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Knowledge, Attitudes, and Practices of Physicians in Africa Regarding Snakes Envenomation

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Abstract

Objectives: To assess physicians' knowledge, attitudes, and practices regarding snake envenomation. **Materials and Methods**: A questionnaire was developed using Google Forms, the link of which was sent via WhatsApp® and Telegram® to healthcare workers. Only general practitioners were included. The assessment of general and specific snake knowledge was based on 7 questions, and the practical level was based on 10 questions. Attitudes were assessed based on the use of guidelines. An overall score was established to classify physicians' knowledge level. **Results**: Sixty-six general practitioners were selected, the majority of whom practiced in Gabon (40) and Côte d'Ivoire (14), in university hospitals (39), and had less than 10 years of professional experience (81.8%). The physicians had an average to good overall level of knowledge. There were more significant gaps in knowledge of snakes responsible for envenomation and envenomation syndromes. First aid procedures were generally well understood, unlike the indication for SAV. University training and prior snakebite management were associated with higher levels of knowledge ($p = 0.03$; $p = 0.004$ and $p = 0.02$). No statistical relationship was found between professional experience, practice location, postgraduate training, and level of knowledge. **Conclusion**: The management of snake envenomation is complicated by sev-

eral gaps in knowledge among healthcare personnel, demonstrating the need for university and postgraduate training.

Keywords

Envenomation, Knowledge, Attitudes, Practices, Snake Bite

1. Introduction

Snake envenomation, or snakebite envenomation, encompasses all the disorders resulting from the inoculation of venom following a bite from a venomous snake [1]. These disorders can lead to serious syndromes such as neurotoxicity, hematotoxicity, cytotoxicity, and, less frequently, nephrotoxicity, myotoxicity, and cardiotoxicity. This inoculation can be fatal, due to viper or cobra syndrome [2] [3]. Snake envenomation is considered a medical emergency and warrants rapid and appropriate medical management, including the administration of antivenom [4].

Despite the existence of effective treatment, snake envenomation remains a significant public health problem, affecting all age groups, men and women, in both rural and urban areas worldwide. Indeed, the WHO estimates that snakebites affect 5.4 million people worldwide each year, with 1.8 to 2.7 million cases of envenomation. Furthermore, between 81,410 and 137,880 people die annually from snakebites, and approximately three times as many results in amputations and other permanent disabilities. Despite these figures, it was only in 2017 that the WHO reinstated snakebite on its list of priority neglected tropical diseases [5]. Moreover, few studies are dedicated to this subject, perpetuating the difficulty of accessing treatment, coupled with its prohibitive cost [6].

It is therefore essential that all healthcare workers worldwide be prepared to deal with a snakebite. Unfortunately, these healthcare professionals appear to lack knowledge about the appropriate responses and practices to adopt when snake envenomation is suspected.

In this context, it is crucial to review the knowledge, attitudes, and practices of healthcare workers regarding snake envenomation. This study aims to assess these aspects in order to identify needs and Opportunities for improvement in the management of snake envenomation, thereby contributing to better patient care and a reduction in morbidity and mortality for public health.

2. Population and Method

2.1. Study Type and Period

This is a prospective, cross-sectional, multicenter descriptive study, with data collection taking place from May 30 to September 30, 2024.

2.2. Study Setting

The study is centralized in Libreville, the political and administrative capital of

Gabon.

2.2.1. Study Population

a. Inclusion Criteria

We included in this study all practicing general practitioners who agreed to complete our survey questionnaire in all African countries to which we had access.

b. Exclusion Criteria

Data collection forms completed by personnel who were not general practitioners were excluded.

c. Recruitment Method

The study questionnaire, composed of four sections, was made available electronically in a secure manner, while protecting the confidentiality of the information, via healthcare professional forums on social media platforms, or via email.

2.2.2. Variables Studied

The variables studied were as follows:

—Respondent information (age, sex, professional qualifications, country of practice, place of work, availability of antivenom at the practice);

—Training and experience in managing snakebites (training during studies, use of guidelines, postgraduate training, experience treating patients with snakebites);

—General and snake-specific knowledge (identification of dangerous snakes, symptoms of envenomation, knowledge of the effects of venom);

—Management of snake bites (important blood tests, first aid measures, use of antivenom, management of anaphylactic shock).

2.3. Methodology

2.3.1. Data Collection

The data collection technique used was based on an individual questionnaire containing the variables studied (see **Appendix I**). The questionnaire was distributed online using the Telegram® and WhatsApp® applications, and the secure online survey platform Google Forms via the link https://forms.gle/CwGS82czPU91eu2z8.

a. Google Forms Platform

Google Forms is an online form editor that allows users to create online forms for a wide variety of purposes: questionnaires, surveys, polls, feedback collection, etc. A Google Form can be sent by email, shared using a unique hyperlink, or shared on social media. The questionnaire was adapted to a questionnaire template on the platform, and its link was then sent to respondents via WhatsApp®. The questionnaire was divided into several successive pages. Data was collected automatically as the questionnaire was completed. At the end of the survey, a database using Excel© software was obtained from the platform.

b. WhatsApp® Application

WhatsApp® is a messaging application available for smartphones. It uses the phone's internet connection. The WhatsApp® application was used to access the

questionnaire via the link from the Google Forms platform, sent to participants individually or collectively.

c. Telegram® Application

Telegram® is a messaging application available on various devices, including smartphones, and requires an internet connection.

