Am. J. Trop. Med. Hyg., 104(2), 2021, pp. 774–782
doi:10.4269/ajtmh.20-1078

The Current State of Snakebite Care in Kenya, Uganda, and Zambia: Healthcare Workers' Perspectives and Knowledge, and Health Facilities' Treatment Capacity

Gaby I. Ooms,[1,2]* Janneke van Oirschot,[1] Benjamin Waldmann,[1] Sophie von Bernus,[1] Hendrika A. van den Ham,[2] Aukje K. Mantel-Teeuwisse,[2] and Tim Reed[1]

[1]*Health Action International, Amsterdam, The Netherlands;* [2]*Division of Pharmacoepidemiology and Clinical Pharmacology, Utrecht Centre for Pharmaceutical Policy and Regulation, Utrecht Institute for Pharmaceutical Sciences (UIPS), Utrecht University, Utrecht, The Netherlands*

Abstract. Snakebites continue to be a public health concern in sub-Saharan Africa, where availability of appropriate medical treatment is rare, even though death and disability can be prevented with timely intervention. A challenge is the lack of sociopolitical studies to inform health policies. This study aimed to identify snakebite patient profiles, healthcare workers' (HCWs) knowledge of snakebite, and facilities' snakebite treatment capacity in Kenya, Uganda, and Zambia to inform interventions to improve access to appropriate treatment. The research comprised a cross-sectional key informant survey among HCWs from health facilities in Kenya ($n = 145$), Uganda ($n = 144$), and Zambia ($n = 108$). Data were collected between March 2018 and November 2019. Most of the HCWs suggested that the number of snakebite incidents was similar between the genders, that most patients were aged 21–30 years, and most people were bitten when farming or walking. Overall, only 12% of HCWs had received formal training in snakebite management. Only about 20% of HCWs in each country said their health facility had the medicines needed to treat snakebites, with antivenom available in 0–34% of facilities across the sectors and countries, and snakebites were not systematically recorded. This research shows that an integrative approach through policies to increase resource allocation for health system strengthening, including community education, HCW training, and improved access to snakebite treatment, is needed. Part of this approach should include regulations that ensure antivenoms available in health facilities meet quality control standards and that snakebites are accommodated into routine reporting systems to assess progress.

INTRODUCTION

Globally, it is estimated that snakebite envenoming is responsible for more than 138,000 deaths and more than 400,000 permanent disabilities each year.[1] In sub-Saharan Africa, 314,000 snakebite envenomings cause between 5,900 to 14,600 amputations and 7,000 to 32,000 deaths annually.[2,3] While displaying a large range, these estimated incidences are also believed to be a gross underestimation of the actual situation, given that studies have shown that up to 70% of snakebite cases remain unreported.[4–6] A study on the burden of snakebite in West Africa estimated that the disability-adjusted life years caused by snakebites exceeded those of many other neglected tropical diseases which currently receive more attention.[7] In addition to a range of morbidities, such as tissue necrosis, persistent nerve damage, and amputation, victims may suffer from psychological distress and stigmatization in their communities.[3,8]

Adequate and timely medical treatment can prevent serious health complications of snakebite envenomings. However, in sub-Saharan Africa, effective treatment is scarce, and issues of poor antivenom production, inadequate distribution, and poor efficacy of antivenom prevail.[9,10] In the past 10 years, the production of antivenom has failed to expand, and the antivenom supply chain is currently inadequate and unstable.[11,12] The lack of access to appropriate antivenom, in combination with traditional beliefs surrounding snakebite, leads victims to seek ineffective or adverse treatment from traditional healers. This also delays evidence-based treatment when time is of the essence.[3,8]

Snakebite envenomings have a massive impact on households and communities, and disproportionally affect poor communities. In sub-Saharan Africa, 97% of snakebite deaths occur in rural areas which depend on outdoor activities for livelihood, such as farming, fishing, hunting, and herding.[2,8,13,14] Snakebite incidents are highest among the most economically productive members of the community, and poor geographical access to and quality of healthcare in remote communities diminish the chance of receiving adequate treatment.[8,11,14] Moreover, even if people do make it to health facilities and treatment is available, treatment costs could cause catastrophic expenditure and additional financial hardship.[10,15] As such, snakebites aggravate socioeconomic inequalities.

Fortunately, with the right training, medicines, and equipment, combined with appropriate health-seeking behavior, snakebite patients can be properly managed, and the burden of snakebite morbidity and mortality can be significantly relieved.[16] To date, however, there are very little research efforts on snakebite in sub-Saharan Africa. In Kenya, Uganda, and Zambia, for instance, the few existing studies that involve primary data collection are generally of limited scale and scope or outdated.[17–21] To contribute to evidence about the country-specific snakebite burden and to inform policy intervention, a survey was conducted among healthcare workers (HCWs) employed in health facilities in Kenya, Uganda, and Zambia to identify snakebite incidents, patient profiles, HCWs knowledge, and health facilities' capacity to adequately treat snakebites.

MATERIALS AND METHODS

Study area and sampling. The sampling strategy used to identify health facilities was adapted from the WHO/Health Action International gold-standard methodology "Measuring medicine prices, availability, affordability, and price components," which recommends surveying 144 facilities from six regions to obtain a representative facility sample to create a picture of the country situation.[22] The methodology has been validated in many countries.[23,24] In Kenya and Zambia, data

* Address correspondence to Gaby I. Ooms, Health Action International, Overtoom 60-2, 1054 HK Amsterdam, The Netherlands. E-mail: gaby@haiweb.org

were collected across six counties and regions, respectively, of which three were thought to be snakebite-endemic areas and three were not. Uganda was divided into six survey regions from which data were collected. Furthermore, according to the sampling methodology, officially in each survey region, 24 health facilities should be randomly selected to participate in the research, equally divided across sectors (public, private, or private not-for-profit [PNFP]) and locations (urban or rural) (see Supplemental File 1). The national definition of urban varies in each of the countries; for the purpose of this study, an urban area was defined as a locality with a population of a minimum of 5,000 people where the main economic activity is nonagricultural and where basic modern facilities are present.[25,26] In this research, 24 facilities were randomly selected per survey region from a list, with allocation to sector and area performed afterward. In Zambia, the levels of health facilities surveyed ranged from health posts to general hospitals, and in Kenya from health posts to national university teaching hospitals. Similarly, in Uganda, the levels ranged from health centers II to regional referral hospitals.

