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Delays, fears and training needs: Perspectives of health workers on clinical management of snakebite revealed by a qualitative study in Kitui County, Kenya

Kieran Barnes [a], Cecelia Ngari [b], Stanley Parkurito [b], Leo Wood [a], Denis Otundo [b], Robert Harrison [a], George O. Oluoch [b], Anna Trelfa [a], Clare Baker [a,*]

[a] Centre for Snakebite Research & Interventions, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool, L3 5QA, UK
[b] Kenya Snakebite Research & Intervention Centre, Institute of Primate Research, PO Box 24481, Karen, Nairobi, Kenya

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ABSTRACT

Key aims of the WHO Strategy to halve snakebite morbidity and mortality include health system strengthening and training of health workers. This requires knowledge of local health system needs and capacity, health worker training needs, and factors influencing health worker decision-making in snakebite management. This study explored health worker experiences and perceptions of snakebite management, both individually and in the context of their local health system.

We used a qualitative study design with semi-structured interviews (n = 14) and focus group discussions (n = 4). We employed a combination of sampling strategies aiming to achieve maximum variation among key informants within resource limitations. We recruited health workers (n = 33) of varying roles from purposively selected tier 2, 3 and 4 health facilities (n = 12) and the community (tier 1) in four sub-counties in Kitui County, Kenya. We conducted inductive thematic analysis of all transcripts.

The results identified that health workers recognised snake envenoming as a time-critical emergency in which delay in care seeking, sometimes exacerbated by health system referral delays, was a major barrier to effective management of patients. Clinicians strongly voiced a need for training in snakebite management, diagnosis and antivenom administration. Unexpressed needs for training were demonstrated in traditional remedy ineffectiveness, syndromic management, and critical appraisal of treatment effectiveness. Under-resourcing in antivenom, other medication, equipment, infrastructure and staffing also challenged management. Fear of snakebite and fear of antivenom, both linked to past experiences, influenced clinical decision-making.

Our findings clearly indicate a need in Kitui County for training programmes that equip health workers for clinical decision-making in snakebite management. We further identify community intervention needs to facilitate prompt presentation to healthcare, including practical affordable transport solutions, and systematic health system resourcing needs. In addition, we recommend supportive supervision and further research in response to the emotional stress resulting from managing difficult cases in under-resourced settings.

1. Introduction

Snake envenoming is a preventable and treatable medical emergency (World Health Organization, 2019). Yet there are an estimated 1.8–2.7 million cases of snake envenoming every year, resulting in 81–138,000 deaths and 400,000 permanent disabilities (Kasturiratne et al., 2008; Chippaux, 1998; Peden et al., 2008). The majority of snakebite victims are impoverished and reside in rural, remote communities with poor access to rapid, effective health care (Harrison et al., 2009, 2019). Clinical management of snake envenoming is challenging. Clinical features range from mild to fatal, vary by snake species and toxin class, and include local tissue damage and systemic features such as neurotoxicity or coagulopathy (World Health Organization, 2019). In addition, antivenom, the treatment of choice for systemic effects, poses high risks of acute adverse effects, including potentially life-threatening anaphylactic reactions (Gutiérrez et al., 2017). The rural, remote, tropical poverty context of most snakebite occurrences compounds the clinical challenges of improving treatment outcomes (Gutiérrez et al., 2017).

The World Health Organization (WHO) strategy to halve snakebite

* Corresponding author.
E-mail address: Clare.Baker@lstmed.ac.uk (C. Baker).

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Abbreviations

CHW	Community Health Worker
FGD	Focus Group Discussion
K-SRIC	Kenya Snakebite Research and Intervention Centre
PHO	Public Health Officer
SSI	Semi-Structured Interview
WHO	World Health Organization

mortality and morbidity by 2030 recognises that strengthening health systems is a crucial component in delivering improved patient outcomes, making evidence on the capacity and needs of local health systems a key research need (World Health Organization, 2019). Health workers, as the core of the health system, the interface between patient and healthcare, and the route of healthcare delivery (Anand and Bärnighausen, 2012), are ideally placed to provide insight on their local health system. Health worker engagement is also a first step toward ownership and development of locally identified solutions, essential principles in delivering effective and sustainable improvements to healthcare quality (WHO Service Delivery and Safety Department, 2018).

Health workers are the agents of evidence-based diagnosis and treatment, which the WHO Strategy aims to deliver through training and development of decision-making tools and guidelines (World Health Organization, 2019). However, research suggests that implementing evidence-based practice may be challenged by a range of other factors that influence a clinician's decision-making process, particularly past experiences, emotions and professional interactions (Hajjaj et al., 2010; Smith et al., 2008). Evidence from high and upper-middle income settings is that patient factors, including socioeconomic status, attitudes and adherence to treatment, may also influence health workers' decision making (Hajjaj et al., 2010; Mckinlay et al., 1996; Bernheim et al., 2008). There is no evidence on whether, or how, these or other factors influence health workers' approach to snakebite management as existing research in sub-Saharan Africa has focussed on health worker knowledge of snakebite (Michael et al., 2018; Ooms et al., 2020; Taieb et al., 2018).

This qualitative study aims to meet this evidence gap in the context of the local health system in Kitui County, Kenya. Kenya has 13 medically important species of venomous snake resulting in an estimated 15,000 bites a year (Kenya Ministry of Health Neglected Tropical Diseases Program, 2019). These include spitting cobras, puff adders and other vipers, boomslang, cobras and mambas, which cause a range of haemorrhagic, coagulopathic, neurotoxic and local tissue destructive effects in victims of envenoming. We aimed to explore the perspectives of health workers on managing this range of snakebite pathology; on barriers to and enablers of effective management, and on their past experiences of and personal approach to clinical management.

2. Methods

2.1. Study site

Kitui County is in the east central region of Kenya, a terrain dominated by arid and semi-arid regions receiving irregular and erratic rainfall. Its economy is dependent on agriculture. 2016 levels of absolute (47.5 %) and food (39.4 %) poverty were both higher than Kenyan national average (County Government of Kitui, 2018). Climate, agricultural activities and poor housing all contribute to a high incidence of snakebite from a range of medically important snakes, including red spitting cobra (*Naja pallida*), puff adder (*Bitis arietans*) and black mamba *(Dendroaspis polylepis)* (Kihiko, 2013).

