Original article

Epidemiology of venomous snake bites in El Salvador from 2011 to 2022

DOI 10.5377/alerta.v8i1.19208

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Abstract
Introduction. According to the World Health Organization, snake bites cause between 81 000 and 138 000 deaths per year worldwide, as well as amputations and permanent disabilities. In El Salvador, 1472 cases were reported in the last twelve years. **Objective.** Characterize the epidemiological trends of venomous snakebites in El Salvador from 2011 to 2022. **Methodology.** This descriptive cross-sectional study analyzed the records of snakebites between 2011 and 2022 from the National Epidemiological Surveillance System of El Salvador. The database was reviewed, and pivot tables were worked to calculate frequencies. Continuous quantitative variables were evaluated with the Anderson-Darling normality test, and measures of central tendency and dispersion were used. Progressive tone maps were also constructed. **Results.** During the study period, 1472 cases of venomous snake bites were registered in El Salvador. Males accounted for 61.1% of the cases, with a male-to-female ratio 2:1; more than 83% of the bites occurred in rural areas. Cases were distributed throughout the year but were concentrated between May and September, coinciding with the rainy season. The highest incidence was observed in the 30-39 years age group. **Conclusion.** Most venomous snake bites occur between May and October, affecting mainly young men in rural areas, especially in the 30-39 age group, with higher incidence in the western part of the country.

Keywords
National Health Surveillance System, Snake Bites, Venomous Snakes.

Resumen
Introducción. Las mordeduras de serpiente ocasionan alrededor de 81 000 a 138 000 muertes al año a nivel mundial según la Organización Mundial de Salud, así como amputaciones y discapacidades permanentes. En El Salvador en los últimos doce años se notificaron 1472 casos. **Objetivo.** Caracterizar las tendencias epidemiológicas de las mordeduras por serpientes venenosas en El Salvador, durante el periodo 2011 al 2022. **Metodología.** Este estudio descriptivo de corte transversal analizó los registros de mordeduras por serpiente entre 2011 y 2022 del Sistema Nacional de Vigilancia Epidemiológica de El Salvador. La base de datos fue revisada y se trabajaron tablas dinámicas para calcular frecuencias. Las variables cuantitativas continuas se evaluaron con la prueba de normalidad de Anderson-Darling y se utilizaron medidas de tendencia central y dispersión. También se construyeron mapas de tonalidades progresivas. **Resultados.** Durante el periodo de estudio se registraron 1472 casos de mordeduras por serpiente venenosa en El Salvador. El 61,1 % de los casos correspondieron a los hombres, con una razón de masculinidad de 2:1; más del 83 % de las mordeduras ocurrieron en zonas rurales. Los casos se distribuyeron a lo largo de todo el año, concentrándose entre mayo y septiembre, coincidiendo con la época de lluvias. La mayor incidencia se observó en el grupo de edad de 30 a 39 años. **Conclusión.** La mayoría de las mordeduras de serpientes venenosas ocurre entre mayo y octubre, afectando principalmente a hombres jóvenes en áreas rurales, especialmente en el grupo de 30 a 39 años, con mayor incidencia en la zona occidental del país.

Palabras clave
Sistema Nacional de Vigilancia en Salud, Mordeduras de Serpientes, Serpientes Venenosas.

Introduction

The ophidian accident is the result of a snake bite. In the case of a venomous snake, it can produce venom inoculation which can vary according to species, causing tissue damage and systemic effect.[i,ii] This event is common in tropical countries, especially in low and middle-income countries.[iii,iv] The incidence is notable in rural settings and agricultural areas, where human interaction with vegetation increases the risk of snake encounters.[v] In June 2017, the World Health Organization (WHO) added

Epidemiología de las mordeduras por serpientes venenosas en El Salvador, 2011-2022

Suggested citation:
Chirino Molina W Y, Mendoza Rodríguez E W, Gavidia Leiva C M. Epidemiology of venomous snake bites in El Salvador from 2011 to 2022. Alerta. 2025;8(1):47-54. DOI: 10.5377/alerta.v8i1.19208

Editor:
Edgar Quinteros.

Received:
June 30, 2024.

Accepted:
October 22, 2024.

Published:
January 22, 2025.

Author contribution:
WYCM, EWMR, CMGL: manuscript design, writing, revising and editing. WYCM, CMGL: literature search and data or software management. WYCM: study design and data collection.

Conflicts of interest:
No conflicts of interest.

snake bite to the list of neglected tropical diseases;[vi-viii] the inclusion of this zoonotic event, which has a higher incidence in poor or geographically difficult-to-access populations, is of global significance.