Within each facility, one informant was selected to participate in a qualitative survey through convenience sampling. This informant needed to be a licensed HCW who had been working at the facility for more than a year.

Data collection tool. A HCW questionnaire was used, which collected informant information about snakebite incidents, patient profiles, HCW's knowledge, and the facility's capacity to treat snakebites. The questionnaire was informed by scientific literature and developed in collaboration with recognized snakebite experts from the Global Snakebite Initiative and local civil society experts. The questionnaire contained 33 questions and inquired about the number of snakebite cases in the last 6 months (Uganda) or 12 months (Kenya, Zambia), proportion of male–female snakebite patients, age of patients, the availability of antivenom at the facility, the type of snakebite treatment offered at the facility, HCWs' training on snakebites, and their perceived knowledge on snakebite treatment. To provide exact numbers on the amount of snakebite incidents and stock availability of antivenom, the HCW was asked to refer to their medical records. The remaining questions were based on the informants' experience. The questionnaire was pilot-tested in 2017 in 108 facilities in Kilifi County, Kenya, after which the tool was refined. The pilot test data were not included in this research. Furthermore, in each country, local partners provided feedback on the questionnaire, resulting in the slightly different phrasing of four questions (age, number of registered cases, knowledge on snakebite treatments, and consultation of traditional healer) between the countries, even though the essence remained the same.

Data collection. Data collection was performed by local organizations with experience in conducting similar research. Data collection teams worked in pairs and were supervised by a local survey manager. Data collectors received a 1-day training course in person (Kenya and Uganda) or through video-calling (Zambia), led by one of the investigators (S. v. B. or G. I. O.). In Uganda, data were collected in March 2018, in Zambia in July 2018, and in Kenya from March to November 2019.

Data analysis. All data collection forms were manually entered into Excel and cross-checked by two researchers for accuracy. Missing data and incorrectly answered questions were excluded from the analysis. Data analysis was performed in Microsoft Excel 365 (Microsoft, Redmond, WA), where an analysis tool was used to calculate medians, minimums, maximums, and frequencies using descriptive statistics.

Ethical considerations. In Zambia, approval was sought from the National Health Research Authority, and in Kenya, by the Amref Health Africa Ethics and Scientific Review Committee. In Uganda, no ethical approval was necessary, but permission for the research and letters of introduction to health facilities were secured from the Ministry of Health. These letters were also acquired in Kenya and Zambia. Informed consent was obtained from all participants, and all identifiers were replaced with codes to maintain anonymity and confidentiality.

RESULTS

Sample. A total of 118 HCWs in Zambia, 144 HCWs in Uganda, and 145 HCWs in Kenya were surveyed. In Kenya and Uganda, HCWS in facilities across the public, private, and PNFP sectors were included. In Zambia, data were collected from HCWs in the public and PNFP sectors only, as the private (for-profit) sector is of very limited scale. Healthcare workers working in PNFP facilities were subsequently excluded from analysis because of the small sample size. Hence, the included sample for Zambia totaled 108 HCWs working in public sector facilities. Table 1 is an overview of the participants' characteristics.

Snakebite demographics. Over a 6-month period in Uganda, 593 snakebite cases were registered in 140 facilities. In Kenya and Zambia, a respective 801 cases in 108 facilities and 662 cases in 86 facilities were registered over a 12-month period. In all three countries, most of the cases were registered in rural health facilities (see Table 2). In Kenya, the highest median number of registered cases was noted in level IV facilities; in Uganda and Zambia, it was noted in level III facilities.

In Kenya, HCWs' experiences regarding the months in which they saw most snakebites varied, and no clear patterns could be distinguished. Multiple months could be chosen. In Zambia, a clear majority of HCWs saw most snakebites in November to January. In Uganda, the largest proportions of HCWs saw more snakebite cases from October to December, and from April to June (see Figure 1).

Snakebite patient profile. In Kenya, almost half of HCWs claimed that the male–female ratio among snakebite patients was equal, whereas 30.4% thought there were mostly male patients and 18.8% thought there were mostly female patients. In Uganda and Zambia, the responses were similar (see Table 3). When asked about the age of those bitten by snakes, HCWs from all three countries indicated that individuals aged 21–30 years were most often bitten by snakes. In Uganda and Zambia, this was followed by the 11–20 years age-group, whereas the second most commonly mentioned age-group in Kenya was 31–45 years (see Table 3). According to HCWs in all three countries, farming was the most common activity performed by people at the time of the bite (55.3–75.4%), followed by simply walking, collecting firewood, and herding (depending on country) (see Table 3).

In Kenya, the survey further asked about the most commonly bitten body part. Multiple body parts could be chosen. More than eight in 10 HCWs believed the legs to be one of the most commonly bitten body parts, whereas about 30%

TABLE 1
Characteristics of study participants from Kenya, Uganda, and Zambia, per sector

	Kenya (*n* = 145)				Uganda (*n* = 144)				Zambia (*n* = 108)
	Public	Private	PNFP	Total	Public	Private	PNFP	Total	Public
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Facility location									
Urban	11 (10.6)	11 (47.8)	3 (16.7)	25 (17.2)	26 (40.6)	28 (66.7)	16 (42.1)	70 (48.6)	33 (30.6)
Rural	93 (89.4)	12 (52.2)	15 (83.3)	120 (82.3)	38 (59.4)	14 (33.3)	22 (57.9)	74 (51.4)	75 (69.4)
Profession									
Assistant	2 (1.9)	1 (4.3)	1 (5.6)	4 (2.8)	9 (14.1)	1 (2.4)	2 (5.3)	12 (8.3)	15 (13.9)
Nurse	60 (57.7)	7 (30.4)	9 (50.0)	76 (51.7)	30 (46.9)	17 (40.5)	17 (44.7)	64 (44.4)	61 (56.5)
Physician	37 (35.6)	15 (65.2)	8 (44.4)	60 (41.4)	24 (37.5)	24 (57.1)	19 (50.0)	67 (46.5)	31 (28.7)
Pharmacist	5 (4.8)	0 (0.0)	0 (0.0)	5 (3.4)	1 (1.6)	0 (0.0)	0 (0.0)	1 (0.7)	1 (0.9)
Facility level*									
Level I	45 (43.3)	12 (52.2)	11 (61.1)	68 (46.9)	17 (26.6)	11 (26.2)	13 (34.2)	41 (28.5)	33 (30.6)
Level II	37 (35.6)	10 (43.5)	5 (27.8)	52 (35.9)	36 (56.3)	27 (64.3)	15 (39.5)	78 (54.2)	63 (58.3)
Level III	16 (15.4)	0 (0.0)	1 (5.6)	17 (11.7)	6 (9.4)	4 (9.5)	10 (26.3)	20 (13.9)	7 (6.5)
Level IV	6 (5.8)	1 (4.3)	1 (5.6)	8 (5.5)	5 (7.8)	0 (0.0)	0 (0.0)	5 (3.5)	5 (4.6)

PNFP = private not-for-profit.
* Health facility levels in Kenya: I. Community health services and dispensary/clinic; II. Health centre; III. Subcounty hospital; IV. County hospital and above. Health facility levels in Uganda: I. Health centre; II. Health centres III and IV; III. Hospital; IV. Regional referral hospital and above. Health facility levels in Zambia: I. Health post; II. Health centre; III. District hospital; IV. General hospital and above.

of HCWs mentioned the feet, hands, and fingers (see Supplemental File 2).