The study took place in 2019 in four sub-counties in northern Kitui county (Table 1) that vary in rainfall and population density, which are respectively positively and inversely correlated with snakebite incidence (Rahman et al., 2010; Chaves et al., 2015; County Government of Kitui, 2018). Rainfall is greater in the highlands, including areas of Mwingi North and Kitui East, than in the lowlands, including much of Mwingi West, Mwingi Central and the eastern part of Kitui East (County Government of Kitui, 2018; Kenya Ministry of Environment et al., 2015). We chose study areas with varying snakebite incidence because snakebite burden may be an influence on management challenges. The study was embedded within a larger project of the Kenya Snakebite Research and Intervention Centre (K-SRIC) for the African Snakebite Research Group (Centre for Snakebite Research and Interventions, 2021).

2.2. Study design

We chose a qualitative study design to allow in depth exploration of health worker perceptions and attitudes on snakebite management (Green and Thorogood, 2004). We used a qualitative description approach, seeking to provide a rich description of the experiences and perceptions of managing snakebite in Kitui County, allowing us to identify unknown factors that influence health worker management of snakebite, begin to understand their inter-relationships and inform interventions (Bradshaw et al., 2017). We used focus group discussions (FGDs) to rapidly generate debates, allowing for emergence of themes and conflicting or deviant ideas (Morgan, 1998). We used individual semi-structured interviews (SSIs) to allow participants to freely explore more sensitive topics, including personal experiences, emotions, and beliefs (Gill et al., 2008). Triangulating both methods allowed us to explore shared and contrasting individual and collective views (Green and Thorogood, 2004).

2.3. Sampling and recruitment

2.3.1. Healthcare facilities

The Kenyan public health system is loosely divided into four tiers (Kenya National Coordinating Agency for Population and Development et al., 2011), described in Table 2. Antivenom for snakebite treatment is typically available only in tier 4 (hospital) and some tier 3 (health centre) facilities. Admission for more than about 6 h' observation is only available in tier 4 facilities. We included tier 2 (dispensary), 3 and 4 health facilities because snakebite victims most commonly present to such facilities and the focus was on management within healthcare (Gutiérrez et al., 2017). We also included community health workers (tier 1) as their role gives them a unique understanding of care seeking for snakebite.

We purposively selected government health facilities by maximum variation sampling (Marshall, 1996) across sub-county, health facility tier, travel distances and snakebite presentations (Table 3). This strategy aimed to ensure we included health workers from settings varying by patient population, facility resources, snakebite workload and experience, and ease of referral, allowing exploration of whether and how these factors influenced decision-making.

Table 1
Characteristics of study sub-counties. All data is for 2018, from the County Government of Kitui (2018) and the Kenyan Ministry of Health (2018).

Sub-county	Population	Population density (persons/km^2)	Estimated number of snakebite presentations to public health facilities Jan–Dec 2018
Mwingi North	155 267	32	83
Mwingi West	115 117	106	135
Mwingi Central	156 641	38	196
Kitui East	136 708	27	106

Table 2
Key services and health workers present at facility tiers 1–4 in the Kenyan government health system. Information taken from the Kenya Service Provision Assessment Survey 2010 (Kenya National Coordinating Agency for Population and Development et al., 2011) and KSRIC experience of snakebite management in the local health system. CO = Clinical Officer. AV = antivenom.

Tier	Facility	Key Services	Health workers (* = main decision-maker and prescriber)	Typical role in snakebite management
1	Community unit	Community level care and health promotion	Community health workers and volunteers; occasionally nurses	Support presentation to facility.
2	Dispensary	Basic outpatient care	Nurses and nurse-in-charge*	Initial assessment and referral. Most do not stock AV.
3	Health centre	Outpatient care; Preventative services; Minor surgical services	Nurses; CO*; occasionally doctors*	Some stock AV. May treat and/or refer. Maximum observation period circa 6 h.
4	District hospital	Surgical, medical and paediatric services; 24 h services	Nurses; CO*; Doctors*	Stock AV. Full treatment and admissions. All snakebite patients usually admitted for 24 h.

2.3.2. Semi-structured interviews (SSIs)

We selected participants for SSIs from all smaller participating health facilities using opportunistic sampling at each site visit. Logistical issues prevented sampling by an alternative method. We supplemented this with key informant and deviant sampling (Marshall, 1996) from FGD participants, inviting those who demonstrated in-depth knowledge, numerous experiences or outlier ideas for an SSI to explore these in more depth. There were no repeat interviews other than a single instance of sampling from an FGD.

2.3.3. Focus group discussions (FGDs)

We conducted FGDs in larger facilities able to provide 4–6 eligible health workers for an FGD. In three facilities, we selected participants by key informant sampling of departments managing most snakebite cases (surgical, paediatric and emergency departments) and maximum variation sampling of professional groups within each department (nurses, doctors and clinical officers) (Marshall, 1996). This enabled us to include, compare and contrast perspectives of the full range of staff who manage most snakebite patients. However, nurses manage most snakebite patients (Gutiérrez et al., 2017) and it was possible that some might be discouraged to freely share their opinions by the presence of staff at a different position in the healthcare professional hierarchy. Therefore, in one facility, we selected FGD participants by homogeneous sampling of only nurses, creating an opportunity for their perspectives to be shared free of the workplace hierarchy and exploiting a natural group used to working together (Gutiérrez et al., 2017).

2.3.4. Recruitment

We routinely first approached the sub-county Public Health Officer (PHO)/Medical Superintendent, who provided a link to the manager or medical officer of each selected facility. After providing study information, we asked this gatekeeper for permission to approach staff in their facility regarding the study. Because of the complexity of arranging an FGD with staff with clinical commitments, the relevant facility gatekeeper recommended a date, time and participants for each FGD. We gave every prospective participant at least 48 h to review a participant information sheet in English and Swahili, which explained the study purpose and process, and an opportunity to discuss the study with, and be introduced to the researcher (KB) before taking written informed consent. No invited participant refused to participate, stating they were keen to share their views and experience.

2.3.5. Participant characteristics

33 health workers from the four sub-counties participated in the study across 14 SSIs and four FGDs (Table 4). Participant roles are shown in Table 5. Participant ages ranged from 20 to 74, with over half (19) aged between 25 and 39. There were 15 male and 18 female participants.

2.4. Data collection

We developed a topic guide for use in both SSIs and FGDs. The initial structure was informed by existing literature on factors influencing clinical decision making. Local researchers and PHOs advised on adaptations to increase its suitability for use in Kitui County. We made further refinements based on a pilot SSI and FGD in two different health facilities and experience throughout the study, either to follow-up participant responses or to refine questions for clarity. This process was recorded in a reflexive diary. Separate field notes were not kept. The

Table 4
Data collection methods used in each sub-county.

