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ORIGINAL ARTICLE

The incidence of snakebite in South Africa and the challenges associated with lack of reporting

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Background: Snakebite is a public health challenge that has a substantial impact on humans and snakes. Annually, millions of people are affected by snakebite globally but there is a paucity of detailed data on snakebite incidences. The aim of this study was to assess the patterns of snakebite incidences in South Africa.

Methods: We collected data from hospital records, information from the National Snakebite Database and records from the AfriTox Telelog database from 2011 to 2024.

Results: The combined dataset showed that 3496 snakebite incidences have been recorded over 12.5 years. The prevalence was calculated to be 5.63 per 100 000 individuals of the population for South Africa, with the highest prevalence in KwaZulu-Natal (8.89). Males made up 65.9% of snakebite incidences and most incidences were recorded between November and March. The snake species responsible for most snakebite incidences was *Bitis arietans*.

Conclusion: Snakebite is generally well managed in South Africa with few recorded deaths despite the relatively high number of bites. However, incidents are often not recorded or have missing information particularly regarding the circumstances of the bite. Our study provides insight on the snake species responsible for snakebite incidences in South Africa and can be used to create prevention measures.

Keywords: epidemiology, prevention, public health, snake behaviour

Introduction

Snakebite is a public health issue which is currently estimated to affect 2.5 million people globally each year.[1,2] Negative interactions between humans and snakes increase the probability of snakebite incidences, especially in cases involving venomous species, which can result in envenomation.[3] Envenomation can lead to death, but if snakebite victims receive medical care and antivenom, they are likely to survive.[2] Besides death, permanent disability can result from necrosis, nerve damage and venom ophthalmia, leading to long-term psychological consequences of snakebite.[4] Having declared snakebite as a neglected tropical disease, the WHO has developed a strategy for the prevention and control of envenoming, to reduce deaths and disabilities due to snakebite by 50% by 2030.[5] This has raised the profile of snakebite as a One Health challenge that needs to be addressed from a transdisciplinary approach.[6]

One Health approaches require the compilation of reliable information on the incidence of snakebite and resulting rates of mortality,[7] information on the behaviour and ecology of medically important venomous snakes, and prevention measures implemented at the community level.[8] However, past research has focused mostly on the treatment of snakebite and not the ecology of snakes in relation to snakebite.[2,4,7] The complexity and context of snakebite varies across global and regional landscapes due to the diversity and distribution of venomous snakes and this can have several implications on rural populations.[8] Only recently have studies showcased the snake species involved in snakebite incidences and the impact on the demographics of the population.[8,9] Various studies have also highlighted regional hotspots for snakebite, including India,[9] Central Africa,[10] South-East Asia, and parts of Central and South America.[11] However, no studies have focused on southern Africa exclusively.

Snakebite incidents in South Africa are relatively common.[12] However, snakebite-related deaths are lower than in tropical, low GDP countries.[13] This is due largely to the antivenom that has been produced by the South African Institute for Medical

Research (SAIMR) and manufactured by the South African Vaccine Producers (SAVP).[14] Antivenom in South Africa has been developed and improved since 1916,[15] and thus there has been a long history in the treatment of snakebite. Despite this longstanding investment in treatment, only some provincial studies have been conducted in the past,[12,13] but the actual patterns of snakebite at the national scale have remained undocumented. Of the 114 snake species in South Africa,[16] approximately 16 can cause significant harm to humans through envenomation and have been categorized by the WHO[4] according to the impact of their venom. Medically important Category-1 South African species include *Dendroaspis angusticeps*, *Dendroaspis polylepis*, *Naja annulifera*, *Naja nivea*, *Naja mossambica* and *Bitis arietans*. Most of these snake species are widespread, occurring over large parts of southern Africa and feature commonly in biting incidents.[4] Category-2 species include *Atractaspis bibronii*, *Dispholidus typus*, *Thelotornis capensis*, *Hemachatus haemachatus*, *Naja subfulva*, *Naja nigricincta woodi* and *Bitis gabonica*. These snakes are featured less often in snakebite incidences and have smaller distributions than Category-1 snakes.[4]

Snakebite in South Africa occurs in two scenarios, which are categorized as 'legitimate' and 'illegitimate'.[17] Legitimate bites are defined as incidents where a person unintentionally and unknowingly provokes a snake, while illegitimate bites are defined as incidents where an individual sees a snake and attempts to catch or kill it, or otherwise interact with it, resulting in a bite.[18] Illegitimate bites typically occur in snake keepers, breeders or snake-removers who are intentionally interacting with venomous species.[19] The circumstances under which legitimate bites occur are often unknown and the snake responsible is also often not identified. Thus, a syndromic approach is often followed for the diagnosis and management of snakebite in South Africa[12,20] instead of relying on snake identification.

