



“At the hospital they do not treat venom from snakebites”: A qualitative assessment of health seeking perspectives and experiences among snakebite victims in Rwanda

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ABSTRACT

Snakebite envenomation (SBE) is a serious medical condition with human, animal, and environmental factors driving occurrence. In Rwanda, the number of SBE cases reported by the medical system is far lower than regional estimates for SBE incidence, suggesting that victims might be seeking care outside of formal medical structures. Our goals were to describe circumstances surrounding snakebite and to explore experiences of snakebite victims in accessing treatment. For this qualitative study, our team recruited individuals bitten by snakes between 2013 and 2018, who sought care either from traditional healers (N = 40) or hospitals (N = 65). In-depth interviews based on a semi-structured interview guide were conducted by telephone in Kinyarwanda. Inductive thematic analysis was conducted by two team members. Our respondents reported similar environmental circumstances surrounding their snake encounters; namely, farm fields, roads, and their homes, as well as inadequate lighting. Unsafe First Aid practices, including burning/sucking/cutting the skin and tourniquet, were often performed immediately after bites. Respondents reported various reasons for seeking traditional or hospital care, such as perceived cost, distance, transportation, and especially, community beliefs and treatment outcomes of other victims. Respondents described envenomation of livestock as well as the sale of livestock to pay SBE-related medical expenses. Improving trust and use of formal medical services will require enhanced hospital delivery of high quality medical services for SBE through improved stocking of appropriate anti-venom and reduced delays during intake. Communities might also benefit from education campaigns that discourage unsafe First Aid practices and address the common misperception that physicians are not trained to treat SBE.

1. Introduction

Snakebite envenomation (SBE) is a serious medical condition that occurs when snake venom is injected into or spat at a victim. It affects up to 2.7 million people each year, killing 81 000–138 000 individuals and inflicting long-term disability, such as blindness, limb amputation, on 400 000 (WHO, 2021). Those at highest risk live in impoverished and rural communities in Sub-Saharan Africa and South Asia and engage in work overlapping with snake habitats (e.g., cultivation, resource extraction; Harrison et al., 2009; Longbottom et al., 2018; WHO, 2021). Factors affecting healthcare delivery often include proximity to health services, availability of essential medicines such as appropriate

anti-venom, and knowledge of medical personnel (Michael et al., 2011; Ooms et al., 2020; Visser et al., 2004).

In Rwanda, it is uncertain how many people are envenomed by snakes each year. One model, based on regional data, estimated that 4171 cases (95% CI: 3454–4885) and 196 deaths (95% CI: 136–391; Halilu et al., 2019) occur throughout the country each year. However, in 2017 and 2018, only 182 SBE cases were reported by hospitals annually (Nduwayezu et al., 2021). The gap between the estimated incidence rate and those presenting for treatment at hospitals is perhaps explained by the number of patients seeking care from traditional healers. Elsewhere in Sub-Saharan Africa, traditional medicine is commonly sought following snakebite and can include application or ingestion of

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herbs/urine/snake bile/oils, use of tourniquets, burning/sucking/cutting the skin, black stone application, and prayer/incantations (Alcoba et al., 2020; Michael et al., 2011; Sloan et al., 2007; Steinhorst et al., 2021). An assessment of hospital records in Rwanda reported that laboratory tests (e.g., complete blood counts, coagulation factor tests) were not routinely ordered for SBE patients and that appropriate anti-venom was unavailable (Nduwayezu et al., 2021). No studies have been conducted in Rwanda to understand SBE victim preferences for formal medical care versus traditional medicine.

Human-snake conflicts, including SBE, are driven by human, animal, and environmental factors, including poverty, human/animal behavior, land use modification, climate, changes in snake distribution, food storage, and housing construction (Gutiérrez, 2020; WHO, 2021). Some factors, such as human behavior, can also be protective when a person chooses to wear closed-toe shoes, carry a torch at night, or avoid snake habitats. Population level consequences of SBE, such as human and livestock morbidity and mortality, snake depopulation, and ecosystem disruptions are multi-dimensional, highlighting the value of exploring SBE through a One Health lens. In Rwanda, human, animal, and environmental circumstances surrounding snakebite occurrence and healthcare experiences have not been documented but could provide valuable insights into SBE prevention and patient care. In this paper, we describe human activities and environment immediately preceding snakebite and characterize experiences accessing formal and informal care.