Sub-county	Number of interviews	Number of FGDs
Mwingi North	3	1
Mwingi Central	3	1
Mwingi West	3	2
Kitui East	5	0
Total	14	4

Table 3
Description of included facility characteristics. All distances and times were estimated using Google maps. Estimated snakebite presentations to the facility in 2018 from Demographic Health Information Systems Data provided by the Kenyan Ministry of Health (2018). Numbers <10 suppressed. Facility names are excluded to maintain participant confidentiality in smaller facilities.

Sub-county	Facility tier	Distance from main road (km)	Distance to referral hospital (km)	Time to referral hospital (mins)	Estimated number of snakebite presentations in 2018
Mwingi Central	3	0	33	30	17
	3	30	64	90	11
	4	0	–	–	63
Mwingi West	2	5	35	45	<10
	2	20	35	40	70
	2	0	10	15	<10
	4	0	–	–	<10
Mwingi North	3	5	55	60	<10
	3	30	90	130	21
	4	0	–	–	11
Kitui East	2	10	15	40	<10
	3	0	24	40	<10

Table 5
Participant occupations by data collection method.

	Community health volunteer	Nurse	Nurse in charge	Clinical Officer	Doctor	Public health officer
FGDs	0	14	1	3	1	0
SSIs	2	3	2	6	0	1
Total	2	17	3	9	1	1

final topic guide can be found in Supplementary File 1. All researchers received training on qualitative research methods.

All data was collected in 2019 by KB, a male British medical student, as part of an MSc degree during which he received training in qualitative research methods. He was introduced to all study facilities by a member of the K-SRIC team, whose work meant they had previously developed relationships with communities and health facilities in Kitui County. We felt use of an outsider interviewee would support health workers feeling they could freely share positives and negatives of their own practice independent of their supervisors or local authorities, and that the link to a local team provided confidence the results would be used locally. The shared medical background between interviewer and interviewee enabled participants to use their normal work language. While, KB was aware of the differences in experience and background between himself and participants, and of his biomedical bias, he was able to use this awareness and an interest in broader healthcare to ask non-judgemental questions.

We conducted SSIs and FGDs in each study facility, either in a quiet side room (SSIs) or private meeting room (FGD). SSIs were 30–60 min in duration and FGDs circa 60 min. All were audio recorded for later transcription. We collected most data in English, an official language in Kenya and in which all health workers in Kitui were conversant. However, two participants were less confident in English and chose to conduct their SSI using an English-Kamba interpreter. We trained the interpreter in interpreting for qualitative interviewing (Murray and Wynne, 2001) and they were familiarised with the topic guide. We used a three-way interpreting technique to allow the researcher to probe and clarify the interpretation, and to ask questions about emotional responses, such as laughter. A bilingual member of the K-SRIC team back-translated one SSI to confirm the validity of the interpretation.

Data collection was deemed complete when target theoretical sample size was reached and themes emerged. Study limitations and timescales did not allow continued data collection for full data saturation.

2.5. Data analysis

We transcribed and analysed all SSIs and FGDs in English. The pilot FGD and SSI were not included in analysis. We carried out inductive thematic analysis supported by 'Nvivo 11' (NVivo, 2015). Two researchers independently coded three transcripts before discussing and agreeing a coding scheme (Green and Thorogood, 2004). One researcher coded all remaining transcripts, with further iterative adaptations to the coding scheme discussed and agreed by two researchers. The coding scheme is provided in supplementary file 2. We explored relationships between codes, similarities and conflicts within and between individual participants and checked for patterns across the whole dataset and by participant and facility characteristics to identify and construct themes. We carried out refutational searches, checking for any disagreement with proposed patterns and themes. We agreed on three key themes, two of which had sub-themes. Project timescales and study geography did not allow for participant checking of transcripts or findings.

2.6. Ethical considerations

The Liverpool School of Tropical Medicine MSc Review Panel (Application 1924) and the Kenyatta National Hospital - University of Nairobi Ethics and Research Committee (Amendment to existing study P347/05/2019) approved the study.

3. Results

3.1. Delays: a major barrier to effectively managing this time-critical emergency

All participants identified delays as a barrier to effective snakebite management and/or described snake envenoming as a time-critical emergency. Some, representing every facility tier, described specific cases in which they felt delays had been a direct cause of adverse outcomes, including digit or limb amputation or death.

> *"The management of a snakebite, I am slowly discovering that time is a factor that is very much essential. The time taken after a bite to seek medical attention"* (SSI, tier 3 facility)

> *"I had an experience here last year … It was a child who was bought here having been bitten by the red snake … The child was referred because at that time we had no anti-snake venom … Instead, the parents did not take the child immediately … They went home, they started looking for other means of survival and in the course of that the child died the same day … Snakebite kills. Especially when there is a delay in terms of management."* (SSI, tier 3 facility)

3.1.1. Delays in care seeking a priority, requiring community education and preparedness

All participants discussed delay between bite incidence and reaching the health facility as a primary cause of delay in management. Participants attributed, either in general or when discussing specific cases, these delays to a range of causes, which could be divided into stages of the process from snakebite to presentation, described in Table 6.

> P1: *"We've amputated a 6 year old girl, an above knee amputation due to a venomous snakebite. But she had stayed for more than a week at home so the limb was already gangrenous … Most people, there is something that they usually apply, some black stone. Then they go to some healer so before they come here they have already taken quite some time at home because of those beliefs and whatever they do at home. That is the major contributing factor."*
> P3: *"… There is that culture but then there is also an aspect of poverty. When a patient is bitten by a snake and they don't have transport to come to the hospital, so that poverty issue is another contributing factor. And also poor knowledge of what can happen after a snakebite. But I think most of it is that traditional culture, poor knowledge and even poverty level. When somebody doesn't have anything to bring themselves to the hospital."* (FGD, tier 4 facility)

Most participants perceived a lack of community knowledge of snakebite management, trust in traditional remedies, poverty, cost of transport and distance from the facility as key drivers of delay. Some described these factors as inter-related, linking the indirect cost of accessing healthcare to choosing traditional remedies. Many also cited the underlying social determinants of snakebite incidence and delay in accessing care (Table 6).

Participants, with the exception of three SSI respondents, all linked delay to accessing healthcare with a need for community engagement and education and/or preparedness in terms of transport to a health facility. Participants described needing to educate communities on preventing snakebite, first aid and immediate attendance at a health facility, both proactively in the community and reactively with individuals who present with snakebite. A few participants mentioned positive progress in community attitudes to care seeking and traditional remedies or the positive impact of the snakebite motorbike ambulance currently being researched in some areas. A few also cited the positive

Table 6
Participant descriptions of perceived drivers of delay and contributing context on the journey of a snakebite victim from bite to a health facility.