The activity of snakes and their movement patterns primarily impact the circumstances leading to a bite and spatial variability in incidences.[21] These incidences of snakebite are highly dependent on environmental factors such as climate and habitat, and human demographics,[22] all of which are undergoing change. Our study aimed to assess the current incidence of snakebite in South Africa and evaluate the differences across a spatial and demographic landscape with the goal of identifying the snake species responsible for the greatest number of bites and creating targeted prevention measures. Three data sources were compared to provide insight into provinces that are at highest risk for snakebite incidences and how these incidents might occur.

Materials and Methods

Three data sources were used to assess the incidence of snakebite in South Africa: hospital records from 36 of 754 private and public hospitals,[23] information from the recently established National Snakebite Database (NSBD) and records from the AfriTox Telelog database established through the Poison Information Helpline of the Western Cape (PIHWC).[24]

Hospital data

A retrospective, cross-sectional study was conducted on data from 36 hospitals across South Africa from August 2011 to December 2022. The following variables were extracted from records: date, time of day when person was bitten, province, patient age, gender, ethnic group, snake species responsible, site of the bite on the body and patient activity at time of the bite (e.g. walking). Patient age was categorized into 10 bins: 0–10, 11–20, 21–30, 31–40, 41–50, 51–60, 61–70, 71–80, 81–90 and 91–100 y. Dates were grouped by month, and time of day was grouped into early morning (midnight to 06:00 h), mid-morning (06:00 h to midday), afternoon (midday to 18:00 h) and night (18:00 h to midnight).

AfriTox Telelog database

A retrospective, cross-sectional study was conducted on data downloaded from the AfriTox Telelog database consisting of calls received by the PIHWC over a 9 y period from 1 June 2015 to 31 December 2023. Data were received on 12 January 2024 for analysis. The PIHWC is a 24 h helpline service for the public to report on poisoning or envenomation events. The centre is part of the University of Cape Town's Department of Paediatrics and Child Health, and it is currently situated at the Red Cross Children's Hospital. The PIHWC telephone service was established on 1 June 2015 and the information has since been captured on the AfriTox database. Data categories included on snakebite were the date and time of the incident, calls from both medical personnel or the public, the province where the bite was recorded, gender and age of patients, and the snake species responsible for the bite. Calls listed under the unidentified snake species category were also included. Any additional notes were consulted to further extract information regarding the site of the bite on the body and the activity when the incident occurred. Only human-related calls were included and repeated calls were not included.

National snakebite database

The National Snakebite Advisory Group has existed in South Africa since 2018 to provide clinical advice, provide medical support, and manage snakebite in both humans and animals.[17] The group is a voluntary team of medical, veterinary and herpetology experts and through the organization of the first South African Snakebite Symposium, the group identified the need for a snakebite database. Thus, a National Snakebite Database was established in January 2023 to collect data on snakebite incidences across South Africa. Our analysis included data collected from the NSBD from 1 January 2023 to 31 January 2024. The variables extracted were the same as those from hospital records.

Combined dataset

All the datasets were combined and analysed using descriptive statistics to provide a complete perspective of snakebite incidences in South Africa, regardless of the source used to collect the data. The combined dataset included data on the date and time of the incident, province (where available), patient age, gender, snake species responsible for the bite, site of the bite on the body and the activity when the incident occurred. To avoid double counting incidents, duplicates were removed from the combined dataset (Box 1).

Box 1. Process of removal of duplicate records from the datasets.

The only overlaps in data were across the AfriTox Telelog database and the NSBD and the AfriTox data and the hospital data. The records with the most information about the circumstances of the bite were chosen and both NSBD and the AfriTox records included more information than hospital records.