It also allowed the study population to receive the link generated by the Google Forms platform individually and access the questionnaire.

2.3.2. Operational Definitions

• Professional experience in the healthcare field, measured in years, was defined as follows:

—Low professional experience: between 1 and less than 5 years;

—Medium professional experience: between 5 and less than 10 years;

—Good professional experience: between 10 and less than 15 years;

—Excellent professional experience: more than 15 years.

By comparing the respondents' answers with those from the literature, physicians' knowledge of snakebite management was assessed. One point was awarded for questions where respondents selected the most appropriate answer. Choosing an incorrect answer or the "I don't know" option resulted in a score of zero.

Knowledge of snake envenomation (general knowledge of snakes and the symptoms of envenomation) was assessed through the following series of questions:

—Which snakes are responsible for envenomation?

—Knowledge of the concept of a "white bite".

—What are the symptoms after a snakebite?

—What is the fatal effect of viper syndrome?

—What is the fatal effect of cobra syndrome?

—What are the general signs of snake envenomation? What are the local symptoms after a snake bite?

In the presentation of our results, correct answers will be shown in green, while incorrect answers will be shown in red. Total scores will be considered as follows:

—Low knowledge of snake envenomation: 2 or fewer correct answers;

—Medium knowledge of snake envenomation: 3 to 4 correct answers;

—Good knowledge of snake envenomation: 5 to 6 correct answers;

—Excellent knowledge of snake envenomation: 7 correct answers.

• Attitudes towards a snakebite

Those familiar with local guidelines or protocols were considered to be using them and to have a good or even excellent attitude.

• To assess practical experience, the questions were related to blood tests and the use of antivenom:

—Which blood tests are important in the case of a viper bite?

—What should be done in the case of a snakebite (first aid practice)? Immobilization? Tourniquet application? Venom aspiration?

—Which medication is contraindicated for pain management in the case of

snake envenomation?

—The indication for antivenom.

—What is the most serious side effect of antivenom?

—What is the reference medication for treating anaphylactic shock after the administration of antivenom?

—What is the route of administration for antivenom?

—Do children receive the same dose of antivenom as adults?

In summary, the following will be considered as having:

—Poor practice: 1 - 2 correct answers

—Average practice: 3 - 6 correct answers

—Good practice: 7 - 9 correct answers

—Excellent practice: 10 correct answers

To align with best practices in the African context, and given the variations in snake species and means between developed and African countries, the reference for correct responses is that of the African Envenomation Society.

2.3.3. Statistical Analysis

The data from this survey were collected on a survey form and then entered into a Microsoft® Office 2021 Excel file. Statistical analysis was performed using Epi Info version 7.2 software.

Quantitative variables were expressed as mean, percentage, and standard deviation. We then conducted statistical tests to investigate the significance and correlations between having low, average, good, or excellent knowledge of snake envenomation and several parameters. The tests performed were the Chi-square test when the validity conditions were met (related to the study's power, *i.e.*, with an expected sample size greater than 5) or Fisher's exact test when the validity conditions of the Chi-square test were not met. Wherever the validity conditions allowed, a correlation was sought among the different parameters. The significance level was set at 0.05 ($p = 0.05$), and correlation was established with the odds ratio when the confidence interval did not exclude 1.

Several associations were calculated using Epi Info© software, including:

—Relationship between professional experience and level of knowledge;

—Relationship between practice location and level of knowledge;

—Relationship between type of training and level of knowledge;

—Relationship between the number of cases managed in the last two years and level of knowledge;

—Comparison between physicians' self-reported level of personal knowledge regarding the management of snakebites and the level found after assessment.

3. Results

3.1. Descriptive Study

During the study period from May 30 to September 30, 2024, 77 healthcare professionals practicing in several African countries participated in the survey. After

excluding participants who were not general practitioners, 66 were retained, representing an inclusion rate of 85.7%.

3.1.1. Sociodemographic Characteristics of the Study Population

The participants' ages ranged from 21 to 49 years, with a mean age of 30.41 years and a standard deviation of 5.08 years ± 5.08 years. Among the participants, 42 physicians were male, resulting in a male-to-female ratio of 1.75. Most of the physicians who participated in the study, 40 (60.6%), practiced in Gabon, followed by 21.2% in Côte d'Ivoire, with a lower representation from the other countries.

d. Place of practice of participants

More than half of the physicians practiced in University Hospital Centers (CHU), representing 39 out of 66 of the total (59.1%). The other places of work included Regional Hospital Centers (CHR), clinics, and dispensaries, with respective representations of 12.1%, followed by 21.2%, and then 7.6% (**Figure 1**).

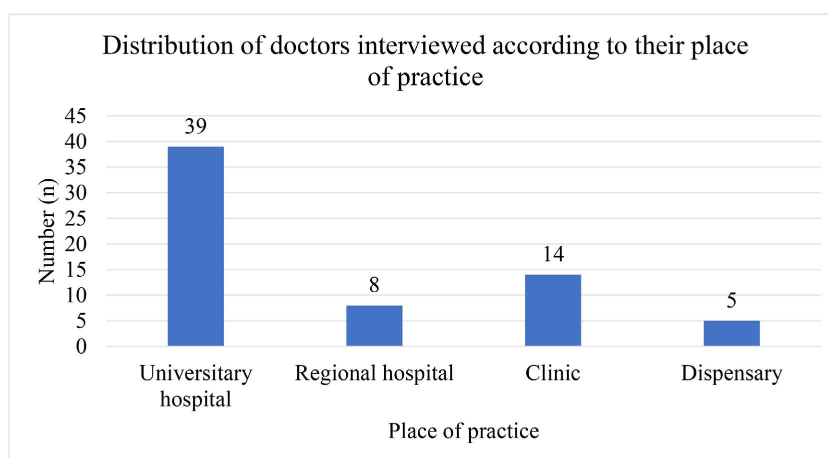

Figure 1. Distribution of doctors interviewed according to their place of practice.

