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ORIGINAL ARTICLE

Snakebites, a neglected public health concern: an analysis of distribution, trends and incidence of snakebite cases reported to health facilities in the Volta Region of Ghana, 2018–2023

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Background: Snakebite affects 5.4 million people annually, causing up to 2.7 million envenoming cases and 137 880 deaths. Its rise has been linked to flooding. This study examines the distribution, trends and incidence of snakebite cases in the Volta Region and identifies snakebite outbreaks in flood-affected districts.

Methods: We undertook a descriptive secondary data analysis of 2018–2023 snakebite cases from the District Health Information and Management Systems II database for the Volta Region. Cumulative Sum was used to identify missed outbreaks. The results are presented in tables, graphs and maps.

Results: A total of 1637 snakebite cases were reported across the 6-y study period, with an overall incidence rate of 15.8 cases per 100 000 population and a case fatality rate of 0.4% (7/1637). Case patients aged 20–34 y were the most affected (26.7%; 437/1637). Most of the cases peaked in March during the rainy season. The incidence of snakebites decreased from 18 cases per 100 000 population in 2018 to 15.8 cases per 100 000 population in 2023. Each of the flood-affected districts reported snakebite outbreaks before the flooding event. No new outbreaks were detected during or after the floods as of December 2023.

Conclusions: While snakebite incidence has decreased overall in the Volta Region, the burden remains alarmingly high in Ketu North. Young adults are particularly vulnerable. Urgent efforts are needed to enhance education, emphasising the importance of protective attire during the wet season for community safety.

Keywords: Akosombo floods, incidence, snakebite, Volta Region

Introduction

Snakebite constitutes a widely neglected public health challenge in numerous tropical and subtropical regions, primarily impacting Africa, Asia and Latin America.[1] Globally, approximately 5.4 million people experience snakebites annually, leading to 1.8–2.7 million cases of envenoming.[1,2] Asia witnesses the envenomation of up to 2 million individuals annually, while Africa grapples with an estimated 435 000–580 000 snakebites requiring treatment each year.[1]

Snakebites are responsible for 81 410–137 880 deaths each year, with three times as many people requiring amputations and experiencing other severe disabilities.[2] Envenoming has a negative impact on women, children and farmers living in impoverished rural communities in low- and middle-income nations. Countries with frail health systems and inadequate medical resources bear the highest burden.[1]

In sub-Saharan Africa, snakebites account for 20 000–32 000 annual deaths.[3] Studies have suggested that the burden of snakebites in sub-Saharan Africa is underestimated. This is because many victims do not seek hospital treatment and prefer traditional remedies.[4,5] Farooq et al. suggest that only 18% of cases seek help from health centres.[4]

In Ghana, the predominant snake species responsible for envenomation is the saw-scaled viper (*Echis ocellatus*), known for inducing critical emergencies, with mortality rates ranging from 11 to 17%.[6,7] In the Western region of Ghana, Mensah and colleagues conducted a comprehensive study, reporting a total

of 7275 snakebite cases over 5 y, with an overall snakebite incidence of 82.8 per 100 000.[8] A much lower rate of 24 snakebite cases per 100 000 over a 5-y period was found in the Volta and Oti regions.[7]

Flooding has become a significant environmental risk factor linked to an increased occurrence of snakebites.[9] This is attributed to the aftermath of flooding, which not only causes destruction but also leaves behind displaced snakes once the waters recede. This displacement, coupled with a reported surge in snakebite incidents, adds to the distress and fear experienced by the population affected by the floods.

On 12 October 2023, the Volta Regional Health Director received notification of flooding in one of its districts. This was a consequence of the controlled spilling of the Akosombo and Kpong Dams in the country, initiated on 15 September 2023, due to escalating water levels in the Volta River upstream. By 10 October 2023, the cumulative impact of the spillage led to the flooding of communities along the Volta Lake, resulting in the displacement of about 26 000 people and associated health challenges.

In response to this public health emergency, the Disease Surveillance Unit of the Volta Regional Health Directorate conducted a comprehensive review and secondary data analysis of snakebite cases to describe their distribution, trends and incidence in the Volta Region and to identify snakebite outbreaks in flood-affected districts. The findings aim to guide targeted interventions and improve preparedness strategies in response to this public health threat.

Methods

Study design and population

We undertook a descriptive secondary data analysis of reported snakebites in the Volta Region of Ghana for the period 2018–2023. We employed a methodological approach similar to previous studies[7,10] for this study.

Study setting

The study was conducted in the Volta Region, which is one of the 16 administrative regions of Ghana. The region is located in the Eastern part of Ghana and shares borders with Togo. It contains the Volta Lake, which is the largest reservoir or artificial lake in Ghana and West Africa. The lake was created as a result of the construction of the Akosombo Dam on the Volta River. The Lake stretches for about 400 km (250 miles) in length and plays a significant role in the development of the region, providing not only electricity, but also supports transportation, fishing and irrigation. The region occupies a surface area of about 20 570 km^2 and it is divided into 18 administrative districts [See appendix 1 Figure A1].[11] Based on the 2021 National Population and Housing Census, the population of the region in the year under review was 1 659 040, with an annual average growth rate of 2.1%.[11] The region has a total of 732 health facilities, which comprise 482 community-based health planning and services, 45 clinics, 156 health centres, 14 maternity homes, four polyclinics, 30 hospitals and a teaching hospital.