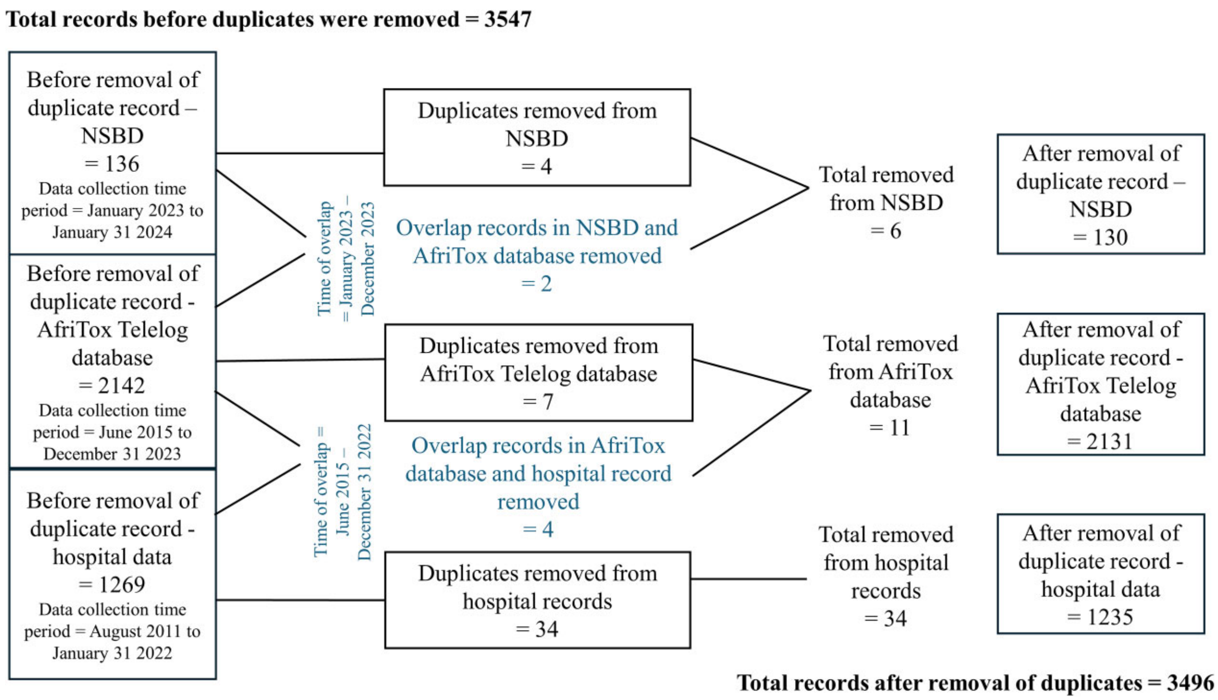

Fig.1

Results

Hospital data

Data from the hospital records indicate that over the 11 y and 5 mo of data capture, 1235 snakebite incidences were recorded. Of these, there was only one recorded death, which was recorded in 2018. Overall, the only categories missing no data were age, time of bite and month. All additional categories had cases of missing or unrecorded data. Thus, results were based on available data and the rest were considered as unknown in the analysis. From the total bites, more males (65.1%) were bitten than females (34.8%), and this pattern was generally the same for each year. One record did not report the gender (0.1%). The ethnic group with the highest recorded incidences was White (47.8%) and the lowest was Coloured (3.7%, Table 1). Incidences were highest in the 21–30 y age demographic than other age categories. The majority of snakebite incidents occurred during summer/rainfall months (October–March) and fewest occurred during cooler months (April–September, Table 2). Most cases occurred between 18:00 h and midnight.

Provincial locations were only recorded for 1057 of the 1235 incidences (85.6%). The province with the highest record of snakebite incidences was KwaZulu-Natal (40.9%), followed by Gauteng (30.7%), and fewest incidences were recorded in Northen Cape (0.1%, Table 2). From the available data (only 2.4% of the reported incidents included the snake species), the snakes responsible for snakebite incidents included *Naja* spp. (n=12) (species not specified), *D. polylepis* (n=2), *B. arietans* (n=6), *H. haemachatus* (n=2), *Causus rhombeatus* (n=4), *A. bibronii* (n=3) and *B. atropos* (n=1). The most common part of the body recorded as bitten was the foot (4.5%), followed by finger (3.2%) and hand (3.1%). However, in 83.1% of cases, the site of the bite on the body was not recorded.

AfriTox Telelog database

A total of 2131 incidences of snakebite were recorded from the AfriTox Telelog database. Of these, 2009 were bites and 122 were spitting events. Only 26% of the reported incidents included the snake species. *Bitis arietans* was most commonly responsible for bites, while 38 other species were responsible for at least one bite. Most bites were recorded in 2023, mainly due to *B. arietans* and *N. mossambica*. The majority of bites were on the foot (23.3%), the finger (13.5%) and the hand (11.8%, Table 2). In total, the site of the bite on the body was not recorded for 25% of records. The majority of snakebite incidents were recorded in KwaZulu-Natal (25.4%) and the fewest in Northern

Table 1. Snakebite incidents and the demographics of the individuals in South Africa recorded from August 2011 to January 2024 from three data sources (total for Hospital records=1235, National Snakebite Database=130, AfriTox Telelog Database=2131)

