REVISTA ECUATORIANA DE CIENCIA, TECNOLOGÍA E INNOVACIÓN EN SALUD PÚBLICA

CÓDIGO ISSN 2588-0551

DOI: 10.31790/inspilip.v10i29.757

ARTÍCULO ORIGINAL:

Epidemiology, clinical features, and risk factors of snakebites in the hospital "Delfina Torres de Conche", Esmeraldas, Ecuador, 2017 - 2020

Epidemiología, clínica y factores de riesgo de las mordeduras de serpientes en el hospital "Delfina Torres de Concha", Esmeraldas, Ecuador, 2017 - 2020

Acceso abierto

Citación

Calvopiña M., Silva D., Montalván N., Romero D., *Epidemiology, clinical features, and risk factors of snakebites in the hospital "Delfina Torres de Conche", Esmeraldas, Ecuador, 2017 - 2020* **INSPILIP 2025, Volumen 9 Número 29**

Url: https://www.inspilip.gob.ec/index.php/inspi/article/view/757

Manuel Calvopiña. [a, *], manuelcalvopina@udla.edu.ec

Daniela Silva Martinod. [a], danielasilvamartinod@gmail.com

Nelson Montalván. [b], montalvan21@gmail.com

Daniel Romero Álvarez. [c], daniel.romero@uisek.edu.ec

a. One Health Research Group, School of Medicine, University of the Americas (UDLA), Quito, Ecuador.

b. Department of Epidemiology, Delfina Torres de Concha Provincial Hospital of Southern Esmeraldas, Ministry of Public Health, Esmeraldas, Ecuador.

c. School of Health Sciences, SEK International University, Quito, Ecuador

***Correspondence author:** Manuel Calvopiña. University of the Americas (UDLA), Vía a Nayón PO BOX 17-17-9788. Mobile: 593-985208455. Quito-Ecuador. manuelcalvopina@gmail.com / manuel.calvopina@udla.edu.ec

Admission date: 19/08/2024
Approval date: 24/08/2024
Publication date: 05/05/2025

Revista científica INSPILIP. Volumen 9, Número 29.

El autor declara estar libre de cualquier asociación personal o comercial que pueda suponer un conflicto de intereses en conexión con el artículo, así como el haber respetado los principios éticos de investigación, como por ejemplo haber solicitado las autorizaciones de la institución donde se realizó el estudio, permiso para utilizar los datos, consentimientos informados y en caso de tratarse de estudio observacionales y ensayos clínicos, autorización de un CEISH, ARCSA, Medio Ambiente, entre otros, de acuerdo a la categoría. Además, la licencia para publicar imágenes de la o las personas que aparecen en el manuscrito. Por ello INSPILIP no se responsabiliza por cualquier afectación a terceros, tampoco el INSPI como entidad editora, ni el Editor, la responsabilidad de la publicación es de absoluta responsabilidad de los autores.

Patricio Vega Luzuriaga
EDITOR EN JEFE

Summary

Introduction: Venomous snakebites are life-threatening emergencies and are prevalent in people living in tropical regions of developing countries. **Objective:** To evidence the epidemiology, risk factors, clinical features, and severity in patients admitted to a public hospital located on the Coast of Ecuador. **Materials and methods:** A cross-sectional study carried out at the Provincial Hospital of Esmeraldas 'Delfina Torres de Concha' of the Ministry of Public Health (HDTC-MSP) was developed with the objective of retrospectively analyze the data recorded in the epidemiological and medical records of hospitalized patients with ICD-10 T63.0 diagnosis—venomous snakebite—, period 2017-2020. **Results:** During the 4 years, 191 patients were hospitalized: 24, 21, 58 and 81 for the years 2017, 2018, 2019 and 2020, respectively, with 1 deceased. The highest number of cases was found among men (137; [72 %), the age group 11-20 years (52; [27 %]), farmers (59; [31%]), those from rural areas (139; [72 %]), primary education (132; [69 %]), and during the months of October and May. The only identified snake was Bothrops spp. Severity was classified in as moderate in 82 (45 %), severe in 69 (38%), and mild in 33 (17 %) patients. A total of 69 (37.5%) patients received antivenom before arriving to the Hospital and 100% received it while hospitalized. Empirical treatments included the use of the tourniquet, potion of snake bile and consulting to the Shaman/healer. Edema and pain at the local and bleeding gums at the systemic level prevailed. The recorded complications were compartment syndrome, necrosis, and abscesses with 14 fasciotomies, three surgical cleanings and four amputations. **Conclusions:** Snakebites have an increasing trend in the HDTC-MSP. The low mortality is probably due to the opportune administration of the antivenom. Many patients continue to seek empiric procedures. The groups with the highest frequency of bites should be

considered at risk and health authorities should focus protection and education measures on them.

Keywords: Snakebites. Coast. Epidemiology. Esmeraldas. Ecuador.