Data sources

We used data from the District Health Information Management System II (DHIMS-II) database. The DHISM-II database is a national electronic database that collects, collates and manages routine health services data in an aggregated form for the Ghana Health Service. New cases of snakebite are usually recorded at health facilities' outpatient departments (OPDs) and entered into DHIMS II through the monthly OPD morbidity reporting form. Snakebite cases upon admission are reported through the inpatient morbidity and mortality report form in the event database of DHIMS II.

Data collection

We extracted snakebite data from the monthly OPD morbidity form from the DHIMS-II database. Variables that were collected included the number of cases reported, period of reporting, age, gender and reporting districts of the cases. Snakebite cases from 2018 to 2023 were extracted and exported into (Microsoft Corporation, 2021)[12] for cleaning and analysis. The snakebite mortality data were extracted from the Cause of Death database, which is jointly managed with the DHIMS-II database by the Centre for Health Information Management within the Ghana Health Service. Information regarding the underlying cause of death was extracted from the various causes of death forms (Form A, B, C and D), each representing a potential cause of death.

Data analysis

The exported data were analysed descriptively by person, place and time using frequencies, proportions and maps. Incidence rates were estimated by the total number of snakebites recorded per year and were divided by the mid-year population. The overall snakebite incidence was calculated by the total number of cases that were recorded over the 6 y divided by the mid-year population per 100 000.

The Cumulative Sum (CUSUM) is a statistical method widely used to set seasonal thresholds that has been applied in several studies[7,10,13–16] for detecting outbreaks in syndromic surveillance systems. Building on the approach used in previous studies,[7,10] we utilised the CUSUM method to identify potential snakebite outbreaks in the Volta Region and its flood-affected districts (North Tongu, Central Tongu and South Tongu districts) before, during and after the flood under the study period.

The CUSUM method is designed to detect shifts in the mean of a time series that is stationary between two change-points and performs best with normally distributed data. To ensure these assumptions were met, we first assessed the normality of the data using the skewness test, obtaining a p-value of 0.7858, which indicated that the data were normally distributed. We then tested the stationarity of the data using the Dickey–Fuller and Phillips–Perron tests, both of which returned $p<0.05$, confirming that the data were stationary (Supplementary file).

We calculated the seasonal threshold using the CUSUM formula: the mean plus three times the SD of the last seven surveillance points, with a 2-mo lag.[7,10] An outbreak

was identified when reported snakebite cases exceeded this threshold.

For spatial analysis, we used the Quantum Geographic Information System (QGIS) to generate a choropleth map displaying the incidence rate of snakebites by district. A choropleth map uses a colour gradient to represent variations in a quantitative variable across different locations. District shapefiles for the Volta Region were obtained from the Ghana Demographic and Health Survey. We then linked the district names and estimated snakebite incidences to the shapefiles using the join tool in QGIS. The results are presented in tables and maps.

Ethical considerations

Snakebite is routinely reported into DHIMS-II as part of the Integrated Disease Surveillance and Response; hence we used aggregated secondary data for the analysis and no formal ethical approval was required for this study. This aligns with the Public Health Act, 2012, which mandates the Ghana Health Service to maintain and update surveillance data for epidemic-prone diseases and public health events.[17] Therefore, this study falls under the purview of this act, which promotes routine analysis and publication of such data. We obtained administrative permission to access the dataset from the Volta Regional Health Directorate. All data were anonymised to remove any personal identifiers.

Results

Background characteristics of cases

A total of 1637 snakebite cases were reported across the 6-y study period. Case patients aged <1 y were the least affected (0.3%; 5/1637), whereas those aged 20–34 y were the most affected (26.7%; 437/1637). Males were more affected (57.7%; 944/1637) than females (Table 1).

Regarding age and gender distribution, the highest proportion of cases was observed among males aged 20–34 y. However, snakebites affected both males and females across all age groups in the region (Figure 1).

Table 1. Age and gender distribution of snakebite cases, Volta Region, 2018–2023

Variable	Frequency (N=1637)	%
Gender		
Male	944	57.7
Female	693	42.3
Age group, y		
<1	5	0.3
1–4	46	2.8
5–9	92	5.6
10–14	150	9.2
15–17	110	6.7
18–19	82	5.0
20–34	437	26.7
35–49	382	23.3
50–59	181	11.1
60–69	90	5.5
≥70	62	3.8
Period		
2018	313	19.1
2019	314	19.2
2020	272	16.6
2021	224	13.7
2022	244	14.9
2023	270	16.5

Seasonal distribution of snakebite cases

The seasonal distribution of snakebite cases shows an unstable pattern, as cases were increasing and decreasing across the period under review. However, most of the cases peaked in March, April, September, and October (Figure 2).