Health facilities' resources and response. *Training and knowledge of snakebite management.* Training of HCWs on snakebites was found to be uncommon, ranging from 2.6% in the PNFP sector in Uganda to 22.2% in the PNFP sector of Kenya (see Table 4). Low percentages were also obtained for questions related to knowledge to treat snakebite adequately. In Uganda, less HCWs in the public sector believed they had the knowledge to adequately treat snakebites than those in the private and PNFP sectors (28.6% versus 65.9% and 57.9%, respectively) (see Table 4). In Zambia, 58.5% of the HCWs believed there was someone in the health facility, not specifically the HCW surveyed, who had the knowledge to treat snakebites, whereas in Kenya, 34.8% of HCWs believed they could differentiate a venomous snakebite from a nonvenomous snakebite. The overwhelming majority of HCWs in Uganda and Zambia referred to a lack of training and the need for more specialized training on how to manage snakebite patients as the reason for their lack of knowledge.

Treatment. In all three countries, both nurses and physicians are the ones commonly providing care to snakebite patients, with assistants not commonly treating snakebites (see Table 4). Only about 20% of HCWs across the countries said they had the necessary equipment and medicines available at the health facility to treat snakebites. In all countries, supportive treatment, comprising painkillers, fluids, tetanus vaccines, antibiotics, and hydrocortisone, was the most

TABLE 2
Total or median number of registered snakebites per location, geographic region, and facility level in Kenya, Uganda, and Zambia

	Kenya*		Uganda†		Zambia*	
	Facilities tracking cases	No of cases (12-month period)	Facilities tracking cases	No of cases (6-month period)	Facilities tracking cases	No of cases (12-month period)
	N (%)	*N* (range)	*N* (%)	*N* (range)	*N* (%)	*N* (range)
Per location, total						
Urban	16 (64.0)	211	67 (95.7)	231	22 (66.7)	149
Rural	92 (76.7)	590	74 (100.0)	362	64 (85.3)	513
Per geographic region, total‡						
Region I	23 (100.0)	191	29 (93.5)	183	16 (69.6)	229
Region II	12 (50.0)	99	34 (94.4)	123	26 (92.9)	171
Region III	15 (60.0)	53	36 (100.0)	160	29 (100.0)	174
Region IV	20 (83.3)	392	41 (100.0)	127	15 (53.6)	88
Region V	24 (100.0)	12	NA	NA	NA	NA
Region VI	14 (58.3)	54	NA	NA	NA	NA
Per facility level, median§						
Level I	48 (70.6)	1.0 (0–22)	41 (100.0)	1.0 (0–10)	29 (87.9)	3.0 (0–20)
Level II	39 (75.0)	1.0 (0–76)	76 (97.4)	2.0 (0–39)	50 (79.4)	6.0 (0–65)
Level III	16 (94.1)	8.0 (0–48)	20 (100.0)	5.5 (0–23)	5 (71.4)	17.0 (3–30)
Level IV	5 (62.5)	12.0 (1–47)	4 (80.0)	3.0 (0–41)	2 (40.0)	5.5 (3–8)

NA = not applicable.
* Snakebites registered over the previous 12 months.
† Snakebites registered over the previous 6 months.
‡ In Kenya, region I: Kajiado County; region II: Kilifi County; region III: Kirinyaga County; region IV: Kwale County; region V: Nyandarua County; region VI: Taita Taveta County. In Uganda, region I: Central region; region II: Eastern region; region III: Northern region; region IV: Western region; region V–VI: NA. In Zambia, region I: Luapula Province; region II: Muchinga Province; region III: Northwestern Province; region IV: Northern Province; region V–VI: NA.
§ Health facility levels in Kenya: I. Community health services and dispensary/clinic; II. Health centre; III. Subcounty hospital; IV. County hospital and above. Health facility levels in Uganda: I. Health centre II; II. Health centres III and IV; III. Hospital; IV. Regional referral hospital and above. Health facility levels in Zambia: I. Health post; II. Health centre; III. District hospital; IV. General hospital and above.

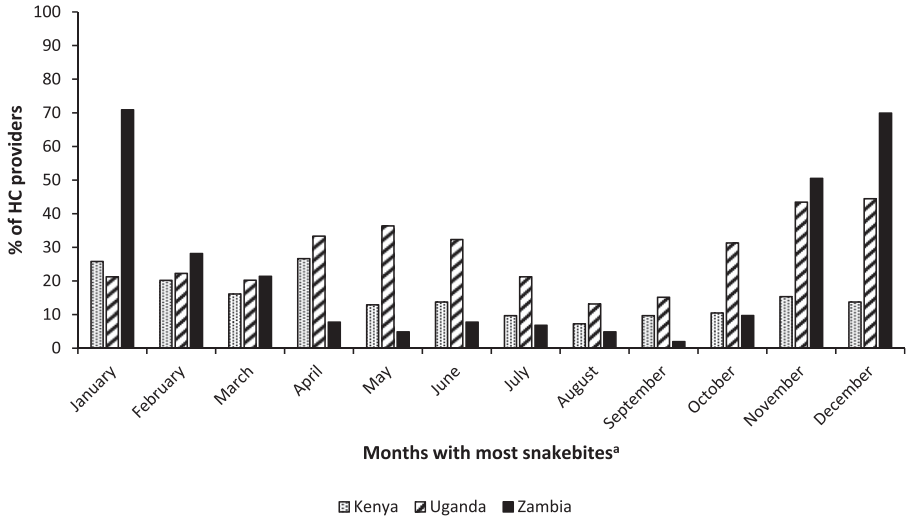

FIGURE 1. Months in which healthcare workers (HCWs) reported to see most snakebite cases, per country. [a]Healthcare workers could indicate multiple months, so totals may sum to more than 100%.

commonly offered treatment for snakebite patients (see Figure 2). Health facilities also commonly referred patients to other facilities.

