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Incidence and traditional management of snakebites in the Bofidji-Bolenge Grouping, Wangata Commune, Mbandaka City, Democratic Republic of the Congo

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ABSTRACT

Introduction

Snakebites represent a significant public health problem, particularly in rural and remote areas where access to medical facilities and antivenoms is limited.

Purpose

The purpose of this study was to investigate the incidence and traditional management of snakebites in the Bofidji-Bolenge Grouping, Wangata Commune, Mbandaka City, Democratic Republic of the Congo

Methods

The study area includes sites such as Mbandaka ea Mbula, Lokekya, Bopenzola, and Ikengo. The survey, conducted from January 2019 to December 2020, focused on mainland populations. A mixed-methods approach was employed, combining quantitative surveys of households and qualitative interviews with local residents, including doctors, herbalists, traditional healers, snakebite victims, their caregivers, and land chiefs. Questionnaires were administered to gather comprehensive data on snakebite occurrences and their management within the community.

Results

Epidemiological investigations recorded 1,569 pathological cases, with 780 men (49.71%) and 789 women (50.29%) affected. Pregnant women were particularly impacted, comprising 15.36% of cases. Men with pregnant partners at the time of the bite represented 12.94%. Men and women, in general, accounted for 11.92% and 11.66% of cases, respectively. Children were also affected, with boys at 7.52% and girls at 4.33%. The highest annual prevalence was at the Lokekya site (4.31%). The study identified 37 medicinal plants used in traditional treatments for snakebites and envenomations.

Conclusion

The study underscores the pivotal role of traditional medicine in addressing public health challenges, particularly in managing snake bites through indigenous plant treatments and the expertise of traditional healers. To improve snakebite management in the DRC, it is recommended to conduct phytochemical analyses of the 37 identified medicinal plants to verify their active compounds.

INTRODUCTION

Worldwide, the number of deaths due to snakebites is around 125,000 per year, including 100,000 in Asia, 5,000 in America, and 20,000 in Africa, resulting from one million accidents each year (Chaka, 2021; Chippaux, 2002; Chippaux, 2008; Diarra, 2008; Deschamps, 2013; Mokekola et al. 2022a; Mokekola et al., 2022b; Ngbolua et al., 2021). Africa is well known for its venomous animals: scorpions and snakes, such as cobras, mambas, and vipers. In rural areas, foresters and their families face the risk of encounters with scorpions and venomous snakes (Chaka, 2021). Snakes have always been the most fearsome venomous animals for humans. In Côte d'Ivoire, in 1982, the number of bites was estimated at 168 per 100,000 inhabitants per year, with a mortality rate of 1.5 per 100,000 inhabitants per year (Chippaux, 2002a, b, c). Approximately 5 million snakebites, scorpion stings, and anaphylactic reactions to insect bites occur each year worldwide and cause more than 100,000 deaths annually. In Africa, where few precise data are available, there is a large margin of uncertainty about the number of snakebites and deaths occurring each year (Chippaux, 2006). However, it has recently been estimated that one million snakebites, causing more than 20,000 deaths, could occur each year in Africa (Danielle, 2004).

For a long time, the modern medical management of snakebites was treated in an approximate way and left to the discretion of each practitioner without any real protocol to which to adhere (Hartland, 2012). The WHO Snakebite Roadmap (Descola, 2005; Duda et al., 2021) represents a unique opportunity to raise awareness of this issue around the world, end neglect, and remove barriers that prevent people from accessing modern treatments. In any case, this problem remains unresolved, and statistics on snakebites in developing countries are often misleading, as they are based on hospital records, while most victims prefer to be treated by a traditional healer rather than in a hospital. Potet (2018) and Zoumenou et al. (2023) state that with 100,000 fatal bites per year, snake envenomation is now considered a neglected tropical disease, which, in common with other diseases of the same category, affects the vast majority of the poorest communities in developing countries, most often in rural areas. Due to a lack of political clout, patients suffering from these diseases are often neglected by the health authorities. Due to a lack of economic clout, they are neglected by the pharmaceutical industry.

Snakebite is a public health problem (Chippaux 2002a, 2002b, 2002c; Naciri, 2012; Chaka, 2021; Zarambaud et al., 2022; Mensah et al., 2016), especially in Africa, where mortality and morbidity rates remain high due to the envenomations they cause. In addition, it is known that in endemic areas, the high frequency of bites and envenomation accidents by snakes most often contrasts with the low level of available epidemiological, clinical, and therapeutic data (Chippaux, 2006; Gampini et al., 2016). According to the WHO, the number of people affected by snakebites worldwide is 5 million per year (WHO, 2002), while 400,000 suffer from serious sequelae (WHO, 2021). In view of the danger posed by snakebites, African tradition has never been indifferent. In developing countries (Chippaux, 2005; Ilumbe et al., 2019), where the risk of envenoming accidents is great, the health infrastructure, the availability of medicines, and the training of personnel are insufficient to meet a health demand that is otherwise poorly specified. It is therefore essential to improve our knowledge of the epidemiology of snakebites in order to better organize their care. The implementation of a care offer adapted to the conditions in the field, combined with the training of the health personnel present, should significantly reduce mortality, which remains unacceptable given the effectiveness of current antivenomous immunoglobulins.

In this perspective of establishing a healthcare offer adapted to rural conditions, which can be found in the tradition of the "Mongo" peoples in the Democratic Republic of the Congo, in addition to the many reasons mentioned above, several bite accidents, such as those of envenomation, would find their pseudo-reasons in a background of dietary and cultural prohibitions vis-à-vis a totem. In this case, these facts are attributed to the totemic serpent which is the guarantor of maternal fertility, the protection of the members of the clan, and also the provider of wealth. This reality is not lost on the "Mongo" peoples occupying the Bofidji – Bolenge in the commune of Wangata, a customary environment recognized as very conservative, which constitutes our research environment.
In light of such thoughts, for example, should we not point out that in the DRC, a culturally diverse country, a

pregnant woman is subjected to all kinds of prohibitions with regard to totem poles, and the child who is born is also subjected to a very overwhelming regime of innumerable dietary and cultural prohibitions imposed on her for a so-called bright future. All in all, in the Mongo tradition of the Bofidji-Bolenge Grouping, incidental cases of bites remain moments of great speculation and insinuations against the traditional power that fails in its mission to protect the members of the clan. At such times, sometimes, in many families, we witness contradictions going as far as the denial of this failing power and insults to the family totem. This is also the time for the seer to consult the psychic, most often the only one for the whole clan, to find out the real reasons for the bite. If the interpretation made gives rise to a background of rupture of the complex relationships established with this animal, we thus ritually consult a traditional therapist, naturally endowed with the power to heal, conferred on him by the chief of the land via the spirits who manage the food and cultural prohibitions as the case may be (Chippaux, 2002a, 2002b, 2002c; Garine, 1980; Pagezy, 1988, 2008). In these cases, the traditional therapist would absolutely have an evocative power that allows him to discover, case by case, new medicinal recipes revealed to him by the spirits, some of whose constituents are kept secret (plants/animals) and can only be revealed to the initiated. This implies that the ethnobotanical information received from traditional therapists is sometimes only partial in some cases.

In the search for solutions to such complex issues, Descola (2005) believes that man's relationship with nature is not always easy to grasp and that often through myths and legends, we find the answers to such questions. The present study is intended to be retrospective from 2017 to 2021, and in its first part, is concerned with a community survey of households affected by snakebite cases and envenomations. The section devoted to a survey of traditional practitioners who treat this pathology will follow in the near future. The two studies may help in a comparison between the two levels of knowledge, perceptions, attitudes, and drug recipes in the fight against snakebites and their envenomations. Based on the above, and in view of the problem of snakebites in rural Mongo, in what we call traditional Mbandaka, our study chose as a framework for study the cultural space of the Bofidji-Bolenge Grouping, an environment that claims to be indigenous where some traditional influences are still observable.