Incidence and case fatality rate of snakebite

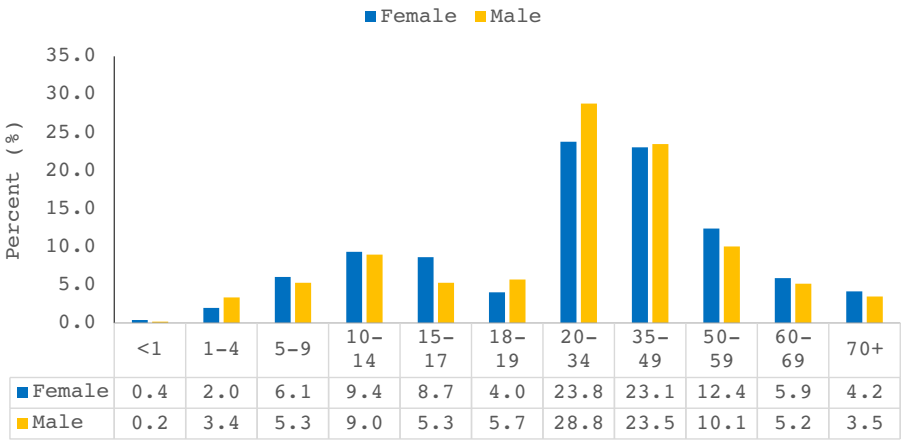
The incidence of snakebite decreased from 18 cases per 100 000 population in 2018 to 15.8 cases per 100 000 population in 2023 (Table 2). The year 2021 recorded the lowest incidence rate of 13.7 cases per 100 000 population. The incidence rate was highest in 2018, with 18.0 cases per 100 000 population. The Volta Region recorded an overall incidence rate of 15.8 cases per 100 000 population. The case fatality of snakebite was highest in 2022, with a rate of 1.6%. There was no mortality from 2018 to 2021. Overall case fatality during the study period was 0.4% (7/1637) (Table 2).

Snakebite outbreaks in Volta Region and flood-affected districts

Figure 3 shows the distribution of snakebites and the outbreak threshold in the Volta Region and the flood-affected districts (North Tongu, Central Tongu and South Tongu) from 2018 to 2023. The results indicate that only one snakebite outbreak occurred during this period, spanning from March to June 2022, with a peak in April 2022. Although the number of snakebite cases surged in September 2023, the total remained below the outbreak threshold, meaning that no outbreak was identified. During the floods in October 2023, 15 snakebite cases were reported, but this figure did not exceed the threshold, and cases dropped to zero by the end of December 2023 [See appendix 1 Figure A2(a)].

Regarding the distribution of snakebite cases and outbreak thresholds in the flood-affected districts, three snakebite outbreaks were recorded in the North Tongu District, with the first occurring in March 2019 and the most recent in March 2023 [See appendix 1 Figure A2(b)]. Although there was a spike in cases during the October 2023 flood, no outbreaks were detected by the end of December 2023 (Figure 3).

In Central Tongu District, four outbreaks were recorded before the floods in October 2023. The first occurred in August 2019, and the last was reported in April 2023 [See appendix 1 Figure A2(c)]. Similarly, South Tongu District experienced four outbreaks, beginning in May 2019 and ending with the most recent in February 2023 [See appendix 1 Figure A2(d)]. Notably, no new outbreaks were detected during or after the floods as of December 2023 (Figure 3).



	<1	1–4	5–9	10–14	15–17	18–19	20–34	35–49	50–59	60–69	70+
Female	0.4	2.0	6.1	9.4	8.7	4.0	23.8	23.1	12.4	5.9	4.2
Male	0.2	3.4	5.3	9.0	5.3	5.7	28.8	23.5	10.1	5.2	3.5

Figure 1. Age and gender distribution of snakebite cases, Volta Region, 2018–2023.

