58.66%), while men accounted for 136 cases (41.34%). Post-treatment consequences were more prevalent among women (23 cases, 6.99%) compared to men (14 cases, 4.25%).

Figure 10:
Monitoring of Care Admissions at Household Level in the Study Area.



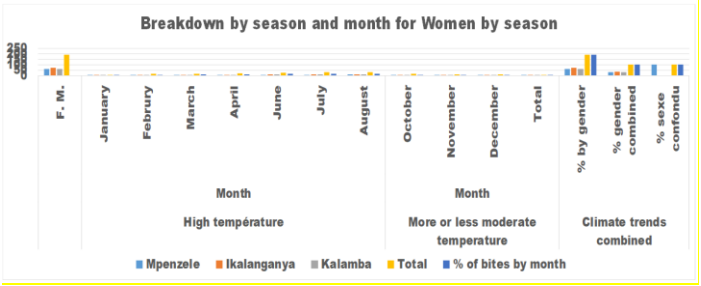
Among 329 individuals bitten by snakes between 2017 and 2021 in the Bofidji-West Groupement, 249 recovered, representing 75.68% of the sample, while 37 experienced delayed consequences (11.25%), and 43 did not recover, accounting for 13.07% (Figure 10). The data also reveals that women were more affected by snakebites, with 193 cases (58.66%) compared to 136 cases (41.34%) for men. Additionally, within each gender, females were more affected by delayed consequences after treatment, with 23 cases (6.99%) compared to 14 cases (4.25%) for males.

Figure 11:
Distribution of Bite Frequencies in Males by Season and Month of the Year.



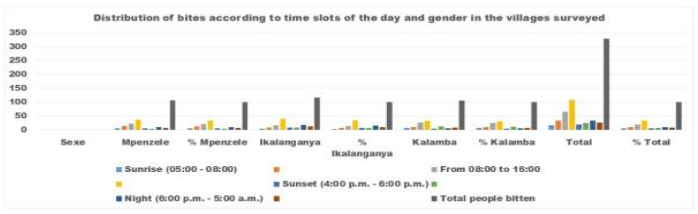
For men, the highest frequencies of snakebites occurred between January and July each year, coinciding with the hot season. This period includes the beginning of land-clearing activities for new plots, the preparation of fallow land, and the final digging phase. The peak occurred in April, a critical time for intense activity essential for the subsequent harvest, followed by a gradual decline between May and July, with a significant drop in cases between August and December (Figure 11).

Figure 12:
Distribution of Bite Frequencies Among Women by Season and Month of the Year



For women, the highest number of snakebites occurred between spring and July, with a peak in July. The number then dropped to a lower level between August and January. This pattern suggests that agricultural activities typically begin around spring and end in August, after the extended harvest is completed, before the September rains arrive, which could disrupt drying and marketing processes.

Figure 13:
Distribution of Bite Frequencies in the Overall Sample (Gender Combined) by Season and Month of the Year.



Summing all snakebite cases for both sexes, the highest number of incidents occurred between January and August each year (Figure 13). This period corresponds to the peak of the agricultural season, which is ideal for hunting and fishing. Traders are actively purchasing food, and children are in school. The favorable climate for snakes during this time increases their visibility, even in the huts, which accounts for some of the nocturnal bites. The pattern reveals a clear correlation between rising temperatures and an increase in snakebite incidents. Socially, this period also coincides with ceremonial activities, and in the Bofidji-West region, the snake is considered a tribal symbol.

Figure 14:
Distribution of Snakebite Cases by Level of Education

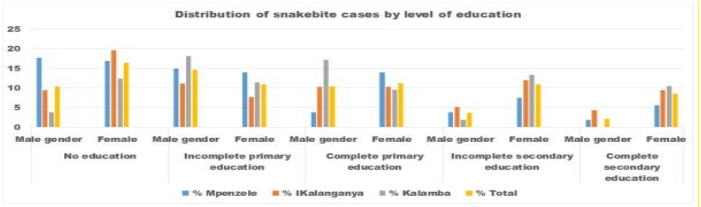
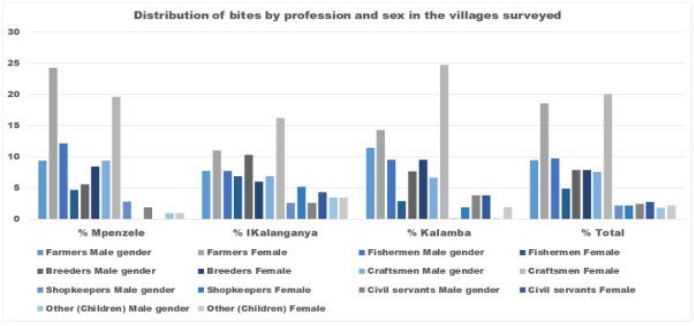


