Epidemiological overview of snakebites in the Baja California peninsula, Mexico (2003-2018)

Jesús M. Rodríguez-Canseco¹, Gustavo Arnaud-Franco², Everardo Gutiérrez-López¹ and Guillermo Romero-Figueroa^{1*}

¹Faculty of Sciences, Universidad Autónoma de Baja California, Ensenada, Baja California; ²Environmental Planning Program, Centro de Investigaciones Biológicas del Noroeste, La Paz, Baja California Sur, Mexico

Abstract

Introduction: Ophidian accident is a global public health problem. In Mexico, there is a high incidence of snakebites, which cause medical complications that can leave severe sequelae. **Objective:** To analyze the epidemiological overview of snake venom poisoning in the Baja California (BC) peninsula within the 2003-2018 period. **Method:** A descriptive, retrospective analysis of reported cases was carried out, based on data collection and interpretation. **Results:** A total of 541 records were obtained, out of which 273 occurred in BC and 268 in Baja California Sur (BCS), with an annual average of 17.06 and 16.75, respectively. The incidence rate for BC was 7.62, while for BCS it was 33.09. The highest annual incidence rate in the state of BC corresponded to southern Ensenada, with a value of 42.3, while in BCS it corresponded to the municipality of Comondú, with a value of 54.04. **Conclusions:** Epidemiological analyses allow a better local, state and regional understanding of the problem, in order to develop efficient action protocols to face an ophidian accident, as well as to determine the training requirements of medical personnel and establish a support network for the treatment of cases.

KEY WORDS: Ophidian accident. Poisonous snakes. Incidence rate. *Crotalus*.

Panorama epidemiológico de las mordeduras por serpientes en la península de Baja California, México (2003-2018)

Resumen

Introducción: El accidente ofídico es un problema de salud pública mundial. En México existe una alta incidencia de mordeduras por serpientes, que provocan complicaciones médicas que pueden dejar secuelas severas. **Objetivo:** Analizar el panorama epidemiológico del ofidismo en la península de Baja California (BC) en los años 2003-2018. **Método:** Se hizo un análisis de tipo descriptivo y retrospectivo de los casos presentados, a partir de la recopilación e interpretación de la información. **Resultados:** Se obtuvieron 541 registros, de los cuales 273 se presentaron en BC y 268 en Baja California Sur (BCS), con un promedio anual de 17.06 y 16.75 respectivamente. La tasa de incidencia para BC fue de 7.62 y para BCS de 33.09. La tasa de incidencia anual más alta en el Estado de BC correspondió al sur de Ensenada, con un valor de 42.3, mientras que en BCS fue en Comondú, con un valor de 54.04. **Conclusiones:** Los análisis epidemiológicos permiten tener un mejor entendimiento local, estatal y regional de la problemática, para poder desarrollar protocolos de acción eficientes para enfrentar un accidente ofídico, así como para determinar las necesidades de capacitación del personal médico y establecer una red de ayuda para el tratamiento de casos.

PALABRAS CLAVE: Accidente ofídico. Serpientes venenosas. Tasa de incidencia. *Crotalus*.

Correspondence:

*Guillermo Romero-Figueroa

E-mail: gromero4@uabc.edu.mx

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Introduction

Ophidian accidents correspond to injuries caused by the bite of a snake (venomous or non-venomous) that result in any type of harm. In the case of venomous snakes, the bite includes inoculation of a toxic substance or venom, which causes tissue damage and local or systemic pathophysiological alterations of varying severity¹. The World Health Organization considers this type of accident a public health problem that causes between 1.8 and 2.7 million cases of envenoming annually in the world, which result in between 80 and 140 thousand deaths every year². Most affected regions are Asia, Africa and Latin America, where the largest diversity of these reptiles is found, with rural populations being the most vulnerable group³. In Mexico, the occurrence of ophidian accidents (or ophidism) has varied over time. In the 1994-95 period, 627 cases were recorded, with 30 deaths, whereas in 1997, a considerable increase in the number of cases was reported, with 27,480 registries and 136 deaths⁴, while average annual registration in the years comprised between 2003 and 2018 was 3,700⁵.