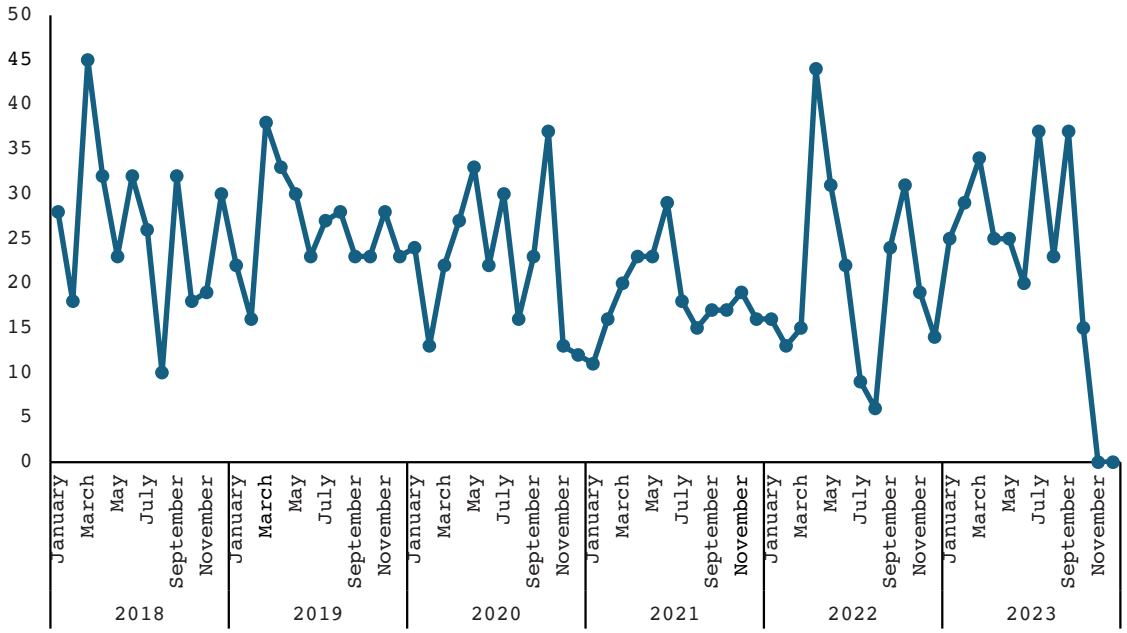


Figure 2. Seasonal distribution of snakebite cases, Volta Region, 2018–2023.

Geospatial mapping of the snakebite incidence rate

Regarding the district distribution of snakebite cases, we observed that from 2018 to 2021, Ketu North consistently reported the highest incidence rates, ranging from 62.2 to 71.3 cases per 100 000 population (Figure 4). Additionally, in 2022 and 2023, North Tongu and Ho West reported the highest incidence rates of snakebite cases, with 39.3 and 30.7 cases per 100 000 population, respectively [See appendix 2 Figure A3(e) and (f)]. The Akatsi North district reported no incidence of snakebite cases in four successive periods from 2018 to 2021 (Figure 4).

Discussion

We observed a decline in snakebite incidence during the study period, consistent with previous studies in the Western Region of Ghana, Volta and Oti.[7,8] This reduction may be attributed to ongoing community education and awareness efforts. The increased knowledge about preventive measures and safety precautions over the years could lead to greater caution in snake-prone areas, resulting in less risky behaviour and a reduced number of snakebite incidents.

Our study revealed a lower regional cumulative incidence rate of snakebite of 15.8 per 100 000 population. This finding was lower than the 24 per 100 000 population found by Ceesay et al. in 2021 in the Volta and Oti Regions and much lower than the 92 per 100 000 population reported by Punguyire et al. in two district hospitals in Northern Ghana in 2014. A comprehensive analysis by Mensah et al. in the Western Region of Ghana in 2016 further corroborates this huge discrepancy.[7,8,18] Furthermore, the incidence rate in our study is significantly below the figures reported

Table 2. Incidence and case fatality rate of snakebite, Volta Region, 2018–2023

Period	Number of cases	Number of deaths	Population	Incidence rate	Case fatality (%)
2018	313	0	1 742 501	18.0	0.0
2019	314	0	1 792 483	17.5	0.0
2020	272	0	1 832 999	14.8	0.0
2021	224	0	1 636 779	13.7	0.0
2022	244	4	1 670 764	14.6	1.6
2023	270	3	1 705 849	15.8	1.1
Overall	**1637**	**7**	**10 381 375**	**15.8**	0.4