CÓDIGO ISSN 2588-0551

Resumen

Introducción: *Las mordeduras de serpientes venenosas son emergencias prevalentes en pobladores residiendo en regiones tropicales de países en vías de desarrollo, como es el Ecuador.* ***Objetivos:*** *Evidenciar la epidemiología, factores de riesgo, clínica y severidad en pacientes ingresados en un hospital público ubicado en la Costa del Ecuador. Materiales y métodos: Estudio transversal en el Hospital Provincial de Esmeraldas 'Delfina Torres de Concha" del Ministerio de Salud Pública (HDTC-MSP), analizando retrospectivamente los datos registrados en las fichas epidemiológicas e historias clínicas de hospitalizados con diagnóstico CIE-10 T63.0—mordedura de serpiente venenosa—, periodo 2017-2020.* ***Resultados:*** *En los 4 años se hospitalizaron 191 pacientes: 24, 21, 58 y 81 para los años 2017, 2018, 2019 y 2020, respectivamente, con 1 fallecido. El mayor número de casos fue encontrado en hombres (137; [72 %]), en el grupo de edad 11-20 años (52; [27 %]), en los agricultores (59; [31 %]), en los procedentes de zonas rurales (139; [72 %]), de instrucción primaria (132; [69 %]) y en los meses de octubre y mayo. La única serpiente identificada fue Bothrops spp. La severidad fue clasificada en moderada en 82 (45 %), severa en 69 (38 %) y leve en 33 (17 %) pacientes. Un total de 69 (37.5%) pacientes recibieron suero antiofídico antes de acudir al Hospital y el 100 % en hospitalización. Tratamientos empíricos incluyeron el torniquete, brebaje de hiel de serpiente y acudir al Shaman/ curandero. Predominaron el edema y el dolor a nivel local y la gingivorragia a nivel sistémico. Las complicaciones registradas fueron el síndrome compartimental, necrosis y abscesos con 14 fasciotomías, tres limpiezas quirúrgicas y cuatro amputaciones. Conclusiones: Las mordeduras de serpientes tienen tendencia al aumento en el HDTC-MSP. La baja mortalidad probablemente se debe a la oportuna administración del suero antiofídico. Los pacientes continúan acudiendo a procedimientos empíricos. Los grupos con mayor frecuencia de mordeduras deberán ser considerados en riesgo y las autoridades de salud deberían enfocar medidas de protección y educación en estos.*

Palabras clave: Mordedura de serpientes. Costa, Epidemiología. Esmeraldas. Ecuador.

Introduction

Since 2017, the World Health Organization (WHO) has reclassified snakebite envenoming among the 20 neglected tropical diseases due to its high incidence and mortality in tropical countries (1). It is estimated that annually there are 5.4 million cases, which result in up to 137,880 deaths, as well as three times more amputations and other permanent disabilities. Although snakebites have been reported across all latitudes, they are prevalent in the tropical regions of megadiverse countries that are developing and have high percentages of populations residing in rural areas (1).

In Ecuador, the Ministry of Public Health (MSP) considers snakebites a health problem because of the high incidence, morbidity, and severity they represent, which in many cases lead to disability or death. Snakebites have been reported in the tropical ecoregions of the Coast and Amazon, as well as in subtropical regions of the Andean provinces (2,3). According to the most recent national study covering the period 1998–2007, the average annual incidence and mortality were 11 and 0.5 per 100,000 inhabitants, respectively (4). However, the official information provided by the Ecuadorian Epidemiological Gazette SIVE ALERTA of the MSP is limited in data (5). Therefore, studies based on clinical-epidemiological data generated from hospitalized patients at local, regional, and national levels are required.

Ecuador is located in the northwest of South America, below the equatorial line (0°), which places it within the torrid zone. Approximately 64% of the continental territory contains subtropical and tropical ecosystems in both the Coast and Amazon regions, which are divided by the Andes mountain range. Administratively, Ecuador is divided into 24 provinces, including the insular Galápagos. Seven provinces are located in the Coast, including Esmeraldas; six in the Amazon; and ten in the Andes. The tropical and subtropical regions provide favorable conditions within various dry and rainy tropical ecosystems for the development of diverse snake species. Approximately 230 snake species, including 35 venomous ones, have been described in Ecuador (2).

At the national level, according to the

Epidemiological Gazette (SIVE ALERTA of the MSP), 1,450, 1,431, 1,489, and 1,438 cases were reported in 2017, 2018, 2019, and 2020, respectively. Of these, 708 (49%), 650 (50%), 772 (52%), and 730 (51%) cases were recorded in the Coast region, which were reported in 22 of the 24 provinces, including cases in the subtropical regions of the Andean provinces (5). In 2020, the Coast was the most affected region, with the provinces of Manabí and Esmeraldas reporting the highest number of cases: 272 and 126, respectively. Furthermore, it was recorded that men (943 cases) and the age group between 20 and 49 years (648 cases) were the most affected populations. Ten patients died; severity was classified as mild in 681 (47.3%), moderate in 525 (36.5%), and severe in 232 (16.1%) cases. The epidemiological weeks with the highest case counts ranged from week 7 to week 20, which corresponds to mid-February to mid-May (5). The only clinical-epidemiological study conducted in the province of Esmeraldas analyzed 107 cases that occurred over 8 months in 2014 (6).

Nationally, the snakes causing the greatest number of accidents belong to the family Viperidae, especially Bothrops spp., locally known as “equis,” and Lachesis, known as “verrugosas,” which induce hemorrhages and/or tissue necrosis that can lead to amputations (2,7). Snakes of the genus Micrurus from the family Elapidae are present in both the Coast and Amazon and are known as “corals”; they cause neurotoxicity that leads to death by paralysis of the respiratory muscles, although their bite prevalence is only 1% (2,8).