The WHO estimates that around 5.4 million snake bites occur each year, of which between 81 410 and 137 880 result in death, and almost three times as many result in amputation and permanent disability.[vi]

The Pan American Health Organization estimates that in the Latin American and Caribbean region, between 80 229 and 129 084 snakebite cases and an estimated 560 to 2268 deaths per year were recorded,[ix] with a higher incidence in areas where access to medical care is limited due to geographic and demographic barriers.[x-xii]

In Central America, there are 150 snakes species; of these, 41 are classified as venomous.[xiii] El Salvador has 58 snake species, with two venomous families, Elapidae and Viperidae.[i] A study conducted in 2002 by the Ministry of Health of El Salvador identified *Crotalus simus* and *Porthidium ophryomegas* as the main ones responsible for these incidents, followed by the *Cerrophidion wilsoni* and *Micrurus nigrocinctus*. This study also determined that the most common anatomical regions of the bites were the feet and hands.[i] This study aims to characterize the epidemiological trends of venomous snake bites in El Salvador from 2011 to 2022 to highlight the importance of this zoonosis.

Methodology

A descriptive cross-sectional study was conducted to characterize the epidemiological trends of venomous snake bites, based on a secondary analysis of a database containing the records of patients who consulted due to venomous snake bites from 2011 to 2022. The database was obtained from the National Epidemiological Surveillance System of El Salvador. The technical guidelines for epidemiological surveillance defines this event as any person of any age and sex who has been bitten by a venomous snake and presents progressive edema of the bite region, dizziness, and mild to severe hypotension; in addition, hemorrhages, paresthesia, necrosis of the bite area, palpebral or bipalpebral ptosis may be present.[i]

Snake bites belong to the group of events that require mandatory notification in the first twenty-four hours, as stated in the technical guidelines.

The information from the database was migrated to a Microsoft Excel sheet, version 2019, where a search for inconsistencies was performed. The database was subjected to a debugging and review process to verify the quality of the data and the completeness of the information for each variable. The universe of the study included the records of venomous snake bites registered by the notifying units of the national surveillance system. During the study period, the initial database contained 1503 records. Six duplicate records and 25 records of foreign persons were excluded. As a result, the final base for the analysis was 1472 records.

The database was structured in 24 variables, and the following were selected: notification date, epidemiological week of occurrence, area of origin, department of origin, health facility, age, and sex of the affected person.

The Ministry of Health of El Salvador divides the country's departments into five health regions: western region (Ahuachapán, Santa Ana and Sonsonate), central region (Chalatenango and La Libertad), metropolitan region (San Salvador), paracentral region (Cuscatlán, Cabañas, La Paz, San Vicente) and eastern region (Usulután, San Miguel, Morazán, La Unión); this variable was also included in the analysis. An additional variable was added to measure the time elapsed from the occurrence of the event to the time of care at the health facility.

The study worked with frequencies and incidence rates per 100 000 population. To calculate these rates by department, the denominator used was the population corresponding to each year, 2011 to 2022, according to the demographic projections provided by the National Population and Housing Census 2007. In addition, 95 % confidence intervals were calculated for the proportions using Wilson's method. The normality of the age distribution of the cases was evaluated using the Anderson-Darling test, finding that the data did not follow a normal distribution ($p < 0.05$); therefore, we chose to use the median and the interquartile range as measures of central tendency.

The Mann-Whitney U test was used to determine whether there was a difference between the median age by sex and area, calculated using the RStudio program version 4.2.2. Microsoft Excel 365 with the Real Statistics add-on and the Epi Info software version 7.2.4.0 were used for data processing and analysis, and the free QGIS software version 3.22 was used for geospatial analysis. In addition, in the geospatial analysis, rates were presented using a quartile stratification with a scale of progressive shades in a grayscale palette.

This study was conducted following the ethical guidelines of the Council for Organizations of Medical Sciences (CIOMS) and respecting the Helsinki principles for research on human subjects. Only the information contained in the existing database was used, which was anonymized and coded to guarantee the confidentiality of the people included.

This study has the approval of the Health Research Ethics Committee of the National Institute of Health under approval number N°CEINS 2024/001.

Results

During the twelve years, 1472 cases of venomous snake bites were recorded; 61. 1 % were male, and the 83. 2 % were from rural areas(Table 1).

The difference in proportions by area of origin was statistically significant with the rural area being the most affected ($p < 0.05$). The ratio of rurality was five cases in the rural area for each case in the urban area.