Key points on the snakebite victim's route to a health facility	Perceived driver of delay	Underlying social determinants
Recognising a snakebite	Low snakebite knowledge in the community	Health literacy and education
	Night-time bites (sleep and darkness affecting recognition)	Poor quality housing
	Sight of biting animal limited by bush/foliage	Rural environment and activities
	Unsupervised children unable to give history	
Understanding the need for healthcare after a snakebite and where to access it	Low snakebite knowledge in the community	Health literacy, including awareness of health care
	Uncertainty over which facilities can manage snakebite or stock antivenom	
	Belief/trust in traditional remedies	Cultural and/or religious norms
	Superstition or spiritual beliefs that curses are a cause of snakebites	
	Religious beliefs that prohibit accessing healthcare (Kavonokya sect)	
Having or obtaining the means to access healthcare (communication and/or transport)	Not owning a mobile phone	Communication infrastructure Remote rural location Transport infrastructure Poverty
	Being in an area with no mobile network coverage (patient or CHV)	
	Not owning a vehicle	
	Not having any fuel for the vehicle Lack of funds for fuel or hiring transport	
	Time needed to obtain informal community support to identify funds or transport	
Travel to health facility	Distance to health facility	Remote rural location Health system delivery model Road infrastructure
	Road quality limiting transport options to slower choices (walk/ motorbike)	
	Flooding and road damage after rains	

impact of Kitui Health Cover in making treatment free of charge, while noting its impact was limited by some eligible people not having taken up cover and because it did not remove the cost of transport to a health facility.

3.1.2. Further delays to receipt of treatment after accessing care result from inconsistent ability of health facilities to manage snakebite and limited referral infrastructure

Most participants described the time between deciding to refer a patient to another facility with the expertise and resources to manage snakebite and their arrival at that facility as an important cause of delay. Issues cited were the distance between facilities, reliance on deployment of an ambulance at another facility increasing travel time, limited ambulance numbers resulting in frequent unavailability and health system prioritisation of maternity cases over all other cases. Some participants also described difficulties finding affordable alternative transport if there was no ambulance available. A few said they had personally offered loans to patients to fund their transport. Participants stated that *"the main reason we refer people is for antivenom"* (SSI, tier 3 facility) and five advocated for antivenom being available in all facilities to remove these delays.

> *"We couldn't give antivenom so we had to refer. At that time, we only had one ambulance and it was already out taking another patient so we had to wait until that ambulance came back before the patient was taken. She reached but later she died because of the delay of treatment"* (SSI, tier 4 facility)

While one participant did describe the ambulance service as reliable, they had never needed to use it for a snakebite case.

A few participants linked gaps in knowledge or resources to delay because of the time taken to consult colleagues, either in facility or at another facility, or research guidance. A few described delays due to needing to borrow antivenom from another facility.

3.2. Both expressed and normative needs for training and system resources identified

3.2.1. Clinical training needs strongly expressed by patient-facing professionals

Every participating clinician, by which we mean a patient-facing health professional delivering care in tier 2,3 and 4 facilities, expressed a desire for training in snakebite management. Most of these participants said they were not confident managing snakebite.

> *"I think … at long last people will come to the facility, so one of the biggest challenges we have now is the knowledge gap in the healthcare workers."* (SSI, tier 3 facility)

> *"I had no idea of the management … I have that knowledge gap so training is needed, or updates on snakebite management."* (SSI, tier 2 facility)

A few clinicians expressed some confidence, all but two of whom had received some training. In one FGD, statements of confidence were led by the facility lead saying they were confident in their staff, who had been trained. Five other participants expressed limited confidence, but stated they were not confident giving antivenom. Participants from five facilities reported having received some form of post-qualification training. Three of these described limitations; one could not attend the whole training, one described it as *"very shallow" (FGD, tier 2 facility)* and one said it was *"sensitisation … some years back, I think 2003" (FGD, tier 4 facility)*.

Participant descriptions of training needs are illustrated in Table 7. The most frequent needs were a general request for training in clinical management and specific requests in accurately identifying venomous from non-venomous bites and using antivenom. Antivenom-related requests were the only training requests patterned by either facility or health worker characteristics. Six of the nine individuals or groups wanting antivenom training worked in facilities which currently or had recently stocked antivenom. The other three all viewed training as a required component of bringing antivenom to more facilities as a solution to referral delays. One of these described their facility having once had antivenom in stock but being unable to give it to patients with snakebite because no-one was trained. Antivenom training requests included storage, when to (not) give, how to give, and management of adverse reactions.

A few participants made recommendations on the nature of or system for training. A few requested posters and flow charts for display in facilities. A few advocated for in-facility or nearby rather than distant training, and repeated sessions to ensure staff transferred into a snakebite region were trained. One highlighted the need for senior

Table 7
Areas of training requested by patient-facing health professionals. Patient-facing health professionals in this study (n = 30) were nurses, nurses in charge, doctors and clinical officers across 11 SSIs and 4 FGDs.

Requested area for training	Number of FGDs/SSIs in which identified			
	Tier 2 (n = 6)	Tier 3 (n = 5)	Tier 4 (n = 4)	Total (n = 15)
Case management	4	3	2	9
Accurate diagnosis of venomous snakebites	4	2	2	8
Antivenom	2	2	4	8
… Of which specifically mentioned adverse reactions	1	0	4	5
Counselling patients, advising community	1	1	1	3

commitment to snakebite management training to ensure all staff, including those in single-staffed facilities, received it.

3.2.2. Traditional beliefs and remedies illustrate normative training needs

Participants showed varied attitudes to traditional remedies. Most participants advised against tourniquets and cutting, describing harm due to ischaemia and haemorrhage or infection respectively. Three participants said tourniquets were effective. The black stone was a source of debate. Five participants confidently stated that the black stone did not work, while four felt it did work, one of whom said it worked specifically for a *"dry bite"*. Ten participants from all facility tiers expressed uncertainty over whether it did work, some of whom felt it gave psychological benefit and a few of whom identified it as a research need. Participants did not discuss whether application of a black stone was preceded by cutting. Most of those who said traditional remedies or tourniquet were effective were from the community or tier 2 facilities, but not all.

> *"The stone we don't remove. We keep it there until it falls down so you find the client feels like I'm okay now, I have been cured, because it is their belief."* (SSI, tier 2 facility)

Many described traditional beliefs as a cause of delay in care seeking, but some, including both community health volunteers, found it difficult to advise against them, mostly the black stone, in the context of the remote location of most snakebites, patient report of benefit, and the absence of alternatives. A few described having themselves bought a black stone.