Category	Hospital records (%)	National Snakebite Database	AfriTox Telelog Database	Total
Sex				
Male	65.1	70.0	66.1	65.9
Female	34.8	29.2	33.6	33.9
Unknown	0.1	0.8	0.3	0.2
Ethnicity				
White	47.8	33.1	NA	18.1
African	39.4	54.6	NA	15.9
Coloured	3.7	2.3	NA	1.4
Indian	7.6	3.1	NA	2.8
Unknown	1.5	6.9	NA	0.8
Age, y				
0–10	11.4	15.4	22.0	18.0
11–20	13.0	16.9	18.0	16.2
21–30	19.6	16.9	20.1	19.8
31–40	19.4	15.4	16.5	17.5
41–50	16.9	16.2	11.0	13.3
51–60	11.0	12.3	6.5	8.3
61–70	6.2	3.8	4.0	4.7
71–80	2.3	0.8	1.6	1.8
81–90	0.2	NA	0.3	0.3
91–100	NA	0.8	NA	0.1
Unknown	NA	1.5	NA	0.1

NA=not applicable.

Cape (2.7%, Table 2). Males made up 66.1% of all snakebite incidents and most were recorded in people aged 0–10 y (22%, Table 1). The majority of incidents were recorded between October and March and between midday and 18:00 h (36.6%, Table 2). Of the known activities (173/2130, ∼8%), walking ranked highest.

National snakebite database

In total, 130 incidences of snakebite were recorded between the beginning of January 2023 and end of January 2024 on the NSBD. Males made up 70.0% of people bitten. One entry in the database did not record the gender. The ethnic group recorded with most incidences was African (54.6%) and fewest was Coloured (2.3%, Table 1). The ethnicity of 6.9% of people was not recorded. The age category with the most snakebite incidences recorded was 11–20 (16.9%) and 21–30 y (16.9%). The majority of incidents were recorded from November to April, and between 18:00 h and midnight (35.4%). The majority of incidents were recorded in KwaZulu-Natal (39.2%) and fewest in Northern Cape (0.8%, Table 2). The NSBD listed 17 species responsible for bites and these were recorded for 68% of incidences. *Bitis arietans* was responsible for the greatest number of bites.

Table 2. Characteristics of snakebite incidents in South Africa recorded from August 2011 to January 2024 from three data sources (total for Hospital records=1235, National Snakebite Database=130, AfriTox Telelog Database=2131)

Category	Hospital records (%)	National Snakebite Database	AfriTox Telelog Database	Total
Time of day				
Midnight to 06:00 h	7.0	6.2	9.7	0.1
06:00 h to midday	20.0	23.8	19.5	0.2
Midday to 18:00 h	34.2	33.1	36.6	0.2
18:00 h to midnight	38.9	35.4	34.2	0.3
Unknown	0.0	1.5	0.0	0.1
Time of year				
January	14.9	20.0	14.7	15.0
February	11.2	2.3	11.9	11.3
March	15.1	9.2	13.6	13.9
April	8.3	15.4	8.1	8.4
May	4.7	10.0	4.4	4.7
June	1.7	2.3	2.8	2.4
July	2.8	1.5	1.7	2.1
August	3.4	1.5	1.6	2.2
September	4.9	3.1	5.7	5.3
October	8.6	5.4	9.6	9.1
November	12.6	10.0	12.0	12.2
December	11.9	19.2	14.0	13.5
Province				
Eastern Cape	2.5	4.6	9.2	6.7
Free State	0.6	2.3	2.5	1.8
Gauteng	30.7	32.3	11.8	19.2
KwaZulu-Natal	40.9	39.2	25.4	31.4
Limpopo	3.9	7.7	9.6	7.5
Mpumalanga	0.9	0.0	11.5	7.3
North-West	4.1	4.6	12.3	9.2
Northern Cape	0.1	0.8	2.7	1.7
Western Cape	1.9	2.3	14.9	9.8
Site of bite on the body				
Ankle	0.9	11.5	7.4	5.3
Foot	4.5	20.0	23.3	16.5
Hand	3.2	19.2	11.8	9.0
Finger	3.2	15.4	13.5	9.9
Knee	0.0	1.5	2.7	1.7
Calf	0.0	3.8	1.5	1.1
Face	1.0	1.5	1.4	0.9
Eyes (spat)	NA	5.4	5.7	4.0
Shoulder	0.0	0.0	0.2	0.1
Abdomen	0.0	0.0	0.2	0.1
Lower arm	0.8	3.1	1.9	1.6
Upper arm	0.5	0.8	0.4	0.5
Lower leg	2.3	9.2	3.9	3.5
Upper leg	0.4	1.5	1.0	0.8
Buttocks	0.0	0.0	0.3	0.6
Unknown	83.1	8.5	24.7	44.7