Regarding sex distribution, a 2:1 male-to-female ratio was determined. This finding underlines a significant disparity in the incidence of ophidian accidents between both sexes ($p < 0.05$). The study covered a wide age range, from under one year old to 98 years old, with a median age of 28 years (interquartile range [IR]: 16 - 46 years). For the male group, the median was 29 years (IR: 17 - 47 years); in the female group, the median was 27 years (IR: 14 - 44 years).

Application of the Mann-Whitney U test to evaluate differences in median age by sex revealed a value of $p < 0.05$, confirming the existence of statistically significant differences in median age between the two sexes.

It was observed that there are cases of snake bite during all months of the year, mainly concentrated from May to September, coinciding with the rainy season in the country which goes from May to October (Figure 1 and Table 1). The analysis by epidemiological week showed that week 24 registered the highest number of cases with 52 records.

When analyzing the distribution of cases by health region, the western region accounted for 51 % of reported cases, followed by the central region with 24 %, the paracentral region with 14 %, the eastern region with 6 % and finally the metropolitan region with 5 % (Figure 2).

When analyzing the incidence rates greater than three per 100 000 population over the 12 years period, it was observed that the 30-39 age group presented rates greater than three in two years, the 40-49 age group, the 10-19 age group and finally the 20-29 age group presented rates greater than or equal to three in at least one year (Table 2).

Tabla 1. Distribution by sex, origin and month of occurrence of the event

Variable	N (1472)	%	Intervalos de confianza (95 %)
Sex			
Male	900	61.1	(58.6-63.6)
Female	572	38.9	(36.-44.3)
Area of origin			
Urban	247	16.1	(14.9-18.7)
Rural	1225	38.2	(81.2-85.0)
Month			
January	63	4.3	(3.3-5.4)
February	56	3.8	(2.9-4.9)
March	75	5.1	(4.0-6.3)
April	66	4.5	(3.5-5.6)
May	141	9.6	(8.1-11.1)
June	205	13.9	(12.2-15.7)
July	205	13.9	(12.2-15.7)
August	140	9.5	(8.1-11.1)
September	157	10.7	(9.1-12.3)
October	103	7.0	(5.8-8.4)
November	165	11.2	(9.6-12.9)
Decembrer	96	6.5	(5.3-7.9)

The 30-39 age group had the highest rate in 2019 (3. 4 per 100 000 population), the 40-49 age group had the highest rate in 2022 (3. 5 per 100 000 population), the 10-19 age group had the highest rate in 2021 (3. 0 per 100 000 population) and the 20-29 age group had the highest rate in 2011 (3. 2 per 100 000 population).

Cases of venomous snake bite have been reported in all 14 departments of El Salvador. The highest incidence rates for all years have been recorded in the western region and the department of Chalatenango, which belongs in the central region.

The department of Santa Ana presented the highest rate in 2021 (9. 5 per 100 000 population) followed by the department of Sonsonate (7. 6 per 100 000 population), Ahuachapán presented the highest rate in 2022 (7. 4 per 100 000 population) and Chalatenango presented the highest rate in 2011 (17. 3 per 100 000 population). In addition, an increase in the incidence of cases has been observed in the department of San Vicente during the last five years (Figure 2).

Discussion

Among the findings of this study, it was observed that the highest number of cases of venomous snake bite occurred in males, with a median age of 28 years. These results coincide with other investigations, such as a study carried out in Ecuador, where the median age was 28 years and 67. 3 % of snake bites affected men.[xiv] Similarly, another study carried out in Mexico showed that 62. 5 % of the cases registered were also male.[xv] The predominance of the male sex as the most affected group can be attributed to several variables, such as the different types of agricultural work, the lack of personal protection, such as the use of high boots and long pants to reduce the risk of snake bite or carrying out outdoor recreational activities.[iii]

A 2019 study of snake bites in Rio Grande, Brazil, presented a useful framework for comparing incidence, recording 3909 reported cases, of which 62. 7 % occurred in rural areas.[xvi]

Table 2. Distribution of snakebite rates by age group per 100 000 population in El Salvador 2011 -2022