2. Methods

2.1. Study setting

Rwanda is a low-income country based in Sub-Saharan Africa. It is densely populated (~499 persons/km²) with approximately 12.2 million residents who are mostly engaged in subsistence cash-crop and livestock production (FAO, 2019). Human healthcare is organized from village to provincial levels with 3–4 Community Health Workers (CHWs) elected per village to provide basic services and referrals. People share the land with thirteen species of medically important snakes. Those classified as highest medical importance (i.e., Category 1) include puff adders (*Bitis arietans*), Jameson's mambas (*Dendroaspis jamesoni*), and black-necked spitting cobras (*Naja nigricollis*) (WHO, 2010a). Those of secondary medical importance (Category 2) include Bibron's burrowing asp (*Atractaspis bibronii*), variable burrowing asp (*Atractaspis irregularis*), East African Gaboon viper (*Bitis gabonica*), rhinoceros viper (*Bitis nasicornis*), black mamba (*Dendroaspis polylepis*), forest vine snake (*Thelotornis kirtlandii*), boomslang (*Dispholidus typus*), banded water cobra (*Naja annulata*), forest cobra (*Naja melanoleuca*), and Gold's tree cobra (*Pseudohaje goldii*) (WHO, 2010a). The year is divided into two rainy and two dry seasons.

2.2. Data collection

Previously, our team evaluated the demographics and medical care of patients who sought treatment for SBE at all district and provincial hospitals in Rwanda in 2017 and 2018 (Nduwayezu et al., 2021). In this qualitative follow-up study, we reconnected with those hospital patients (HPs) to better understand the circumstances of their snake encounter and treatment experiences. Because we did not have permission to contact patients directly after their hospital discharge, we asked hospital clinical staff to contact them using the number reported in the hospital files. For those who could not be reached by telephone, we requested CHWs stationed in the patients' villages to contact the patients, explain the purpose of the research, and request permission for our data collectors to contact them. The same CHWs were also asked to contact other community members bitten by snakes during the previous five years, regardless of whether they had sought treatment from formal (e.g., government hospital) or informal (e.g., traditional healer, self-care)

sources. This was considered the best option for recruitment because CHWs have detailed and long-term knowledge of individual health events, have access to contact information, and have a high level of trust within communities.

An in-depth interview guide was developed in English, translated to Kinyarwanda, pre-tested, and modified according to enumerator and participant feedback (Supplemental File 1). Interview themes followed One Health principles to best understand the human, animal and environmental factors surrounding SBE. Specific questions addressed demographics (age, sex, occupation, socio-economic status), patient activities and environment immediately preceding the bite, First Aid performed, care-seeking behaviors and beliefs (formal versus informal), treatment experiences, treatment satisfaction, and knowledge of livestock SBE. Due to national COVID-19 movement restrictions, interviews were conducted remotely, using either the CHW or respondent's mobile phone. In Rwanda, the Rapid SMS program provides all CHWs with mobile phones for use in reporting, referral and follow up of patients. Therefore, phone ownership did not limit participation. Two phone call attempts on separate days were made to contact potential participants before they were considered unavailable. Two enumerators (MTM and DMR) conducted the interviews in Kinyarwanda either directly with the SBE patient, or in the case of children or those with hearing impairment, by a legal guardian or close family member. Both are fourth year medical students, one male and one female, familiar with conducting patient interviews. Each interview took approximately 25 min to complete, were audio-recorded, transcribed in Kinyarwanda, translated into English, and then checked by AD and RN for translation errors.

2.3. Analysis

The data were analyzed using a grounded theory approach. Two researchers (JMS, AD) conducted inductive thematic analysis by developing a draft codebook after reading 20 randomly selected transcripts and then added codes as necessary to capture emerging themes. Transcripts were coded using NVivo v12 (QSR International, Melbourne, Australia) and compared using Cohen's Kappa with a minimum agreement threshold of 0.8. Discrepancies between coders were resolved through discussion. The research team adhered to the Standards for Reporting Qualitative Research checklist in developing this manuscript (O'Brien et al., 2014).