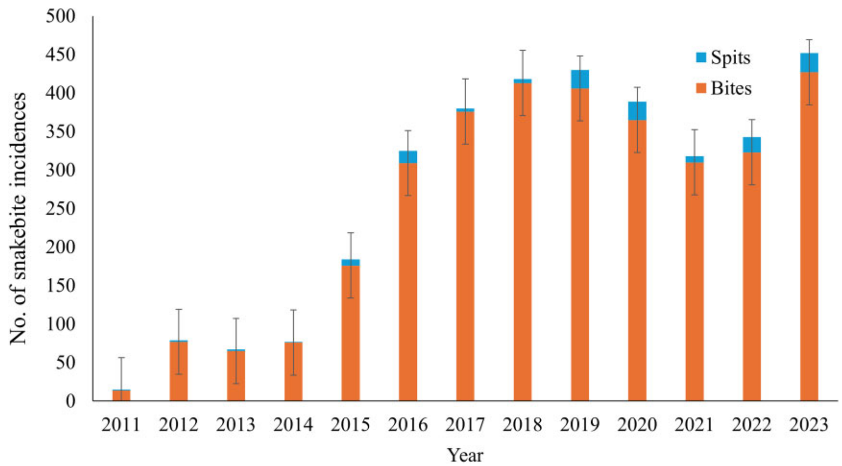

Figure 1. The number of snakebite incidences recorded in South Africa each year from August 2011 to December 2023. Spitting incidents (blue) were separated from biting incidents (orange). The year 2011 did not include datasets for the full year. Standard bars represent standard statistical error.

Combined dataset

The combined dataset showed that 3547 snakebite-related incidences were recorded between 2011 and 2024 from the three data sources. Fifty-one duplicates across the three sources were removed and a total of 3496 incidences were included in the study. Of the total incidences, 141 were spitting incidences that did not lead to bites. Based on the three available datasets, an average of 280 (±SD=167.5) incidents of snakebite were recorded per year over 12.5 y. The majority of incidences were logged during 2023 (427 bites and 25 spitting incidences, Figure 1). Snakebite records were low from 2011 to 2015, but, since 2015, more than 150 bites were recorded per year (Figure 1). The prevalence was calculated as 5.63 for South Africa per 100 000 individuals of the population and provincially the rate was highest in KwaZulu Natal (8.89, Figure 2).

More males (65.9%) were bitten than females (33.9%, Figure 3a) and most records of incidences were in individuals aged 21–30 y (19.8%). The majority of incidents were recorded between midday and midnight (25%, Figure 3b) and between November and March (Figure 3c). For 92% of incidences, the activity at the time of the incidences was not recorded. Of the 8% of bites for which the activity was recorded, people were bitten most while they were walking (Figure 4). In 55.3% of the known records for the site of the bite on the body, most occurred on the foot (16.5%, Figure 3d). Overall, snake species were listed for 32.1% of snakebite incidences and the top 10 were *B. arietans*, *N. mossambica*, *A. bibronii*, *N. nivea*, *Causus* spp., *H. haemachatus*, *D. polylepis*, *Boaedon capensis*, *D. typus* and *Bitis atropos*.

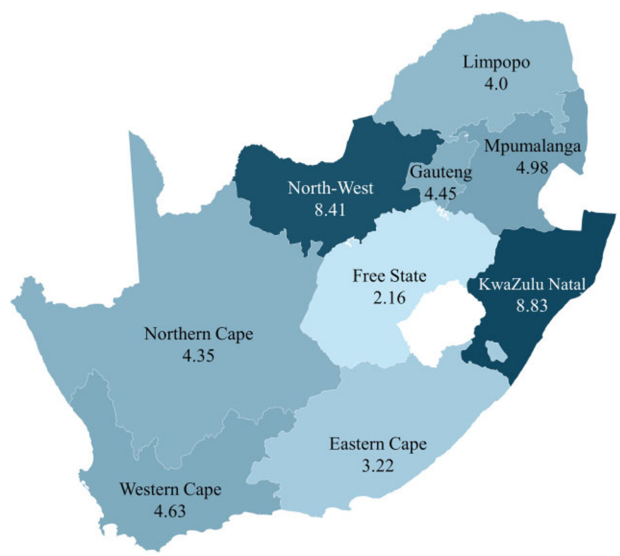

Figure 2. The prevalence of snakebite from the available dataset over 12.5 years was calculated per 100 000 individuals of the population in each province in South Africa with the highest rate in Zulu Natal (8.83).