The antivenom serum used in Ecuador is imported from Costa Rica and is polyvalent against Viperidae snakes but ineffective against Micrurus snakes. It is available free of charge at primary care health centers and hospitals located in tropical and subtropical regions. The MSP recommends immediate administration of antivenom serum following a Viperidae bite. The WHO, MSP, and other health institutions contraindicate empirical practices such as tourniquets, cutting, suction of the bite, and home remedies, which can generate complications or delays in medical attention (2,9).

Snakebites in Ecuador are mandatorily reported to the National Directorate of Epidemiological Surveillance - MSP and are recorded weekly in the epidemiological gazette through SIVE-ALERTA with the International Classification of Diseases code ICD-10 T63.0 (5). Patients must be admitted for observation, severity classification, management at primary care centers, or referral to more complex hospitals. Upon emergency admission, the physician completes the “Clinical-epidemiological record for ophidian accidents or snakebites,” and during hospitalization, antivenom administration and discharge status are recorded in the clinical history (2). The purpose of this research, which is based on a retrospective review of data recorded in epidemiological forms and clinical histories of patients admitted to the Provincial Hospital “Delfina Torres de Concha” located in the city of Esmeraldas (2017–2020), is to highlight epidemiological and clinical aspects that will serve to delineate the reality of ophidian accidents over the last four years, with the aim of informing health authorities about the epidemiology, clinical features, and identified risk factors in order to provide comprehensive care to the affected population. Hospitalizations occurring after 2020 were not analyzed due to irregularities in record-keeping during the COVID-19 pandemic.

Materials and methods

The "Delfina Torres de Concha" Southern Provincial General Hospital (HDTC-MSP), a public second-level facility, provides care in four basic specialties—General Surgery, Internal Medicine, Pediatrics, and Gynecology-Obstetrics—along with intensive care services, emergency attention, and referrals for complex cases. This institution serves the northern region of Esmeraldas Province, located in the Coastal Region of Ecuador (Figure 1).

Figure 1. Political map of Esmeraldas Province, which borders Colombia to the north and the Pacific Ocean to the west. The province is divided into seven cantons. The map illustrates the number and percentage of the origin, by canton, of the 191 patients analyzed in this study. The HDTC-MSP is located in the city of Esmeraldas (yellow star). The province has a humid tropical climate, with an average annual temperature of 24.5°C and year-round rainfall, peaking between December and June. Esmeraldas forms part of the Chocó macrorregion, which is recognized globally as a biodiversity hotspot (https://es.climatedata. org/america-del-sur/ecuador/provincia-deesmeraldas/ esmeraldas-2961/).

Study Design, Population, and Sample

This was a cross-sectional epidemiological study that retrospectively analyzed data obtained from the "Clinical-epidemiological form for ophidian accidents or snakebites" and from the medical records of all patients admitted with a diagnosis of venomous snakebite (ICD-10 T63.0) during the period from 2017 to 2020 (four years).

Data Collection

The data recorded and analyzed included: geographic variables (urban or rural locality, canton, and province where the bite occurred); sociodemographic characteristics (age, sex, self-identified ethnicity, occupation, and educational level); type of snake involved ("equis" = Bothrops spp. or Bothriopsis spp., "pudridora/verrugosa" = Lachesis spp., "coral" = Micrurus spp.); temporal data: month and climatic season of the bite; pre-hospital care: time to hospital arrival, first aid and treatments received before hospital admission (antivenom administration, suction, immobilization, local cold application, tourniquet, incisions or cuts, or none), and whether a shaman/healer was consulted; clinical information: anatomical site of the bite, severity level (mild, moderate, or severe), clinical manifestations (local and systemic), complications, surgical procedures, and discharge condition (survival or death). Due to the absence of epidemiological forms in seven patients, certain variables were assessed in 184 cases (see Table 1).

Statistical Analysis and Ethics

Data were independently entered by two individuals, stored in Excel, and analyzed using the R programming language. Categorical variables were expressed in absolute frequencies and percentages. Associations between variables were assessed using the Student's t-test, ANOVA, and Chi-square test, depending on variable type, with statistical significance set at $p < 0.05$. This study was approved by the Human Research Ethics Committee of SOLCA (Authorization No. 2.084.630).

Results

Prevalencia total y distribución geográfica

Overall Prevalence and Geographic Distribution

A total of 191 patients with the diagnosis ICD-10 T63.0 were hospitalized over the four-year study period. The annual prevalence was 24 (13%), 21 (11.4%), 58 (31.5%), and 81 (44.8%) cases for 2017, 2018, 2019, and 2020, respectively (Table 1 and Figure 2). Bothrops spp. was identified in 107 out of 184 cases (58.2%), while the remaining patients were unable to identify the snake species. One patient (0.9%) died in 2017. The cantons from which most cases were referred to HDTC-MSP were Quinindé and Esmeraldas, accounting for 94 (49.2%) and 39 (20.4%) cases, respectively (Table 1 and Figure 1). The highest numbers of snakebite admissions occurred in October (n = 25; 13.1%) and May (n = 21; 10.9%). During the rainy season in Esmeraldas -December through June- 99 cases (52%) were recorded (Figure 2).