> *"I will not discourage them using that [black stone], whatever means they have. I will not discourage them because I don't know if it works."* (FGD, tier 4 facility)

3.2.3. Gaps in health infrastructure and resourcing are a barrier to snakebite management

3.2.3.1. Antivenom. Participants from six facilities (three tier 4, two tier 3, one tier 2) reported that they currently stock antivenom, but all six facilities said stock-outs were an issue and three facilities described borrowing antivenom from other facilities.

> *"Now the two [antivenom] vials that we have [been] given, one is expired so we don't have them. So now it's difficult to manage a snakebite."* (FGD, tier 2 facility)

Of the remaining six facilities who didn't stock antivenom, one previously had but couldn't at the time of the interview because of a broken fridge, one reported having once received antivenom that no-one knew how to administer, and one said it was ordered but never received.

3.2.3.2. Other medication, equipment and infrastructure. Participants from all three tier 4 facilities stated they had sufficient other resources for snakebite management except for one participant saying they lacked specialist equipment for limb elevation. However, participants from seven of the nine tier 2 or 3 facilities described lack of in-facility resources as barriers to effective emergency management. While some of these referred to gaps in equipment or medicine stock in general, the following specific resource needs were mentioned in at least one tier 2 or 3 facility; electricity and lighting (3 facilities), adequate bed capacity for observation (2 facilities), equipment for monitoring vital signs (2 facilities), oxygen supply (1 facility), analgesia (1 facility), anaphylaxis medications (1 facility) and laboratory investigations (1 facility).

> *"Sometimes we have failure of our equipment, like you can't check the vital signs … because of failure of the equipment we have. So, in short, you're just using your eyes … If the patient is in pain we can give pain killers and most of the time the villagers also have some slight idea of how to manage it, some of them have the black stone, some don't have, some tie … But sometimes we also lack the pain killers."* (SSI, tier 2 facility)

3.2.3.3. Human resources. Participants from eight of twelve health facilities and the community described under-staffing as an issue. This was mostly linked to challenges managing multiple patients, with one saying it added to fear of antivenom complications. A few linked understaffing, mostly lone working, to low confidence in management and being unable to consult colleagues. Some described informal consultation of friends and colleagues as a route to addressing this isolation.

3.3. Tension between fear of snakebite and fear of antivenom, both linked to past experiences

Fear was the dominant emotion participants used to describe snakes and snakebite and connected this to the severity of the potential outcomes, from life-changing wounds or amputations to death. Some participants described greater worry over children presenting with snakebites, and in a few cases, pregnant women.

However, there was a difference in health worker fears and tension between facilities that did or did not routinely stock antivenom. Participants in facilities without antivenom described fears, tension and strain being exaggerated by feeling unable to help patients.

> *"I just felt pity because … I have nothing I can do with this patient so I had to refer immediately and felt sorry because when you have a patient and you can't manage you feel like you have done nothing. And they were not satisfied because no first aid, nothing. They were like, you don't have the antivenom?"* (SSI, tier 2 facility)

Those with experience of giving antivenom discussed side-effects. Some felt this was a reason for additional caution and/or senior supervision, but were still positive about antivenom. These participants had all either not experienced antivenom reactions or had successfully managed reactions. Many described experiences in which they directly linked administration of antivenom to a good patient outcome or delay in receipt of antivenom to an adverse patient outcome. Two participants described deaths of patients not receiving antivenom after the clinical team had disagreed on whether to give antivenom.

> *"So, what I think my self is, there are very few patients who react on it. So, we cannot fear giving the antivenom because it is the only saviour of that patient. So, if we have the phobia of giving the venom then we are not helping that patient in anyway. So maybe out of 20 only one will react. Unless when a patient comes and he or she is very late in the hospital. You don't understand whether it is the venom which is in the blood or what. Sometimes you are confused, is it the venom, is it the antivenom. So according to me that reaction is not so high. There are very few. So, for me I think we need the antivenom … It comes to that extent you don't know*

what else you can do for the child. Although we have a minor fear you just give, you cannot just deny. There is a little fear of what will happen but you still give." (FGD, tier 4 facility)

However, some experienced fear of antivenom, mostly because of adverse reactions. The three participants who expressed greatest fear all described experiences of patient deaths from (sometimes suspected) antivenom reactions. Three participants said they had not given available antivenom because of fear, while a few others described referrals because other facilities were not willing to give antivenom.

P4: *"You fear these days. You don't know the severity to give the antivenom and when not to give the venom so that's why we say it's better to give the other resuscitative drugs."*
P3: "*Eh, it's better without antivenom.* "
P4: "*Some experiences make us just fear."* (FGD, tier 4 facility)

4. Discussion

Health workers from a range of tier 2, 3 and 4 health facilities in Kitui County all described delay in presentation to healthcare, which could be exacerbated by further delays within the health system, as a major barrier to effective management of patients with snake envenoming. In terms of personal approach to management, a picture emerged of clinicians feeling the tension of difficult choices when trying to minimise harm to the patient. The life and limb-threatening potential of snake envenoming was in tension with recognised risks of treatment; referral to another facility risked delay and out of pocket expenditure, while administering antivenom risked potentially severe adverse reactions. Past experiences were major influences on this risk assessment and feelings of worry. Most clinicians described facing this high-consequence decision-making in a context of little training in snakebite management and facility under-resourcing.

4.1. Community engagement, traditional remedies and care seeking behaviour

Both the WHO Snakebite Strategy (World Health Organization, 2019) and our participants identify a need for community engagement and education on snakebite prevention, first aid and care seeking. The enduring community belief in and use of traditional snakebite-remedies seen in our study was similar to that reported in surveys in other settings, including Nigeria, India, Myanmar and Sri Lanka (Iliyasu et al., 2015; Mahmood et al., 2019; Samuel et al., 2020; Ediriweera et al., 2017). However, our qualitative methods enabled identification of a relationship perceived by health workers between use of traditional remedies and cost of, or difficulty reaching healthcare. This relationship was also described in a qualitative study on snakebite in Myanmar (Schioldann et al., 2018). While evidence from the community itself is needed, our findings highlight that community education on care seeking for snakebite will need to be accompanied by practical solutions to enable access to healthcare, such as free or reduced cost emergency transport, for maximum effectiveness.