Discussion

This is the first study to assess the incidence of snakebite in South Africa using multiple data sources. The combined data sources revealed that the incidence of snakebite was much higher than expected with 3355 cases and 141 spitting incidences recorded from August 2011 to January 2024. We also detected an increase in the number of recorded cases from 2015, with more than 150 bites recorded each subsequent year. However, it is not clear if this rise in reported cases is due to an increase in the number of snakebite incidents or improved reporting. Overall, the number of snakebite incidents reported in this study is clearly a significant underestimation of the actual snakebite incidence in the country as records were available from only 4.5% of hospitals in South Africa and only 51 of the snakebite incidents were recorded in more than one of the databases. This highlights the need for a more rigorous snakebite reporting system in South Africa.

We detected several consistent patterns in the different data sources for snakebite incidence in South Africa. For example, all datasets revealed that males made up the majority of snakebite cases, and most cases occurred during the summer months when snakes are most active and searching for prey.[21] KwaZulu-Natal Province had the highest prevalence of snakebite in all

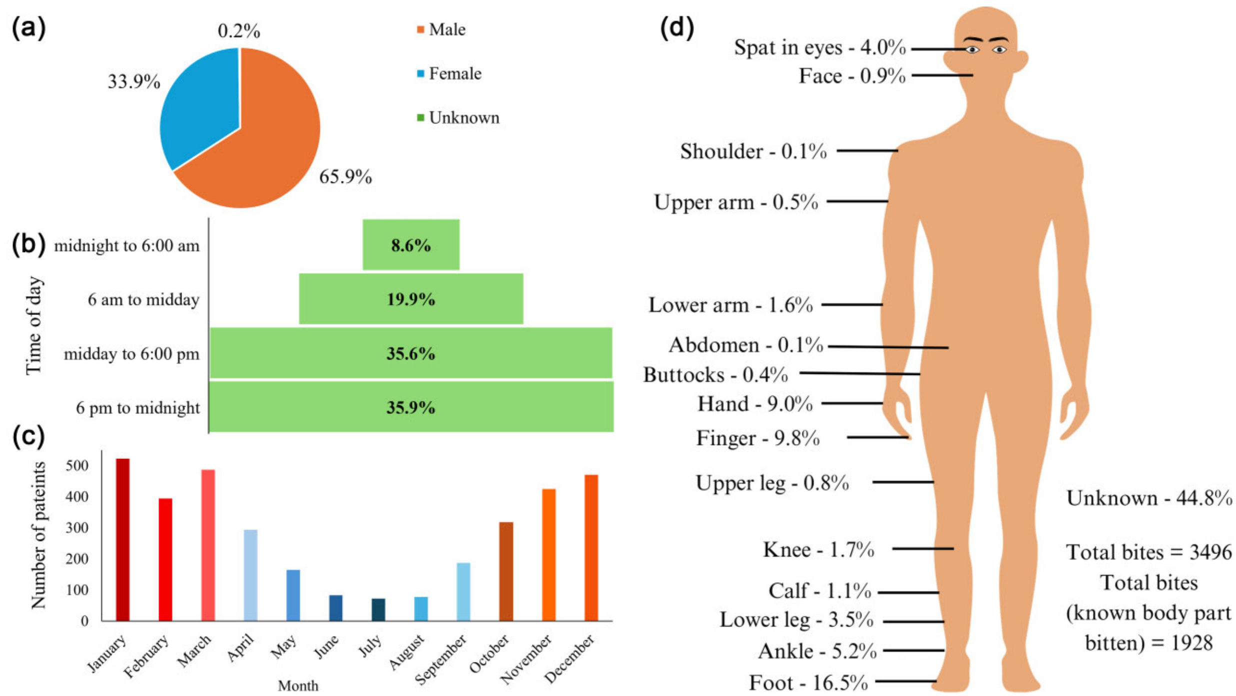

Figure 3. (a) Comparison of the incidence of snakebite between males and females, (b) the time of day when incidences of snakebite were recorded, (c) the time of year when incidences of snakebite were recorded and (d) records of the incidence of snakebite on different parts of the body.

three datasets, probably due to the warm mesic climate in this province. This supports findings of previous studies that also report on high prevalence from hospitals in KwaZulu-Natal.[12,25] *Bitis arietans* was recorded as the species responsible for most snakebite incidents, with incidences for this species peaking in March at the beginning of the mating season for *B. arietans*.[26] This finding was expected given that *B. arietans* is one of the most widely distributed and common snake species in South Africa.[27]