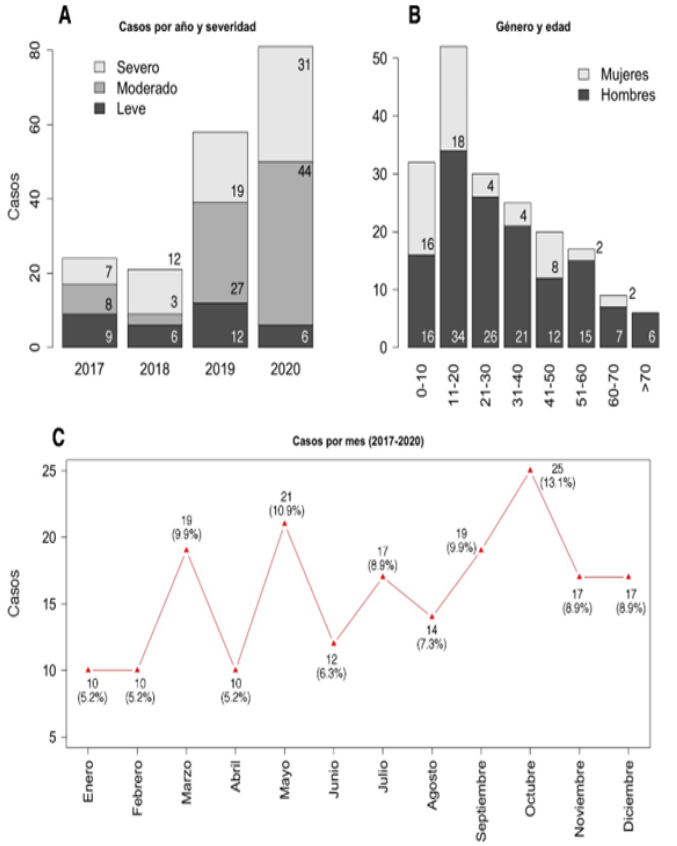

Figure 2. Statistics on patients admitted due to snakebite at HDTC-MSP, Esmeraldas-Ecuador, 2017–2020: (A) case count and severity by year, (B) sex and age groups, and (C) case count by month over the four-year period. Bar graphs and timeline numbers represent the count of each category (severity in panel A, sex in panel B, and monthly case count and corresponding percentage in panel C).

Sociodemographic Characteristics

Table 1 and Figure 2 display the numerical and percentage distribution by sex, age group, place of residence, educational attainment, and occupation. The median age was 25 years, ranging from 0 to 78.

Envenomation Severity, Clinical Manifestations, and Complications

The distribution of severity levels is summarized in Table 1 and Figure 2. Figure 3 illustrates the most frequent anatomical sites of the bites, while Figure 4 shows the frequency of local and systemic symptoms. Complications were reported in 23 patients: compartment syndrome (15), necrosis (6), and abscesses (2). Two of the 184 cases (1%) experienced allergic reactions to the antivenom, which were successfully managed with H1-antihistamines in accordance with MSP guidelines [2]. The reported complications align with findings by Jiménez [16], who identified local infections (60%), necrosis (20%), and compartment syndrome (6.6%) as the most frequent. These complications are attributed to the proteolytic and hemorrhagic effects of Viperidae venom.

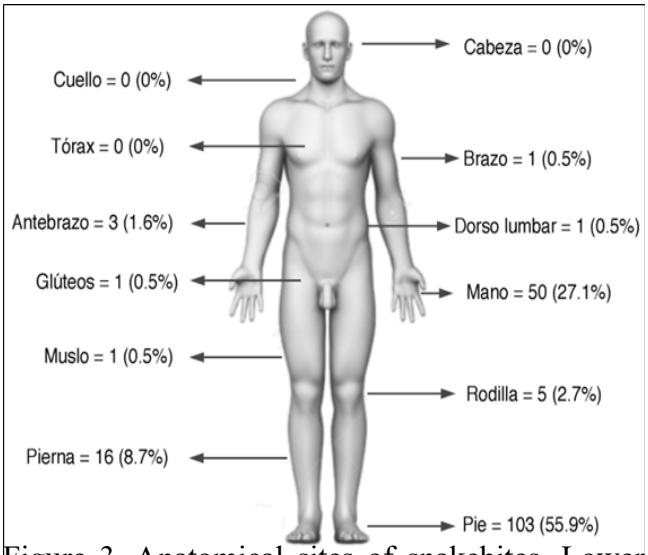

Figure 3. Anatomical sites of snakebites. Lower limbs were the most commonly affected areas (cumulative = 126/181 [69.6%]). Three patients presented bites on both upper and lower limbs, bringing the total to 184 cases.