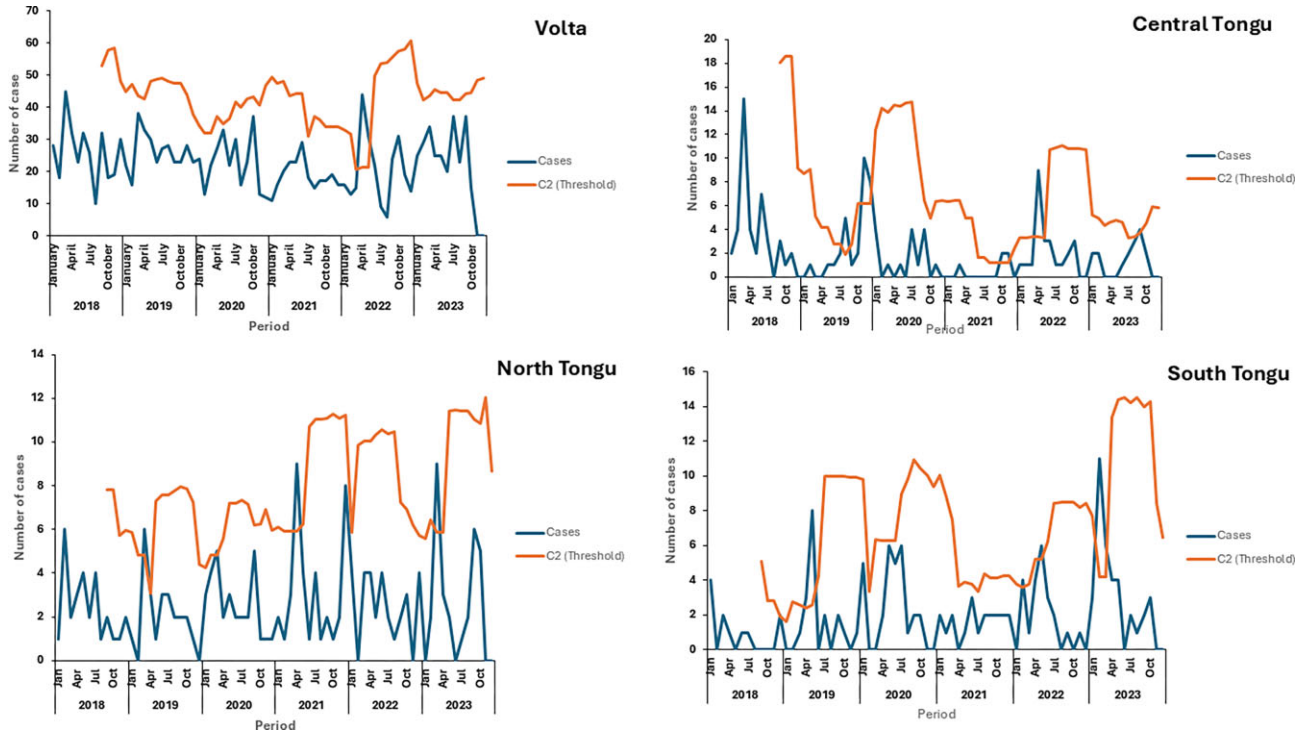


Figure 3. Distribution of snakebite cases and threshold (C2) in Volta Region and flood-affected districts, 2018–2023.

in a meta-analysis conducted in sub-Saharan Africa. The meta-analysis, which estimated snakebite incidence through national reporting systems and household surveys, indicated rates of 65.1 (39.2–90.9) and 204.6 (172.1–237.2) per 100 000 population, respectively.[5] This suggests the possibility of an underestimation in our study, potentially attributed to the under-reporting of snakebite cases in the region.

Also, the difference in incidence rates may be due to the methodological differences. Our health facility-based reporting could lead to underestimation, especially given the poor health-seeking behaviour of snakebite victims, who often resort to traditional remedies.[4,5] The study in Northern Ghana, using a prospective approach, may have identified more cases, emphasising the need for a comprehensive understanding of the true burden of snakebites. It is also known that hospital-based studies underestimate disease burden compared with community-based surveys.

We observed an overall case fatality rate of 0.4%. This finding was lower than the 0.6% reported in a previous study in the Western Region of Ghana,[8] 3% in a household survey in Northern Ghana[19] and 1.1% in sub-Saharan Africa.[5] The observed low case fatality rate in our study may be due to the availability of antisnake venom at the health facilities in the region. Also, the lower rate could be attributed to a majority of the bites being from non-venomous snakes and the fact that our study relied on facility-level data, in which case our rate could be an underestimate. We recommend that future studies in the Volta Region focus on assessing and accurately uncovering the true burden of snakebite-related mortality.

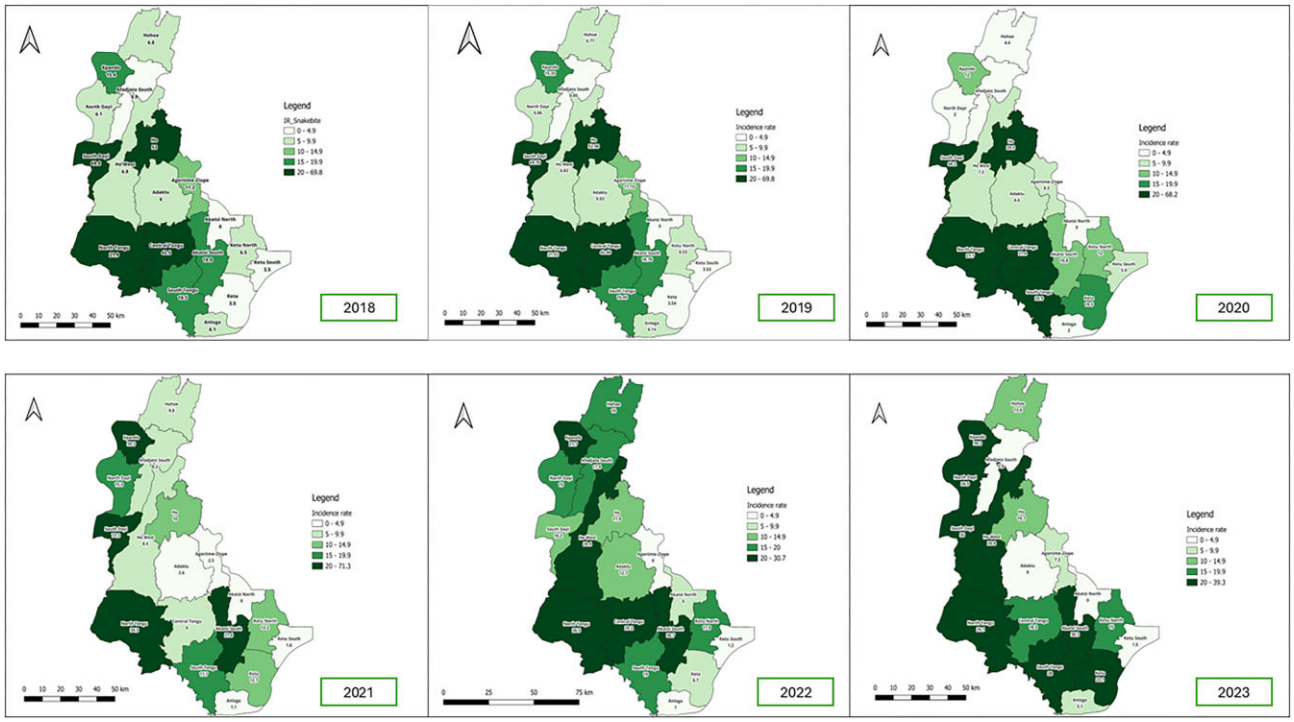


Figure 4. Geospatial mapping of snakebite incidence rate, Volta Region, 2018–2023.