Grupo de edad	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
<1	0	0	0	0.9	0	0	0	0	0	0	0	0
(1-4)	2.2	1.1	0.2	0.9	0.7	1.8	1.1	0.7	1.9	1.6	1.2	1.0
(5-9)	1.9	1.3	1.0	1.5	2.1	1.1	0.9	0.9	1.3	0.9	2.4	1.9
(10-19)	2.5	2.1	2.5	2.4	2.7	2.6	2.0	1.6	1.6	1.6	3.0	2.1
(20-29)	3.2	1.9	0.9	1.9	2.9	2.5	1.3	1.2	1.4	1.5	2.4	2.3
(30-39)	2.9	2.2	1.6	2.3	3.1	1.7	1.5	1.6	3.4	2.0	2.3	2.8
(40-49)	1.4	1.7	2.4	2.4	2.4	1.6	2.1	2.2	1.7	2.6	2.5	3.5
(50-59)	2.0	1.5	2.5	2.7	1.6	2.0	1.0	2.1	2.6	2.8	2.2	2.1
>60	2.5	1.5	0.8	0.7	2.6	1.7	2.4	1.2	2.5	2.5	2.3	1.7
Total	2.4	1.7	1.5	2.0	2.5	1.9	1.8	1.4	1.9	1.8	2.5	2.2

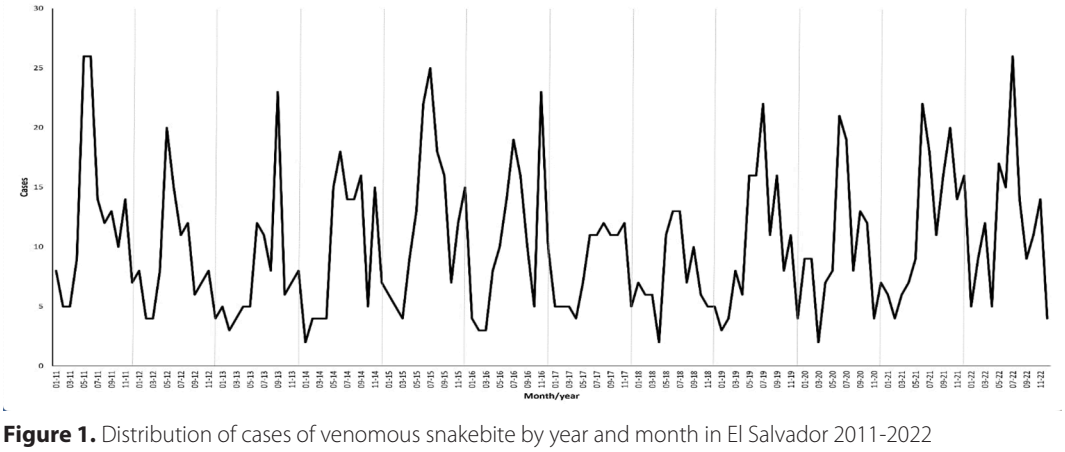

Figure 1. Distribution of cases of venomous snakebite by year and month in El Salvador 2011-2022

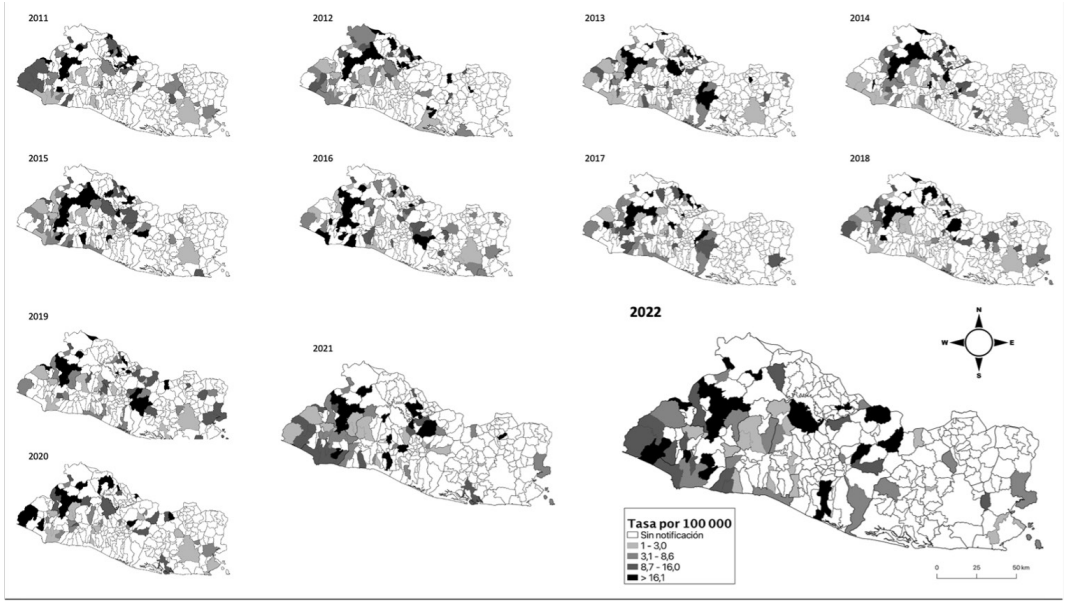

Figure 2. Distribution of incidence rate per 100 000 population of venomous snake bites by year in El Salvador, 2011-2022

The findings of this study reflect a trend similar to that observed in this investigation. The Brazilian study highlights the importance of understanding the epidemiology of snake bites, health management, and the influence of the environmental setting.[xvi] It also supports the notion that rural areas are particularly vulnerable to this type of accident.