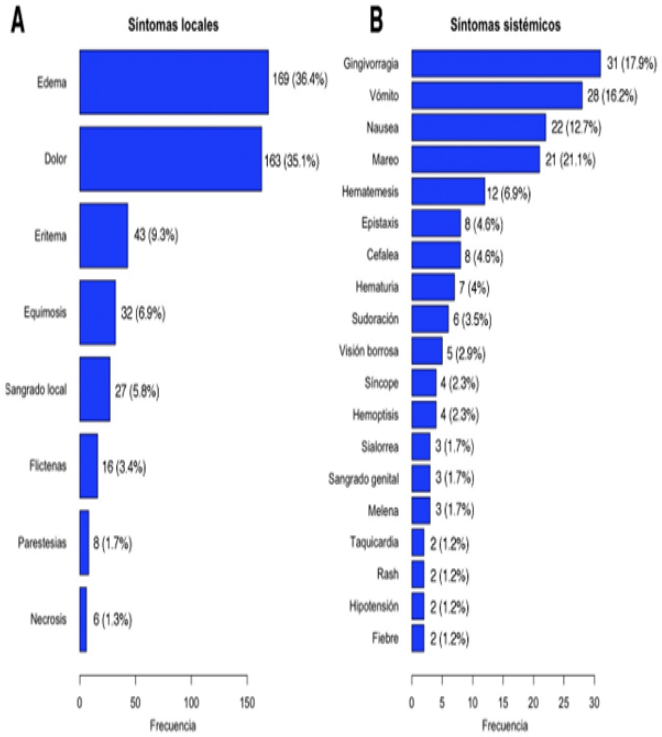

Figure 4. Numerical and percentage distribution of local and systemic symptoms/signs. (A) A total of 464 local symptoms/signs were reported, and (B) 174 systemic symptoms were recorded. Localized edema and pain were the most frequent local symptoms, while hemorrhage and nausea-vomiting predominated among systemic signs. Creagh et al. (2015) reported similar findings—pain in 100% of cases and edema in 85%. Hemorrhages are related to Viperidae toxins, which cause consumption coagulopathy and increase the risk of bleeding.

Time to Hospital Arrival and Antivenom Treatment

Table 1 summarizes the time elapsed between the bite and hospital arrival. All patients received antivenom therapy during hospitalization. Two patients developed allergic reactions to the serum. Figure 5 presents the number and percentage of empirical treatments and surgical procedures performed.

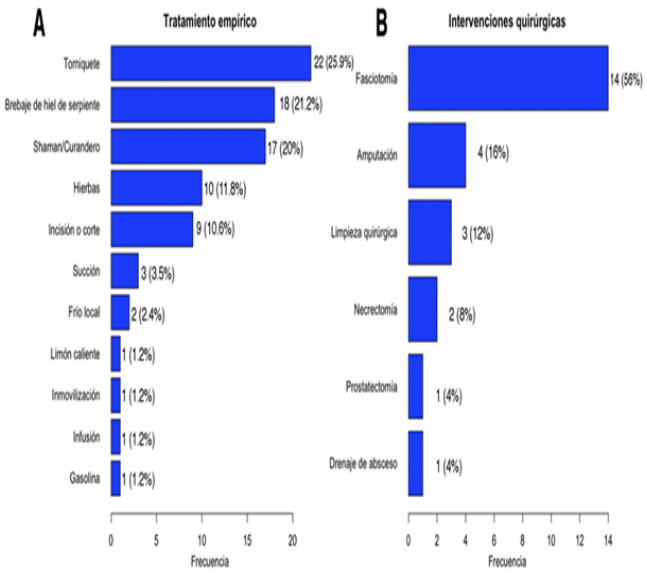

Figure 5. Empirical procedures and surgical interventions performed (2017–2020). (A) A total of 85 empirical treatments were registered, with the use of tourniquets and snake bile concoctions being the most frequent. (B) Among 25 surgical interventions, fasciotomy, amputation, and surgical debridement were the most commonly performed procedures.

Statistical Associations

Associations were examined between envenomation severity and other variables (Table 1). No statistically significant differences were found in relation to age, sex, or ethnicity. However, significant associations were identified with area of residence, year of admission, canton of occurrence, and time to hospital arrival ($p < 0.05$). No significant differences were found between hospitalization duration and age group ($F = 0.003$, $p = 0.959$), sex ($F = 0.018$, $p = 0.893$), ethnicity ($F = 0.167$, $p = 0.684$), or severity level ($F = 2.521$, $p = 0.083$).

Discussion

The 191 cases admitted over four years (2017–2020) at HDTC-MSP reveal an increasing trend in the last two years: 24 cases in 2017 compared to 81 in 2020 (42.4%). However, at the national level, there is little variation in annual incidence, with cases ranging between 1,431 and 1,489 during the study period (5). This increase may be attributed to factors such as: greater human intrusion into mountainous areas and deforestation for subsistence farming, higher snake population density, and/or improved surveillance and healthcare access in rural areas facilitated by better road and digital infrastructure. Therefore, we recommend conducting specific local and cantonal studies to validate these hypotheses.

The national study based on official data from the Ministry of Public Health (MSP) identified the Coastal region as having the highest prevalence of snakebite incidents, a finding consistently supported by MSP records over the last four years (4). The HDTC-MSP, the setting of this study, is located in the coastal province of Esmeraldas. Our findings corroborate the high prevalence reported in 2014 for this province, where 107 cases were recorded over eight months (6). Notably, this study is strengthened by its analysis of clinical data, complications, and antivenom use—variables not previously reported in national surveys (4,6). In line with WHO (2019) guidelines, our findings confirm that snakebite envenoming is a public health issue, primarily affecting rural populations in tropical regions (9).

Only one death (0.9%) was reported over the four-year period, which aligns with the low case fatality rate observed nationally and in other Ecuadorian studies (2,4,7,10,11). In 2020, the MSP reported 10 deaths (0.7%) out of 1,438 cases nationwide (5). This low mortality may be attributed to: 1) timely and effective clinical management and the availability of polyvalent antivenoms at this and other referring hospitals and health centers; 2) the strategic placement of primary healthcare facilities in rural endemic areas; 3) efficient importation of antivenom from Costa Rica and its adequate distribution—although local production is strongly recommended (12,13,4); 4) the implementation and dissemination of the national clinical protocol for snakebite and scorpion sting management (2), which includes stratified algorithms for various healthcare levels and severity grades; 5) the inclusion of tropical medicine in Ecuadorian medical school curricula; 6) improved road infrastructure in rural regions; 7) healthcare personnel's expertise in managing snakebite cases; and 8) enhanced digital communication between patients, physicians, and health centers. Nevertheless, underreporting—particularly in the Amazon region—must be considered (4). Between 1996 and 2000, the mortality rate in the Amazonian region reached 2.9% (14), likely due to the scarcity of healthcare services in that area.