Our study also revealed a higher incidence of snakebites in men compared with women. This finding is similar to what has been documented in previous studies in Ghana.[7,18,19] In many rural communities in Ghana, men are commonly engaged in activities such as hunting, fishing and farming. The inherent nature of these occupations may predispose men to an elevated risk of snakebites. Therefore, interventions aimed at reducing snakebite incidence in the Volta Region should specifically target men.

Our findings highlighted a higher incidence of snakebites among individuals aged 20–34 y, which aligns with previous research conducted in Ghana.[7,18,19] Adults in this age group are at a higher risk of snakebites, primarily because of their economic activity. Snakebites are often considered an occupational hazard, particularly in agricultural settings. In rural Ghana, adults are predominantly involved in farming, fishing and hunting, and this increases their exposure to snakebites. However, we recognise that our study design was not specifically robust enough to accurately assess the risk of snakebite in this age group. Therefore, future research should explore whether the incidence of snakebites is indeed higher among individuals aged 20–34 y compared with younger populations.

Our analysis revealed that most snakebite cases occurred during March–July, which coincides with the rainy season in Ghana. This finding is consistent with previous studies in Ghana, where snakebite cases were highest during the rainy season and harvesting periods from March to July and August to November.[7,18–20] The observed pattern is likely due to the significant impact of rainfall on snakebite incidence, as highlighted in previous studies.[21,22] Probably the increased rainfall creates a favourable environment that amplifies the risk of snakebite. We recommend that future studies further explore the relationship between rainfall and snakebite incidence in the Volta Region.

Our study revealed that, prior to the floods in October 2023, there were outbreaks of snakebites in the flood-affected districts. The Central Tongu and South Tongu districts experienced higher numbers of outbreaks, while North Tongu recorded the least. The findings implied that these districts were not new to outbreaks of snakebite and that there could be a potential surge in snakebite cases during or after the floods in these districts if nothing was done. Additionally, most of the outbreaks in these districts occurred at the onset and towards the end of the rainy seasons in previous years, suggesting a seasonal pattern. Therefore, interventions were needed to mitigate the potential outbreak of snakebite during or after the flood.

Based on these findings, we collaborated with the regional health promotion unit to develop and disseminate key messages addressing snakebites, diarrhoeal diseases and other flood-related health concerns during the response phase of the flooding. The unit also organised media briefings and facilitated radio discussions across all flood-affected districts. Furthermore, extensive awareness campaigns were launched in safe havens and surrounding communities. These strategic efforts were significant as neither of the districts recorded any incidence of snakebite during and after the flood. However, our study was unable to identify the possible cause of the recorded outbreaks in the previous years preceding the floods. This was because we were focused on identifying outbreaks in the previous years to inform our interventions in response to the flood. We acknowledge that identifying the possible causes of the outbreaks will

be instrumental in guiding interventions to prevent future occurrences of such outbreaks. We therefore recommend that future studies should investigate the possible causes of these outbreaks in previous years preceding the flood in the flood-affected districts in the region.

Limitations

First, we used data from DHIMS II, which has data quality issues such as completeness, which could have affected our estimates. Additionally, DHIMS II has limited variables related to snakebites, lacking crucial information such as the type of snake, bite location, administration of antisnake venom and the nature of activities at the time of the bite. These variables are indispensable for public health for planning and devising targeted strategies and preventive interventions to address snakebite-related health issues in the Volta Region. Despite these limitations, our study demonstrates that DHIMS II data analysis can be useful for providing valuable and timely insights for decision-making and the formulation of interventions aimed at reducing the incidence of snakebites in the region.

Conclusions

Snakebites are prevalent but exhibit low fatality rates in the Volta Region of Ghana. Productive young men are particularly susceptible to snakebites in the region, with the incidence being notably higher in the Ketu North district. To address this public health concern, collaborative efforts between the Regional Health Directorates and District Health Directorates are recommended to continue to enhance education initiatives on the importance of using protective clothing, especially during the rainy season, within the general population. Further research is imperative to accurately assess the true burden of snakebite in the Volta Region.

Supplementary data

Supplementary data are available at *Transactions* online.

Authors' contributions: SAB and CK conceived the idea, with CK contributing to the technical evaluation design and overall supervision of this work. JYJ, FKK, EYB and AN supported acquiring, managing and interpreting the data. SAB and SKD supported the analysis. The manuscript was prepared by SAB and CK, and all authors contributed to the writing and revision of the manuscript. All authors approved the final version and submission of the manuscript for publication.

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Competing interests: The authors declare no competing interests.

Ethical approval: Not required.