Traditional treatment, such as black stone and tourniquets, was offered at 0.8% of Kenyan, 7.0% of Ugandan, and 14.6% of Zambian facilities. In addition, considerable numbers of HCWs believed the majority of patients sought traditional treatments before visiting the health facility (50.0% in Kenya, 39.0% in Uganda, and 30.8% in Zambia, see Table 4).

Administering antivenom was not a common treatment practice, offered by 32.3% of Kenyan facilities, and a respective 7.7% and 12.6% of Ugandan and Zambian facilities (see Figure 2). When asked about the general effect of antivenom, 62.3% of HCWs in Uganda and 38.1% of HCWs in Zambia believed it had the desired effect (see Table 4). This question was not included in the Kenyan survey. In Kenya, 33.7% of public facilities, 0% of private facilities, and 23.5% of PNFP facilities surveyed had antivenom available and in stock at the time of the survey (see Table 4). In Uganda and Zambia, this was the case for less than 10% of facilities across all sectors surveyed. The types of antivenom stocked in each country can be found in Table 5.

In all three countries, reasons given for the unavailability of antivenom included that it was not supplied to the facility, either because the level of care of the facility was too low, it was too expensive to stock, or the facility never stocked

TABLE 3
Healthcare workers' perspectives on snakebite patient characteristics

	Kenya HCWs (overall)	Uganda HCWs (overall)	Zambia HCWs (public)
	N (%)	*N* (%)	*N* (%)
Proportion of male–female patients			
Only male	6 (5.4)	3 (2.2)	3 (2.9)
Mostly male	34 (30.4)	41 (30.6)	37 (36.2)
Same number of males and females	50 (44.6)	48 (35.8)	41 (39.0)
Mostly female	21 (18.8)	29 (21.6)	23 (21.9)
Only female	1 (0.9)	13 (9.7)	0 (0.0)
Age-group of snakebite patients* (years)			
0–10	20 (18.1)	33 (24.6)	18 (17.1)
11–20	26 (23.6)	64 (47.8)	55 (53.3)
21–30	61 (55.5)	93 (69.4)	63 (61.0)
31–45	58 (52.7)	61 (45.5)	40 (38.1)
46–65	9 (8.2)	11 (8.2)	6 (5.7)
> 65	1 (0.9)	0 (0.0)	1 (1.0)
Activity at the time of snakebite*			
Playing	12 (10.5)	26 (19.4)	21 (19.8)
Herding	36 (31.6)	22 (16.4)	1 (0.9)
Sleeping	15 (13.2)	20 (16.4)	4 (3.8)
Farming	63 (55.3)	101 (75.4)	67 (64.2)
Walking	30 (26.3)	63 (47.0)	64 (60.4)
Charcoal burning	10 (8.8)	6 (4.5)	5 (4.7)
Fishing	0 (0.0)	7 (5.2)	7 (6.6)
Collecting firewood	32 (28.1)	6 (4.5)	33 (31.1)
Activities inside the house	24 (21.1)	3 (2.2)	0 (0.0)
Other	0 (0.0)	9 (6.7)	7 (6.6)

HCW = healthcare worker.
* HCWs could indicate up to three categories, so totals may sum to more than 100%.

TABLE 4
Healthcare workers' perspectives on treatment and their health facilities' capacity to treat snakebite

	Kenya (*n* = 145)				Uganda (*n* = 144)				Zambia (*n* = 108)
	Public	Private	PNFP	Total	Public	Private	PNFP	Total	Public
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Training on snakebite treatment									
Yes	11 (10.6)	3 (13.0)	4 (22.2)	18 (12.4)	6 (9.4)	5 (11.9)	1 (2.6)	12 (8.3)	17 (16.0)
No	93 (89.4)	20 (87.0)	14 (77.8)	127 (87.6)	58 (90.6)	37 (88.1)	37 (97.4)	132 (91.7)	89 (84.0)
Knowledge on snakebite treatment									
Yes	34 (34.3)	11 (52.4)	3 (16.7)	48 (34.8)	18 (28.6)	27 (65.9)	22 (57.9)	67 (47.2)	62 (58.5)
No	65 (65.7)	10 (47.6)	15 (83.3)	90 (65.2)	45 (71.4)	14 (34.1)	16 (42.1)	75 (52.8)	44 (41.5)
Treats snakebite*									
Assistant	1 (1.0)	0 (0.0)	0 (0.0)	1 (0.7)	11 (18.0)	1 (2.4)	5 (14.3)	17 (12.4)	8 (7.6)
Nurse	56 (57.1)	7 (30.4)	9 (52.9)	72 (52.2)	43 (70.5)	21 (51.2)	22 (62.9)	86 (62.8)	69 (65.7)
Physician	61 (62.2)	18 (78.3)	9 (52.9)	88 (63.8)	44 (72.1)	36 (87.8)	27 (77.1)	107 (78.1)	60 (57.1)
Not treated at facility	8 (8.2)	1 (4.3)	2 (11.8)	11 (8.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Commodities available to treat snakebite									
Yes	23 (23.2)	3 (13.6)	3 (18.8)	29 (21.2)	9 (14.1)	9 (21.4)	10 (26.3)	28 (19.4)	20 (19.0)
No	73 (73.7)	19 (86.4)	13 (81.3)	105 (76.6)	55 (85.9)	30 (71.4)	28 (73.7)	113 (78.5)	72 (68.6)
I do not know	3 (3.0)	0 (0.0)	0 (0.0)	3 (2.2)	0 (0.0)	3 (7.1)	0 (0.0)	3 (2.1)	13 (12.4)
Antivenom available at facility									
Yes	33 (33.7)	0 (0.0)	4 (23.5)	37 (26.8)	4 (6.3)	1 (2.4)	1 (2.7)	6 (4.2)	9 (8.7)
Not at the moment	29 (29.6)	14 (60.9)	9 (52.9)	52 (37.7)	9 (14.1)	3 (7.1)	12 (32.4)	24 (16.9)	5 (4.9)
Generally not	36 (36.7)	9 (39.1)	4 (23.5)	49 (35.5)	50 (78.1)	36 (85.7)	24 (64.9)	110 (77.5)	53 (51.5)
I do not know	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (1.6)	2 (4.8)	0 (0.0)	2 (1.4)	36 (35.0)
Outcome of antivenom treatment									
Desired effect	NA	NA	NA	NA	35 (61.4)	25 (64.1)	21 (61.8)	81 (62.3)	37 (38.1)
No effect	NA	NA	NA	NA	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Negative effect	NA	NA	NA	NA	22 (38.6)	14 (35.9)	13 (38.2)	49 (37.7)	0 (0.0)
I do not know	NA	NA	NA	NA	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	60 (61.9)
Traditional treatment sought beforehand									
Yes	47 (51.6)	11 (57.9)	5 (31.3)	63 (50.0)	16 (27.6)	21 (51.2)	16 (43.2)	53 (39.0)	32 (30.8)
No	44 (48.4)	8 (42.1)	11 (68.8)	63 (50.0)	42 (72.4)	20 (48.8)	21 (56.8)	83 (61.0)	41 (39.4)
I do not know	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	31 (29.8)