This study documented complications and surgical interventions, likely due to the high proportion (82%) of patients admitted with moderate or severe

envenomation. Additionally, 8.2% of patients arrived at the hospital more than 72 hours post-bite; the fatality occurred within this subgroup. We observed a statistically significant association between hospital presentation time and severity, suggesting that care within the first six hours may reduce progression to complications and need for surgical intervention. No significant association was found between length of hospital stay and severity ($F = 2.521$, $p = 0.083$), which we attribute to effective inpatient management. We found no significant correlation between envenomation severity and prior consultation with shamans or use of traditional remedies.

Moderate and severe cases accounted for 82% of our sample, whereas nationally, mild cases predominate at 52.4% (2,5). This discrepancy may reflect selection bias, as this study was conducted at HDTC-MSP—a provincial referral center for complex cases. Milder cases are typically managed at primary healthcare centers and cantonal hospitals, per MSP guidelines (2). Accordingly, reports from first-level care centers show higher proportions of mild cases and lower proportions of severe cases. For example, studies from Zamora Chinchipe, rural areas in northwestern Pichincha, and other coastal cantons report severe case rates of only 2%, 16.6%, and 6.8%, respectively (3,7,15).

Surgical procedures included 14 fasciotomies and 4 amputations. López D (2013) indicates that compartment syndrome necessitates fasciotomy. Jiménez J (2017) asserts that 1–8% of complicated snakebite cases require amputation due to tissue loss and necrosis. These are the most serious complications, leading to permanent disabilities (9), and were observed in patients who received inappropriate wound care, used tourniquets, and received delayed antivenom administration, as emphasized by Gualán S (10).

This study identified several potential risk factors:

1. Occupation: Farmers and students were the most affected groups. Agriculture is the main occupation for 65% of rural Ecuadorians (18), who often spend 8–12 hours daily in fields, pastures, and plantations. This occupational risk is widely recognized in the literature (2,4,6,9,11). Students are at risk while traversing vegetation-rich areas to reach school. These results align with a previous study in Esmeraldas, where 66.4% of cases involved farmers and 17.8% students (6). Farming and livestock activities are predominantly performed by young adult males. Snake habitats—particularly mountainous areas and croplands—are rich in rodents and frogs, which are their primary prey (9,19).

2. Rural residence: Represented a significant risk factor (72.3%; $p < 0.05$), consistent with prior studies (6,9,11). However, 27.2% of bites occurred in urban zones. Snakes may enter urban areas in search of food; small towns intersected by rivers and forested ravines often host rodents feeding on garbage. Informal interviews with urban victims revealed that many bites actually occurred in rural properties. Thus, we recommend adding a question to the MSP epidemiological form to record the precise geographic location of the bite incident.

3. Sex: Males predominated (71.7%), which aligns with Creagh et al. (75.7%) (15) and the national data (sex ratio of 1.75:1 in favor of males) (4), as well as reports from the coastal zone-5 of Ecuador (7). In 2020, 948 of 1,355 cases (70%) nationwide involved men (5). This trend is likely due to male involvement in farming and nocturnal hunting activities—periods when snakes are most active. No significant association was found between sex and severity (Table 1).

4. Age: The age groups 11–20 and 0–10 years reported the highest number of bites (52 and 32 cases, respectively), similar to findings by Vélez et al. (7). These groups include schoolchildren and economically productive young adults. No statistically significant association was found between age group and severity. A prior study in Esmeraldas (6) reported more cases in the 20–49 age group, possibly due to incomplete year-round data that excluded the school season. Nationally, men aged 10–54 are most frequently affected, while the 25–34 age group is the most affected when both sexes are considered (4). In 2020, the 20–49 age group represented 48% of national cases (5).

5. Body region affected: The lower limbs were most commonly involved (69.6%). A study in northwestern Pichincha reported 80% of bites affecting upper and lower limbs (3,15). Preventive recommendations include the use of high rubber or leather boots for agricultural and livestock work and while walking through snake-endemic trails. Leather gloves are also advised during grain collection (e.g., coffee and corn).

6. Educational level: Although 69.1% of victims had only primary education, we believe that schooling per se is not a risk factor; rather, it reflects the fact that individuals with lower educational attainment are more likely to engage in agricultural work and live in rural areas (20).

7. Traditional practices and delayed treatment: The absence or delay in antivenom administration and the use of traditional remedies should be considered risk factors for severity, complications, and amputations. A total of 69 out of 184 patients received antivenom before arriving at HDTC-MSP, demonstrating its availability at lower-level facilities. All patients received antivenom either upon arrival or during hospitalization. However, the use of traditional remedies—e.g., tourniquets, snake bile, etc.—and shaman visits (reported in 20% of cases) remain common. These practices reflect a lack of public health education and strong cultural traditions. We recommend public education campaigns in native languages and mass media, such as television. Continued medical education in tropical medicine and dissemination of MSP protocols to healthcare providers in endemic regions is also crucial, as some hospitals do not strictly adhere to official protocols (21).