Our study adds to the existing evidence that some health workers in sub-Saharan Africa believe in the effectiveness of traditional remedies (Ooms et al., 2020; Taieb et al., 2018; Michael et al., 2018). Such remedies are advised against in International and Kenyan guidelines for snakebite management (World Health Organization Regional Office for Africa, 2010; Kenya Ministry of Health Neglected Tropical Diseases Program, 2019). Our qualitative findings provide new understanding that health workers are more confident advising patients against traditional remedies where they clearly understand the harms of the remedies, and less confident where they feel their own knowledge is limited or they have no good alternatives to offer. This latter attitude was typified in the black stone, which was only identified as harmful if it contributed to delayed presentation at a health facility. Participants did not explicitly associate the black stone with cutting, which accords with a 2018 Kenyan leaflet publicising black stone that did not advocate cutting before its application (Rural Extension with Africa's Poor (REAP), 2018). Local practices in applying black stone should be researched, but these findings raise the possibility of a harm-minimisation approach in which traditional healers are engaged to facilitate prompt transfer to a health facility, but may choose to apply a black stone without cutting. A similar strategy to integrate traditional healers into community education, first aid and transport to health facilities was proposed by researchers in Myanmar after noting persistent beliefs in traditional remedies for snakebite and under-use of healthcare (Schioldann et al., 2018). Further research and engagement with the community and traditional healers is needed to explore this. On a wider perspective, our findings indicate an urgent need for close-to-community treatment to address both delay to treatment and use of traditional remedies. Research to develop new toxin-neutralising small molecule-based snakebite treatments holds considerable promise because their safety, non-cold chain dependency, oral delivery and affordability characteristics suggests they could be dispensed at community-level facilities, instead of in hospital – a paradigm shift in snakebite management (Albulescu et al., 2020).

4.2. Health worker training needs and system resourcing

Our findings highlight that satisfactory care is needed to reinforce presentation to a health facility, and that significant training and resourcing is required to ensure consistent quality care. Participating clinicians' demand for patient-management focused clinical training and aids such as management flow charts is reflected in the objectives of the WHO Snakebite Strategy, launched the same year as this study (World Health Organization, 2019). Our findings provide the first published descriptions by health workers of their needs in clinical snakebite training. General requests for "case management" training suggest low baseline knowledge, while specific requests focused on diagnosis and antivenom. The link many made between distinguishing venomous from non-venomous snakes and antivenom administration suggests that, in common with health workers in Nigeria (Michael et al., 2018), some health workers think antivenom treatment is indicated for all bites from venomous snakes. This indicates poor participant knowledge of syndromic management, advised in International and Kenyan snakebite management guidelines (Kenya Ministry of Health Neglected Tropical Diseases Program, 2019; World Health Organization Regional Office for Africa, 2010). The presence of unexpressed training needs (syndromic management, traditional remedy ineffectiveness and critical appraisal of association, causation and evidence of effectiveness) suggests that training priorities identified by health workers will need to be combined with normative assessments of essential training in snakebite management.

We identified that health system resourcing needs ranged from the basic (eg. lighting) to the more complex (eg. antivenom supply). Our findings of stock-outs being a challenge in snakebite management indicate that the stock-outs reported in a 2009 Kenyan government survey remain an ongoing issue (Ministry of Medical Services and Ministry of Public Health and Sanitation, 2009). This reflects a continent-wide shortfall in antivenom, with an estimated less than 5 % of a required 1.5–2 million antivenom doses being supplied annually (Stock et al., 2007; Brown, 2012). While addressing these stock-outs requires action at a national and international tier from stakeholders in health, pharmaceuticals, government and regulatory agencies (World Health Organization, 2019), our findings indicate these need to be combined with local interventions such as ensuring fridges are functional and deliveries are made to facilities with trained staff confident to administer antivenom, thereby ensuring available stocks are not wasted.

4.3. Health worker emotions associated with managing snakebite

To our knowledge, this is the first confirmation of anecdotal reports of health workers deciding against administering available, indicated antivenom because of fear of antivenom-induced adverse reactions (Warrell, 2010). Little is known about the exact frequency of adverse reactions to antivenom in Kenya specifically, but national guidelines recognise their potential for serious adverse effects and recommend consideration of pre-treatment with subcutaneous adrenaline to reduce their incidence (Kenya Ministry of Health Neglected Tropical Diseases Program, 2019). Although we cannot comment on incidence, we identified reports of past, negative experiences of managing antivenom-induced adverse reactions having a major bearing on health worker lack of confidence in using antivenom to manage a patient. As management of adverse effects of antivenom was also identified by participants as a training need, it is difficult to know how much of this fear can be addressed by training in managing adverse reactions and whether, and if so to what extent, further support in processing past experiences would be indicated. It is clear, however, that health workers find the training and resourcing gaps emotionally challenging in their impact on the delivery of quality care. Exploring the detail of individual participants' emotional responses to stress was outside the scope of this study and may have been limited by use of participants' second language (Murray and Wynne, 2001), but our findings identify, at minimum, a need for supportive supervision (Avortri et al., 2019) for health workers exposed to traumatic cases of snakebite management, particularly where affected by system under-resourcing. Addressing training and resourcing gaps are a priority, but further research on health worker stress and emotional responses might identify a need for more specialised psychological support.

4.4. Study limitations

Qualitative methods are not generalisable, and our study included relatively small numbers of participants, all working in the north of Kitui County. Nevertheless, many of our findings concur with snakebite research literature, which suggests some findings will be relevant in other settings. Our participants also represented only the public health system, while private health facilities make up 49 % of health service providers in Kenya and differ from public facilities in areas such as cost of treatments and facility organisation (Kenya National Coordinating Agency for Population and Development et al., 2011). Patient costs were perceived to be a significant barrier to care seeking, which would, if true, suggest that more snakebite patients attend government facilities than private. This is supported by evidence from other poor rural communities in Kenya, where the most commonly used health facilities are more likely to be public facilities (Ngugi et al., 2017). Care seeking behaviour was raised as an important barrier to effective management of snake envenoming, so we recommend triangulating our findings on health worker perceptions with research on community perceptions.

Our study only included one doctor, which is a limitation. However, doctors are only commonly found in tier 4 of the Kenyan health system (Kenya National Coordinating Agency for Population and Development et al., 2011), and our study included tiers 1–4. In addition, clinical officers in Kenya outnumber doctors and are known to provide doctor-like services in rural district hospitals, akin to our study setting (Mbindyo et al., 2013). Therefore, the low numbers of doctors in our participants also likely reflects the type of staff that commonly deliver snakebite care in Kitui County.

It is possible that health workers felt more inclined to specifically raise barriers they felt that K-SRIC could address, such as training. We sought to counteract this bias by asking open-ended questions about previous experiences of managing snakebite, as well as more specific questions on training already received and both enablers and challenges in resources and support. Triangulating expressed training needs with detail provided on previous training, descriptions of previous experiences, and emotions associated with these experiences supports a conclusion that identified training needs are real.