HCW = healthcare worker; NA = not applicable; PNFP = private not-for-profit. The question was not asked in the country.
* HCWs could indicate up to three categories, so totals may sum to more than 100%.

antivenom. In the non-endemic areas, a low snakebite incidence was also mentioned as reason for not having antivenom available.

Complications. In Kenya, HCWs were asked about the complications they most commonly observed after a snakebite. Multiple-answer options could be chosen. According to the HCWs, when complications occurred, the most common ones were swelling (55.9%), pain at the site of the bite (32.2%), cellulitis (23.7%), and respiratory distress (20.3%) (see Supplemental File 2).

DISCUSSION

This research is one of the first to study HCWs' perspectives on snakebite demographics, their knowledge on treatment, and their health facilities' treatment capacity in Kenya, Uganda,

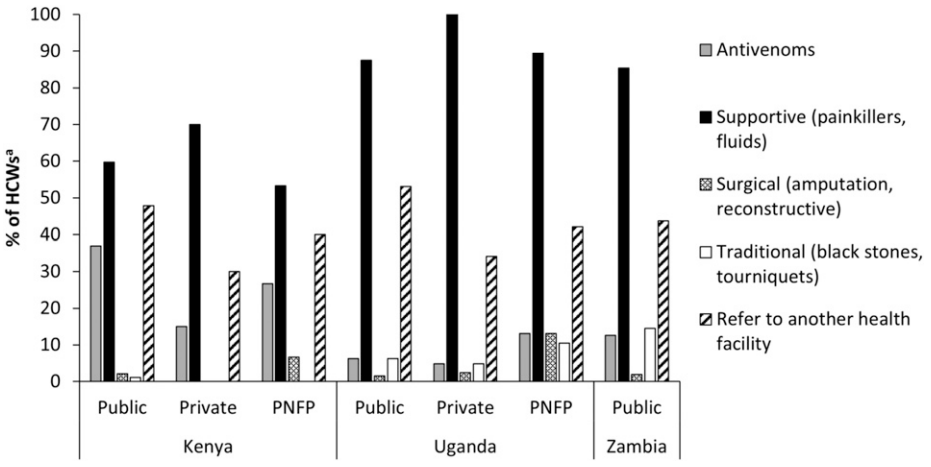

FIGURE 2. Type of treatment provided at health facility in response to snakebites, per country and sector. [a]Healthcare workers (HCWs) could indicate multiple treatments, so totals may sum to more than 100%.

TABLE 5
Type of antivenoms stocked in health facilities, per country and sector

	Number of health facilities						
	Kenya			Uganda			Zambia
	Public	Private	PNFP	Public	Private	PNFP	Public
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Snake venom antiserum (African) Manufactured by VINS Bioproducts Ltd.	28 (87.5)	0 (0.0)	3 (75.0)	4 (100.0)	0 (0.0)	0 (0.0)	6 (75.0)
SAIMR polyvalent snake antivenom Manufactured by South African Vaccine Producers (PTY) Ltd	4 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	1 (100.0)	1 (12.3)
Inoserp PANAFRICAIN Manufactured by INOSAN Biopharma	2 (6.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Unclear origin	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (12.3)

PNFP = private not-for-profit; SAIMR = South African Institute for Medical Research.

and Zambia. According to most HCWs, there were no differences in snakebite incidents between genders, most patients were aged 21–30 years, and activities often performed when bitten were farming and walking. Supportive treatment was the most commonly offered type of treatment, and 85–90% of HCWs had not received any training in snakebite management. About 80% of HCWs across the countries thought their health facility did not have the necessary equipment and medicines available to treat snakebite. Accordingly, a mere 27.0% of HCWs in Kenya, 4.2% in Uganda, and 7.6% in Zambia stated they had antivenom in stock at the time of survey.

Snakebite envenoming is a significantly understudied neglected tropical disease. Existing studies cover just one hospital or are outdated.[17–21] One Kenyan study had a similar research question and approach (albeit it only covered four high-level urban facilities).[27] The current study provided insight into the snakebite issue from the perspective of HCWs. Because none of the three countries have a national snakebite reporting and surveillance system, current evidence on snakebite incidents is mostly anecdotal.[27–30] This research is an attempt to provide a comprehensive overview of snakebite incidents by randomly sampling health facilities throughout multiple regions in each country, which can be used as evidence for policy-makers to inform and strengthen snakebite policies, including reporting systems. Although these not insubstantial numbers registered at the facilities only give cautious indications toward the actual number of snakebites taking place, also because not all facilities registered the snakebites cases seen by the facility, they confirm that in general, health facilities regularly have to deal with a number of snakebites. Given that multiple studies have shown snakebite underreporting is as high as 70%, real snakebite incidents will be much higher.[4–6] Fortunately, in all three countries, ministries of health are willing to take encouraging steps to strengthen snakebite surveillance and reporting mechanisms. Reliable estimates of snakebite incidents and burden will improve opportunities for intervention and resource allocation.[3]

Countries need to be prepared for seasonal variations in snakebite incidents. For example, in Zambia, HCWs reported an increase in snakebite cases from November to March. This might be explained by Zambia's climate, which has extreme droughts in May to August, and higher precipitation and temperatures from November to March.[31] In Uganda, many HCWs also observed peaks in snakebite cases in months which corresponded to the rainy season.[32] Other studies (in Costa Rica and Ghana) found similar patterns of increased snakebite incidents during the rainy season.[33,34] In Kenya, the findings were not congruent with the rainy season.[35] Information about snakebite incidents over the months can help authorities to anticipate on fluctuations in demand for treatments and adjust stock accordingly.