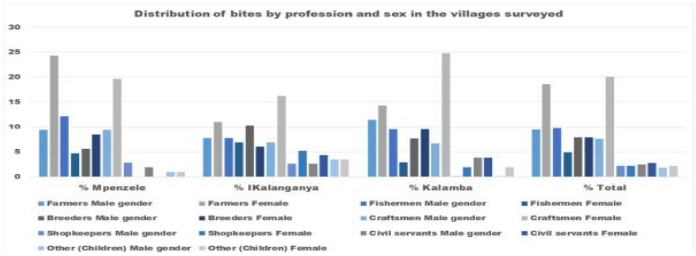
Figure 14 shows the distribution of snakebite cases based on education level, broken down by city and with an overview of rates at both the city and global levels. Individuals with no schooling or inadequate basic education are the most affected. Education appears to play a significant role in susceptibility to snakebites, likely due to limited awareness of the risks associated with snakebites.

Figure 15:
Distribution of Bites by Age and Sex in Surveyed Villages



This model allows for a comparison of bite rates by age and sex across different cities, highlighting demographic patterns in the epidemiology of snakebites (Figure 15). The age groups most affected are 21-30 and 31-40, likely due to increased exposure related to economic activities. Adolescents and middle-aged adults are more prone to snakebites, possibly due to their involvement in work in high-risk areas.

Figure 16:
Distribution of Bites by Profession and Sex in Surveyed Villages.



This Figure (16) examines which professions are most vulnerable to snakebites, categorized by city and gender, and identifies occupational patterns related to the risk of being bitten (Figure 16). Farmers represent the majority of snakebite victims (65%), followed by fishermen (20%), herders (10%), and professionals (5%). Individuals working outdoors, particularly farmers, are at greater risk of snakebites due to the proximity of their work environments to natural snake habitats.

Figure 17:
Distribution of Bitten People According to Treatment Received from Traditional Healers, Traditional Practitioners, and/or Modern Health Structures in the Villages Surveyed

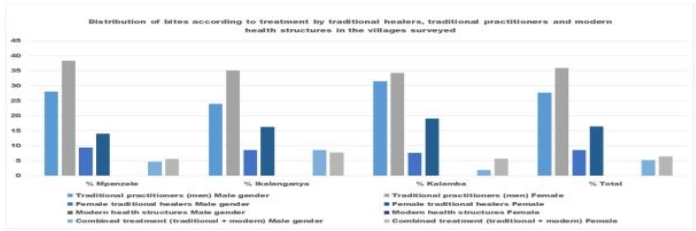


Figure 17 illustrates the most frequently used treatment facilities for snakebites, based on the city, the sex of the individual bitten, and the type of treatment available (traditional, modern, or combined). It shows that traditional treatment is the most sought after, while also highlighting a certain level of respect for traditional healers among both conventional and modern medical professionals.

Figure 18:
Distribution of Bites by Severity of Symptoms and Sex in the Villages Surveyed

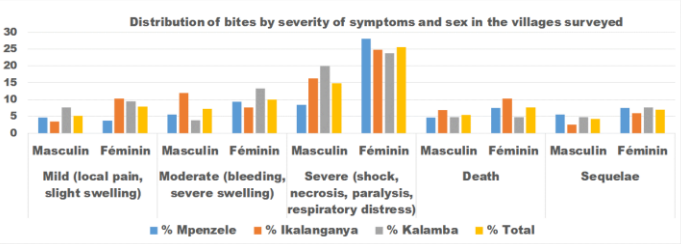


Figure 18 illustrates the severity of snakebites in different cities, based on gender and the severity of side effects. Severe bites accounted for just over 40% of the 329 cases recorded in the study, followed by moderate bites at approximately 17.32%, and mild bites representing 13.07%. Deaths and delayed consequences each accounted for 13.07% and 11.33%, respectively. Some severe cases are believed to be due to potent venom, but psychosomatic reactions, such as nervousness, anxiety, and stress, may also play a role. These reactions can impact the healing process.

Figure 19:
Distribution of Snakebites by Type of Snake and Sex in the Villages Surveyed

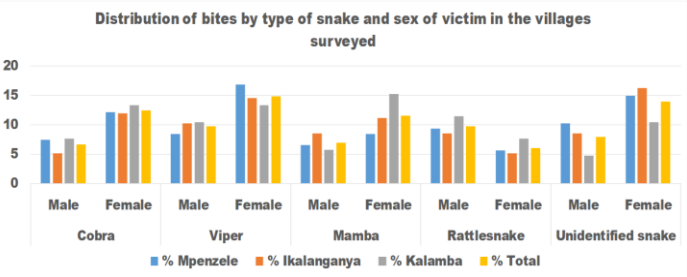


Figure 19 shows the prevalence of snakebites by snake type, gender, and town. The most common snake in Mpenzele is the Ibate, with 10.28% of males and 14.95% of females being bitten. In the towns of Kalamba and Ikalanganya, the Ibate caused relatively fewer bites. The Mumbito/Bolele snake caused bites in 14.02% of women and 6.54% of men. In terms of overall impact, these species are considered dangerous. The Lokonga species, a snake commonly found in the region, appears to cause less widespread harm. Given these figures, it would be advisable to conduct a more detailed study of the population and environment of this reptile.