Professional Experience in the Healthcare Field

Only 5 physicians (7.6%) in the study had extensive professional experience, defined as more than 15 years of practice. Thirty-two (32) physicians (48.5%) had average professional experience, ranging from 6 to 10 years of practice, and 22 (33.3%) had limited experience, ranging from 1 to 5 years of practice.

For 48 physicians (72.7%), antivenom was not permanently available at their practice, and 7.6% were unaware of its availability at their facility. However, among the 13 participants who had antivenom available at their facility, Inoserp® was used by 10 physicians (15.2%) and Fav-Afrique® by 2 physicians.

3.1.2. Training and Experience in Snakebite Management

a. University Training

Among the participants, 37 physicians had received university-level training on envenomation. The duration of this training varied: 19 (24.2% of the physicians) had received 1 to 2 hours of training, and only 3% had received 9 to 10 hours.

Regarding the content of the training, 31 (47%) studied snakes, venoms and envenomation syndromes, as well as the diagnosis and treatment of envenomations.

Twelve physicians (12) received supplementary training on bite prevention, and 7 physicians were trained on adverse reactions to antivenoms. Finally, 9.1% of the physicians had completed comprehensive courses.

During their studies, they should have received training on snakes, snake venom and envenomation syndromes, prevention, diagnosis, treatment of snakebites, and adverse reactions to antivenoms.

b. Use of Guidelines

The study revealed that 48 physicians (72.7%) did not use the management protocols. Regarding the accessibility of these protocols, 38 physicians did not know if they were available in their practice settings, while 18 stated that they were not.

c. Postgraduate Training in Envenomation Management

The survey revealed that 50 physicians (75.8%) had not received postgraduate training in envenomation. Of the remaining 16, 10 had received 1 to 2 hours of training.

Regarding the training content, 10 physicians (15.2%) learned about snakes, venoms, and envenomation syndromes, 14 (21.2%) about envenomation treatment, and 13 (19.7%) about diagnosis. Five (5) physicians (7.6%) had been trained in adverse reactions to antivenoms, and 2 physicians (3%) in bite prevention.

The study showed that more than half of the participants, 37 physicians (56.1%), had never treated a case of envenomation since the beginning of their careers. However, among those who had encountered envenomation, the most recent case had occurred between 1 and 5 years prior. For 10 other physicians, this last case was less than a year old (**Table 1**).

Table 1. Distribution of physicians according to the date of their last case of snakebite.

	Number (n)	Percentage (%)
Last consultation < 1 year 10 34.5	10	34.5
Last consultation [1 - 5 years] 16 55.2	16	55.2
Last consultation > 5 years 2 6.9	2	6.9
Not specified 1 3.4	1	3.4
TOTAL	**29**	**100**

Regarding the number of envenomation cases treated by each physician since the beginning of their career, more than half, or 24 physicians (82.8%), had treated between 1 and 5 cases. Furthermore, it was observed that only one physician practicing in Côte d'Ivoire had treated more than 30 cases since the beginning of their career (**Figure 2**).

We noted that 7 physicians, or 10.7% of the participants, had experienced deaths during the management of patients with snake envenomation. The cause

of death for 6 of these patients was attributed to a delay in treatment, and for 4, to complications related to snake envenomation. However, one physician practicing in the Democratic Republic of Congo (DRC) reported that the death was due to the absence of antivenom.

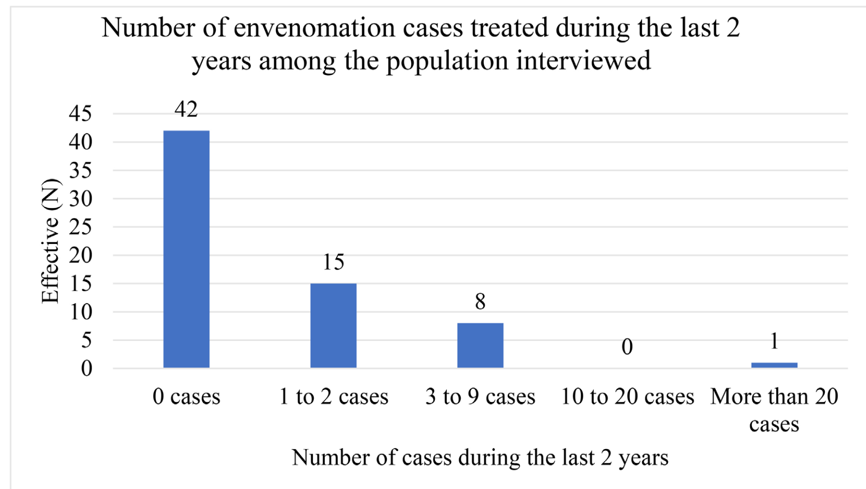

Figure 2. Number of envenomation cases treated during the last 2 years among the population interviewed.