Although a few studies have investigated snakebite patient profiles in Kenya and other sub-Saharan African countries, to our knowledge, there are no such studies in Uganda and Zambia. Given most studies (including ours) are small scale, or based on experience, the level of generalizable and wholly reliable evidence is poor. Nevertheless, our findings largely correspond to those findings in the literature: a study of Kenyan case records showed roughly equal cases of males and females, whereas clinicians believed males were more likely to be bitten.[27] Similar findings were also observed in Ghana and South Africa.[34,36]

In our study, people aged 21–30 years were believed to be most prone to snakebites. This again resonates with previous research, which often finds highest incidence in relatively young age-groups.[27,34,36] Also, HCWs suggest farming to be the most common activity performed at the time of the bite, which supports other studies' findings that it is people in rural areas, dependent on agriculture for livelihood, who are most at risk.[13,34] At the same time, these people are most vulnerable to adverse health outcomes after snakebites because of poorer access to quality health care in rural areas.[14]

This research underscores the paucity of HCW training on snakebite management: a mere 8–16% of HCWs had received any training. A similar percentage was found in a study in Cameroon (15%).[37] Healthcare workers' perspectives on their knowledge about snakebite treatment also exposed serious shortcomings. Although the questions in our research did not measure actual knowledge on snakebite treatment, the low numbers of trained HCWs and their own perceived lack of knowledge and confidence are alarming; an adequate treatment response can mean the difference between full recovery, and permanent disability or even death.[38] Snakebite management training should be given to all HCWs during initial training as part of the curricula, and in service as continuing professional development, especially in endemic areas.

Even if HCWs receive adequate training, there remains a considerable chance that resources are not available at health facilities. The health facilities in the sample mostly offered

supportive treatment, with only a minority offering antivenom as part of the treatment pathway. This is supported by the finding of low antivenom availability, which remains a problem in many sub-Saharan African countries. The lack of trust in antivenoms we found among some HCWs might be explained by the overall lack of knowledge and the fact that ineffective antivenoms are regularly marketed and used in these countries.[10,15,39–42] For instance, only a few health facilities across the countries had South African Institute for Medical Research polyvalent snake antivenom manufactured by South African Vaccine Producers (PTY) Ltd. available, which is seen as the "gold-standard" antivenom.[43] Most facilities stocked snake venom antiserum (African) manufactured by VINS Bioproducts Ltd., which only showed signs of preclinical effectiveness for *Naja nigricollis* (black-necked spitting cobra), and ineffectiveness for other East and Southern African snake species such as *Bitis arietans* (puff adders) and *Dendroaspis polylepis* (black mambas), which are also found in Kenya, Uganda, and Zambia.[43,44]

Ineffective traditional treatment, for example, using a black stone and tourniquets, is still sometimes offered by HCWs, particularly at Zambian health facilities. Interestingly, previous research in Cameroon showed that "pierre noire," similar to black stone, was believed effective for snakebite treatment by 64% of surveyed HCWs, whereas 37% believed use of tourniquets was recommended.[37] Again, this is a training gap which needs to be addressed, as offering these types of treatments at health facilities can lead to negative health outcomes. It can cause infections from the method itself, as well as lead to a delay in providing appropriate medical care.[45] Notably high was the number of HCWs who thought most snakebite patients sought traditional treatments before a health facility visit. This type of health-seeking behavior leads to delays in seeking appropriate medical care, which in case of envenomings can lead to serious morbidity and death.[46] Efforts should focus on engaging and empowering communities through strategies which improve their knowledge, attitudes, and practices on effective prevention measures, first aid, and health-seeking behavior.

To gain a more in-depth understanding of snakebite incidence and its health and socioeconomic impact on fragile communities, it is vital to collect data from the community perspective. Household surveys and qualitative studies, which have been conducted in other countries, should also be completed in Kenya, Uganda, and Zambia.[47,48] In addition, studies assessing availability and affordability of snakebite treatment and barriers to access are needed to inform resource allocation and intervention development.

Although this study provides further insights into the snakebite situation in Kenya, Uganda, and Zambia, limitations should be noted. This research is based on data collected at health facilities, whereas a substantial portion of snakebite patients have limited access to health care and might instead visit a traditional healer.[8,14] It therefore only provides part of the picture on the snakebite issue. In addition, although informants included were predominantly nurses and physicians, the fact that perspectives were obtained from just one informant per facility poses a risk for respondent bias. Their function in the facility, as well as the extent of their personal experience with treating snakebites, and knowledge about health facility resources and capacity may vary. Information on snakebites was collected retrospectively, which could have incurred recall bias. Except for obtaining the exact number of snakebite cases registered at the facilities, we did not make use of registries to identify the profile of snakebite patients, which might also have led to recall bias. Furthermore, with surveys, there is always a risk of interviewer bias, with informants answering in such a way that they think is desirable. We aimed to mitigate this by ensuring questions were phrased objectively, and they were asked by the data collectors as they are and not interpreted or paraphrased.

Data were collected consecutively in the three countries. After feedback from local partners, some adjustments were made, resulting in four differently phrased questions in the three countries. Furthermore, knowledge on how to treat snakebites was not tested, but the participants were asked to reflect on it themselves. This should be taken into consideration when looking at the numbers, as it is possible that the participants under or overrated their knowledge.

Finally, the sampling strategy also has limitations. Sampled regions included snakebite-endemic and non-endemic areas. This strategy was chosen to obtain insight into the country's situation in general, and to ensure random sampling did not include only endemic or non-endemic areas. In each survey region, facilities were randomly sampled, and afterward stratified per sector and location. As a consequence, the facilities were not equally distributed across these strata: fewer private and PNFP facilities were surveyed, as well as fewer urban locations than rural locations. However, this might provide a better representation of the division of facilities across the sectors and the snakebite-endemic locations. Snakebites occur more often in rural areas, and the public sector is the main provider of health care in the three countries.[2,49–51] In Zambia, the 10 surveyed PNFP facilities were excluded as this sample was too small to be representative.

In conclusion, this study shows that snakebites most often affect agricultural workers of any gender in the age category 21–30 years, and that enormous gaps in snakebite care exist as HCWs lacked training and equipment to properly manage snakebites. To tackle this, an integrative approach including community education, HCW training, and improved access to snakebite treatment is vital. Regulations should also ensure that antivenoms available in health facilities meet quality control standards, and that snakebites are accommodated into routine reporting systems to assess progress on snakebite treatment and management at the subnational and national levels. Snakebite envenoming, as a neglected tropical disease, has long suffered from lack of attention. The burden of disease still does not correspond with resources allocated to research and health system strengthening for snakebites. To make up the necessary ground, a significant increase in resources is essential.