2.4. Ethics

This research was reviewed and approved by the Institutional Review Board at the University of Global Health Equity (#0076) and the Rwanda Ministry of Health in collaboration with Rwanda Biomedical Center. All participants provided informed consent prior to being interviewed.

3. Results

3.1. Demographics

Of the 363 SBE patients who sought hospital care in 2017 and 2018, 116 provided a telephone number in their patient file or sufficient geographic information that we could identify a CHW linked to their village. Of these, 56 consented to participate. Two declined to participate; the remainder did not answer their phone despite repeated attempts and could not be located by a CHW. CHWs enrolled a further nine SBE patients who sought formal medical care and 40 who sought care from traditional healers.

Of the 65 HPs (47 females and 18 males), the median age was 28 years (range: 1–80 years) with participants' ubudehe (socioeconomic) status distributed between the 1st (lowest) tier (16%), 2nd tier (44%), and 3rd tier (38%). The median age among the 40 traditional healer patients (THPs; 17 females and 23 males) was 36 years (range 12–90

years), with ubudehe represented in the 1st (18%), 2nd (53%) and 3rd tiers (29%). No participants belonged to the wealthiest income category (4th tier). Occupation was consistent between HPs and THPs with half identifying as farmers (50%), followed by students (25%), tradespersons (11%), unemployed (10%), and CHW/homemaker (1% each). One-fourth (25%) were under 18 years, with no occupation. Participants lived in 62 different sectors across all five provinces. Among those who visited district hospitals, 63% were treated as inpatients.

Transportation for seeking care differed between HPs and THPs. Those seeking hospital care most often travelled by motorcycle taxi (68%), followed by walking (13%), car (9%), ambulance/bicycle taxi (each 8%), bus (3%) and carried on foot (3%). In contrast, THPs often required no transportation as traditional healers visited them at home (37%). Those remaining walked (31%), were carried on foot by stretcher (17%), bicycle taxi (11%), or motorcycle taxi (3%). Those seeking hospital care reported up to three modes of transportation (e.g., walking, motorcycle taxi, ambulance) while THPs reported only one mode of transportation. Respondents who incurred out-of-pocket medical costs covered their expenses through various means: savings (44%), loans from family, friends, or community organizations (20%), Community Based Health Insurance (CBHI -12%), family/employer (10%), selling livestock or agricultural produce (9%), or negotiating a payment plan (2%). As one patient said, "We have sold our cow to pay the hospital".

3.2. Snakebite circumstances

Snakebite patients reported similar environments and activities preceding snakebites, regardless of care-seeking decisions. Outdoor environments were mentioned often; specifically, public roads (36%), agricultural locations (fields, forests, marshlands; 24%) and directly outside homes (14%). Respondents were often walking or biking on public roads or performing agricultural tasks, such as cultivating crops, preparing land, herding livestock, cutting grass for livestock, collecting firewood, or fetching water. Respondents also reported bites that occurred inside their homes (26%), usually while the victim was asleep or performing domestic chores. A few were bitten when they arose during the night to use the latrine or to answer the door. Low visibility was consistently mentioned, either due to overgrowth of vegetation or poor/absent lighting (e.g., indoors or on public roads). Almost all were surprised by the bite and did not see the snake until afterwards. Accidentally stepping on the snake was a common precursor to being bitten. Respondents were generally unable to identify the snake.

3.3. First Aid

Directly following the snakebite, HPs and THPs described being supported by family, friends, and strangers who performed First Aid techniques, offered advice on where to seek treatment, and often killed the snake. Most respondents (68%) received some type of First Aid prior to seeking care from a traditional healer or medical doctor. This included application of a tourniquet to slow the spread of venom (often with long grasses or a cloth), burning the bite area with matches to suck out venom, drinking herbal concoctions, cutting the skin with razor blades to remove snake fangs, putting a black stone, charcoal, or candle wax on the bite site, or urinating on the wound. One respondent said, "the people with me tied me above the foot using a long herb called umucaca and burnt the area to suck out the venom [HP 154]." Others received spiritual support: "The only help I got was prayers. Christians came and prayed for me, even the pastor came [HP 156]."