3.1.3. General and Specific Knowledge of Snakes

A series of questions was posed to the study participants to assess their general and specific knowledge of snakes.

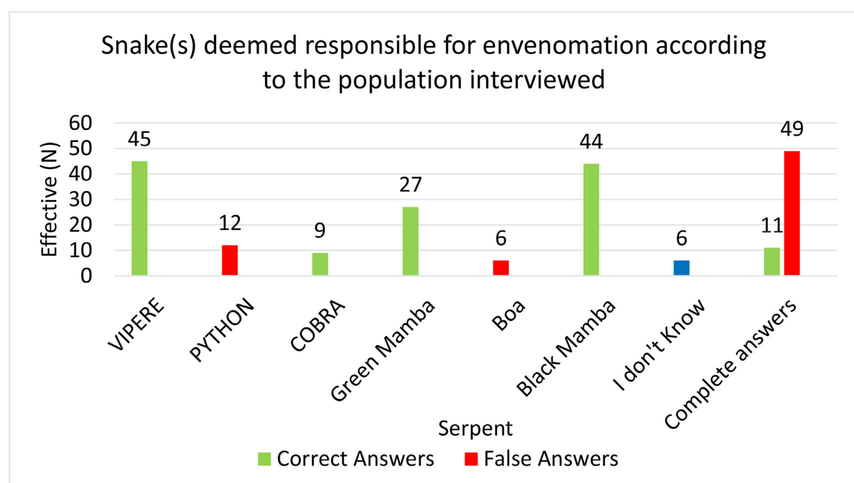

Figure 3. Snake (s) deemed responsible for envenomation according to the population interviewed.

Among the snakes mentioned, such as viper, python, cobra, green mamba, boa, and black mamba, only 11 physicians (16.7%) were able to correctly identify the snakes responsible for the envenomation (**Figure 3**).

- The syndromes observed after a snakebite, including neurotoxicity, hemato-

toxicity, and cytotoxicity, were recognized by 35 (54.2%) of the participants, while 29 gave incorrect or incomplete answers (**Figure 4**).

The concept of a "white bite" was known by only 25 participants (37.9%), but 41 physicians (62.1%) stated that it was possible for a venomous snake to bite without injecting venom.

Regarding the cobra, only 12 physicians (18.2%) recognized muscular paralysis with respiratory failure as its fatal effect. Fourteen physicians were informed about the lethal effects of vipers, particularly their hematotoxicity, but only two recognized the local signs that can occur during envenomation by these snakes in general, such as edema, blistering, and necrosis.

General signs following envenomation, such as nausea and vomiting, were recognized by only 3 (4.6%) of the physicians.

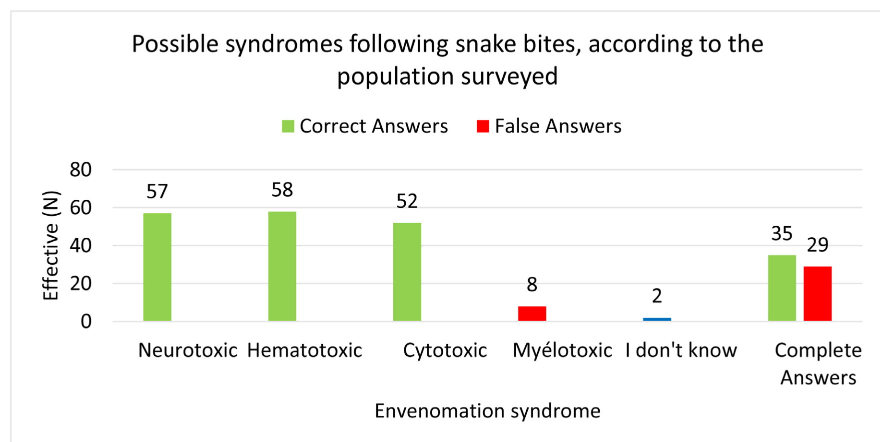

Figure 4. Possible syndromes following snake bites according to the population interviewed.

3.1.4. Management of Envenomations

To assess physicians' management of envenomations, several questions were asked.

Among the blood tests to be ordered in cases of envenomation, 5 physicians (7.6%) selected platelet count, prothrombin time, and renal function tests—in other words, correct answers.

Regarding first aid measures, tourniquets were not recommended by 46 people (69.7%), immobilization of the patient and the bitten limb was suggested by 58 (87.9%) physicians, and venom aspiration was rejected by 43 (65.1%) of them.

Anti-inflammatory drugs were recommended as analgesics by 45 (68.2%) physicians. Furthermore, 40 of them (60.6%) recommended the use of opioids in cases of envenomation. When asked if all patients bitten by a venomous snake require antivenom, just over half of the participants answered negatively, specifically 37 physicians (56.1%). Regarding antivenom use, anaphylactic shock was recognized as a serious side effect by 69.7% of physicians. Adrenaline was indicated as the treatment for anaphylactic shock by 48 physicians (72.7%), and the intravenous route was chosen by just under half of the participants for antivenom administra-

tion, specifically 34 physicians.

When asked about the antivenom dose for children, 14 (21.2%) physicians correctly indicated that they receive the same dose as adults. Regarding knowledge of published treatment protocols for snakebite envenomation, only 16 of the 66 physicians surveyed (24.2%) reported being familiar with them.