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

Appendix 1: Snakebite Outbreaks in Volta Region and Flood affected Districts

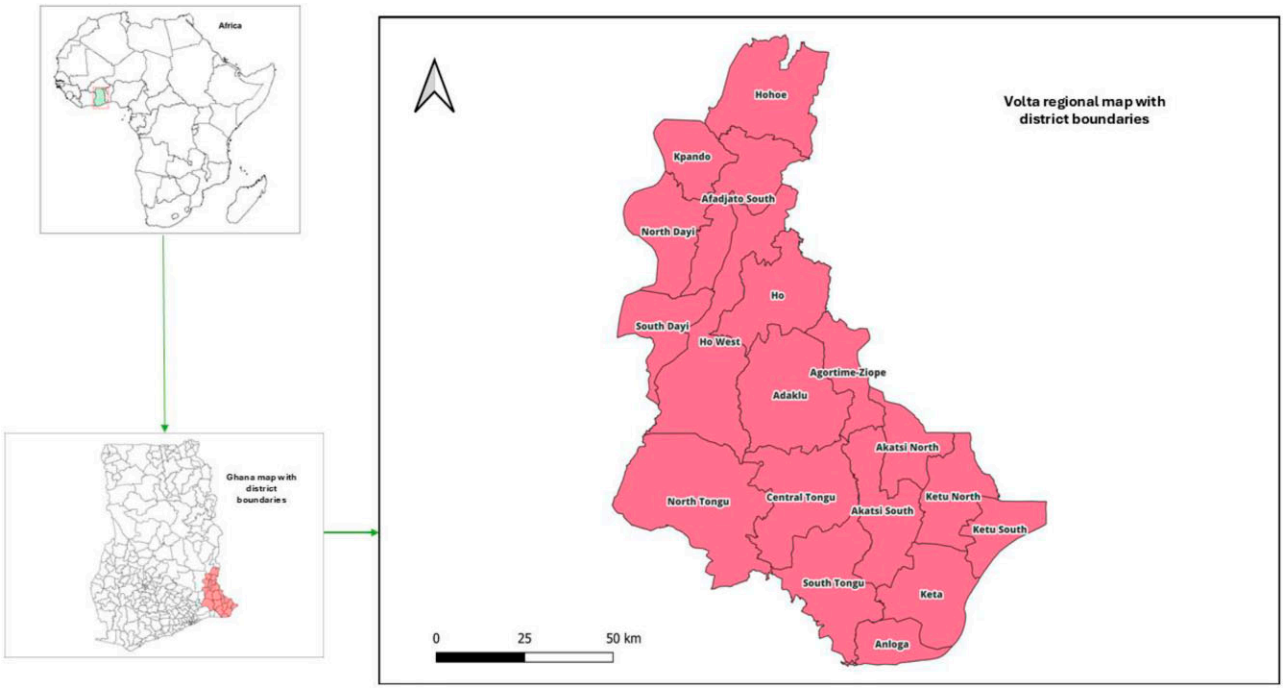

Figure A1. Map of the Volta Region Showing District Boundaries

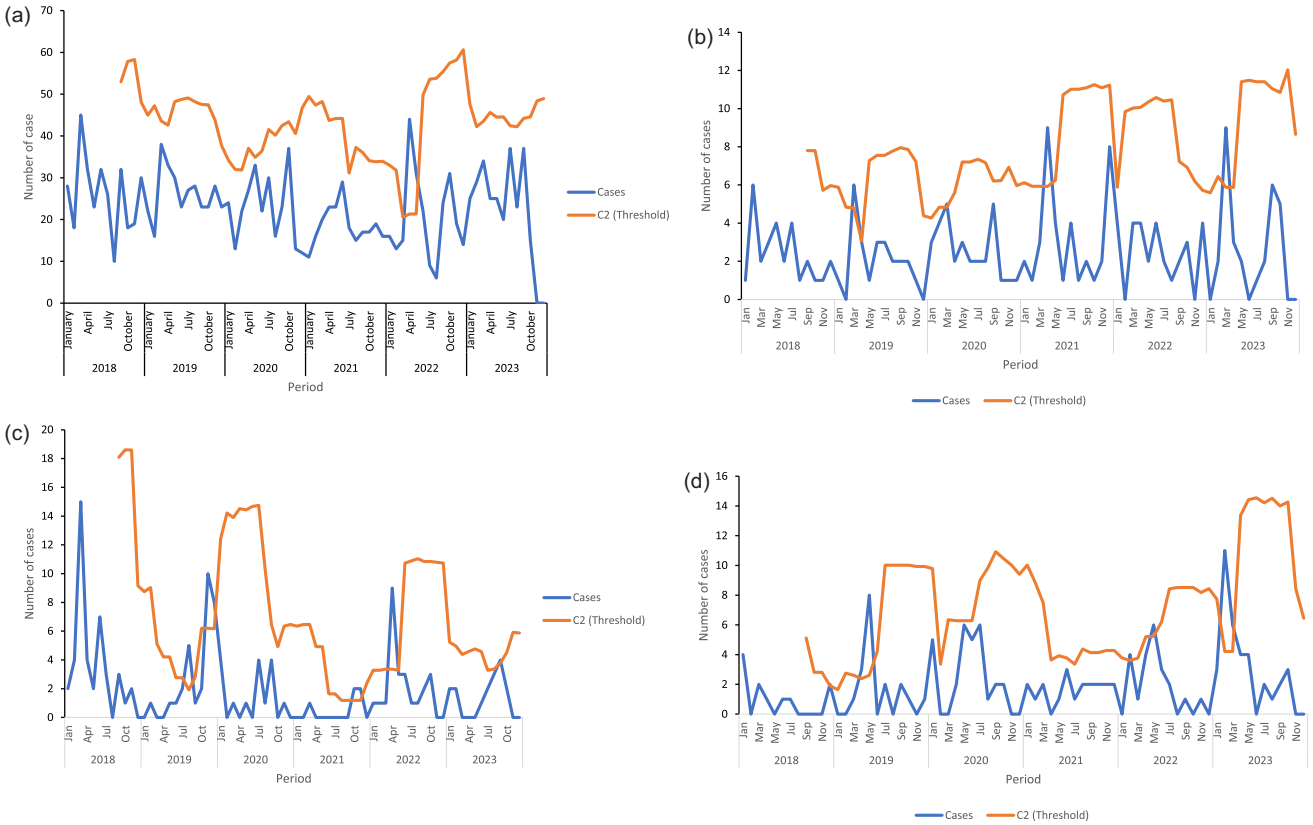

Figure A2. (a) Distribution of snakebite cases and threshold (C2), Volta Region of Ghana, 2018–2023. (b) Distribution of snakebite cases and outbreak threshold in North Tongu District, Volta Region of Ghana, 2018–2023. (c) Distribution of snakebite cases and outbreak threshold in Central Tongu District, Volta Region of Ghana, 2018–2023. (d) Distribution of snakebite cases and outbreak threshold in South Tongu District, Volta Region of Ghana, 2018–2023.