HPs and THPs reported various symptoms including pain, sudden and severe swelling, inability to stand or walk, nausea (including vomiting, diarrhea), numbness/paralysis, fever/chills, sweating, drooling, difficulty swallowing, uncontrolled bleeding, dizziness, blurred vision, itching, and skin reactions such as hives and color changes. One THP described his experience as follows: "It spat me in the face, and I was blind immediately. My eyes hurt like they had chili pepper in them. I

couldn't open my eyes [THP 220]." Many felt afraid and thought they might die: "I got afraid, leg swelling, weakness, chills, and I was feeling that I was going to die. All I wanted was to be lying down [HP 204]." A few did not experience any serious symptoms or feel worried.

3.4. Healthcare experiences

Altogether, HPs and THPs described several care seeking routes:

1. Seeking formal care immediately (CHW, health clinic, or hospital)
2. Seeking informal care immediately (traditional healer)
3. Waiting at home until symptoms worsened and then seeking care (traditional healer or hospital)
4. Seeking care from a traditional healer and then transferring to a hospital
5. Seeking care from a hospital and then transferring to a traditional healer

Respondents generally understood that snakebites could be serious due to the rapid spread of venom and that they should seek care quickly: "What I can tell you is that a snake has strong venom. When it bites you, it feels like needles, you have nausea and severe pain. If it comes to a child, it's even fatal [HP 173]." Many of those who went to a hospital felt that they did not wait long to be examined by a physician. However, delays in the interval between bite and treatment did occur, and these were due to distance to hospital, difficulty obtaining transportation, lack of ambulances to transfer patients, seeking traditional medicine first, adopting a wait and watch approach, being denied care until their national identity card was presented, being triaged behind other patients, and being transferred because the first facility did not have necessary medicines. "I was in a bad condition, and we kept calling motorcyclists and they were all saying they cannot go during the night. We could not get a motorbike until it was 3 a.m. [HP 156]." A few respondents received no treatment and were told to go home and return if the wound became swollen.

THPs and HPs generally did not know what specific care they received and described treatments as tablets, injections, ointments, herbal drinks and cutting the skin. "It was red pills, but I don't remember the name ... at [X] District Hospital, again they gave me some pills, also an injection, and they applied a small black stone to suck out the venom [HP 178]". Some arrived at facilities with stock outs of essential medicines and were obliged to go elsewhere or buy medicines at a private pharmacy. Black stone therapy was administered by both traditional healers and physicians despite patient feedback that the stone was ineffective in reducing pain or swelling.

Although most respondents visited either a hospital or traditional healer, some patients visited both. This occurred due to treatment failure, referral, or loss of trust. One respondent went to a hospital first: "After getting to hospital I was not cared for properly. I took a tablet that they gave me, but I was not injected because injections were out of stock. So, they sent me to a pharmacy outside of the hospital to buy these bottles of injections. I paid for those injections and waited until it became too late. I thought I could die ... I decided to leave the hospital and went to traditional healers to seek their help [HP 201]." Another sought formal care only after traditional medicine failed: "I ran to the traditional healer who they said was an expert in treating snakebite victims. But he failed to help me. I went back home in the evening. I became severely ill, and I was feeling that I was about to die so I decided to go to the hospital [HP 77]."

3.5. Satisfaction/perspectives on care

Patients who sought care from hospitals were largely satisfied with the care they received, regardless of whether they encountered delays or recovered fully. "I was satisfied with the treatment I was given at the hospital, for if I had not gone there, I would not have lived [HP 2]." Some

believed they might die or experienced overwhelming pain that physicians were able to relieve; others were surprised that physicians could treat snakebite: “Yes, I was satisfied, because there is a myth saying that at the hospital, they do not treat venom from snakebites, that the traditional healers are the one who can treat it, so I was very surprised, but I was happy with how I was healed at the hospital [TP 124].”

