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Retrospective hospital-based study on snakebite envenomation in Sudan

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Background: Snakebite statistics are lacking in Sudan despite the high estimated burden. In this study we aimed to describe the incidence of snakebite envenomation and death in Sudan and to show the state-wise distribution of snakebite episode.

Methods: We retrospectively analyzed hospital-based data on snakebite for 2014–2018. Data were obtained from the annual health statistical reports of the Ministry of Health. Descriptive statistics were used to illustrate the results.

Results: A total of 63 160 people were envenomed during 2014–2018 with an average of 12 632 cases/year. The death rate between inpatient cases was 2.5%. The annual incidence was 18– 47 cases/100 000 population. Gadarif state recorded the highest incidence (132/100 000 population) of snakebite envenomation in Sudan whereas Northern state had the least incidence (5/100 000 population). The 15–24 y age group experienced the highest risk of snakebite and males were more exposed to snakebites than females.

Conclusions: Although hospital-based records underestimate the burden of snakebite, they can still provide an insight regarding the actual numbers. Here, we highlight the at-risk states in Sudan to be targeted for further questionnaire-based epidemiological studies and to guide health authorities to reduce the burden of snakebite envenomation by insuring proper antivenom distribution to the highly affected areas.

Keywords: envenomation, hospital-based, retrospective, snakebite, Sudan

Introduction

Snakebite is a neglected public health problem in many tropical and subtropical countries. It was added to the WHO's list of neglected tropical diseases in April 2009[1] and formally listed as a high priority neglected tropical disease in June 2017.[2] The annual estimate of snakebite envenoming ranges from 1.8 to 2.7 million worldwide with fatalities ranging from 81 000 to 183 000,[3] with 400 000 cases resulting in permanent physical disabilities.[4]

The actual statistics of snake envenomation remain underestimated due to the fact that many victims do not seek medical care and therefore are invisible to official reports.[5–7] The problem is of particular concern in Africa, the continent which includes some of the world's poorest communities. In sub-Saharan Africa, there are an estimated 1000 000 snakebites annually, resulting in 500 000 cases of envenomation and 20 000 fatalities.[7] The problem is not minor and in some regions of Africa the burden of snakebite is higher than trypanosomiasis, leishmaniasis and onchocerciasis,[8] and mortality by snakebite can be even higher than malaria.[9] The reasons for the high levels of snakebite fatalities in African include antivenom deficiency, poor health systems and a lack of rapid access to health centers.[10,11]

Data on venomous snakes in Sudan are limited to work published more than 70 y ago.[12] That study reported the presence of 17 snakes of great medical importance that belong to three main families, Atractaspidae, Elapidae and Viperidae. These snakes become numerous during and after the rain season and most snakebite victims are agricultural workers.[12]

Snakebite statistics are lacking in Sudan despite the high estimated burden of snakebite envenomation.[13] Data on snakebite in Sudan are represented by a few records of the Natural History Museum in Khartoum from early in the last century.[12,14] They attributed the difficulty of assessing an accurate number of snakebite accidents in Sudan to the fact that many inhabitants are firm believers in traditional healers and therefore do not seek medical treatment. Moreover, many victims die shortly after snakebite accidents and therefore are absent from hospital records.