8. Rainy season: Although several studies consider the rainy season a risk factor (2,4,6), our study did not find significant seasonal differences. Most cases occurred in October (13%), May (11%), and March (10%) (Figure 2). The peak in May aligns with findings by Creagh et al. (6). Rain may increase risk by forcing snakes out of their flooded shelters (4).

9. Regarding ethnicity: Afro-Ecuadorians represent the predominant ethnic group in the province of Esmeraldas, accounting for 51% of the population (20,22). However, in this study, mestizos were the most affected group. Ethnicity was self-reported, with mestizos comprising 86.4% of cases. Most patients were referred from the canton of Quinindé, which has a higher proportion of mestizo and Indigenous (e.g., Chachi communities) populations. Conversely, referrals from cantons with predominantly Afro-Ecuadorian populations—such as Borbón and Limones—were less frequent.

10. Snakes of the genus Bothrops spp. were identified as the aggressor in 107 out of 184 cases. Other studies have reported Bothrops spp. as the causative species in 100% and 55.6% of cases, respectively (6,7). The remaining patients were unable to identify the snake involved, likely because most bites occur at night, and the snake often escapes quickly. Although coral snakes are present in the study region, no cases were reported. National data indicate that Micrurus species are responsible for only 1% of snakebites (2). In our study, the absence of neurotoxic symptoms confirms that no envenomation by this genus occurred (8).

Finally, we recommend the implementation of digital infrastructure that would facilitate easier and more accurate access to clinical information for all hospitalized patients. Additionally, we urge national authorities to ensure the continuity and completeness of weekly epidemiological reports via digital platforms such as SIVE-ALERTA, as some weeks currently lack any published reports (23).

Conclusions

The prevalence of hospitalizations due to snakebite envenomation at this hospital showed an increasing trend during the final two years of the study, which may reflect a growing demand for antivenom procurement and hospital care. Moreover, the year-round incidence of cases suggests that healthcare personnel should maintain a state of continuous alert. The hemorrhagic and proteolytic symptoms typical of Bothrops spp. envenomation underscore the need for the provincial hospital, canton-level facilities, and local health centers in Esmeraldas Province to consistently stock polyvalent antivenoms. Ideally, these should be locally manufactured to reduce costs and streamline customs procedures.

Acknowledgements

We thank the Hospital Docente "Delfina Torres de Concha" and its authorities for allowing the completion of this research.

Conflict of Interest Statement

The authors declare no conflicts of interest.

Funding

None.

Author Contributions

Manuel Calvopiña: Research mentor, obtained ethics committee and Ministry of Public Health

approvals, and contributed to the review and final editing of the manuscript.

Daniela Silva-Martinod: Data collection, statistical analysis, data interpretation, manuscript drafting, and contribution to the final review and editing.

Nelson Montalván: Data collection and verification from clinical records and patient files.

Daniel Romero-Álvarez: Figure design, data analysis, and contribution to the review and final editing of the manuscript.

Bibliographic references

1. Chippaux JP. Snakebite envenomation turns again into a neglected tropical diseases. J Venom Anim Toxins Incl Trop Dis. 2017 Aug 8;23:38. doi: 10.1186/s40409-017-0127-6. PMID: 28804495; PMCID: PMC5549382.

2. Ministerio de Salud Pública. Manejo clínico del envenenamiento por mordeduras de serpientes venenosas y picaduras de escorpiones. Protocolo basado en evidencia. 2017. https://aplicaciones.msp.gob.ec/ salud/archivosdigitales/documentosDirecciones/dnn/archivos/AC_00153_2017 21 NOV.pdf.

3. Gaus DP, Herrera DF, Troya CJ, Guevara AH. Management of snakebite and systemic envenomation in rural Ecuador using the 20-minute whole blood clotting test. Wilderness Environ Med. 2013 Dec;24(4):345-50. doi: 10.1016/j.wem.2013.08.001. Epub 2013 Oct 9. PMID: 24119570.

4. González-Andrade F, Chippaux JP. Snake bite envenomation in Ecuador. Trans R Soc Trop Med Hyg. 2010 Sep;104(9):588-91. doi: 10.1016/j.trstmh.2010.05.006. Epub 2010 Jun 17. PMID: 20708124.

5. Ministerio de Salud Pública. Dirección Nacional de Vigilancia Epidemiológica Subsecretaría de vigilancia de la salud pública subsistema de vigilancia SIVE-ALERTA efectos tóxicos año 2021. https:// www.salud.gob.ec/wp-content/uploads/2021/01/Toxicos-y-quimicos-SE-53.pdf).

6. Creagh I, Pérez Y, Gámez D, Dueñas O. Características clínico epidemiológicos de los accidentes ofídicos. Ecuador, 2014. 2015. http://journal.intramed.net/index.php/Intramed_Journal/article/view/540.

7. Vélez L, Real J, Idrovo K, Alvarado H, Jaramillo L, Ordóñez J. Caracterización del accidente por mordedura de serpiente atendidos en unidades de Salud, Zona 5, Ecuador. 2019. https://www.inspilip.gob.ec/wp-content/uploads/2019/06/A.