Some patterns varied between the datasets. For example, in the Telelog dataset results revealed that individuals aged 0–10 y tended to be at higher risk of being bitten. However, the NSBD showed that individuals aged 11–20 and 21–30 y were most at risk and hospital records recorded a higher snakebite incidence among individuals aged 21–30 y. Hospital records may represent a more filtered dataset of snakebite incidents since only bites resulting in hospitalization would be recorded. Overall, all datasets showed that young people are at highest risk of being bitten. The list of snake species responsible for bites also varied depending on the data source, as hospital records usually did not list or identify the snake species. In contrast, the Telelog dataset included snakebite incidences from species that had been correctly identified by experts and thus bites were recorded from 39 species. Disparities in patterns between datasets also suggest that the recorded incidence of snakebite in South Africa significantly under-represents the actual incidence. Thus, we recommend that systems be put in place to make the reporting of snakebite more comprehensive.

Although the majority of bites were reported to occur on the feet while walking, bites from *A. bibronii* were generally recorded on the fingers. This is probably the result of this species being misidentified as a non-venomous species leading to irresponsible handling. Records generally did not state whether the bite was illegitimate or legitimate. Since legitimate bites are unlikely to occur on the hand while walking, it is likely that bites on the hand were the result of catching, killing, or interacting with the snake, resulting in illegitimate bites. The relatively high number of bites on the arms and legs suggests that illegitimate bites make up a higher proportion of bites than previously thought. Almost half of the recorded incidents by *H. haemachatus* and *N. mossambica* were for spitting, often on the face, as spitting snakes generally defend themselves by spitting as a first line of defence.[28]

Many snakes in South Africa are crepuscular[27] and this correlates with the time of incidences in the dataset. Most snakebite incidences were recorded from midday to 18:00 h in the Telelog dataset and from 18:00 h to midnight in the hospital records and the NSBD, suggesting that individuals should be cautious of moving snakes during the afternoon and night. Studies have shown that the use of torches at night can be useful in preventing bites.[21] Although the number of cases reported on snakebite in Gauteng Province was the second highest in South Africa, the prevalence was higher in North-West Province (8.41 per 100 000 individuals in the population). A similar study that used data records from the PIHWC also found a high prevalence of snakebite in North-West Province.[29] However, as numbers on incidents vary based on region and data records,[9] it is recommended that prevalence for snakebite should include information on the geographical area.

There were several challenges in the reliability of information from the datasets used in our analysis. The high number of incidents recorded in Western Cape on the AfriTox Telelog