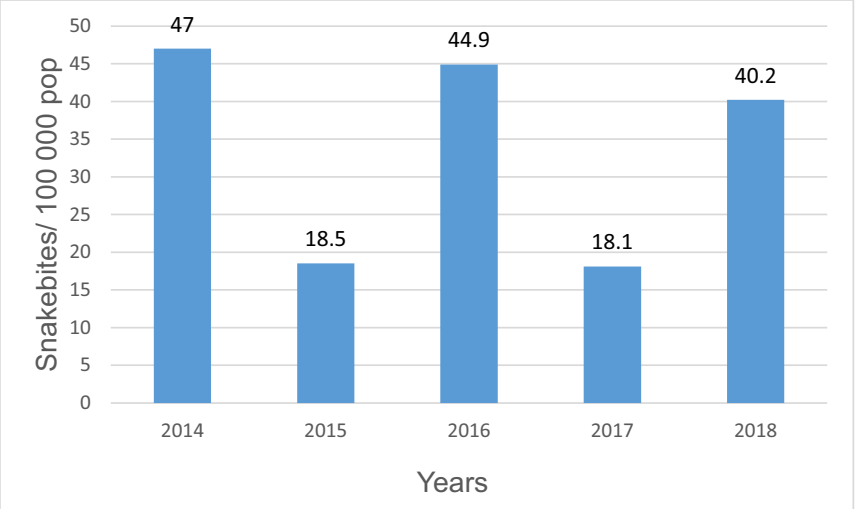

Figure 1. Incidence of snakebite envenomation in Sudan during 2014–2018.

The objective of this study was to determine the incidence of snakebite envenomation and death in Sudan based on retrospective hospital records during 2014–2018. The data obtained from this study will help health authorities to reduce the burden of snakebite envenomation by ensuring proper antivenom distribution to the highly affected areas and to provide health education to those communities at risk of snakebite.

Materials and Methods

The data were obtained online from the Sudan Health Observatory, Ministry of Health (http://www.sho.gov.sd/controller/). Data concerning snakebite morbidity and mortality from 2014 to 2018 were obtained and analyzed to determine the incidence of snakebite envenomation and death in Sudan. A population projection for 2014–2018 was obtained from the Central Bureau of Statistics, Sudan, based on the last population census in 2008. Snakebite cases were categorized according to age, gender and states. Sudan was divided into 12 states instead of the 18 known states; the three states of Kordofan and the five states of Darfur were regarded as one region owing to the multiple modifications that have taken place in these two regions throughout recent years. Patients were categorized as either inpatients (admitted to hospital) or outpatients (treated at an outpatient clinic). Descriptive statistics were used to illustrate the results using Microsoft Excel 2016 (Microsoft corporation, Redmond, Washinton, U.S.) SPSS version 16 (SPSS Inc., Chicago, IL, U.S.) and Statistical Package for the Social Sciences (SPSS). Additionally, we mapped statewise incidence of snakebite envenomation in Sudan via Geographic Information System (GIS) methods to highlight the most affected states using ArcMap software version 10.2.

Results

Hospital-based records of inpatient and outpatient cases for snakebite envenomation were obtained and analyzed to quantify the burden of snakebite envenomation in Sudan during 2014–2018. Data of snakebite envenomation for both inpatient and outpatient cases revealed that a total of 63 160 people were envenomed during 2014–2018 with an average of 12 632 cases/year. The incidence of snakebite envenomation per 100 000 population is shown in Figure 1. The number of cases was highest among middle-aged people in the community (aged 15–44 y), of whom the 15–24 y age group displayed the highest percentage (33%). Males displayed a higher exposure to snakebite (59%) than females (41%) (Figure 2). However, the difference was not significant ($p > 0.05$). The geographical distribution of snakebite cases across Sudan (Figure 3) revealed that Gadarif state had the highest incidence, followed by Kassala, Khartoum and Sinnar, while the lowest rate of snakebite was recorded in Northern state (Figure 4).

The number of patients admitted to Sudan hospitals (inpatients) due to snakebite accidents during 2014–2018 ranged from 2587 to 4793 patients with an average of 3327 patients/year. The death rate among inpatients was 2.5%, with males having a higher percentage of death (67%) than females (33%) (Figure 5). Among states, Gadarif displayed the highest rate of death from snakebite envenomation, accounting for approximately 48% of the total fatality rate of Sudan, followed by Sinnar and Kassala (Figure 6).

Discussion

The current study is the first attempt to describe the incidence of snakebite envenomation in Sudan. It was conducted as a response to the WHO strategy launched in May 2019 for the prevention and control of snakebite envenomation.[15] The strategy aims to reduce the numbers of deaths and cases of disability due to snakebite envenoming by 50% by 2030. This is based on providing community education to the most highly affected areas regarding the risk of snakebite and encouraging them to seek medical treatment.