Received August 25, 2020. Accepted for publication October 8, 2020.

Published online November 23, 2020.

Note: Supplemental files appear at www.ajtmh.org.

Acknowledgments: We would like to thank the data collection teams in Kenya led by Dorothy Okemo, Royjan Taylor, and Clare Taylor; in Uganda led by Denis Kibera; and in Zambia led by Liyoka Liyoka. We also want to thank the HCWs for the time they invested to participate in this study.

Financial support: This work was supported by the Lillian Lincoln Foundation and the Hennecke Foundation.

Authors' addresses: Gaby I. Ooms, Health Action International, Amsterdam, The Netherlands, and Division of Pharmacoepidemiology

and Clinical Pharmacology, Utrecht Centre for Pharmaceutical Policy and Regulation, Utrecht Institute for Pharmaceutical Sciences (UIPS), Utrecht University, Utrecht, The Netherlands, E-mail: gaby@haiweb.org. Janneke van Oirschot, Benjamin Waldmann, Sophie von Bernus, and Tim Reed, Health Action International, Amsterdam, The Netherlands, E-mails: janneke@haiweb.org, ben@haiweb.org, sophie@haiweb.org, and tim@haiweb.org. Hendrika A. van den Ham and Aukje K. Mantel-Teeuwisse, Division of Pharmacoepidemiology and Clinical Pharmacology, Utrecht Centre for Pharmaceutical Policy and Regulation, Utrecht Institute for Pharmaceutical Sciences (UIPS), Utrecht University, Utrecht, The Netherlands, E-mails: h.a.vandenham@uu.nl and a.k.mantel@uu.nl.

REFERENCES

1. World Health Organization, 2019. *Snakebite Envenoming: What Is Snakebite Envenoming?* Geneva, Switzerland: WHO. Available at: https://www.who.int/snakebites/disease/en/. Accessed February 1, 2020.
2. Chippaux JP, 2011. Estimate of the burden of snakebites in sub-Saharan Africa: a meta-analytic approach. *Toxicon 57:* 586–599.
3. World Health Organization, 2019. *Snakebite Envenoming. A Strategy for Prevention and Control*. Geneva, Switzerland: WHO.
4. Fox S, Rathuwithana AC, Kasturiratne A, Lalloo DG, de Silva HJ, 2006. Underestimation of snakebite mortality by hospital statistics in the Monaragala district of Sri Lanka. *Trans R Soc Trop Med Hyg 100:* 693–695.
5. Mohapatra B, Warrell DA, Suraweera W, Bhatia P, Dhingra N, Jotkar RM, Rodriguez PS, Mishra K, Whitaker R, Jha P, 2011. Snakebite mortality in India: a nationally representative mortality survey. *PLoS Negl Trop Dis 5:* e1018.
6. Tchoffo D, Kamgno J, Kekeunou S, Yadufashije C, Nana Djeunga HC, Nkwescheu AS, 2019. High snakebite underreporting rate in the centre region of Cameroon: an observational study. *BMC Public Health 19:* 1040.
7. Habib AG, Kuznik A, Hamza M, Abdullahi MI, 2015. Snakebite is under appreciated: appraisal of burden from west Africa. *PLoS Negl Trop Dis 9:* e0004088.
8. World Health Organization, 2019. *Snakebite Envenoming: Prevalence of Snakebite Envenoming*. Geneva, Switzerland: WHO. Available at: https://www.who.int/snakebites/epidemiology/en/. Accessed February 1, 2019.
9. Simpson ID, Blaylock RSM, 2009. The anti snake venom crisis in Africa: a suggested manufacturers product guide. *Wilderness Environ Med 20:* 275–282.
10. Brown NI, 2012. Consequences of neglect: analysis of the sub-Saharan African snake antivenom market and the global context. *PLoS Negl Trop Dis 6:* e1670.
11. Habib AG, Brown NI, 2018. The snakebite problem and antivenom crisis from a health-economic perspective. *Toxicon 150:* 115–123.
12. Theakston RDG, Warrell DA, 2000. Crisis in snake antivenom supply for Africa. *Lancet 356:* 2104.
13. Harrison RA, Hargreaves A, Wagstaff SC, Faragher B, Lalloo DG, 2009. Snake envenoming: a disease of poverty. *PLoS Negl Trop Dis 3:* e569.
14. Longbottom J et al., 2018. Vulnerability to snakebite envenoming: a global mapping of hotspots. *Lancet 392:* 673–684.
15. Williams DJ, 2015. Snake bite: a global failure to act costs thousands of lives each year: vulnerable populations need urgent access to effective and affordable treatments. *BMJ 351:* H5378.
16. Gutiérrez JM, Burnouf T, Harrison RA, Calvete JJ, Kuch U, Warrell DA, Williams DJ, 2014. A multicomponent strategy to improve the availability of antivenom for treating snakebite envenoming. *Bull World Health Organ 92:* 526–532.
17. Snow RW, Bronzan R, Roques T, Nyaimawi C, Murphy S, Marsh K, 1994. The prevalence and morbidity of snake bite and treatment-seeking behaviour among a rural Kenyan population. *Ann Trop Med Parasitol 88:* 665–671.
18. Coombs MD, Dunachie SJ, Brooker S, Haynes J, Church J, Warrell DA, 1997. Snake bites in Kenya: a preliminary survey of four areas. *Trans R Soc Trop Med Hyg 91:* 319–321.
19. Wangoda RM, Watmon B, Kisige M, 2004. Snakebite management: experiences from gulu regional hospital Uganda. *East Cent Afr J Surg 9:* 1–5.
20. Kihiko DK, 2013. Venomous snake bite injuries at kitui district hospital. *Ann Afr Surg 10:* 15–20.
21. Yerzingatsian KL, 1997. Snakebite–rest and elevation in the management of a selected group of patients in an urban setting. *S Afr J Surg 35:* 188–189.
22. World Health Organization, Health Action International, 2008. *Measuring Medicine Prices, Availability, Affordability and Price Components*, 2nd edition. Geneva, Switzerland: WHO.
23. Madden J, Meza E, Laing R, Stephens P, Ross-Degnan D, 2010. Measuring medicine prices in Peru: validation of key aspects of WHO/HAI survey methodology. *Rev Panam Salud Publica 27:* 291–299.
24. Cameron A, Bansal A, Dua T, Hill SR, Moshe SL, Mantel-Teeuwisse AK, Saxena S, 2012. Mapping the availability, price, and affordability of antiepileptic drugs in 46 countries. *Epilepsia 53:* 962–969.
25. Zambia Central Statistical Office, 2016. *2015 Living Conditions Monitoring Survey Report*. Lusaka, Zambia: Zambia Central Statistical Office.
26. International Labour Organization. *Inventory of Official National-Level Statistical Definitions for Rural/Urban Areas*. Available at: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/genericdocument/wcms_389373.pdf. Accessed February 9, 2018.
27. Ochola FO, Okumu MO, Muchemi GM, Mbaria JM, Gikunju JK, 2018. Epidemiology of snake bites in selected areas of Kenya. *Pan Afr Med J 29:* 217.
28. Z'gambo J, Siulapwa Y, Michelo C, 2016. Pattern of acute poisoning at two urban referral hospitals in Lusaka, Zambia. *BMC Emerg Med 16:* 2.
29. Malangu N, 2008. Acute poisoning at two hospitals in Kampala–Uganda. *J Forensic Leg Med 15:* 489–492.
30. Kasturiratne A, Wickremasinghe AR, De Silva N, Gunawardena NK, Pathmeswaran A, Premaratna R, Savioli L, Lalloo DG, De Silva HJ, 2008. The global burden of snakebite: a literature analysis and modelling based on regional estimates of envenoming and deaths. *PLoS Med 5:* 1591–1604.
31. The World Bank, 2020. *Average Monthly Temperature and Rainfall of Zambia for 1901–2016*. Washington DC: Climate Change Knowledge Portal. Available at: https://climateknowledgeportal.worldbank.org/country/zambia/climate-data-historical. Accessed January 23, 2020.
32. The World Bank, 2020. *Average Monthly Temperature and Rainfall of Uganda for 1901–2016*. Washington DC: Climate Change Knowledge Portal. Available at: https://climateknowledgeportal.worldbank.org/country/uganda/climate-data-historical. Accessed January 23, 2020.
33. Chaves LF, Chuang TW, Sasa M, Gutiérrez JM, 2015. Snakebites are associated with poverty, weather fluctuations, and El Niño. *Sci Adv 1:* e1500249.
34. Musah Y, Ameade EPK, Attuquayefio DK, Holbech LH, 2019. Epidemiology, ecology and human perceptions of snakebites in a savanna community of northern Ghana. *PLoS Negl Trop Dis 13:* e0007221.
35. The World Bank, 2020. *Average Monthly Temperature and Rainfall of Kenya for 1901–2016*. Washington DC: Climate Change Knowledge Portal. Available at: https://climateknowledgeportal.worldbank.org/country/kenya/climate-data-historical. Accessed January 23, 2020.
36. Wood D, Sartorius B, Hift R, 2016. Snakebite in north-eastern South Africa: clinical characteristics and risks for severity. *South Afr Fam Pract 58:* 62–67.
37. Taieb F et al., 2018. Knowledge, attitude and practices of snakebite management amongst health workers in Cameroon: need for continuous training and capacity building. *PLoS Negl Trop Dis 12:* e0006716.
38. WHO, 2020. *Snakebite Envenoming - Antivenoms*. Geneva, Switzerland: WHO. Available at: https://www.who.int/snakebites/antivenoms/en/. Accessed January 29, 2020.