5. Conclusions and recommendations

Health workers in a range of tier 2, 3 and 4 health facilities in four northern sub-counties of Kitui County, Kenya, identified delays and health worker knowledge gaps as major challenges in management of snake envenoming. Delays were predominantly in care seeking, but also in the referral system. This study found that clinical decision-making in snakebite management is frequently influenced by knowledge gaps, resource shortages, including in medication, equipment, infrastructure and staffing, and clinician fears. Past experiences of adverse outcomes of snakebite and of antivenom adverse reactions were major influences on these fears. The following recommendations arose from our study:

- Community engagement is required to continue improving care seeking behaviour, with research needed on exploring options for engaging traditional healers in referring victims to health facilities and on options for affordable reliable transport, such as including emergency transport costs in health insurance cover
- Snakebite management training for clinicians is urgently needed, which should focus on case and syndromic management, antivenom administration and management of adverse-reactions, and deliver flow chart management aids where possible
- Systematic adequate resourcing of health facilities for emergency management and observation of patients with snake envenoming is required
- Development of treatments for snake envenoming with lower side effect profiles and potential for administration closer to the community should be a research priority
- Health workers managing snakebite are exposed to traumatic situations while feeling under-resourced to respond and should receive supportive supervision and resourcing in addition to further research on their emotional support needs.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.toxcx.2021.100078.

References

Albulescu, L.-O., Xie, C., Ainsworth, S., Alsolaiss, J., Crittenden, E., Dawson, C.A., Softley, R., Bartlett, K.E., Harrison, R.A., Kool, J., Casewell, N.R., 2020. A therapeutic combination of two small molecule toxin inhibitors provides broad preclinical efficacy against viper snakebite. Nat. Commun. 11, 6094.

Anand, S., Bärnighausen, T., 2012. Health workers at the core of the health system: framework and research issues. Health Pol. 105, 185–191.

Avortri, G.S., Nabukalu, J.B., Nabyonga-Orem, J., 2019. Supportive supervision to improve service delivery in low-income countries: is there a conceptual problem or a strategy problem? BMJ Glob. Health 4, e001151.