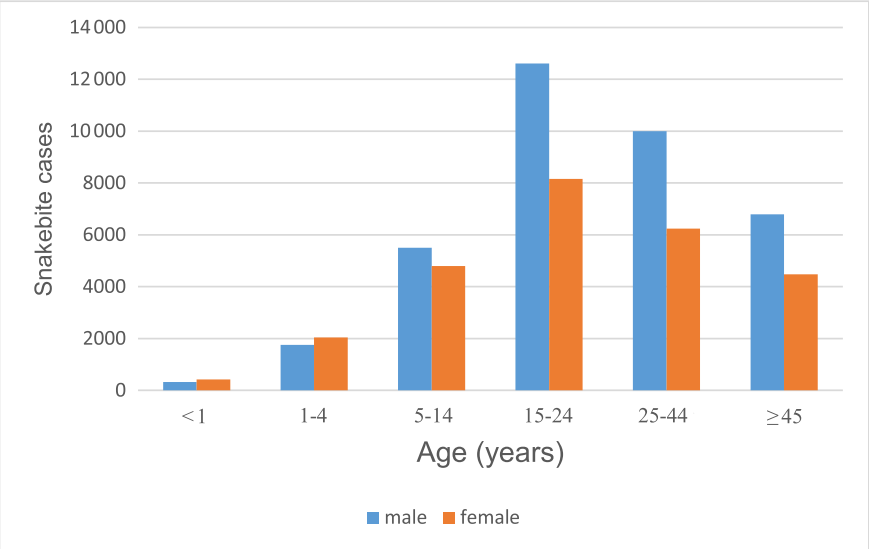

Figure 2. Snakebite cases during 2014–2018 according to age and gender.

In this work, we analyzed snakebite data from the annual health statistical reports for 5 y (2014–2018) to show the burden of snakebite envenoming in Sudan. Our results highlight that an average of 12 632 people were envenomed per year; about 3327 patients were admitted to hospitals. The fatality rate was 2.5% of admitted cases. Our results reflect a decrease in snakebite mortality rate compared with that reported in a series of 231 snakebite cases from different hospitals in Sudan, in which 13 patients (5.6%) died and 11 patients (4.5%) survived with permanent disability.[14] This might be attributed to the ease of hospital access in recent years compared with the last century, in addition to the availability of the cold chain needed for antivenom preservation. In other series of snakebite cases reported by Corkill in 1949 and Bloss in 1950, the percentage of death was 6.4% and 2%, respectively.[12] The main cause of snakebite accidents were the saw-scaled viper *Echis carinatus*, the burrowing viper *Atractaspis mecrolipidota* and the buff adder *Bitis arietans*.

In Africa, the percentage of death due to snakebite envenomation is estimated to be 4%.[9] This emphasizes that hospital-based data give lower estimates as many victims in Sudan do not seek medical treatment and prefer traditional remedies. The situation is similar in many countries of Africa and Asia where snakebite envenomation is endemic.[16]

Our results also stated that the greatest proportion of envenomation and fatality appear within the younger age group (15–24 y), that is, the most active age group, which has the greatest involvement with agricultural field work in Sudan. The current study showed that the difference regarding snakebite episodes according to gender is not significant and can be explained by the fact that females are also participating in agricultural field work in many parts of Sudan, especially during the harvesting season. Actually, agriculture is the main occupation of the vast majority of Sudanese living in rural areas and most of the croplands are unmechanized, a fact that put numerous farmers at risk of snakebite. In many areas of Sudan, the high rate of snakebite envenomation negatively affects the agricultural season and leads to massive wastage of yields. Farmers are usually barefooted and most snakebite accidents occur in feet and legs when they accidently step on snakes.[12] Worldwide, several reports have concluded that young males are at the highest risk of snakebite envenomation.[17–22]

Among the states of Sudan, the highest incidence of snakebite was reported in Gadarif (132.4/100 000 population) followed by Kassala (76.7/100 000). These two states are important agricultural regions in Sudan, as Gadarif is the main state for sesame production and Kassala for banana production. The reported incidence of snakebite in Gadarif in the current study is higher than the snakebite incidence reported by Omer et al.,[19] who reported 6.8/100 000 people/year. We believe that the current data represent the entire Gadarif state as these were collected from different health centers, including both urban and rural areas.