Finally, we asked participants to rate their overall knowledge of the subject. Twenty-six physicians rated their knowledge as weak, 31 as average, 8 as good, and only one as excellent as shown in Figure 5.

The study participants were then categorized according to their overall knowledge level based on their total score at the end of the questionnaire. The results showed that 57.6% had an average level of knowledge, and 36.4% had a good level (Table 2).

Table 2. Distribution of participants according to their level of knowledge about snake envenomation.

Knowledge Level	Number of Participants (n)	Percentage (%)
Low	**3**	**4.6**
Medium	**38**	**57.6**
Good	**24**	**36.4**
Excellent	**1**	**1.5**
Total	66	100

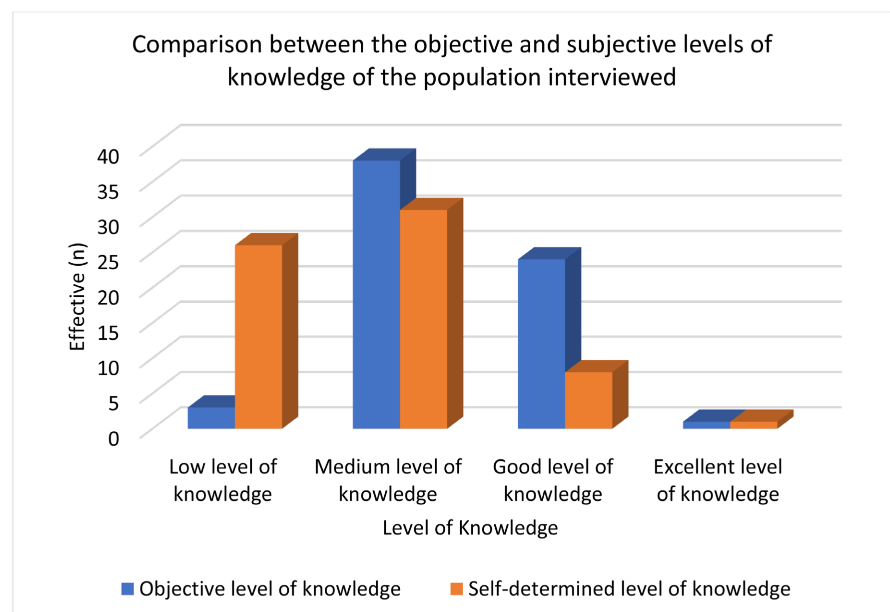

Figure 5. Comparison between the objective and subjective levels of knowledge of the population interviewed.

Finally, we compared the results obtained after self-assessment by the surveyed physicians with the objective results obtained after evaluation using the established questionnaire, which was classified into four categories: low, medium, good, and

excellent. We observed a significant difference between the two. The objective level of knowledge was clearly better than the self-reported level.

3.2. Analytical Study

Several associations were investigated between the level of knowledge and some of the parameters studied.

a. Relationship between workplace and level of knowledge

We were unable to establish a significant link between workplace and level of knowledge (Table 3).

Table 3. Relationship between workplace and level of knowledge.

PARAMETERS	Low knowledge	Average knowledge	Good knowledge	Excellent knowledge
Doctor working at a university hospital	p = 0.21 (fisher) OR = ? IC = ?	p = 0.12 OR = 0.44 IC = [0.16 - 1.26]	p = 0.44 OR = 1.50 IC = [0.53 - 4.27]	p = 0.61 (fisher) OR = ? IC = ?
Doctor working in a clinic	p = 0.48 (fisher) OR = ? IC = ?	p = 0.97 OR = 0.98 IC = [0.30 - 3.22]	p = 0.60 OR/ = 1.42 IC = [0.43 - 4.72]	p = 0.79 (fisher) OR = ? IC = ?
Doctor working in a dispensary	p = 0.79 (fisher) OR = ? IC = ?	p = 0.29 (fisher) OR = 3.18 IC = [0.34 - 30.10]	p = 0.40 (fisher) OR = 0.41 IC = [0.04 - 3.93]	p = 0.92 (fisher) OR = ? IC = ?

b. Relationship between the type of training received and the level of knowledge

Table 4. Relationship between the type of training and the level of knowledge.

PARAMETERS	Low knowledge	Average knowledge	Good knowledge	Excellent knowledge
Physician with limited professional experience	p = 0.71 (fisher) OR = 1 IC = [0.09 - 11.67]	p = 0.38 OR = 0.63 IC = [0.22 - 1.77]	p = 0.59 OR = 1.34 IC = [0.47 - 3.84]	p = 0.33 (fisher) OR = ? IC = ?
Physician with average professional experience	p = 0.48 (fisher) OR = 2.2 IC = [0.19 - 25.52]	p = 0.77 OR = 1.15 IC = [0.43 - 3.07]	p = 0.74 OR = 0.85 IC = [0.31 - 2.31]	p = 0.52 (fisher) OR = ? IC = ?
Physician with good professional experience	p = 0.71 (fisher) OR = ? IC = ?	p = 0.64 (fisher) OR = 0.98 IC = [0.20 - 4.78]	p = 0.50 (fisher) OR = 1.36 IC = [0.28 - 6.65]	p = 0.89 (fisher) OR = ? IC = ?
Physician with excellent professional experience	p = 0.78 (fisher) OR = ? IC = ?	p = 0.29 (fisher) OR = 3.18 IC = [0.34 - 30.10]	p = 0.40 (fisher) OR = 0.41 IC = 2[0.04 - 3.93]	p = 0.92 (fisher) OR = ? IC = ?