8. Manock SR, Suarez G, Graham D, Avila-Agüero ML, Warrell DA. Neurotoxic envenoming by South American coral snake (Micrurus lemniscatus helleri): case report from eastern Ecuador and review. Trans R Soc Trop Med Hyg. 2008 Nov;102(11):1127-32. doi: 10.1016/j.trstmh.2008.03.026. Epub 2008 May 16. PMID: 18486170.

9. Organizacion Mundial de la Salud 2019. Mordeduras de serpientes venenosas. 2019. https://www.who.int/es/news-room/fact-sheets/detail/snakebite-envenoming.

10. Gualán, S. Caracterización epidemiológica y clínica de los pacientes que presentaron accidente ofídico, atendidos en el «Hospital Marco Vinicio Iza» de la provincia de Sucumbíos durante el período de Enero a Diciembre del año 2010. 2011.https://1library.co/document/rz31exdycaracterizacion-epidemiologica-y-clinica-de-lospacientes-que-presentaron-accidente-ofidicoatendidos-en-el-hospital-marco-vinicio-iza-de-laprovincia-de-sucumbios-durante-el-periodo-deenero-a-diciembre-del-ano-2010.

11. Calvopiña M, Guamán-Charco E, Ramírez K, Dávalos F, Chiliquinga, Villa-Soxo S, Oña-Vistin R, Romero-Alvarez D. Epidemiología y Características Clínicas de las Mordeduras de Serpientes Venenosas en el Norte de la Amazonía del Ecuador (2017-2021) (Submitido en el año 2022).

12. Smalligan R, Cole J, Brito N, Laing GD, Mertz BL, Manock S, Maudlin J, Quist B, Holland G, Nelson S, Lalloo DG, Rivadeneira G, Barragan ME, Dolley D, Eddleston M, Warrell DA, Theakston RD. Crotaline snake bite in the Ecuadorian Amazon: randomised double blind comparative trial of three South American polyspecific antivenoms. BMJ. 2004 Nov 13;329(7475):1129. doi: 10.1136/bmj.329.7475.1129. PMID: 15539665; PMCID: PMC527684.

13. Ortiz-Prado E, Yeager J, Andrade F, Schiavi-Guzman C, Abedrabbo-Figueroa P, Terán E, Gómez-Barreno L, Simbaña-Rivera K, Izquierdo-CondoyJS. Snake antivenom production in Ecuador: Poor

implementation, and an unplanned cessation leads to a call for a renaissance. Toxicon. 2021 Oct 30;202:90-97. doi: 10.1016/j.toxicon.2021.09.014. Epub 2021 Sep 25. PMID: 34571098.

14. Praba-Egge AD, Cone SW, Araim O, Freire I, Paida G, Escalante J, Carrera F, Chavez M, Merrell RC. Snakebites in the rainforests of Ecuador. World J Surg. 2003 Feb;27(2):234-40. doi: 10.1007/s00268-002-6552-9. PMID: 12616443.

15. Zamora G. Incidencia de casos de accidentes ofídicos en los subcentros de salud de San Miguel de los Bancos, Pero Vicente Maldonado y Puerto Quito de Septiembre 2013 a Septiembre 2014. 2015. http://www.dspace.uce.edu.ec/handle/25000/6740.

16. Jiménez J. Incidencia y severidad de accidentes ofídicos tratados en el Hospital General "JULIUS DOEPFNER" de la provincia de Zamora Chinchipe en el año 2016. 2017. http://192.188.49.17/jspui/.

17. López D. Usefulness of antibiotic therapy in relation to the presentation of complications in snakebite accidents in patients treated at the Puyo Provincial Hospital from January 2012 to August 2012. 2013. https://repositorio.uta.edu.ec/handle/123456789/5871Alexandra

18. INEC, 2020. Population Projection by Province, Sex, and Area 2010-2020. 2020. https://www.ecuadorencifras.gob.ec/proyecciones-poblacionales/

19. Ochoa-Avilés A, Heredia-Andino OS, Escandón SA, Celorio-Carvajal CA, Arias-Peláez MC, Zaruma-Torres F, Caldeira CADS, Soares AM, Da Silva SL. Viperidae snakebites in Ecuador: A review of epidemiological and ecological aspects. Toxicon X. 2020 Jul 8;7:100051. doi: 10.1016/j.toxcx.2020.100051. PMID: 32760910; PMCID: PMC7393321.

20. INEC, 2020b. Esmeraldas Provincial Fascicle. 2020. https://www.ecuadorencifras.gob.ec/wp-content/descargas/Manu-lateral/Resultados-provinciales/esmeraldas.pdf

21. Valarezo-Sevilla D, Pazmiño-Martínez A, Sarzosa-Terán V, Morales-Mora N, Acuña-Santana P. Snake accident in patients of the Basic Hospital of Jipijapa (Manabí, Ecuador) [Internet]. 2017. Holguín Medical Scientific Mail (CCM) 2017; (3).

22. Astaíza M. Afro-descendant people in Ecuador. 2012. http://repositorio.dpe.gob.ec/bitstream/39000/64/1/IT-010-pueblo afrodescendiente en el ecuador.pdf

23. Valverde-Muñoz G, Romero-Alvarez D. Measuring the epidemiological uncertainty in snakebite case reports in 2016 Ecuador. Int J Infect Dis. 2018;73: 211. doi: https://doi.org/10.1016/j.ijid.2018.04.3894.