Khartoum state, where the capital city is located, is in third position. We believe that the expansion of the capital of Sudan in recent years due to the concentration of all services (healthcare, education) in Khartoum may reflect the increased envenomation rate. Many of the new residents dwell in the natural habitat of some snakes, putting them at particularly high risk. Some of them work in agriculture and usually they keep livestock in their houses, which attracts snakes to their homes. In the southern parts of Khartoum (e.g. Gabel Awlia), many species of snakes are drifted with the river current and located near the damp area. Many cases of snakebite are recorded in these areas, especially at the time of river floods.

Unexpectedly, Gazira state, where the greatest agricultural scheme in Africa (Gezira Scheme) existed comes in the sixth position. However, we believe that the actual incidence of snakebite envenomation is higher. A possible explanation for this could be that residents believe in traditional healers instead of medical treatment, as previously reported by Carkill.[14]

The Northern state, which is located in a semidesert region, reported the least number of cases of snakebite envenomation. In this region, human and snake populations live apart and

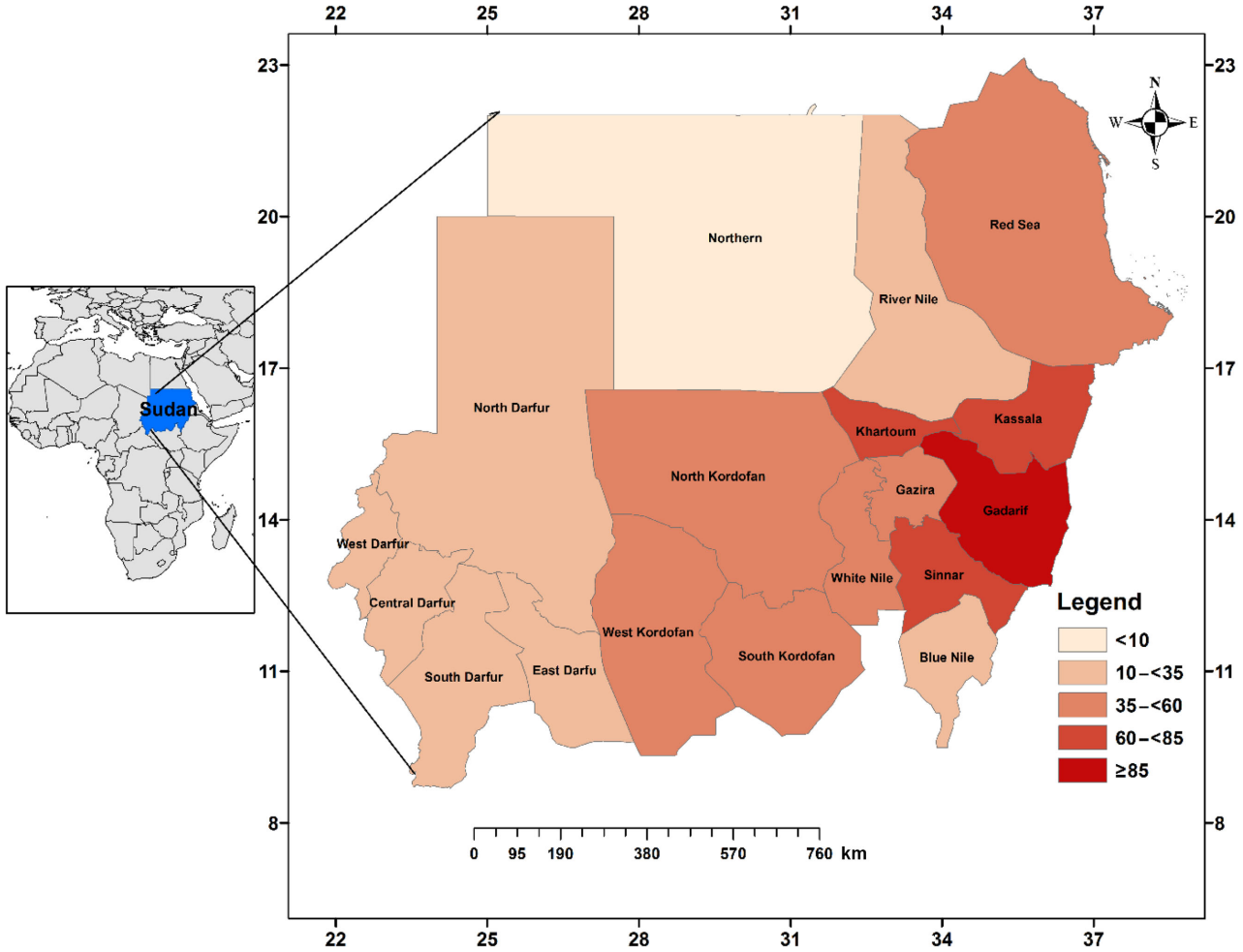

Figure 3. Geographic distribution of snakebites in Sudan (2014–2018). Mean incidence/100 000 population.

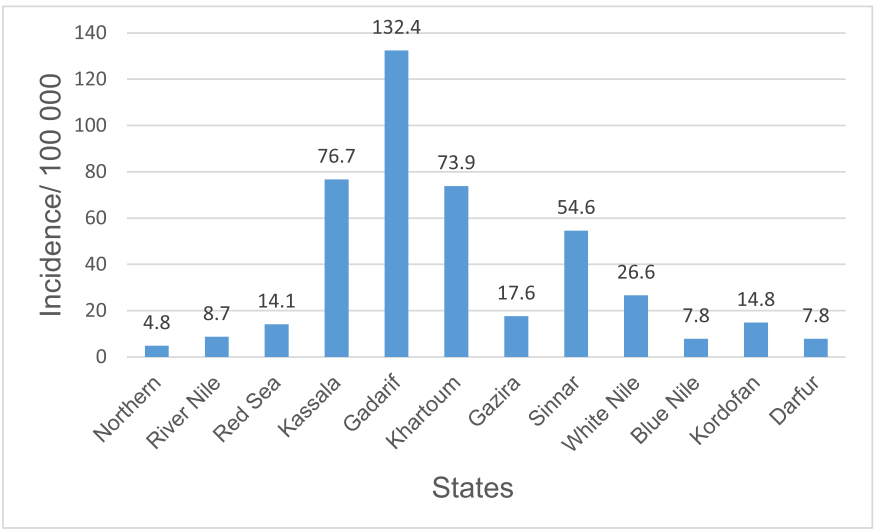

Figure 4. Incidence of snakebite envenomation during 2014–2018 in Sudan states.

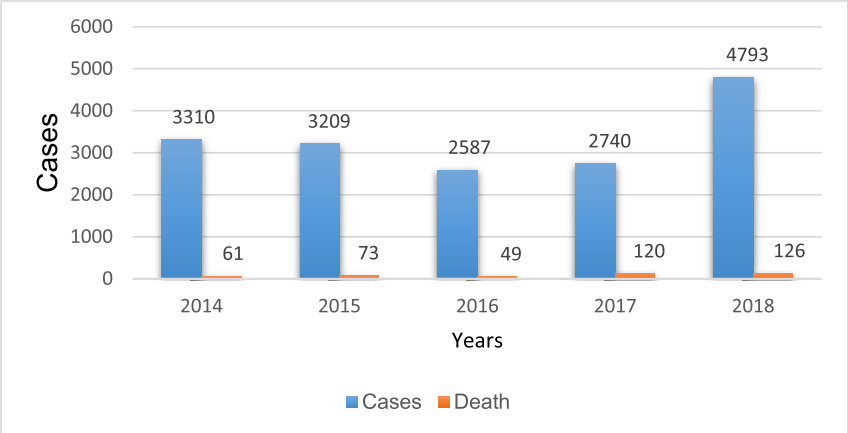

Figure 5. Snakebite cases and death among inpatients during 2014–2018.