The chi-square test showed an association between having received university-level training on envenomations and an average or good level of knowledge.

Indeed, the significance threshold was 0.003 and 0.004, respectively, which is less than 0.05. Similarly, a correlation was sought, revealing a strong relationship between university-level training and a good level of knowledge, with an odds ratio of 5.07 for a confidence interval [1.59 - 16.15], thus not containing the value 1.

Furthermore, no link could be established between having received postgraduate training and any level of knowledge.

c. Relationship between level of professional experience and level of knowledge

The level of professional experience was established based on the number of years of practice, and we then looked for an association between this and the level of knowledge. We were unable to establish a statistical link between these two parameters (Table 4).

d. Relationship between the number of envenomation cases treated and level of knowledge

We investigated the statistical relationship between the number of envenomation cases treated by physicians during the two years preceding the year of our study and their overall level of knowledge about snake envenomation.

This relationship was significant between those who treated more than 20 cases and those with an excellent level of knowledge, with a p-value of 0.02 (Table 5).

Table 5. Relationship between the number of cases handled during the last two years and the level of knowledge.

PARAMETERS	Low knowledge	Average knowledge	Good knowledge	Excellent knowledge
Doctor who has treated 0 cases in the last 2 years	p = 0.25 (fisher) OR = ? IC = ?	p = 0.35 OR = 1.63 ICn n = [0.60 - 4.48]	p = 0.23 OR = 0.53 IC = [0.19 - 1.49]	p = 0.36 (fisher) OR = ? IC = ?
Doctor who has treated 1 to 2 cases in the last 2 years	p = 0.46 (fisher) OR = ? IC = ?	p = 0.71 OR = 0.80 IC = [0.25 - 2.55]	p = 0.35 OR = 1.75 IC = [0.54 - 5.64]	p = 0.77 (fisher) OR = ? IC = ?
Doctor who has treated 3 to 9 cases in the last 2 years	p = 0.67 (fisher) OR = ? IC = ?	p = 0.46 (fisher) OR = 0.71 IC = [0.16 - 3.10]	p = 0.31 (fisher) OR = 1.9 IC = [0.42 - 8.4]	p = 0.88 (fisher) OR = ? IC = ?
Doctor who has treated more than 20 cases in the last 2 years	p = 0.95 (fisher) OR = ? IC = ?	p = 0.42 (fisher) OR = ? IC = ?	p = 0.64 (fisher) OR = ? IC = ?	**p = 0.02 (fisher)** **OR = ?** **IC = ?**

4. Discussion

Snakebite envenomation, which particularly affects developing countries, was removed from the list of Neglected Tropical Diseases (NTDs) in 2013, then reinstated in June 2017 as a Category A NTD. It is a source of disability and death, and represents a major global medical and health challenge. In Africa, the high mortality rate is multifactorial, linked on the one hand to a lack of antitoxins, and on the other hand to a lack of knowledge about this disease among healthcare

professionals. This observation led us to assess the knowledge, attitudes, and practices of general practitioners in several African countries.

Thus, this was a prospective and cross-sectional study, whose multicenter nature could be a strength, as it allows for the collection of data from different African countries and institutions. However, we identified some limitations.

4.1. Limitations

—The participants were not representative of all practitioners dealing with envenomations in each country;

—The knowledge assessment was based on self-reporting, with a risk of overestimating or underestimating the parameters assessed;

—The participation rate depended on the target population's interest in the topic;

—Using social media to recruit interviewees could create a selection bias by excluding some practitioners, particularly those in rural areas, where Internet access is difficult who are more frequently confronted with snake bites and their treatment.

Furthermore, the reference framework chosen for the correct answers is that of the African Society of Envenomation. Some interviewees may have incorporated and/or applied knowledge on the topic from other learned societies, which could introduce bias into the responses. However, the various recommendations are fairly consistent; the results of this study can be analysed and compared with existing literature.

4.2. Workplace

The survey revealed that the majority of physicians interviewed practiced in university hospitals, *i.e.*, in urban areas.

This predominance could be explained by these physicians' easier access to the internet, given their urban location, which allowed them to receive and complete the questionnaire online. However, as mentioned above, this could be a factor of bias in the overall assessment of practitioners and obscure a significant difference in the approach to snakebite envenomation. It would have been beneficial to distinguish between physicians practicing in rural and urban areas.

4.3. Professional Experience and Level of Knowledge

The professional experience of the physicians interviewed was mostly average or even low, with less than 10 years of professional practice. This result could be explained by the fact that the target population consisted primarily of general practitioners, most of whom were just entering the profession. These physicians typically begin their specialist training later in life. A study conducted in Ghana in May and June 2019 on the overestimation of healthcare professionals' knowledge regarding snakebite management identified 112 professionals with less than 5 years of experience out of 186 interviewed (60.2%) [7].

Logically, it is generally accepted that knowledge accumulates with experience. However, we were unable to establish a significant link between professional experience and the level of knowledge. This finding simply suggests that years of practice do not necessarily imply experience in managing this condition.

In other words, although the number of years of practice was high, the physicians interviewed had not treated enough patients with snakebites and therefore could not have improved their level of knowledge.

4.4. Availability of Antivenom and Use of Guidelines

According to the survey results, antivenom was not available at practice sites for 72.7% of physicians, while 7.6% of participants were unaware of its availability.