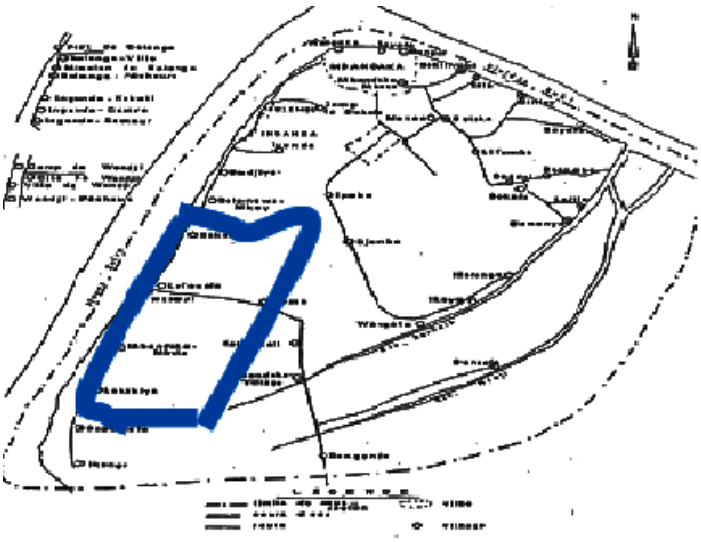
The most important concern remains that of knowing what link can be made between the snakebite, which is, in these circumstances, a response given by the snake that is transgressed, and pierced by the clan through acts ranging from its physical slaughter to cultural and/or dietary prohibitions not respected by the members of the community in front of its own animal, that is to say, his own totem, which is the serpent. In other words, to understand the place of totems in the problem of bites and envenomations, we need a community study of the evaluation of incidents and prevalence around snakebites by integrating socio-cultural elements linking humans and nature in a totemic context. Such an approach could help to regain the place of the totem pole through the statistics produced for this purpose by various emblematic social and cultural groups thus affected by bites.

The purpose of this study was to investigate the incidence and traditional management of snakebites in the Bofidji-Bolenge Grouping, Wangata Commune, Mbandaka City, Democratic Republic of the Congo.

Study Environment

Map of the Study Area

Figure 1:
The Bofidji-Bolenge Grouping, Wangata Commune, Mbandaka City, Democratic Republic of the Congo



History of the City of Mbandaka

The city of Mbandaka is situated at the confluence of the Ruki and Congo rivers. Its terrain is characterized by numerous marshes, swamps, and streams, with their thickness often dependent on rainwater. According to Hulstaert (1994) and Mumbanza (1982), the names of the marshes and streams in Mbandaka are as follows: Bonkele, a large stream originating upstream of Wangata; Isambe, whose source is located in the Balongo b'anto marsh, a large swamp between Ifeko and Wangata; Isondage, another swamp between Ifeko and Wangata w'ibonga; and Botemaofankele, the name given to various streams that overflow during floods caused by torrential rainwater.

The capital, first of the District (1888-1917), then of the Province (1917-1972), and since 1972 of the Equateur Region, Mbandaka is located in the Cuvette Centrale, at the confluence of the Zaire and Ruki rivers. The city's geographical coordinates, according to the Verfinden milestone installed near the residence of the Governor, are at 0°03'49" N and 18°16'40" E. The average altitude of the city varies between 355 and 340 meters. Surrounded by forest and marsh vegetation, Mbandaka experiences an equatorial climate characterized by scorching heat that often precedes torrential rains. Although the dry season is almost non-existent, there is a slight drop in water levels due to reduced precipitation. However, the temperature rarely drops below 20°C. It should be noted that Mbandaka was established as an urban constituency on February 23, 1895, and was elevated to city status in September 1958.

METHODS

The methodology for this retrospective study was adapted from Guyavarch (2005), Chaka Dembele (2021), and ICASEES MICS6-RCA (2021), tailored to evaluate snakebites within the Mongo tradition. In the Mbandaka ea Mbula clan, where the snake holds emblematic totemic significance, snakebites are culturally significant occurrences linked to violations of food and cultural taboos ingrained in collective memory. Demographically, the study expanded beyond gender to categorize groups affected by these totemic prohibitions. Note that "pseudo reasons" refer to explanations or justifications that appear valid but are actually false, misleading, or superficial. They often rely on logical fallacies or emotional appeals rather than factual evidence. On the other hand, a "totemic serpent" holds symbolic or spiritual significance in various cultures, typically representing qualities like wisdom, protection, or renewal. These serpents serve as totems, embodying spiritual powers and playing roles as guardians or guides within their cultural or religious contexts.

Study Design

This study employed a retrospective, cross-sectional household survey conducted over a 25-day period from March 5 to March 30, 2022.

Study Population

The study population comprised individuals who had experienced or were affected by snakebites within households that had been victimized by such incidents. Each household was represented by a single respondent selected through the survey process.

Survey Techniques and Data Analysis

Survey techniques included structured interviews designed to gather information on snakebite incidents. Data analysis involved calculating frequencies and percentages to assess the prevalence of snakebites, with arithmetic means used to summarize data over the two-year evaluation period, stratified by sex.

Selection Criteria for Survey Sites

Survey sites were chosen based on the incidence of reported snakebite cases within the study period. Selection criteria aimed to capture a representative sample of households affected by snakebites.

Administration of the Survey

Surveys were administered through direct interviews with participants, ensuring standardized data collection. Potential biases, such as recall bias, were acknowledged and mitigated through careful questionnaire design and rapport-building techniques during interviews.

Sampling

Heads of households or their knowledgeable representatives about snakebite cases within their families were interviewed, as well as the victims of the bites themselves or those who had supported the victims during the period of care. This approach allowed for the categorization of bite victims in a cluster sample,

considering individuals subject to dietary and cultural prohibitions in relation to the "Serpent" totem. Statistical analyses (Ascending Hierarchical Classification) were performed using R software.

Statistical Methods

Statistical methods included frequency calculations to determine the occurrence of snakebites and percentage calculations to analyze demographic distributions. The rationale behind these methods was to provide a comprehensive understanding of snakebite prevalence within the studied population.

Ethical Considerations

During this study, several ethical considerations were taken into account. Firstly, informed consent was obtained from all participants, including community members, traditional healers, and healthcare providers, clearly explaining the study's purpose, potential risks and benefits, and ensuring voluntary participation. It was crucial to respect cultural sensitivities and preserve local cultural beliefs and practices related to snakebite management, collaborating closely with community leaders for a respectful approach. Additionally, mechanisms were established for fair benefit sharing and discussions regarding any potential commercialization of traditional knowledge arising from the study, in accordance with the Access and Benefit-Sharing regulations of the Convention on Biological Diversity. All collected data were treated confidentially, with strict measures for privacy and anonymity to safeguard participants' privacy. Ethical approval was obtained from the Ethics Committee of the Department of Biology (Faculty of Science and Technology, University of Kinshasa) (Letter No. 005/CE/CDB/FST/PMM/20218). Finally, community engagement and local capacity building were promoted to ensure responsible, respectful, and equitable research, thereby contributing to sustainable development and the preservation of traditional knowledge systems within the community.

RESULTS AND DISCUSSION

The total number of respondents from the four randomly selected villages amounts to 382 subjects, representing 382 households selected during a pre-survey. Of this sample, there were 173 women (45.29%) and 209 men (54.71%), as shown in the table below. The different sites were well represented: Mbandaka ea Mbula with 23.04%, Lokekya with 21.20%, Bopenzola with 24.08%, and Ikengo with 31.68%.