39. Warrell DA, 2008. Unscrupulous marketing of snake bite antivenoms in Africa and Papua New Guinea: choosing the right product-'What's in a name?'. *Trans R Soc Trop Med Hyg 102:* 397–399.
40. Habib AG, 2013. Public health aspects of snakebite care in west Africa: perspectives from Nigeria. *J Venom Anim Toxins Incl Trop Dis 19:* 27.
41. Potet J, Smith J, McIver L, 2019. Reviewing evidence of the clinical effectiveness of commercially available antivenoms in sub-Saharan Africa identifies the need for a multi-centre, multi-antivenom clinical trial. *PLoS Negl Trop Dis 13:* e0007551.
42. Visser LE, Kyei-Faried S, Belcher DW, Geelhoed DW, van Leeuwen JS, van Roosmalen J, 2008. Failure of a new antivenom to treat *Echis* ocellatus snake bite in rural Ghana: the importance of quality surveillance. *Trans R Soc Trop Med Hyg 102:* 445–450.
43. Harrison RA et al., 2017. Preclinical antivenom-efficacy testing reveals potentially disturbing deficiencies of snakebite treatment capability in East Africa. *PLoS Negl Trop Dis 11:* e0005969.
44. WHO Regional Office for Africa, 2010. *Guidelines for the Prevention and Clinical Management of Snakebite in Africa*. Geneva, Switzerland: World Health Organization.
45. Habib AG, Abubakar SB, 2011. Factors affecting snakebite mortality in north-eastern Nigeria. *Int Health 3:* 50–55.
46. Gutiérrez JM, 2012. Snakebite envenoming: a public health perspective. *Public Health – Methodology, Environmental and Systems Issues*. Rijeka, Croatia: InTech, 131–162. Available at: http://www.intechopen.com/books/public-health-methodology-environmental-and-systems-issues/snakebite-envenoming-a-public-health-perspective.
47. Kasturiratne A, Pathmeswaran A, Wickremasinghe AR, Jayamanne SF, Dawson A, Isbister GK, de Silva HJ, Lalloo DG, 2017. The socio-economic burden of snakebite in Sri Lanka. *PLoS Negl Trop Dis 11:* e0005647.
48. Vaiyapuri S et al., 2013. Snakebite and its socio-economic impact on the rural population of Tamil Nadu, India. *PLoS One 8:* e80090.
49. Ministry of Health Republic of Zambia, 2013. *The 2012 List of Health Facilities in Zambia*. Lusaka, Zambia: Ministry of Health Republic of Zambia.
50. Okwero P, Tandon A, Sparkes S, McLaughlin J, Hoogeveen JG, 2010. *Fiscal Space for Health in Uganda: Volume 186 of World Bank Papers, Africa Human Development Series*. Washington DC: World Bank Publications.
51. Muga R, Kizito P, Mbayah M, Gakuruh T, 2005. Overview of the health system in Kenya. *Demographic and Health Survey*. Nairobi, Kenya: Central Bureau of Statistics, 13–26.