Figure 20:
Distribution of Bites by Day of the Week and Sex in the Villages Surveyed

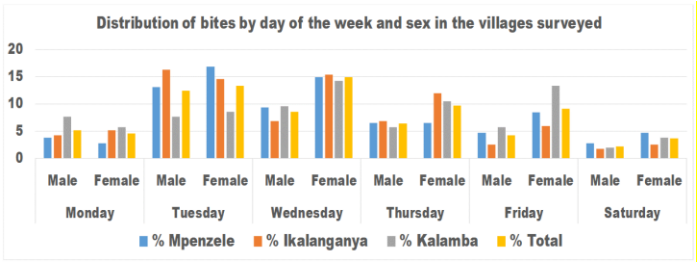


Figure 20 shows the distribution of snakebites by day of the week, taking into account the sex of the individual bitten and transportation by city. Snakebites can occur at any time, but the data reveals that Tuesday stands out with a significant number of bites. In the local context, Tuesday is traditionally considered a day when the native population avoids regular visits to the woods and streams, which may explain the notable frequency of bites on this particular day.

Figure 21:
Distribution of Bites by Time of Day and Sex in Surveyed Villages

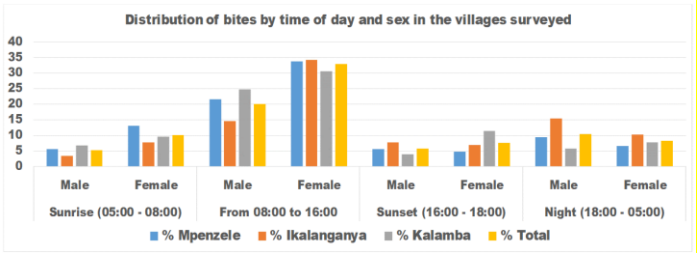
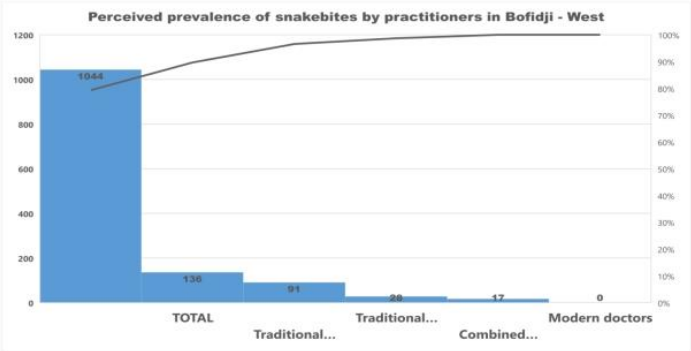


Figure 21 shows the distribution of snakebites by time of day, considering the sex of the individuals bitten and the distribution by location. According to the time distribution, the highest number of snakebites occurred between 08:00 and 16:00 (52.89%), which aligns with the working hours of the population. During this time, common activities include gardening, caterpillar collection, wood collection, market visits, schooling, fishing, and hunting. Nocturnal bites account for 18.54%, typically occurring during rest hours. These are often associated with the proximity of huts, which are not urbanized and are closely situated to the forest.

https://dx.doi.org/10.4314/orapj.v6i1.6

Figure 22:
Perceived Prevalence of Snakebites by Practitioners in Bofidji-West



To assess the prevalence of snakebites by type of healthcare provider—traditional healers, conventional medical practitioners, modern medical providers such as doctors and nurses, and informal collaborations between traditional and modern medicine providers—it is estimated that approximately 0.61% of men in the total population have experienced snakebites according to traditional healers. This approach is similarly applied to the other categories (see **Figure 22**). Furthermore, factors such as the "season of risk," "perceived effectiveness of traditional treatment," and "perceived effectiveness of modern treatment" indicate the need for qualitative data collection or specific assessments to better understand the dynamics and treatment preferences within the community.