Abbreviations

Regarding the abbreviations used for the socio-traditional categories targeted by the snakebite, the meanings are as follows:

1. **M** = Male Without special status
2. **MMWP** = Man whose spouse is pregnant
3. **MLC** = Man recognized as cursed
4. **W** = Widowed man
5. **MC** = Male child
6. **Wo** = Woman without special status
7. **WP** = Pregnant woman
8. **WK** = Woman recognized as cursed
9. **Wi** = Widowed woman
10. **FC** = Female child

Proportions of Respondents by Site and Gender

Figure 2:
Proportions of respondents by site and gender

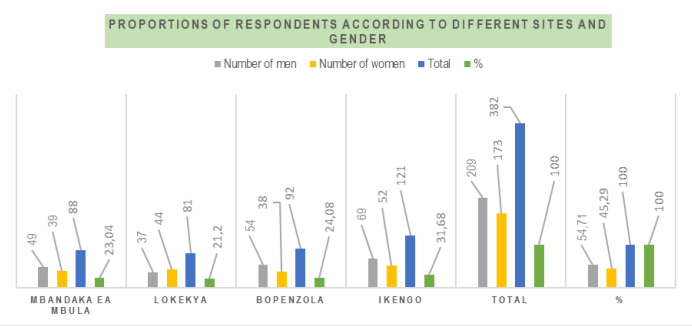
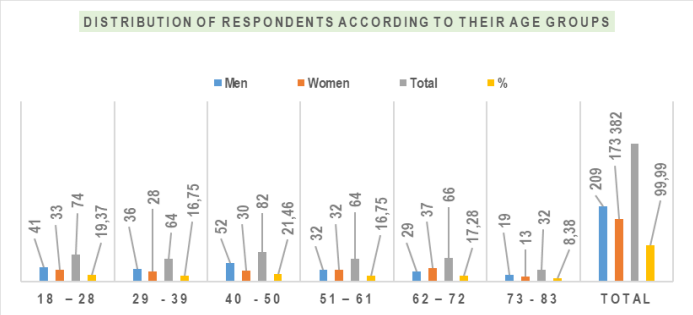


Figure 2 shows the proportions, in both number and percentage, of respondents in the various study sites in the Bofidji-Bolenge grouping in the commune of Wangata, Mbandaka on the Bikoro axis. The survey included a total of 382 respondents, comprising 209 men (54.71%) and 173 women (45.29%).

Distribution of Respondents by Age and Sex

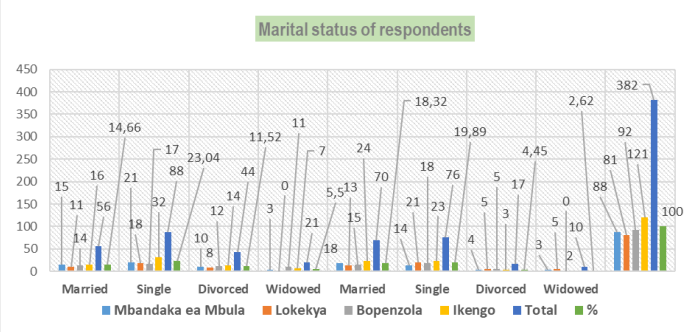
Figure 3:
Distribution of respondents by age and sex



The most dominant age group is 40–50 years old (21.46%), while the least represented age group is 73–83 years old.

Marital Status of Respondents

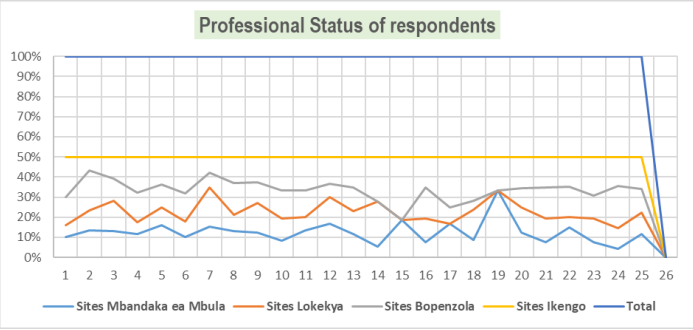
Figure 4:
Marital status of respondents



In terms of marital status, single men are the largest group with 88 respondents (23.04%). This is followed by single women with 76 respondents (19.89%). The married group includes 70 married women (18.32%) and 56 married men (14.66%). Widows are the least represented at only 2.62%.

Respondents' Employment Status

Figure 5:
Respondents' employment status

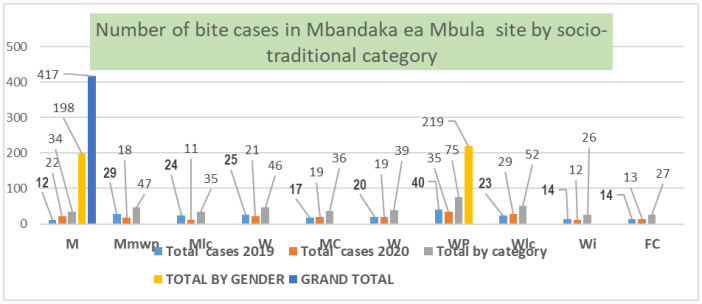


The marital status results are repeated here: single men (88 respondents, 23.04%), single women (76 respondents, 19.89%), married women (70 respondents, 18.32%), and married men (56 respondents, 14.66%). Widows are represented by only 2.62%.

Results of the Epidemiological Investigation

Result 1: *Village Mbandaka ea Mbula Center*

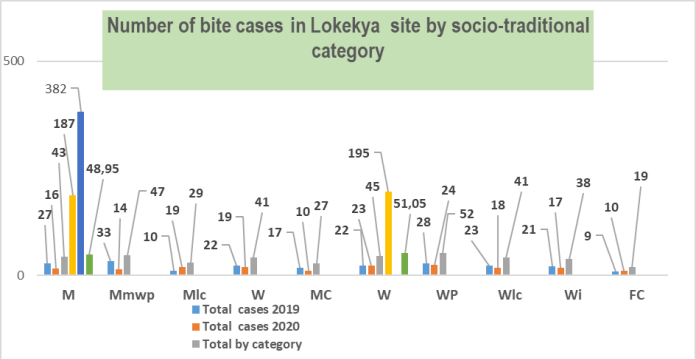
Figure 6:
Number of bite cases in Mbandaka ea Mbula by socio-traditional category



Over a period of 2 years, the highest number of snakebite cases was recorded among pregnant women (75 cases, 34.25% of females and 17.98% of the entire community) and men whose partners were pregnant (47 cases, 23.73% of males and 11.27% of the community). Women declared cursed (52 cases, 23.74% within the population and 12.47% of the overall sample) were more affected than men with curses (35 cases, 17.68% of males and 08.39% of the community). Non-special women had 39 cases (17.81% within the female sex and 09.35% of the community), outperforming non-special men, who had 34 cases (17.17% of males and 08.15% of the community). Widowers (46 cases, 23.23% of males and 11.03% of the community) were more affected than widows. There were also more bites in male children compared to female children.

Result 2: *Lokekya Village*

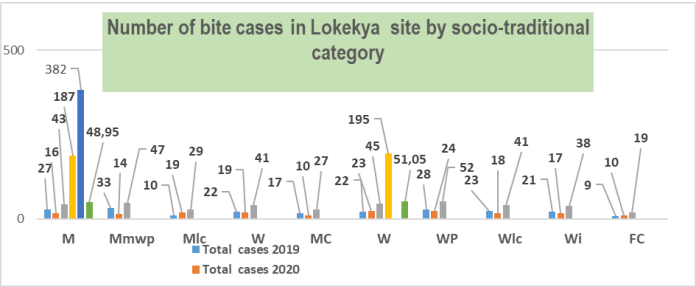
Figure 7:
Number of bite cases by socio-traditional category in Lokekya



Over 2 years, the highest number of snakebite cases was recorded among pregnant women (52 cases, 26.67% of females and 13.61% of the community) and men whose partners were pregnant (47 cases, 25.13% of males and 12.30% of the community). Women declared cursed (41 cases, 21.02% of the population and 10.73% of the sample) were more affected than men with curses (29 cases, 15.51% of males and 07.59% of the community).

Result 3: *Bopenzola Village*

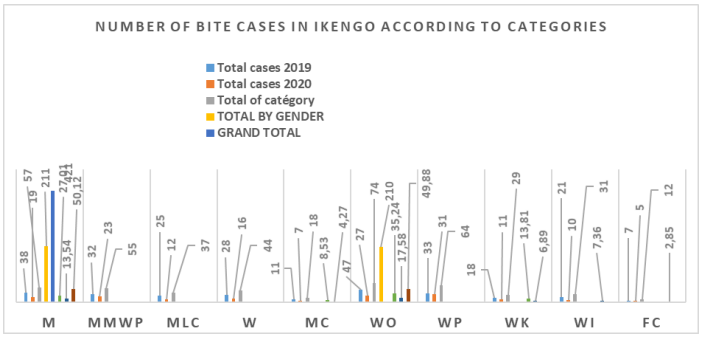
Figure 8:
Number of bite cases in Bopenzola by socio-traditional category



Over 2 years, the highest number of snakebite cases was among pregnant women (50 cases, 30.30% of females and 14.33% of the community) and men whose partners were pregnant (29 cases, 29.35% of males and 15.47% of the community). Women declared cursed (44 cases, 26.67% of females and 12.61% of the sample) were more affected than men with curses (25 cases, 13.59% of males and 07.16% of the community).