Appendix 2: Geospatial mapping of snake bite incidence rate

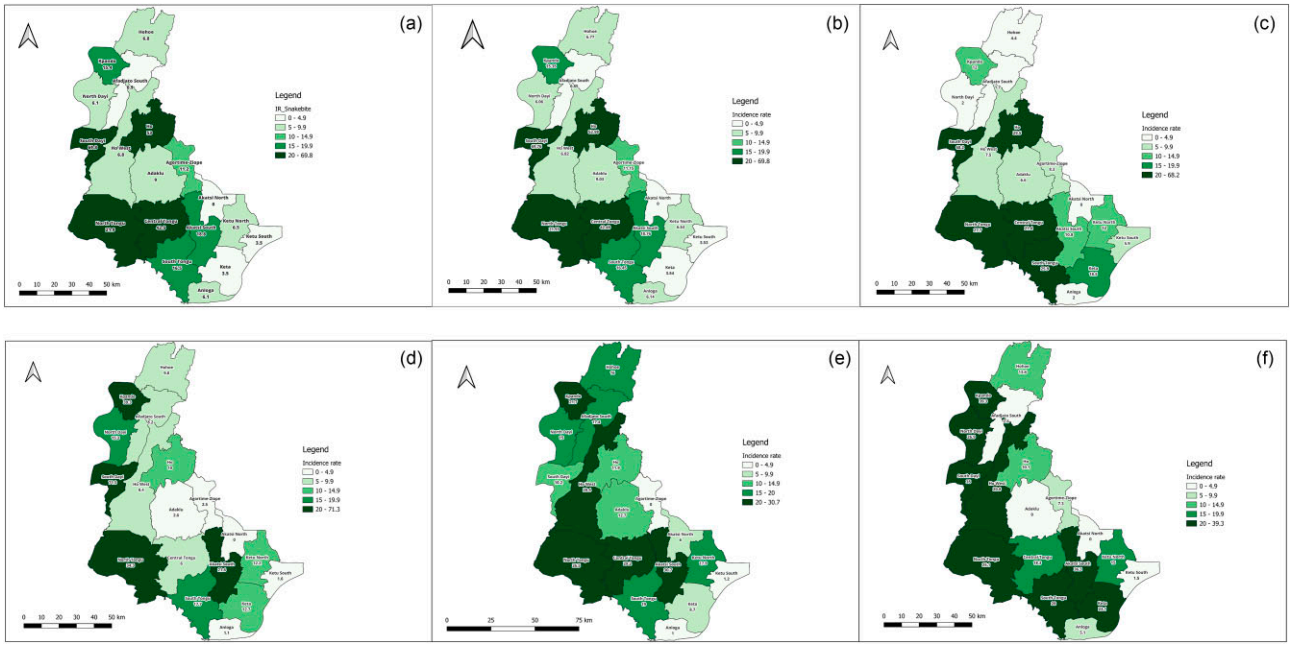

Figure A3. (a) Geospatial mapping of snake bite incidence rate, Volta Region, 2018. (b) Geospatial mapping of snake bite incidence rate, Volta Region, 2019. (c) Geospatial mapping of snake bite incidence rate, Volta Region, 2020. (d) Geospatial mapping of snake bite incidence rate, Volta Region, 2021. (e) Geospatial mapping of snake bite incidence rate, Volta Region, 2022. (f) Geospatial mapping of snake bite incidence rate, Volta Region, 2023.

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