Patients who sought care from traditional healers were largely influenced by the success or failure of the treatment they received. Those who recovered fully were satisfied while those suffering long-term effects were not: “No. Before the snakebite, I used to walk normally. During that period of 4 months when I was sick, I couldn’t walk for long, and I started to walk abnormally. People who have been seeing me walking, told me I no longer walk as before [THP 232].”

These two groups also differed in the care seeking recommendations they would give to other victims. Those who had been treated by physicians stated they would advise other snakebite victims to immediately seek hospital care:

“Even though there is some fake news that people come and talk about traditional care, I have talked with someone who said that his mom spent 3 years with a wound caused by a snake bite, but me I had no wound not even a scar, and I think all of this are due to medications from the hospital. That’s why I advise those people to seek medical care because they have anti-venom medications which kill those venoms to prevent them from having a negative effect on someone’s body [HP 60].”

“Yes, at the hospital I paid them, and they treated me. If someone is bitten by a snake, I would advise him to seek medical care and not go to traditional healers because I paid them a lot of money and they failed to help me [HP 77].”

THPs offered two types of advice. Some recommended traditional medicine due to their own positive experiences, the convenience of having traditional healers in their village, or stories of people dying of SBE in hospitals. Traditional healers were perceived to cost less than hospitals and to offer flexible repayment plans: “Because I did not have health insurance, we thought we would be charged a lot of money, so to ease things, we decided to seek the traditional healer”. One common belief was that physicians could not treat SBE. “I have never seen a snakebite victim who went to the hospital; they all go to the traditional healers [THP 146].” This influenced several respondents to seek traditional medicine despite having access to CBHI.

Other THPs recommended hospital care, despite going to a healer themselves, and listed several reasons for their own decision: lack of health insurance, peer pressure from family, perceptions about healers, distance to care, and physician availability:

“I can encourage them to go to the hospital. I have seen that snakes have bad venoms. There is a woman here in our village who was bitten, and her leg was about to be amputated ... It is good to go to the hospital. The reason why we don’t go there is the problem of health insurance [THP 206].”

“The reason is that at the hospital they are educated, they have spent time learning how to treat people. You can go to the traditional healers only if the hospital is far away from you [THP 230].”

3.6. Prevention

Few respondents described taking measures to reduce the risk of snake encounters. These included patching mouse holes in the walls of their homes, removing vegetation or gardens near their homes, killing snakes, and wearing tall boots. When encountering a snake, people could kill it, run away, or cover their eyes to avoid envenomation. Protective footwear was not feasible for all respondents: “How can you cultivate while wearing shoes? When you are going to cultivate, you

remove them. That’s when it bit me [THP 216].” Several respondents mentioned that traditional medicine protected against future bites. A few mentioned the use of torches to examine their wound or to search for the snake after being bitten but not to avoid snakes. “After knowing that I was bitten by a snake I went to see a traditional healer. He treated me and told me that he removed the snake’s teeth and he told me that me and the people we were with will never be bitten by a snake again [THP 208].”

3.7. Livestock

Approximately half of respondents were aware of domestic animals that were bitten by a snake. These included cattle, goats, sheep, chickens, and dogs. Livestock were often bitten while grazing and many died quickly thereafter. Respondents were divided on treatment options. Some believed that there was no treatment for animals, “They can’t treat them. How can you treat a chicken [THP 218]?”. However, most respondents, regardless of whether they sought care for their own bite from a hospital or traditional healer, relied on traditional healers to cure their animals. One person mentioned calling a veterinarian as a last resort, “To stop the poisons from spreading, traditional healers give it medications. If that fails, they go to the veterinary doctor [HP 125]”. Respondents were unanimous that envenomed livestock were unsafe for human consumption and reported burying the deceased animal, “They bury it because you can’t eat a snake bitten cow. The venom would kill you [THP 146].”