Result 4: *Ikengo Village*

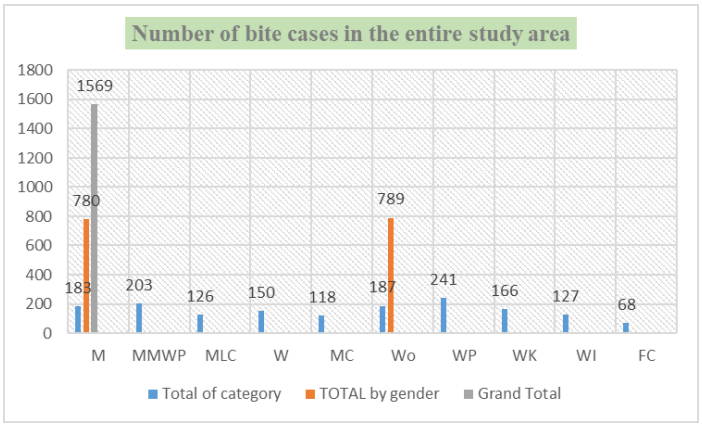
Figure 9:
Number of bite cases in Ikengo by socio-traditional category



Over 2 years, the highest number of snakebite cases was among males without special status (57 cases, 27.01% of males and 13.54% of the total) and females without special status (74 cases, 35.24% of females and 17.58% of the total). This was followed by men with pregnant wives (55 cases, 26.07% of males and 13.06% of the total) and pregnant women (64 cases, 30.48% of females and 15.20% of the total). Men with curses had 37 cases, slightly more than women with curses (29 cases). Male children with curses (18 cases) were more affected than female children (12 cases).

Summary Results of the Epidemiological Survey in the Bofidji-Bolenge Cluster

Figure 10:
Summary results of the epidemiological survey in the Bofidji-Bolenge Cluster

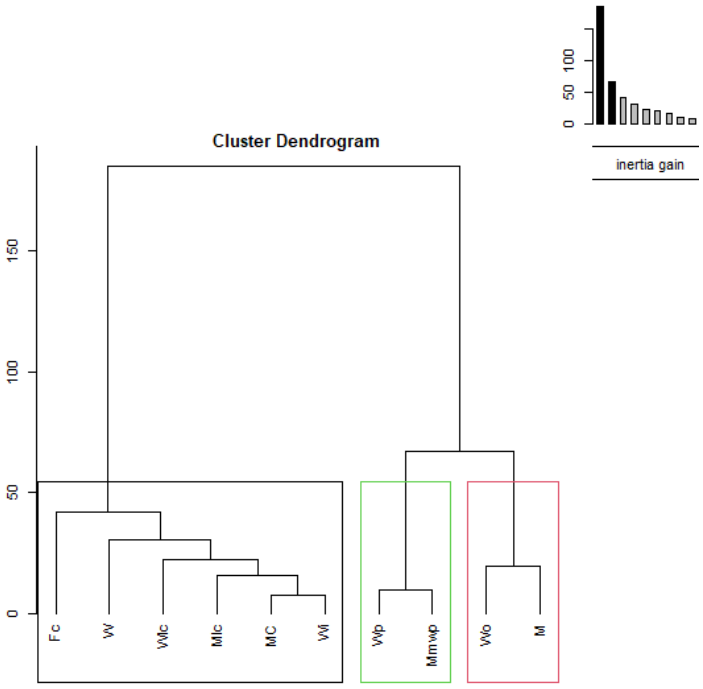


From our investigations, 1,569 people were bitten over the 2-year period. Of these, 780 were men (49.71%) and 789 were women (50.29%). Among the most affected socio-traditional groups, pregnant women recorded 241 cases (30.54% of females and 15.36% of all cases). Men whose

partners were pregnant had 203 cases (26.02% of males and 12.94% of all cases). All categories are affected by snakebites, but at different rates. Statistical tests using software allow for valid interpretation.

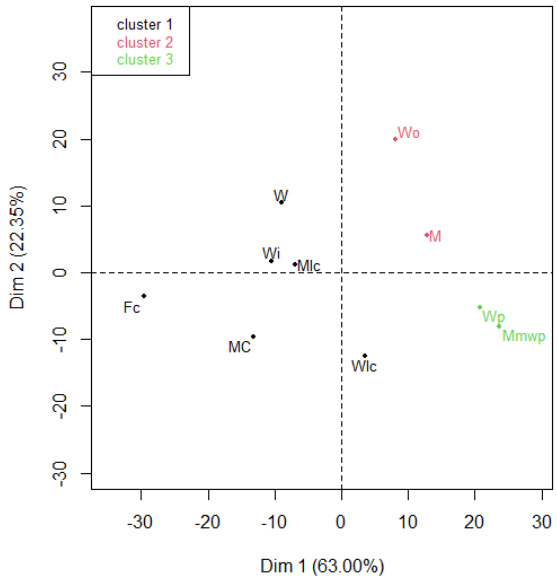
Epidemiological Results for 2019

Figure 11:
Hierarchical tree (Ascending Hierarchical Classification)



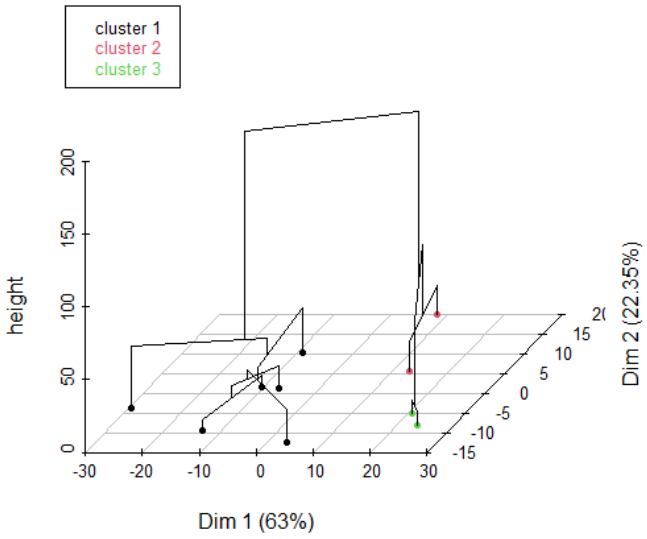
The classification reveals 3 classes.

Figure 12:
Hierarchical Classification of individuals



Class 1 includes individuals such as W, MC, WLC, and FC, characterized by low values for Ikengo and Lokekya variables. **Class 2** includes individuals such as Wo, with high values for Ikengo. **Class 3** includes individuals such as MMWP and WP, with high values for Mbandaka ea Mbula and Bopenzola.

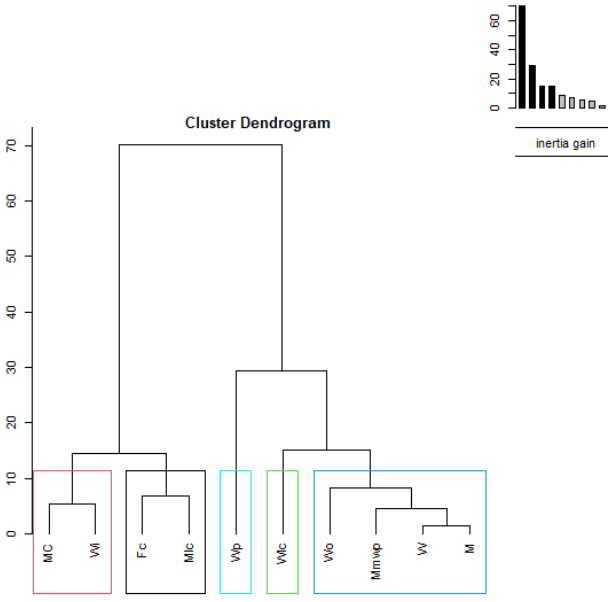
Figure 13:
Hierarchical tree on the factorial plane



The hierarchical tree can be visualized on the factorial map with individuals colored according to their clusters.