A research conducted in Trinidad and Tobago, highlights the importance of implementing preventive measures and educational programs specifically aimed at rural communities to mitigate the impact of snake bites[xvii] and strengthen the understanding of the social and environmental determinants that influence the incidence of snake bites and supports the need to develop comprehensive strategies for this zoonotic event in rural communities.

A study conducted in Ghana in 2019 highlights that most cases occurred during the rainy season,[xviii] and in another study conducted in the Republic of Congo, 80. 25 % of snake bites occurred during the rainy season.[xix] In the specific case of El Salvador, where the rainy season extends from May to October, a higher incidence of venomous snake bites was observed during May to September, suggesting that snakes are more active and more likely to seek new habitats during this period, which increases the risk of encounters with humans.

The increase in snake bite cases in several countries can be attributed to several environmental and behavioral factors related to snakes and human activity during the rainy season.[xx,xxi] During this season, vegetation tends to grow more easily, providing snakes with more places to hide and search for prey. In addition, increased humidity and the presence of water can affect the snakes' natural habitats, forcing them to seek refuge in more accessible areas, such as near crops or areas inhabited by humans.

On the other hand, agricultural and human activity may contribute to increased encounters between snakes and people during the rainy season. The planting and harvesting crops can disrupt the snakes' natural habitats, forcing them to move to more exposed areas, where they are more likely to come into contact with humans.[xxii,xxiii]

Snake bite is a medical emergency that requires immediate attention during the first 24 hours; however, there are cases not attended to during this period due to the difficult geographical access to health facilities that have adequate medication for venomous snake bite care.

A study conducted in the Amazon found that 26. 2 % of patients sought medical attention within 24 hours of the bite, and 22 % died without receiving medical attention. This analysis refers to distance, and in most cases, the areas with the greatest distance are rural, as reported in other countries.[xxiv,xxv] This discrepancy highlights the need to raise awareness of the importance of early medical attention in cases of snake bite.

Medical care is critical to the impact of snake bites. Distance to care centers contributes to this delay; in El Salvador, hospitals at the departmental level are geographically accessible and equipped with the necessary medicines, ensuring prompt and adequate medical care. This availability ensures that patients receive timely treatment,

which is essential to reduce the effects of snake bites and improve clinical outcomes.

In addition to physical distance, cultural factors may also influence the delay in seeking medical care. Some patients may underestimate the severity of a snake bite or may have ingrained beliefs that lead them to avoid or delay medical consultation. It is important to address these misguided perspectives through educational campaigns that highlight the risks associated with snake bites and the importance of timely medical attention.

Snake bites represent a significant threat to public health in many regions globally, especially in rural and tropical areas. In El Salvador, one of the main health challenges is the lack of detailed information on the specific identification of the species and families of snakes responsible for envenomations. The absence of this variable limits the effectiveness of preventive campaigns since it is not possible to identify the most prevalent species in each department; therefore, specific efforts to minimize dangerous interactions between humans and snakes cannot be directed. The incidence reported in this study should be taken with caution since there is a possibility that the database used for this study does not include all cases of venomous snake bites since many people do not consult the health system because they prefer to be treated at home.

Venomous snake bite represents a significant burden on the health and well-being of the population. This challenge must be addressed comprehensively based on the "One Health" approach of WHO, including prevention, treatment, and rapid response measures. It is vital to strengthen healthcare systems and promote public awareness of risks and preventive measures.

In addition, investment should be made in research to develop new surveillance and treatment tools and to recognize the zoonotic nature of snake bites. Cooperation between human, animal, and environmental health sectors should be promoted and strengthened to mitigate the impact of diseases on public health and livelihoods in affected communities.[xi,xxvi,xxvii]

Conclusion

Most cases of venomous snake bites occur during the rainy season from May to October; the main victims are young men living in rural areas, with a higher incidence in the 30-39-year-old age group. Most cases occur in the western part of the country. These findings underscore the importance of epidemiological surveillance focused on these periods.

Acknowledgments

To Nadia Rodríguez and Edgar Quinteros for the workshop on writing original scientific articles given to the Epidemiology and Research residents in 2023.

To Claudia Delgado and Karla Magaña for their support in the analysis.

Funding

No external founds were received for this work

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