4. Discussion

The World Health Organization recommends that individuals bitten by venomous snakes seek immediate care from a hospital equipped to provide appropriate care (Spyres et al., 2016). While some study participants sought hospital care immediately, many delayed by applying inappropriate First Aid, waiting at home until symptoms were unbearable, or seeking care from traditional healers first. Social pressure, misperceptions surrounding physicians’ ability to provide care, distance to hospitals and uncertainty of treatment costs were major reasons our respondents delayed or avoided hospitals. This aligns with other studies spanning Sub-Saharan Africa demonstrating a high usage of traditional medicine (Alcoba et al., 2020; van Oirschot et al., 2021; Sloan et al., 2007; Steinhorst et al., 2021). Moreover, for those bitten in rural and remote locations, traditional medicine is often perceived to be more accessible and affordable (Bénard-Valle et al., 2015; Owuor et al., 2005). In Rwanda, those in the lowest socioeconomic category are mandated to receive free diagnostics and treatment at government facilities under the Rwanda Social Security Board scheme which entitles them to subsidized CBHI. However, this insurance does not generally cover transportation costs unless a patient was transferred by ambulance to a referral facility.

Snakebite victims in this study encountered snakes while working in agricultural areas, walking on roads, and while in their homes/yards, highlighting the importance of managing shared human-snake environments. This finding aligns with other studies in Sub-Saharan Africa where farming and domestic activities (including sleeping) have been highlighted as key activities preceding SBE (van Oirschot et al., 2021; Owuor et al., 2005; Sloan et al., 2007). Poor visibility and lack of closed-toed shoes were common among those bitten in Rwanda. This suggests that simple measures such as wearing shoes, upgrading lighting infrastructure in homes and along roads, carrying a torch, clearing brush from paths, and making homes impervious to snakes could play a major role in reducing the occurrence of SBE. A few respondents already engaged in activities to reduce snake encounters around their homes (e. g., clearing brush); however, most did not and wearing shoes was not universally considered feasible. This has also been documented among individuals experiencing other shoe-preventable NTDs, such as podocniosis, with gender, poverty, culture, and comfort related to the practice of farming barefoot (Kelemework et al., 2016). Our finding that

snake encounters were accidental is common in the African context but differs from other regions where envenomation is also associated with purposeful handling of venomous snakes (Spyres et al., 2016).

Most snakebite victims in this study reported receiving First Aid prior to seeking formal or informal care and killing the snake. The field practices reported in Rwanda (tourniquets, cutting or burning skin, urinating on the wound, and ingesting herbal concoctions) appear to be common regionally and have been reported in several other African countries (e.g., Nigeria, South Africa, Cameroon, Kenya; Alcoba et al., 2020; Michael et al., 2011; van Oirschot et al., 2021; Owuor et al., 2005; Sloan et al., 2007; Steinhorst et al., 2021). Such practices differ from global recommendations from the medical community, which advocate taking distance from the snake to avoid further injury, laying down with the wound below the heart, removing tight jewelry/clothing, and covering the wound with a dry, clean dressing (WHO, 2010b). Applying tourniquets and attempting to remove venom by cutting, burning, or applying suction can cause additional harm and delay the time to receiving evidence-based medical treatment (Alcoba et al., 2020; Bénard-Valle et al., 2015; Michael et al., 2011; Sloan et al., 2007).

Stories about how other SBE victims were treated and whether they recovered strongly influenced respondents' health seeking behaviour. Rwandese patients who sought care at hospitals most often felt they would advise others to do likewise; however, patients of traditional healers were split, either advising future patients to seek formal or informal medical attention. In Ghana, SBE patients have also reported seeking care from traditional healers following a hospital visit, primarily due to medicine stock-outs, insufficient pain relief, and the need for spiritual healing (Steinhorst et al., 2021). Moreover, an intervention to optimize patient care resulted in a 50% increase in SBE hospital admissions, highlighting both the power of word-of-mouth and the importance of ensuring that hospitals have access to appropriate essential medicines, such as anti-venom (Visser et al., 2004).