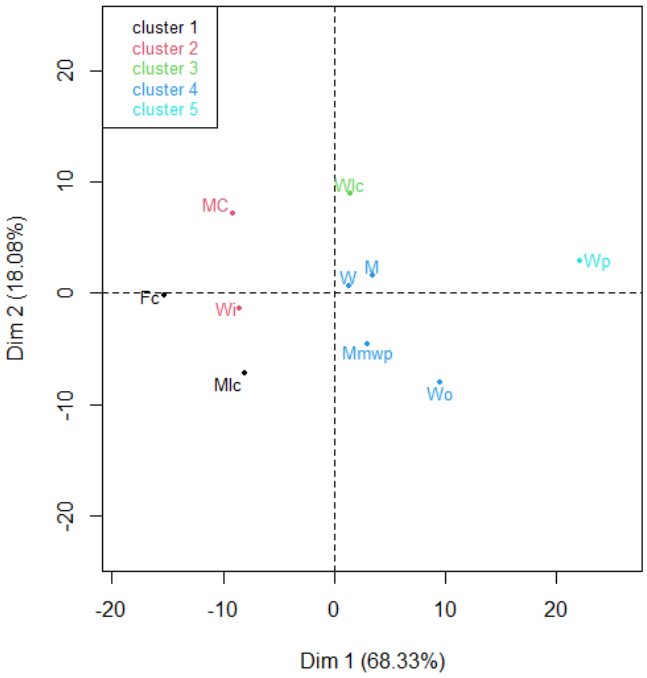
Epidemiological Results for 2020

Figure 14:
Hierarchical tree (Ascending Hierarchical Classification)



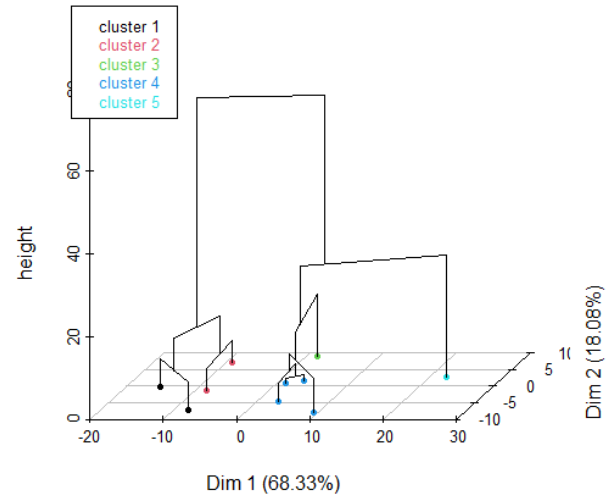
The classification reveals 5 classes.

Figure 15:
Hierarchical Ascending Classification of Individuals



Class 1 includes individuals such as MLC and FC, with low values for the Bopenzola variable. **Class 2** includes individuals such as MC, with variables whose values do not differ significantly from the mean. **Class 3** includes individuals such as WLC, with similar characteristics. **Class 4** includes individuals such as Wo, also with variables close to the mean. **Class 5** includes individuals such as WP, with strong values for Mbandaka ea Mbula.

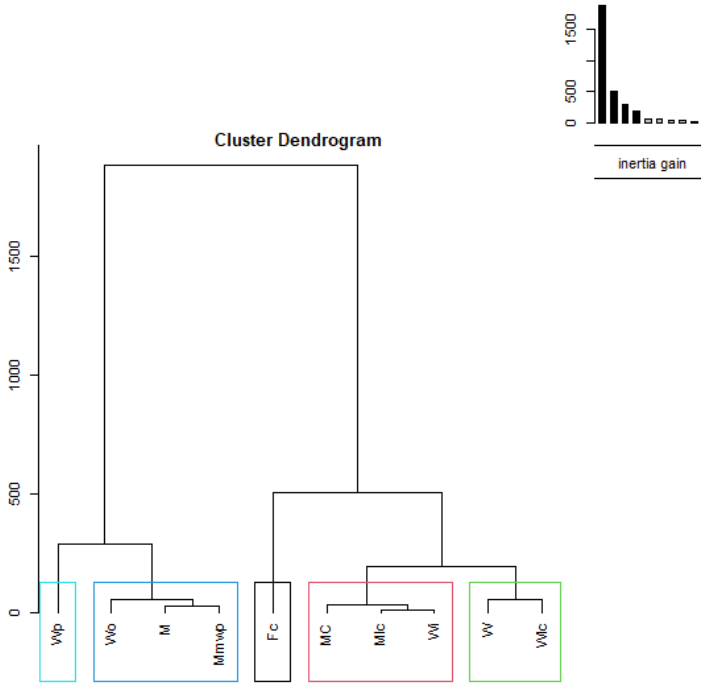
Figure 16:
Hierarchical tree on the factorial plane



The hierarchical tree can be visualized on the factorial map with individuals colored according to their clusters.

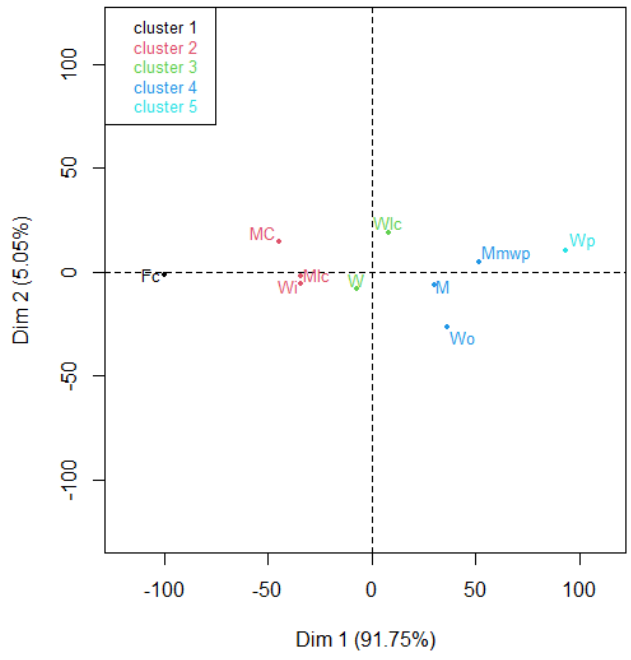
Epidemiological Results for the 2 Years

Figure 17:
Hierarchical tree (Ascending Hierarchical Classification)



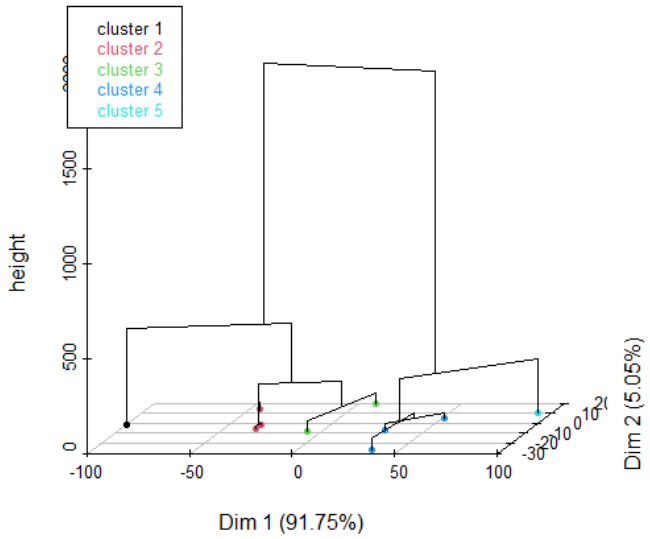
The classification reveals 5 classes.

Figure 18:
Hierarchical Ascending Classification of Individuals



Class 1 includes individuals such as EF, with variables close to the mean. Class 2 includes individuals such as HV, with similar characteristics. Class 3 includes individuals with consistent values. Class 4 includes individuals such as HFE, with variables near the mean. Class 5 includes individuals such as FE, with strong values for the year 2020.