DISCUSSION

This study highlights the importance of improving healthcare infrastructure, particularly in rural areas like Bofidji West, where snakebites represent a major public health issue. The results of the Snakebites study in Bofidji West show that agricultural workers, fishermen, and rural residents (especially women) are most affected, which aligns with broader conclusions from global initiatives such as the SNAKE-BYTE project (Babo Martins et al., 2019). This ongoing four-year project adopts a One Health approach to understand the global burden of snakebites in endemic countries, including Cameroon and Nepal. By collecting data on human and animal mortality, morbidity, symptoms, outcomes, healthcare costs, and animal losses, the project highlights the interrelationship between human and animal health in areas where snakebites frequently occur, such as rural regions with close human-environment interactions. The high vulnerability of rural areas in the West of Bofidji, particularly among women involved in agriculture and fisheries, reflects similar findings from other regions studied under the SNAKE-BYTE project. As observed in Cameroon (Chuat et al., 2021), the population in western Bofidji is exposed to the natural habitat of snakes, increasing the risk of snakebites. This exposure is exacerbated by limited access to modern healthcare, including antivenoms—a major concern highlighted by the SNAKE-BYTE project. The high mortality and morbidity rates from snakebites in Bofidji West, despite the use of traditional remedies, further underscore the critical gaps in health services—a challenge also addressed by the One Health approach of the SNAKE-BYTE project. The project aims to improve healthcare access and treatment efficiency by collecting cross-sectoral data, while acknowledging the role of traditional remedies, as seen in Bofidji West. This points to the need for integrating modern medical care with traditional practices, which is a potential solution for improving treatment outcomes, as recommended for Bofidji West (Mokekola et al., 2024b). Furthermore, the SNAKE-BYTE project's data on livestock production losses and their wider impact on livelihoods are relevant to Bofidji West. In areas like Bofidji West, where livelihoods are closely linked to agriculture and fishing, snakebites disrupt economic activities and affect food security, as noted by the SNAKE-BYTE project. This highlights the multifaceted effects of snakebites on human health and local economies, emphasizing the need for comprehensive interventions to provide not only healthcare access but also economic support to affected communities. The seasonality of snakebites, which coincides with agricultural work periods, underscores the need for targeted preventive measures during this time (Chaves et al., 2015; Ediriweera et al., 2018; Abdullahi et al., 2022). Policy recommendations include improving local health centers by equipping them with antivenoms and trained staff, implementing mobile health units in remote areas, and conducting community education campaigns to raise awareness about snakebite prevention and the importance of seeking timely medical care. Additionally, integrating modern healthcare practices with traditional remedies could improve outcomes, but further research is needed to assess the effectiveness of traditional treatments. Prospective studies, clinical trials of traditional treatments,

and better identification of the snake species responsible are essential to deepen the understanding of snakebite management and strengthen public health responses in rural regions of Africa. It is also crucial to design appropriate public health education programs on snakebite prevention, especially during the rainy season, and establish effective case management protocols. Increasing the accessibility and availability of antivenoms will undoubtedly have a significant impact on reducing mortality and disability related to snakebites.

CONCLUSION AND RECOMMENDATIONS

This study provides an in-depth understanding of snakebite transmission in Bofidji West, assessing local ethnobotanical practices and identifying the demographic groups most at risk. The findings indicate a high prevalence of snakebites among working-age individuals, especially agricultural workers, fishermen, and rural laborers, with men facing higher exposure due to their work activities. Limited access to modern medical care contributes to severe complications and high mortality, while traditional remedies, although culturally valuable, often lack efficacy. Some cases show improved outcomes through informal cooperation between traditional healers and medical staff, but many patients require repeated treatments, highlighting the need for enhanced healthcare and support systems. To address these challenges, recommendations include equipping local health centers with antivenoms and trained staff, conducting community awareness campaigns on snakebite prevention and rapid response, implementing mobile health units for remote areas, and establishing a comprehensive epidemiological monitoring system. Research into traditional remedies could identify plants with therapeutic potential, fostering collaboration between modern and traditional medicine. Additionally, land-use planning to reduce snake habitats near human dwellings could minimize snakebite risks. Implementing these measures could significantly improve snakebite management in Bofidji West, reduce morbidity and mortality, and potentially validate and integrate certain traditional knowledge within modern healthcare frameworks, ultimately strengthening patient outcomes and community resilience.

Ethics Approval: Ethical clearance was obtained from the Department of Biology Ethics Committee, Faculty of Science and Technology, University of Kinshasa, DRC.

Conflicts of Interest: None declared.

ORCID iDs:

Mokekola, B. E.[1,2,3]: https://orcid.org/0009-0000-8302-2923
Ngbolua, K. N.[3,4]: https://orcid.org/0000-0002-0066-8153
Ilumbe, G. B.[3]: https://orcid.org/0009-0004-9866-0943
Assumani, I. Z.[2]: https://orcid.org/0009-0009-5855-8086
Mulonda, A.[2]: https://orcid.org/0009-0002-2055-6850
Mawunu, M.[5]: https://orcid.org/0000-0001-6658-9223
Engomba, G. M.[1]: https://orcid.org/0009-0002-9222-6658
Masengo, C. A.[4,6]: https://orcid.org/0000-0002-9086-5731
Ekamba, G. L.[6]: https://orcid.org/0009-0007-3170-3402

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