Within our study group, SBE was almost universally considered a highly traumatic event, with many experiencing long-term physical and psychological sequelae. Patients' satisfaction with treatment, either from traditional healers or medical doctors, was strongly linked to their recovery rather than inconveniences experienced such as waiting times, pharmaceutical stock-outs, or out-of-pocket costs. Patients presenting at hospitals were generally satisfied with their care; however, several procedural challenges were documented that could seriously impact patient outcomes. These occurred during (1) admission (e.g., patients sent home to retrieve documentation), (2) triage (e.g., waiting to receive care), (3) diagnosis (e.g., physicians chose not to examine patients unless symptoms worsened), and (4) management (e.g., patients prescribed non-standard treatment such as black stone). Like other studies in Sub-Saharan Africa, this confirms the need for improved awareness among healthcare providers to improve hospital and physician capacity for SBE management practices that optimize patient outcomes (Ameade et al., 2021; Michael et al., 2018; Ooms et al., 2020; Taieb et al., 2018). Satisfaction among THPs was divided, with some adamant that they were cured by traditional medicine, and others highly dissatisfied. There is no empirical evidence to support traditional therapies such as herbal drinks, skin burning, or black stone. It is important to note that not all snakes are venomous and that not all individuals bitten by venomous snakes are envenomed, with up to 50% of bites estimated to be 'dry' (WHO, 2016).

Study respondents confirmed two connections between livestock and SBE. First, livestock are routinely sold to repay medical expenses for people who have been envenomed, and second, livestock themselves are envenomed by snakes, sometimes fatally. In both cases, households incur financial loss (Bolon et al., 2019). As in Botswana, respondents reported several strategies for managing livestock bitten by snakes – doing nothing or seeking traditional medicine and/or veterinary care (Bolon et al., 2019; Setlalekgomo, 2015). Knowledge of veterinary services did not appear to be widespread and numerous questions remain regarding the level of trust in veterinarians treating SBE, the quality of

veterinary services, the availability of anti-venom and other essential medicines in SBE management, and the knowledge of veterinary practitioners.

This study had several limitations. The qualitative research design had lower external validity than a quantitative study; however, it allowed us to broadly explore experiences relating to snakebite occurrence and care seeking. We believe these findings are transferable within Rwanda due to the large sample size, broad geographic representation, national uniformity, and alignment with regional data. Our sampling strategy relied on accurate and up-to-date patient contact details in patient files, but these were often incomplete. We attempted to minimize this bias by contacting CHWs closely linking to the available address but also asking CHWs to recruit SBE victims from their communities. Any intervention to improve healthcare reporting should also address issues related to patient identification and contact information. Lack of reporting infrastructure is not unique to Rwanda; a formal SBE reporting mechanism linking villages to national databases would significantly improve future opportunities for follow-up studies (Chippaux, 2008; Ooms et al., 2020; WHO, 2021). Our study did not evaluate envenomation severity and therefore, it is unclear whether this influences care-seeking behavior.

5. Conclusions

This One Health study defines many of the environmental circumstances and human behaviors relating to snake-human conflicts in Rwanda. HPs and THPs reported similar snakebite circumstances, First Aid experiences and approaches to prevention, but differed in age/gender demographics, transportation modes, health care experiences, and overall satisfaction with care. Overall, 41% of respondents covered their treatment costs by loans, financial gifts or selling household property. Like other contexts, this suggests that SBE does present a long-term financial burden in addition to physical pain and suffering (Kasturiratne et al., 2021). Since respondents often chose a treatment option based on community beliefs or the treatment outcome of other victims, providing gold standard medical treatment that optimizes patient outcomes should be a priority for addressing the misperception that physicians are not able to treat SBE. Work to improve community trust should include trusted traditional healers and CHWs working at the village level and should also consider the social, economic, and occupational circumstances of those at highest risk to ensure that any interventions are affordable, acceptable, and accessible.

Author contributions

JMS – Conceptualization, Methodology, Formal analysis, Supervision, Writing - original draft; AD - Formal analysis, Writing - review & editing; MTM – Investigation, Writing - review & editing; DMR – Investigation, Writing - review & editing; RN – Conceptualization, Methodology, Investigation, Supervision, Writing - review & editing; JHA – Conceptualization, Funding acquisition, Resources, Writing - review & editing

Ethical statement

This research was reviewed and approved by the Institutional Review Board at the University of Global Health Equity (#0076) and the Rwanda Ministry of Health. All participants provided informed consent prior to being interviewed.

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Declaration of competing interest

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Appendix A. Supplementary data

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