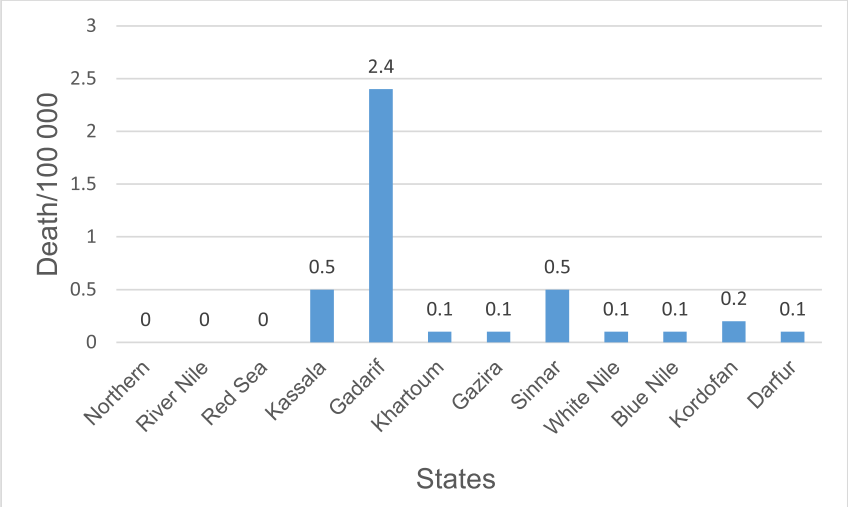

Figure 6. Incidence of death due to snakebite envenomation in Sudan states during 2014–2018.

the probability of encounters is low. This finding was previously demonstrated by Stock et al.[9]

In the current study, only hospitalized patients were involved in measuring the rate of snakebite fatality, because of the inability to follow outpatients after they had attended the outpatient clinic. Again, Gadarif State showed the highest incidence of death due to snakebite envenomation, accounting for 48% of the total death rate in Sudan. This massive amount of death is likely to be due to the North-East African carpet viper, *Echis pyramidium*, which is dominant in the eastern part of Sudan.[23,24] Bites by saw-scaled or carpet vipers (Genus *Echis*) produce moderate severe local swelling, blistering and necrosis, with severe systematic hemostatic disorders.[24,25] This species was previously reported to be the most common cause of snakebites and subsequent death in the northern part of Sudan.[26] Our results are also supported by the clinical manifestations reported in a hospital-based retrospective study at Gadarif Hospital,[19] in which 100% of patients developed local swelling, 54.7% hypotension, 51% nausea, 47.8% vomiting and 13.6% local bleeding. The previous results match those for *Echis* sp. envenomation,[27] and therefore support our hypothesis that most of the envenomation in Gadarif state is due to the pyramidium carpet viper. Khartoum state, which was ranked third for snakebite cases, was ranked sixth for death rate. This may be due to the relatively advanced medical care in the capital or because of the snake species found in Khartoum state, which may be less harmful.

Many admitted patients may die shortly after hospital admission due to the delay in transporting patients to hospitals, along with poor medical care in remote areas. Moreover, antivenom (the only specific treatment for snakebite envenomation) is very expensive and rarely available, so patients have to wait for a long time to start treatment. The specificity of the antivenom is an additional problem facing snakebite patients; the antivenom used in Sudan is imported from India (personal contact; The National Medical Supplies Fund, Khartoum, Sudan) and is produced to act against Indian snake species. This

situation gives snakebite victims two choices, to either use expensive non-specific antivenom or resorting traditional healers.

Conclusions

The current hospital-based study concluded that an average of 12 632 people/year were envenomed through 2014 to 2018, with young males exhibiting more exposure to snakebite accidents than females. The death rate among hospitalized patients was 2.5%. The highest incidences of snakebite envenomation and death were reported in Gadarif state, whereas Northern state recorded the lowest envenomation and death rates.

Authors' contributions: HKH designed the study, analyzed the data and wrote the manuscript. RSA designed and analyzed the data and revised the manuscript. Both authors read and approved the final manuscript.

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Data availability: The data underlying this article will be shared upon reasonable request to the corresponding author.

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