Indeed, in several African countries, antivenom remains a difficult treatment to obtain in hospitals.

This was also revealed by a study conducted between March 2018 and November 2019 on the current state of snakebite care, in which 27% of healthcare professionals in Kenya, Uganda, and Zambia had less than 10% of antivenom in stock at their hospitals at the time of the survey [8].

Thus, multiple factors contribute to the limited availability of quality antivenom in snakebite-affected areas: the high cost of antivenom production makes it inaccessible to many patients, while poor transport networks and inadequate storage facilities further hinder the efficient and rapid distribution of antivenom in affected areas. Rural areas are disproportionately impacted by these factors [9] [10].

For most, if not the vast majority, the antivenom used was Inoserp®. Indeed, it is the most commonly found antivenom on the market in West and Central Africa, following the discontinuation of Fav-Afrique® production. However, other polyvalent antivenoms used in South Africa and North Africa are active against local snake species [11].

Furthermore, 57.6% of physicians were unaware of the existence of treatment protocols in their practice settings, and 72.7% did not use them in their daily practice. These results are concerning and consistent with a study conducted in Malawi in November 2022, which demonstrated the lack of guidelines for the treatment or management of snakebite envenomation in healthcare facilities [12]. The same is true for other countries on the continent, such as Ghana, where, despite the availability of national guidelines, not all facilities had them, according to a 2019 study [7]. In Sudan, only 40.9% of healthcare professionals who participated in a similar study in 2020 reported having management protocols in their facilities [9].

These results remain concerning nonetheless, as clear management guidelines exist, published and updated based on epidemiological data. Indeed, Sorge and Chippaux proposed a decision-making algorithm for managing snakebites at the 2016 Yaoundé workshops, based on the 2010 WHO treatment protocols and disseminated by the African Society of Venimology [4].

Consequently, the lack of treatment guidelines in hospitals and poor knowledge of general snakebite management could increase the inappropriate prescription of anesthetics and, therefore, the mortality rate.

4.5. Training Background, Experience in Patient Care, and Knowledge Level

During their undergraduate studies, 56.1% of physicians had received training on snakebites and envenomation. Subsequently, a significant link was established between undergraduate training and having an average or good level of knowledge.

In contrast, few physicians had received postgraduate training, with no association found with their level of knowledge, which could impact their level of practical skills.

This shows that postgraduate training is not directly linked to the level of knowledge and practice, in that practical knowledge can be acquired through field experience. However, having received undergraduate training could provide a solid foundation of knowledge on the subject.

According to the study conducted in Ghana, healthcare professionals who had no formal training but had acquired their skills in the field overestimated their level of knowledge [7]. In a study conducted in Cameroon in November 2015, healthcare professionals were assessed before and after training on various concepts related to snake envenomation. Indeed, before the training, their estimated level of knowledge was poor, while it improved significantly afterward [13].

These results demonstrate the importance of university-level training, but also the need for continuing professional development throughout one's career to maintain up-to-date knowledge and practice in accordance with the latest recommendations. However, in several universities, courses on snakebites and envenomation are still not offered. This is the case in Laos, where, as of September 2016, the management of patients with snakebites was still not taught in medical schools and colleges of health sciences [14].

In Gabon, envenomation training has been offered at the Libreville Military Health Service Application School (EASSML) since 2015 as part of the University Diploma in Emergency Medicine (DUMU). This training is dedicated to physicians from 14 sub-Saharan African countries, in collaboration with the University of Science and Health (USS) within the framework of this national school with a regional focus (ENVR), according to the agreement between the Faculty of Medicine and the EASSML.

Furthermore, the physicians interviewed had treated a recent snakebite, most of them within the last 5 years, and only 15 of these physicians had seen between 1 and 2 cases in the last 2 years. Subsequently, we were only able to establish a statistical correlation between having treated more than 20 cases and an excellent overall level of knowledge. In the study conducted in Ghana, healthcare professionals who had managed a case of snake envenomation were significantly more informed than those who had never managed a case [7].

This suggests that they are likely to be aware of the latest advances, thus improving patient care. Therefore, prior experience can facilitate the acquisition of practical, but not necessarily theoretical, knowledge. However, recent experience does not guarantee quality care, especially since deaths were reported by the physicians interviewed.

4.6. Management

The results indicate an average general knowledge of the principles of snake envenomation management among physicians.

Indeed, several areas showed gaps in knowledge, particularly regarding the use of antivenom, where half of the participants recommended its administration for any snakebite and indicated the intravenous route, while only 25 physicians were familiar with the concept of a "white bite". A lack of understanding of the concept of a "white bite" can have serious consequences. Indeed, ignoring the fact that not every bite results in envenomation, even if the snake is recognized and identified as venomous, can lead practitioners to the inappropriate and unnecessary use of antivenom, even in the absence of signs of envenomation. The risk would then be exposing the patient unnecessarily to the sometimes-serious side effects associated with the use of antivenom. Furthermore, the inappropriate use of such an expensive and difficult-to-obtain medication requires a thorough understanding of its indications.

These poor practices could be explained by the rare availability of antivenom serum in practice facilities, which practitioners do not always have access to and/or the lack of use of envenomation management protocols, in order to use it in the recommended situations and at the indicated dosage.

In Kenya, healthcare workers focused their training requests on the use of antivenom, as most believed it was indicated for all venomous snakebites, according to a 2019 study [15].