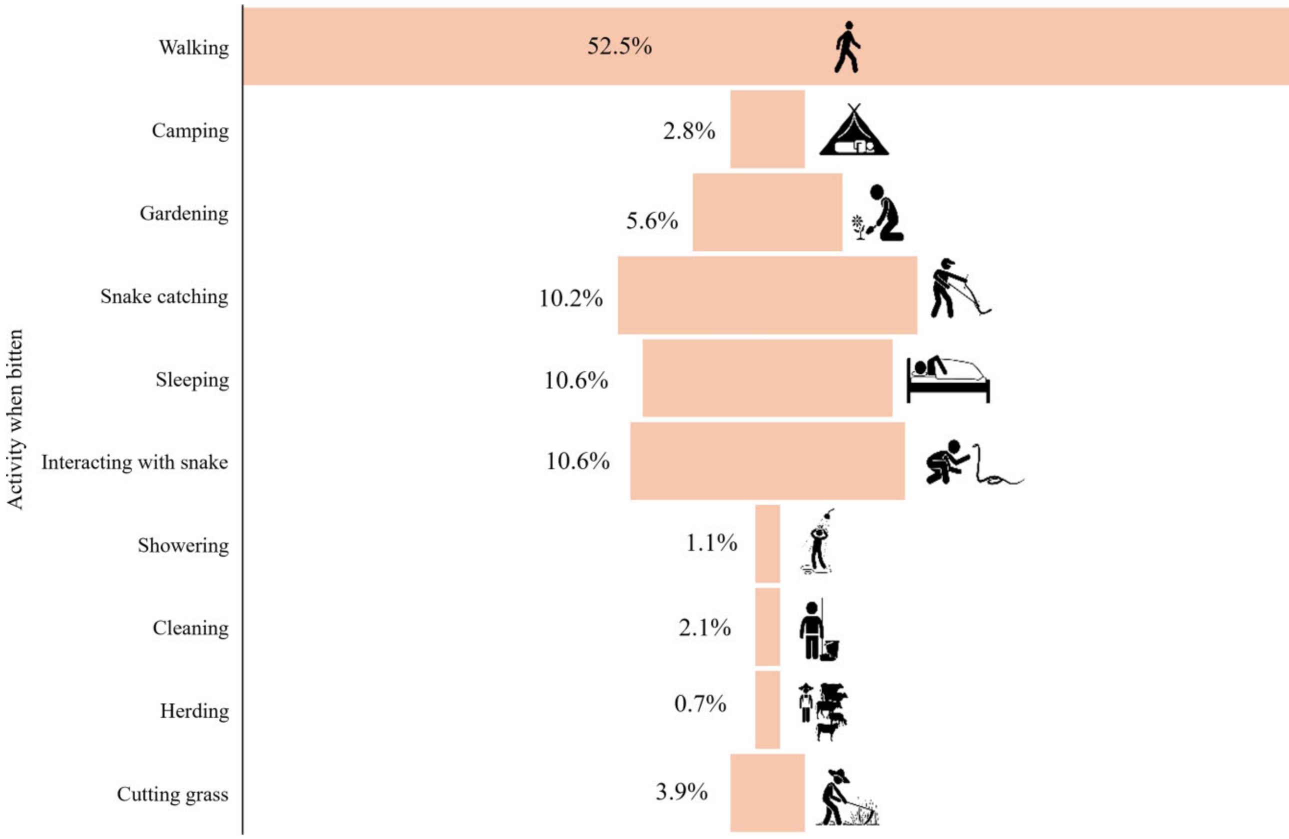

Figure 4. The activity at the time of snakebite incidents. Data have been calculated for only known activities.

database is probably due to the location of the PIHWC in the Western Cape. The NSBD did not record any incidences of snakebite in Mpumalanga Province for 2023 while the AfriTox Telelog database reported 33 cases. These differences in the reported incidence of snakebite are probably due to the recent establishment of the NSBD rather than the absence of bite occurrences in Mpumalanga. Biases also exist within each of the datasets as the reduced number of records from other provinces to the PIHWC may not indicate lower incidences of snakebite in those provinces. As the number of duplicate records in the study was relatively low (14%), and there were disparities in the reported cases for the same provinces, there is a high likelihood that snakebite incidences are significantly under-reported in general in South Africa.

The incomplete nature of all three datasets evaluated in this study significantly impedes estimations on the actual number of snakebite incidences occurring in South Africa. The bureaucracy regarding the collection of data and access to medical records is a further impediment to investigating snakebite in South Africa and provided several limitations to the data collection process of this study. As snakebite is not a reportable incident or notifiable disease in South Africa and healthcare systems lack an easily assessable data collecting protocol, the actual incidence of snakebite remains largely unknown and under-reported. The higher incidence of bites from *A. bibronii* and *Causus* spp. also suggests that frameworks for defining categories for medically important snakes need to be re-evaluated. The focus should rather be on spatial patterns of snakebite incidences within a country.

Other studies have shown similar patterns of incidences of snakebite in other countries and also propose more rigorous data collection protocols of snakebite.[2,8,21,30] Despite these limitations, our study has provided important insight into situations that lead to snakebite incidences and the demographic groups most affected in South Africa. As young people are at higher risk of bites, there is a need for education and prevention measures to be placed at schools. Knowing the snake species responsible for bites and circumstances leading to a bite can assist in creating targeted education campaigns such as snake identification posters to prevent individuals from handling *A. bibronii* as a misidentification. Prevention measures can mitigate the conflict that occurs between humans and snakes and ultimately reduce the burden of relying on antivenom. While there are discrepancies in the data from the past, and there is a means for improved collection of snakebite data (i.e. from the NSBD), important details regarding incidences are not included by record keepers at hospitals and on the databases. This study highlights the importance of creating standardized data collection methods and exploring data around incidences of snakebite to achieve the 2030 goals of the WHO. The insights gained in this study will help future efforts in collecting relevant data on snakes and their behaviour and resolve key mechanisms underlying snakebite risk, which should help in human–snake conflict management planning and resource mobilization.

Authors' contributions: HN and GJA contributed equally to the design of the study, the collection of data, the interpretation of data, and the drafting and revising of the manuscript.

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Competing interests: None declared.

Ethical approval: Research protocols were approved by the University of the Witwatersrand's Human Research Ethics Committee [Non-Medical: clearance number M21/11/94] and the collection of data from the PIHWC was approved. The AfriTox TeleLog database is registered with the University of Cape Town's Faculty of Health Science Human Research Ethics Committee [R014/2014].

Data availability: Data cannot be shared for ethical/privacy reasons. The data underlying this article cannot be shared publicly due to the privacy of individuals in the study. The data will be shared on reasonable request to the corresponding author and approval from the relevant authority.

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