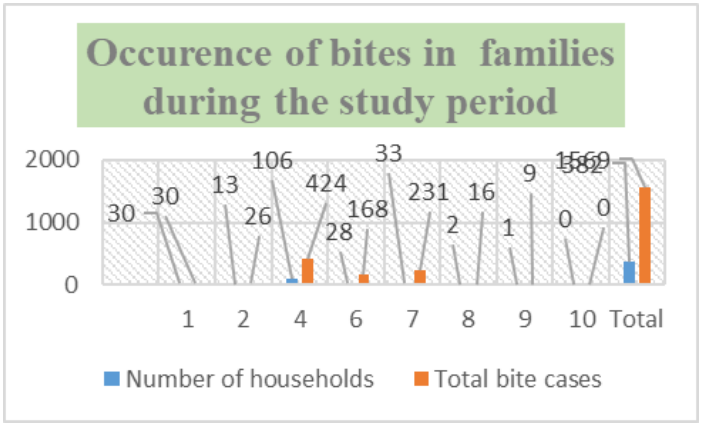
Figure 19:
Hierarchical tree on the factorial map



The hierarchical tree can be visualized on the factorial map with individuals colored according to their clusters.

Occurrence of Snakebites in Surveyed Households/Families Over the Course of 2 Years

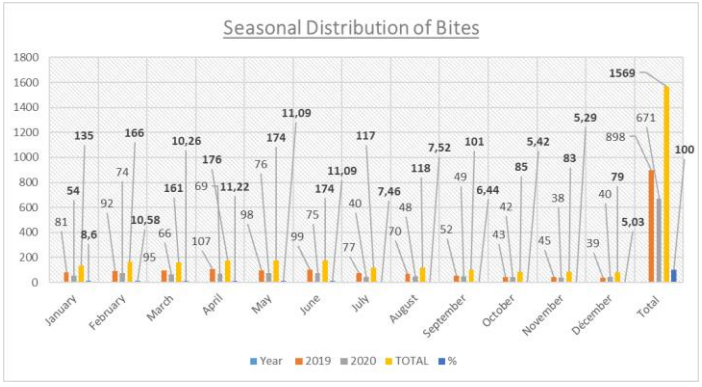
Figure 20:
Occurrence of Snakebites in Surveyed Households/Families Over the Course of 2 Years



From this table, 30 households each recorded a single bite over two years, 13 households each recorded 2 bites, 90 households each recorded 3 bites, 106 households each recorded 4 bites, 79 households each recorded 5 bites, 28 households each experienced 6 bites, 33 households each experienced 7 bites, 2 households each experienced 8 bite cases, and one household experienced 9 bite cases.

Results on the Distribution of Bite Frequencies Over the Seasons

Figure 21:
Distribution of Number of Bites According to Seasons



In the entire study area, the highest frequency of bites was recorded in April, with 134 cases, or 11.51%. This month is when snakes are most mobile, leading to more encounters with humans. It is also a busy month for growers preparing for the next growing season. Similarly, traffickers rush to evacuate produce from the fields before the rainy month of May, which makes agricultural feeder roads much more impassable.

Follow-Up of Cases Handled by Medical Facilities

Management of Envenomation Cases

a. **Follow-Up of Cases Admitted to Medical Facilities**
   - **State Structures**: Our investigations in the health zones of Bolenge found no statistics on bites and envenomations. Even in annual reviews, bites and envenomations do not attract attention despite the significant number of cases in less urbanized areas.
   - **Private Structures**: The situation in private medical facilities in the Bofidji-West cluster is similar to that of state structures: there are no statistics, and nurses lack appropriate medical protocols and anti-venom serum.

b. Follow-Up of Cases Treated by Traditional Practitioners

Figure 22:
Number of People Admitted for Treatment and Declared Cured and Not Cured According to Sex

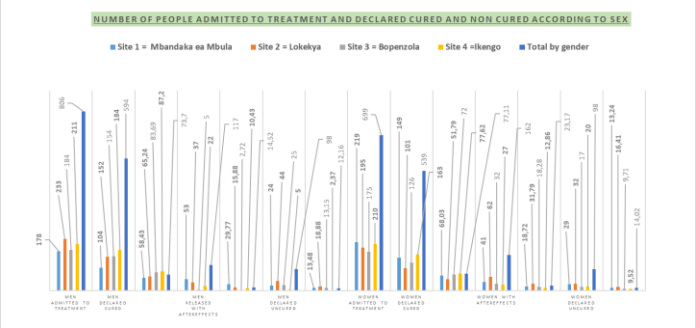
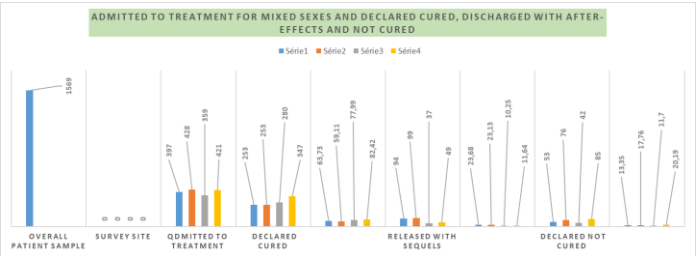


Figure 23: Number of Persons Admitted for Treatment and Reported Cured, Not Cured, by Sex Combined



According to sex, the percentage of those cured is 89.23% for men and 89.98% for women. Men recorded more individuals with sequelae (6.15%) compared to women (4.66%). Slightly more women (5.53%) died compared to men (4.62%). Across all genders, 89.52% of people recovered, while the number of deaths was 59, or 5.07%.

Results on the Cumulative Prevalence of the Disease in the Grouping

Table 1:
Cumulative Prevalence of the Disease in Bofidji - Bolenge

	Mbandaka ea Mbula	Lokekya	Bopenzola	Ikengo	Study zone
Number of bites recorded in years	417	382	349	421	1569
Number of populatios	5.437	4.430	4.830	6.610	21.307
Cumulative Prevalence % for the 02 years	7.66	8.62	7.22	6.37	7.36

The cumulative prevalence for each site ranges from 6.37% to 8.62%. For the entire study area, it is 7.36%. The results obtained at the end of the surveys in the four villages of the area formerly known as traditional Mbandaka, now the Bofidji-Bolenge group, which is predominantly controlled by the Mongo tradition, indicate that snakebite is undoubtedly a public health issue, given the number of cases reported by the victims themselves or through their households.

It should be noted that this retrospective survey, conducted over two consecutive years (2019 and 2020), included dietary and cultural prohibitions related to the totemic snake. While not exclusive to Mongo culture, this totemic snake holds several significant representations, such as a protector, guardian, and guarantor of the progenitor's power.

The survey presented results sectorally, village by village, to compare the evolution of the cultural problem of snakebites. The environment is challenging to access, and its cultural characteristics are identifiable through the collective behavior of the indigenous occupants, despite the effects of cultural mixing and modern civilization.

Surveys have identified several categories or groups within this traditional society. We selected five groups for analysis:

1. Men and women with special status.
2. Men and women whose spouses are pregnant at the time of the bite.
3. Men and women traditionally cursed, i.e., those bearing a community curse not necessarily linked to non-compliance with snake-related customs but to other prohibited actions.
4. Widowed men and women at the time of the bite.
5. Male and female children born to parents with cultural affiliation to the Bofidji-Bolenge Group.

Bites occur in all these categories and in all four villages under study. The most affected are pregnant women and men whose spouses are pregnant at the time of the bite. Tradition explains that women who act immorally (e.g., having multiple lovers) provoke jealousy in the snake, which regards the official spouse as a mere pawn. Similarly, men who violate traditional norms, such as repudiating a spouse chosen by their parents, may incur the snake's wrath.

Another affected group includes those traditionally cursed within their families. For instance, a person who steals or misuses family property, or who deviates from ritual requirements after a spouse's death, may face a curse. Such curses can persist, affecting individuals who deviate from customary practices, including mystical rituals like tattoos and incisions.

Widows and widowers are also affected, as family actions during married life can lead to declarations of war from the totem against anyone involved. Men without special status can also be severely affected, often as a consequence of killing a snake, which is perceived as a declaration of war and leads to a fierce retaliation by the snake.

Data analysis from 2019 and 2020 shows an increase in cases, though the scientific aspects of the totemic snake's impact are challenging to substantiate at this stage. The high prevalence appears linked to the environmental conditions of the Bofidji-Bolenge Group, where sanitation is minimal, and industrial and artisanal deforestation exacerbates the situation. This deforestation contributes to high temperatures, favorable to snake activity and bite incidents. Additionally, the ethnobotanical use of local plants by traditional phytotherapists suggests significant resource exploitation in an area affected by deforestation and climate impact.