Regarding the management of adverse effects, particularly anaphylactoid reactions, adrenaline was the first choice of participants (72.7%). This figure coincides with that found in Laos, where 90.8% of healthcare workers opted for this same treatment [14]. While indicated for anaphylactic shock in routine medical practice, this percentage demonstrates its importance even in managing adverse effects related to the use of antivenom.

Indeed, some morbidities and mortality from this condition are also due, in some cases, to the poor management of adverse effects related to the treatment of envenomation [16]. In contrast, in a similar study conducted in Ghana, half of the participants recommended hydrocortisone, as did the physicians involved in an identical study in Hong Kong SAR [7] [17].

Management of snake envenomation also includes first aid and the use of treatments such as analgesics. The majority of physicians demonstrated good knowledge of first aid procedures performed in practice, such as immobilization, avoiding the use of a tourniquet or suction, to name just a few, as recommended in the literature.

These results are significantly better than those found by Simpson in 2008 in a study conducted in India and Pakistan, where 52% of physicians recommended applying a tourniquet after a snakebite [18]. In Nigeria, however, 75.7% had sufficient knowledge of first aid, according to Michael *et al.* in 2018 [19]. Therefore, first aid procedures are just as important to know, as this would limit the occurrence of complications.

NSAIDs as the analgesic of choice remain favored by a significant number of participants (31.8%). However, their use is strongly discouraged due to the increased risk of hemorrhage in cases of hematotoxic envenomation.

4.7. Level of General Knowledge

We found that 16.7% of physicians were able to recognize and distinguish, from a selection of presented snakes, those that cause envenomation from non-venomous ones. The survey revealed a misconception that pythons and boas are venomous. This confusion could be explained by a lack of professional experience and specific training in snake identification, as well as the fact that the majority of physicians practice in urban areas where snakebites are less frequent. Furthermore, popular beliefs that conflate venom with danger could influence the perception of some physicians.

In Malawi, over 90% of health workers did not know the name and species of non-venomous snakes, a finding supposedly linked to the training program, which reportedly did not include snake identification and could contribute to the likelihood of using an antivenom when not indicated [12].

Furthermore, in South Asia, particularly in Bhutan, health workers who received training on the subject logically achieved significantly better results in snake identification than those who did not [20].

Regarding possible syndromes following envenomation, 54.17% were able to recognize them, but the characterization of cobra and viper syndromes was less well understood, as were the local and general signs present during envenomation.

Our results show that general practitioners, although they have some idea of the possible clinical signs, cannot associate them with the corresponding species. Indeed, the venoms, specific syndromes, and their manifestations are less well known. Local and general signs can manifest differently depending on the type of venom and require particular attention during patient examination. This confirms the lack of training in Africa, a situation not found in other countries where snake envenomation is more prevalent. In Bhutan, 64% of the practitioners interviewed recognized the neurotoxic effect of cobra venom, and 40% of them the hematotoxic effect of viper venom. Along the same lines, specific local signs were recognized in 95% of cases [20].

The physicians surveyed showed a generally average level of actual knowledge for some and a good level for others, according to the questionnaire administered to them. However, during the self-assessment, a large proportion (31 physicians) rated their knowledge as average, and another proportion (29 out of 66) consid-

ered their level to be low. It appears that these physicians clearly underestimate their level of knowledge, which could lead to a lack of confidence when managing envenomation victims.

In Ghana in 2019, the healthcare professionals surveyed had a generally lower level of actual overall knowledge than their perceived level, thus reflecting an overestimation of their knowledge of snakebite management [7]. This disparity could be explained by the fact that the majority of our participants, despite having received university training, lacked prior experience managing envenomation cases. This can lead to an increase in medical errors and raise the risk of disability or iatrogenic death due to inadequate care. Since the need to build their confidence relies primarily on training, which is more reliable than experience, encountering snakebites and therefore learning on the job is logically more challenging.

5. Conclusion

The main objective of this study was to assess the knowledge, attitudes, and practices of physicians in Africa regarding snake envenomation.

The results show that physicians significantly underestimate their overall level of knowledge about snake envenomation, but that substantial gaps still exist. Indeed, the snakes responsible for envenomation, the specific signs of each type of venom, and their lethality are poorly understood, unlike first aid procedures, which are generally well mastered. A lack of use of guidelines established by learned societies, even to the point of ignorance of their existence, combined with an underestimation of their general knowledge level, could undermine the self-confidence of general practitioners and impact their approach to patient care. Furthermore, while antivenom is the only effective and available treatment to date, its indications and the side effects associated with its use remain poorly understood. Thus, we identified a need to strengthen initial and ongoing training on the identification of venomous snake species, the effects of their venom, and the use of antivenom, even in specific cases (pregnancy, children, etc.). This observation leads us to suggest that healthcare training institutions offer a standardized module on the management of snake bites in faculties of Medicine and Nursing. We also highlighted the need to make treatment protocols available at every level of healthcare facility and to improve the availability of antivenom.

However, this study, although extended to other African countries, focused on a limited sample of physicians, making it difficult to generalize the results. Nevertheless, it underscores the importance of regularly evaluating physicians regarding this public health issue in order to optimize training and improve the availability of antivenom serum, thereby limiting medium- and long-term complications such as disabilities and deaths.

Ethical Considerations

Data confidentiality was maintained. This was a computer-based study. Informed consent was obtained implicitly through the provision of the response.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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