Bernheim, S.M., Ross, J.S., Krumholz, H.M., Bradley, E.H., 2008. Influence of patients' socioeconomic status on clinical management decisions: a qualitative study. Ann. Fam. Med. 6, 53–59.
Bradshaw, C., Atkinson, S., Doody, O., 2017. Employing a qualitative description approach in health care research. Glob. Qual. Nurs. Res. 4, 2333393617742282.
Brown, N.I., 2012. Consequences of neglect: analysis of the sub-Saharan African snake antivenom market and the global context. PLoS Neglected Trop. Dis. 6, e1670.
Centre for Snakebite Research and Interventions, 2021. The African snakebite research group [online]. Available. https://www.lstmed.ac.uk/research/centres-and-units/centre-for-snakebite-research/the-african-snakebite-research-group. (Accessed 29 March 2021).
Chaves, L.F., Chuang, T.-W., Sasa, M., Gutiérrez, J.M., 2015. Snakebites are associated with poverty, weather fluctuations, and El Niño. Sci. Adv. 1, e1500249.
Chippaux, J.P., 1998. Snake-bites: appraisal of the global situation. Bull. World Health Organ. 76, 515–524.
County Government of Kitui, 2018. County integrated development plan 2018-2022. Available. https://www.cog.go.ke/downloads/category/106-county-integrated-development-plans-2018-2022/. (Accessed 8 March 2021).
Ediriweera, D.S., Kasturiratne, A., Pathmeswaran, A., Gunawardena, N.K., Jayamanne, S. F., Lalloo, D.G., De Silva, H.J., 2017. Health seeking behavior following snakebites in Sri Lanka: results of an island wide community based survey. PLoS Neglected Trop. Dis. 11, e0006073.
Gill, P., Stewart, K., Treasure, E., Chadwick, B., 2008. Methods of data collection in qualitative research: interviews and focus groups. Br. Dent. J. 204, 291–295.
Green, J., Thorogood, N., 2004. Qualitative Methods for Health Research. Sage Publications, London.
Gutiérrez, J.M., Calvete, J.J., Habib, A.G., Harrison, R.A., Williams, D.J., Warrell, D.A., 2017. Snakebite envenoming. Nat. Rev. Dis. Prim. 3, 17063.
Hajjaj, F.M., Salek, M.S., Basra, M.K., Finlay, A.Y., 2010. Non-clinical influences on clinical decision-making: a major challenge to evidence-based practice. J. R. Soc. Med. 103, 178–187.
Harrison, R.A., Casewell, N.R., Ainsworth, S.A., Lalloo, D.G., 2019. The time is now: a call for action to translate recent momentum on tackling tropical snakebite into sustained benefit for victims. Trans. R. Soc. Trop. Med. Hyg. 113, 835–838.
Harrison, R.A., Hargreaves, A., Wagstaff, S.C., Faragher, B., Lalloo, D.G., 2009. Snake envenoming: a disease of poverty. PLoS Neglected Trop. Dis. 3, e569.
Iliyasu, G., Tiamiyu, A.B., Daiyab, F.M., Tambuwal, S.H., Habib, Z.G., Habib, A.G., 2015. Effect of distance and delay in access to care on outcome of snakebite in rural north-eastern Nigeria. Rural Rem. Health 15, 3496.
Kasturiratne, A., Wickremasinghe, A.R., De Silva, N., Gunawardena, N.K., Pathmeswaran, A., Premaratna, R., Savioli, L., Lalloo, D.G., De Silva, H.J., 2008. The global burden of snakebite: a literature analysis and modelling based on regional estimates of envenoming and deaths. PLoS Med. 5, e218.
Kenya Ministry of Environment, Water and Natural Resources, State Department of Environment and Natural Resources & Kenya Meteorological Service, 2015. Kitui county climate information services strategic plan. Available: https://www.adaconsortium.org/index.php/component/k2/item/343-kitui-county-climate-information-services-strategic-plan. (Accessed 8 March 2021).
Kenya Ministry of Health Neglected Tropical Diseases Program, 2019. Guidelines for prevention, Diagnosis and Management of snakebite Envenoming in Kenya. Ministry of health [Kenya], Nairobi.
Kenya National Coordinating Agency for Population and Development, Kenya Ministry of Medical Services, Kenya Ministry of Public Health and Sanitation, Kenya National Bureau of Statistics & ICF Macro, 2011. Kenya Service Provision Assessment Survey 2010. Kenya, Nairobi. Available: https://dhsprogram.com/pubs/pdf/SPA17/SPA17.pdf. (Accessed 5 July 2021).
Kenyan Ministry of Health 2018. Unpublished data regarding snakebite frequency in Kitui County in 2018.
Kihiko, D., 2013. Venomous snake bite injuries at Kitui district hospital. Ann. Afr. Surg. 10, 15–20.
Mahmood, M.A., Halliday, D., Cumming, R., Thwin, K.T., Myitzu, M., White, J., Alfred, S., Warrell, D.A., Bacon, D., Naing, W., Aung, H., Thein, M.M., Chit, N.N., Serhal, S., Nwe, M.T., Aung, P.P., Peh, C.A., 2019. Inadequate knowledge about snakebite envenoming symptoms and application of harmful first aid methods in the community in high snakebite incidence areas of Myanmar. PLoS Neglected Trop. Dis. 13, e0007171.
Marshall, M.N., 1996. Sampling for qualitative research. Fam. Pract. 13, 522–526.
Mbindyo, P., Blaauw, D., English, M., 2013. The role of Clinical Officers in the Kenyan health system: a question of perspective. Hum. Resour. Health 11, 32.
Mckinlay, J.B., Potter, D.A., Feldman, H.A., 1996. Non-medical influences on medical decision-making. Soc. Sci. Med. 42, 769–776.
Michael, G.C., Grema, B.A., Aliyu, I., Alhaji, M.A., Lawal, T.O., Ibrahim, H., Fikin, A.G., Gyaran, F.S., Kane, K.N., Thacher, T.D., Badamasi, A.K., Ogwuche, E., 2018. Knowledge of venomous snakes, snakebite first aid, treatment, and prevention among clinicians in northern Nigeria: a cross-sectional multicentre study. Trans. R. Soc. Trop. Med. Hyg. 112, 47–56.
Ministry of Medical Services & Ministry of Public Health and Sanitation, 2009. Access to essential medicines in Kenya: a health facility survey. Available. https://pharmacyboardkenya.org/files/?file=Kenya_Health_Facility_Survey_2010.pdf. (Accessed 5 July 2021).
Morgan, D., 1998. The Focus Group Guide Book. Sage Publications, London.
Murray, C.D., Wynne, J., 2001. Researching community, work and family with an interpreter. Community Work. Fam. 4, 157–171.
Ngugi, A.K., Agoi, F., Mahoney, M.R., Lakhani, A., Mang'ong'o, D., Nderitu, E., Armstrong, R., Macfarlane, S., 2017. Utilization of health services in a resource-limited rural area in Kenya: prevalence and associated household-level factors. PloS One 12 e0172728–e0172728.
Nvivo, 2015. Nvivo 11 Qualitative Data Analysis Software, 11 ed. QSR International Pty Ltd.
Ooms, G.I., Van Oirschot, J., Waldmann, B., Von Bernus, S., Van Den Ham, H.A., Mantel-Teeuwisse, A.K., Reed, T., 2020. The current state of snakebite care in Kenya, Uganda, and Zambia: healthcare workers' perspectives and knowledge, and health facilities' treatment capacity. Am. J. Trop. Med. Hyg.
Peden, M., Oyegbite, K., Ozanne-Smith, J., Hyder, A., Branche, C., Rahman, A., Rivara, F., Bartolomeos, K., 2008. World Report on Child Injury Prevention. World Health Organization, Geneva. Available: https://apps.who.int/iris/bitstream/handle/10665/43851/9789241563574_eng.pdf;jsessionid=E5C52917287B95C0C201B47C4A59EBFA?sequence=1. (Accessed 22 March 2021).
Rahman, R., Faiz, M.A., Selim, S., Rahman, B., Basher, A., Jones, A., D'este, C., Hossain, M., Islam, Z., Ahmed, H., Milton, A.H., 2010. Annual incidence of snake bite in rural Bangladesh. PLoS Neglected Trop. Dis. 4, e860.
Rural Extension with Africa's Poor (Reap), 2018. Black stone [Online]. Available: https://reap-eastafrica.org/wp-content/uploads/2018/04/Black-Stone.pdf. (Accessed 14 August 2019).
Samuel, S.P., Soundararaj, C., Williams, H.F., Elamaran, P., Mangaiyarkkarasai, S., Mohanraj, V., Sundhararajan, A., Rajendran, V., Baksh, M.F., Patel, K., Trim, S.A., Duncombe, T.E., Vaiyapuri, S., 2020. Venomous snakebites: rapid action saves lives - a multifaceted community education programme increases awareness about snakes and snakebites among the rural population of Tamil Nadu, India. PLoS Neglected Trop. Dis. 14.
Schioldann, E., Mahmood, M.A., Kyaw, M.M., Halliday, D., Thwin, K.T., Chit, N.N., Cumming, R., Bacon, D., Alfred, S., White, J., Warrell, D., Peh, C.A., 2018. Why snakebite patients in Myanmar seek traditional healers despite availability of biomedical care at hospitals? Community perspectives on reasons. PLoS Neglected Trop. Dis. 12, e0006299.
Smith, M., Higgs, J., Ellis, E., 2008. Factors influencing clinical decision making. In: Higgs, J., Jones, M., Loftus, S., Christensen, N. (Eds.), Clinical Reasoning in the Health Professions., third ed. Butterworth Heinemann, Philadelphia.
Stock, R.P., Massougbodji, A., Alagón, A., Chippaux, J.-P., 2007. Bringing antivenoms to Sub-Saharan Africa. Nat. Biotechnol. 25, 173–177.
Taieb, F., Dub, T., Madec, Y., Tondeur, L., Chippaux, J.P., Lebreton, M., Medang, R., Foute, F.N.N., Tchoffo, D., Potet, J., Alcoba, G., Comte, E., Einterz, E.M., Nkwescheu, A.S., 2018. Knowledge, attitude and practices of snakebite management amongst health workers in Cameroon: need for continuous training and capacity building. PLoS Neglected Trop. Dis. 12, e0006716.
Warrell, D.A., 2010. Snake bite. Lancet 375, 77–88.
World Health Organization Service Delivery and Safety Department 2018. Improving the quality of health services: tools and resources. Geneva: World Health Organization. Available: https://apps.who.int/iris/bitstream/handle/10665/310944/9789241515085-eng.pdf. (Accessed 5 July 2021).
World Health Organization, 2019. Snakebite Envenoming: a Strategy for Prevention and Control. World Health Organization, Geneva. Available: https://apps.who.int/iris/bitstream/handle/10665/324838/9789241515641-eng.pdf?ua=1. (Accessed 8 March 2021).
World Health Organization Regional Office for Africa 2010. Guidelines for the prevention and clinical management of snakebite in Africa. Mauritius: WHO Regional Office for Africa. Available: https://apps.who.int/iris/bitstream/handle/10665/204458/9789290231684.pdf?sequence=1&isAllowed=y. (Accessed 5 July 2021).