Resources used to treat bite and envenomation

Table 2:
List of the plants used to treat bite and envenomation

N°	Species inventoried	Families	Vernacular name	Parts collected	Relative Citation Frequency (CRF) of Medicinal Plant		Ethnobotanical Use Value (VU)		
					Number of citations	Calculated CRF	∑ Si	n	VU
01	***Acacia dudgeoni***	Mimosaceae	Kisengele: Empeye; Lokonda: Wanganjala; Ngwaka: Gbangala	*Stem bark*	186	0.75	336	186	**1.80**
02	*Acanthus arboreus*	Acanthaceae	Ngwaka: Balagalan, gana; Mokula: Lilatela; Mpama: Ipengwa nkoyi; Libinza: Lolemo la nkoyi; Kinunu: Lilanga	Leaves, roots	189	0.76	339	189	**1.79**
03	***Aframomum danielli***	Znigiberaceae	Mpama: Ntondolo; Kiyombe: Tondolo; Kirega: Matungulu; Kitembo: Bosombo; Lokonda: Mohombo; Ngbaka: Yolo, Bulu	Whole plant	208	0.84	394	208	**1.89**
04	***Ageratum conyzoides***	Asteraceae	Ngwaka: Tangbabu, Dagbabu; Kirega: Baneshunda Libinza: Ngele; Lokonda: Emanda, Lutu lo ntaba; Lonkundo: Likotsi Mpama: Ilongia; Budja: Ekbulu Makutu: Mobondo	Whole plant	224	0.91	525	200	**2.62**
05	***Annona senegalensis***	Annonaceae	Lonkundo: Mondenge ya libanda Kitembo: Mondenge	Leaves	196	0.79	458	196	**2.34**
06	***Capscicum frutescens***	Solanaceae	Mono: Djengete; Lingala: Pilipili Ngbaka: Tandala, Kuala: Lolo gbendu	Fruits, leaves	191	0.77	350	150	**2.33**
07	***Cassia sieberiana***	Caesalpiniaceae	Kirega: Kasiya; Budja: Eposo	Stem bark, root bark	181	0.73	360	160	**2.25**
08	***Chenopodium opulifolium***	Chenopodiaceae	Lomongo: Itiiti yolia; Lonkundo: Itiityoliya; Ngbaka: Munganga, Seli; Lubala: Nkanga bakishi; Makutu: Bolia	Leaves	56	0.23	162	56	**2.89**

09	***Citrus limon***	Rutaceae	Ngwaka: Zidolo; Lonkundo: Lilala; Kisengele: Bolala; Kinunu: Bolala		186	0,75	410	165	**2,48**
10	***Combretum platypetalum***	Combretaceae	Mbanza: Ndana Ngbaka: Bangabingi, Mbanza: Ndana; Mpama: Onkese, Engamba; Kiyombe: Musonge	Stem	174	0.70	402	145	**2.77**
11	***Costus afer***	Zingiberaceae	Ngwaka: Bangabingi; Mbanza: Ndana; Mpama: Onkese, Engamba; Kiyombe: Musonge	Leaves, stem	203	0.82	500	190	**2.63**
12	***Cymbopogon citratus***	Poaceae	Kirega: Isasa, Mutosha arufu Nom vulgaire: Citronnelle	Leaves, root	196	0.79	298	106	**2.92**
13	***Dioscorea bulbifera***	Dioscoreaceae	Kisengele: Idungu Ngbaka: Kole ganga, Kole ndunga, Kole donguwi, Kole kula, Wala kole, Kole bô.	Fruit, leaves	81	0.33	222	74	**3.00**
14	*Diospyros fischeri*	Ebenaceae	Ngwaka: Ngongo	Leaves, stem bark, root	63	0.25	180	60	**3.00**
15	***Entandrophragma palustre***	Meliaceae	Kinunu: Bosala Ngbaka: Kpukuli	Stem bark	194	0.78	380	160	**2.37**
16	***Fleurya ovalifolia***	Urticaceae	Libinza: Mokuba, Nsansa ya munene; Lontomba: Lohambiha lo lonene; Lonkundo: Insansa Lomongo: Bompese Lokonda: Losambisa ya munene; Ngbaka: Bambalafolo ; Likoka: Tongo Budja: Bohongo	Stem bark	188	0.76	250	150	**1.67**
17	***Harungana madagascariensis***	Clusiaceae	Mpama: Otunu-otono; Kinunu: Botone Lonkundo: Botonongolo, Montone Ngbaka: Tetoko; Kirega: Matungulu; Libinza: Mototondo; Ngombe: Makia	Stem bark	181	0.73	430	170	**2.27**
18	***Hibiscus suratensis***	Malvaceae	Lingala: Ngayi ngayi	*Leaves*	175	0.71	360	155	**2.32**
19	***Landolphia lanceolata***	Apocynaceae	Lokonda: Botope; Lomongo: Bonsele	*Wall fruit*	146	0.59	340	120	**2.83**
20	***Manihot esculenta***	Euphorbiaceae	Kikongo: Nsaki; Ngbaka: Kalanga, Kaganda, Sadinda; Ngombe: Mapumba; Lokonda: Bingunza; Kitembo: Bokuba; Lomongo: Bangandju; Lingala: Songo, Pondu; Tshiluba: Tshomba	*Leaves*	166	0.67	410	160	**2.73**
21	***Manniophyton fulvum***	Euphorbiaceae	Mono: Kasa; Ngbaka: Kusa; Lingala: Mokosa	*Leaves, root*	163	0.66	401	150	**2.67**
22	***Milicia excelsa***	Moraceae	Lomongo: Bolonda; Ngbaka: Ngolu	Latex et fuilles	183	0.74	510	160	**2.19**
23	***Morinda morindoides***	Rubiaceae	Lomongo: Bokakale; Ngbaka: Bele; Ngombe: Endondombe; Ngbandi: Gbabele; Mbundu: Bebele; Kuala: Gele; Kikongo: Nsiki; Mpama : Mosese; Likoka: Mokele	Leaves, stem bark, raspure of bark	02	0.09	2	2	**1.00**
24	***Nauclea latifolia***	Rubiaceae	Ngbaka: Kilo; Kitembo: Mokesse	Stem bark	188	0.76	296	148	**2.00**
25	***Nicotiana tabacum***	Solanaceae	Kisengele: Ikaya li tumbaco ; Lontomba: Ikaya pama: Likaya; Ngbaka: Gbamanga; Lingala: Tumbaco; Kikongo: Fumu ; Ngbandi: Mbangaya; Mbati: Mbangaya.	*Leaves, seeds*	169	0.68	300	150	**2.00**

26	***Ocimum gratissimum***	Lamiaceae	Mono: Anerakola; Kirega: Basenye; Lomongo: Bonsonsole; Bobangi: Nzangasani; Mpama: Monzangasano, Ososolo; Kisengele: Bonsonsolo Kinunu: Nganga nsali; Tshiluba : Luenyi	*Leaves*	189	0.76	310	160	**1.94**
27	***Palisota schweinfurthii***	Commelinaceae	Kisengele: Itete; Kinunu: Litete	*Fruits,seeds*	127	0.51	153	89	**1.72**
28	***Pentaclethra macrophylla***	Mimosaceae	Kitembo: Ebala; Lomongo: Buadja, Boala Kitetela: Owala; Lonkundo: Boala; Kisengele: Bobala; Mpama: Obala ; Kinunu: Obala; Lokonda: Bobala	*Stem bark, leaves, root, pods*	194	0.78	375	150	**2.50**
29	***Phyllanthus urinaria***	Euphorbiaceae	Lingala: Kisi ya panzi; Kirega: Kamwanga; Mbanza: Gbasirisi ; Ngwaka: Silitula, Silifio, Ngbenzekola; Lonkundo: Nyenye ; Budja: Linui, Djilele; Likoka: Selenge; Lokonda: Loliki ya libanda	*Leaves, whole plant*	100	0.40	263	189	**1.39**
30	***Raphia sese***	Arecaceae	Ngbaka: Nzango	*Root, main rib, basic branch rapure*	126	0.51	260	120	**2.17**
31	*Sansevieria hyacinthoides*	Dracanaeceae	Lomongo: Fulele ya lokoto; Ngwaka: Ndama, Gbua, Kuwa, Pua; Libinza: Lilanga lankoi	Leaves, root rapure	84	0.34	60	38	**1.55**
32	*Sansevieria liberica*	Dracanaeceae	Lomongo: Fulele ya lokoto; Ngbaka: Ndama, Gbua, Kuwa, Pua; Libinza: Lilanga lankoi	Leaves, root rapure	96	0.39	181	99	**1.83**
33	***Sclerocarya birrea***				42	0.17	104	42	**2.48**
34	***Scorodophloeus zenkeri***	Caesalphinaceae	Lomongo: Bofili; Lokonda: Bopili; Mpama: Mbopili	*Stem bark*	24	0.10	41	23	**1.78**
35	***Sida acuta***	Malvaceae	Lonkundo: Nkuzuaende; Mpama: Umponga mwa nkasu kiki; Kirega: Achuchuchunju; Kitembo: Mogbama; Lomongo: Kuluyende, Ikuluaende Topoke: Ngoloakuamu; Likoka: Mukukutu	*Leaves, stem bark*	162	0.65	250	113	**2.21**
36	***Vernonia amygdalina***	Asteraceae	Kirega: Mubilisi; Libinza: Mungangandu; Ngbaka: Oka, Onka, Ngbendele, Okan; Kuala: Ndolo; Langbasi: Koolo; Ngombe: Lingbengbele	*Leaves, rapure root*	136	0.55	156	82	**1.90**
37	***Xylopia aethiopica***	Annonaceae			98	0.40	198	94	**2.11**

Investigations resulted in 37 species divided into 25 families. The predominant families in terms of number of species (2 at most) are: Annonaceae, Caesalpiniaceae, Dracaenaceae, Euphorbiaceae, Malvaceae, Mimosaceae, Rubiaceae, and Zingiberaceae. The other families are represented by a single species. The calculated Ethnobotanical Use Value indicated that the majority of them have very high values. This includes species such as *Annona senegalensis* (2.34), *Capsicum frutescens* (2.33), *Cassia sieberiana* (2.25), *Chenopodium opulifolium* (2.89), *Citrus limon* (2.48), *Combretum platypetalum* (2.77), *Costus afer* (2.63), *Cymbopogon citratus* (2.92), *Entandrophragma palustre* (2.37), *Harungana madagascariensis* (2.27), *Hibiscus suratensis* (2.32), *Landolphia lanceolata* (2.83), *Manihot esculenta* (2.73), *Manniophyton fulvum* (2.67), *Milicia excelsa* (3.19), *Pentaclethra macrophylla* (2.50), *Raphia sese* (2.17), *Sclerocarya*

birrea (2.48), *Sida acuta* (2.21), *Xylopia aethiopica* (2.11), and *Ageratum conyzoides* (2.62). This suggests that these species are widely used and further studies on their distribution in the wild are needed, especially since artisanal and industrial loggers overexploit the study area for timber. This opens new avenues for research in authentic and qualitative ethnobotany.

Indeed, snakebites represent a significant public health problem, particularly in rural and remote areas where access to medical facilities and antivenoms is limited. In the Bofidji-Bolenge grouping, the high incidence of snakebite cases, as indicated by the 1,569 pathological cases recorded over two years, underscores the gravity of this issue. The distribution of cases among different demographic groups, including vulnerable populations such as pregnant women, highlights the widespread impact of snakebites on the community. The reliance on traditional healers and plant-based treatments due to the lack of accessible modern medical care points to critical gaps in the healthcare infrastructure. This reliance poses risks, as the effectiveness and safety of many traditional treatments are not scientifically validated, potentially leading to adverse outcomes or prolonged suffering for snakebite victims. Furthermore, the economic burden on affected households, including loss of productivity and high treatment costs, exacerbates the poverty cycle in these communities. Snakebites also contribute to long-term disabilities, further straining the limited resources of families and healthcare systems. Addressing snakebites as a public health issue requires a comprehensive strategy that includes improving healthcare infrastructure, ensuring the availability of antivenoms, conducting public awareness campaigns, and integrating traditional medicine practices with modern healthcare systems. By acknowledging and tackling snakebites as a public health priority, significant improvements in health outcomes and quality of life for affected populations can be achieved.

The present study reveals significant implications for public health and the Convention on Biological Diversity (CBD). In terms of public health, snakebites are a major source of mortality and morbidity, underlining the importance of access to care, training for health workers, and raising awareness of preventive measures and first aid (Chippaux, 2017). The Democratic Republic of Congo (DRC) is a country rich in biodiversity, hosting a wide range of medicinal plants used by local communities to treat various ailments. This study, focused on the incidences of snakebites and traditional care in the Bofidji-Bolenge grouping, identified 37 plants used to treat bites and envenomations. Some of these plants are also recognized for their medicinal properties in treating other serious diseases such as sickle cell disease, COVID-19, and malaria (Kasali et al., 2014; Tshilanda et al., 2016; Kambale et al., 2016; Tshibangu et al., 2020). The integration of traditional and modern care is thus essential to improve clinical outcomes (Gutiérrez et al., 2010; WHO, 2010). Regarding the CBD (Convention on Biological Diversity, 1992), the use of local medicinal plants by traditional practitioners highlights the need for sustainable management of biological resources. The study also promotes the implementation of Access and Benefit Sharing (ABS) mechanisms, ensuring that local communities benefit equitably from the use of their traditional knowledge and resources. Finally, the documentation and recognition of traditional practices contribute to the conservation of local knowledge, in line with the objectives of the CBD.

Comparisons between the 2019 and 2020 epidemiological results on snakebites and infectious diseases in the Bofidji-Bolenge group and the two previous studies conducted in the province of Équateur in Bonginda and the municipality of Mbandaka show that 1,569 cases in Bofidji-Bolenge have been documented without conventional medical treatment. In Bonginda (Mokekola et al., 2022), 392 cases were recorded, 321 of which were treated with herbs and 71 were admitted to hospitals. The prevalence of traditional healing by traditional healers is estimated at 93.94% in medical structures and 23.94% in medical structures, due to its proximity and accessibility compared to a remote hospital. In Mbandaka (Mokekola et al., 2024), 1,164 cases were recorded without follow-up by conventional structures. The wet forest area is often flooded, causing snakes to migrate to dry areas, increasing the incidence of bites. Compared to rural Savannah, Savannah is more likely (167 cases per 1,000) to occur due to the aggressive Echis romani virus (Zarambaud et al., 2023). In general, five snake species (Bofidji-Bolenge) are considered responsible for bites, mainly from the Viperidae family (90%) and the Elapidae family (10%). The

study identified 37 species of ethnobotany, distributed in 25 families, some of which are common, such as Ageratum conyzoides and Citrus sp., likely due to the transmission of ancestral knowledge and local availability. The plants that belong to each group, such as Synsepalum dulcificum of Bonginda (Mokekola et al., 2022) and Annona senegalensis of Bofidji-Bolenge, show high values of ethnobotanical use, highlighting local expertise and ecological adaptation. These results show the effectiveness of traditional treatment and the need to document and preserve this knowledge to improve treatment management in these regions.

CONCLUSION AND RECOMMENDATIONS

The study underscores the pivotal role of traditional medicine in addressing public health challenges, particularly in managing snake bites through indigenous plant treatments and the expertise of traditional healers. To enhance the integration of traditional and modern medical practices, specific, actionable recommendations are crucial. These include implementing training programs for healthcare professionals on traditional medicine, initiating community health initiatives, and enhancing health infrastructure to ensure accessibility to both traditional and modern treatments. Future research should focus on systematically documenting the efficacy and safety of traditional therapies, exploring the pharmacological properties of commonly used plants, and developing standardized protocols for their integration into mainstream healthcare. Additionally, longitudinal studies are essential to monitor the effectiveness of integrated healthcare approaches over time. By adopting these comprehensive strategies and fostering collaboration between traditional healers and health professionals, we can significantly improve snakebite management and advance public health outcomes in the region while respecting and preserving local knowledge and practices.

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Conflicts of Interest: None declared.

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