Mexico is ranked first in the American continent in terms of venomous herpetofauna, represented by two families of snakes with venom that is potentially deadly for humans: a) *Viperidae* (represented by 10 genera and 64 species), which includes rattlesnakes, *Bothrops asper* (*terciopelo* or *nauyaca*) and *Agkistrodon bilineatus* (*cantil*), and b) *Elapidae* (represented by three genera and 10 species), which includes *coralillos* or coral snakes⁶. The States with the highest incidence of snakebites are Veracruz, Oaxaca, San Luis Potosí, Hidalgo and Puebla⁷, which is attributable to their geographic and climatic characteristics, which favor a wide diversity of ophidians⁸. In contrast, in the Baja California (BC) peninsula, where 20 genera and 28 species of snakes are distributed⁹, there are only seven venomous species, which correspond to rattlesnakes¹⁰. In this region, snakebite registry is lower than in other Mexican States⁴.

The BC peninsula is a territory with a wide-ranging surface (200,000 km²), made up of three main regions according to their climate and biological composition: 1) Mediterranean-temperate region, located in the northwest, with a temperate sub-humid climate and presence of rainfall in winter; 2) tropical region, located at extreme south in the area known as the Cape region, with winter and summer rainfall, and 3) desert region, located between the former two, with a very

dry-semi-warm climate, with winter and summer rainfall, covering 60% of the peninsular surface¹¹⁻¹³. These three regions are subdivided into 14 ecoregions, defined by the composition of their species and their ecological dynamics¹⁴.

Although snakebite registry is lower in the peninsula in comparison with other regions of Mexico⁴, the medical complications resulting from these accidents can be severe, not only due to the possibility of death, but also because of the sequels envenoming can originate¹⁵, as well as those resulting from the application of inadequate medical care¹⁶. Regarding both peninsular States, BC has a population of 3,583,605 inhabitants (46 people per km²), out of which 92.2% are concentrated in urban areas and 7.7% in rural areas, while in Baja California Sur (BCS), the population is 809,833 inhabitants (10 people per km²), with 86.1% concentrating in urban areas and 13.8% in rural areas¹⁷⁻¹⁹. Here, the lack of anti-venom or fabotherapeutic agents availability, as well as the large distances between urban centers where hospital care can be obtained, exacerbate the problem, since the hospitals that can provide the best medical care are at extreme north (Tijuana, Ensenada and Mexicali) and at extreme south (La Paz and Los Cabos), separated by a distance of more than 1,000 km.

In this context, the purpose of this study was to analyze the epidemiological outlook of ophidian accidents in the BC peninsula for the 2003-2018 period.

Materials and methods

Data on snakebite incidence in the states of BC and BCS were obtained from the Epidemiological Bulletin, published by the National Epidemiological Surveillance System, and the Unique Information System of the Ministry of Health of the Federal Government of Mexico. Given that the information provided by said bulletin does not include the geo-localization of the place where the incident occurred by municipality or jurisdiction, the data were supplemented with information from the State Epidemiology Department of the BC Institute of Public Health Services and the BCS Department of Public Health Services in order to group them by State, municipality and jurisdiction. BC is made up of five municipalities, divided into four jurisdictions, while BCS is also made up of five municipalities, each one representing one jurisdiction.

Snakebite registries annual averages were estimated, as well as the incidence rate (total number of cases divided by total population and multiplied by 100,000

Table 1. Total ophidian accidents and annual rate in Baja California (BC), Baja California Sur (BCS) and Mexico (Mx)

Year	Total BC	Rate BC	Total BCS	Rate BCS	Total Mx	Rate Mx
2003	17	0.47	26	3.21	2,666	2.22
2004	9	0.25	26	3.21	3,229	2.69
2005	19	0.53	16	1.98	3,515	2.93
2006	10	0.28	21	2.59	3,701	3.09
2007	7	0.2	19	2.35	3,351	2.79
2008	26	0.73	15	1.85	3,797	3.17
2009	11	0.31	14	1.73	3,725	3.11
2010	15	0.42	18	2.22	3,449	2.88
2011	24	0.67	7	0.86	3,535	2.95
2012	24	0.67	7	0.86	4,225	3.52
2013	25	0.7	15	1.85	3,961	3.3
2014	12	0.33	14	1.73	4,430	3.69
2015	21	0.59	11	1.36	4,378	3.65
2016	12	0.33	18	2.22	3,790	3.16
2017	15	0.42	16	1.98	3,700	3.08
2018	26	0.73	25	3.09	3,726	3.11
Total	273	7.62	268	33.09	59,178	49.34
Average	17.06	0.48	16.75	2.07	3,698.63	3.08
Population	3,584,605		809,833		119,938,473	

population), in order for bias in the differences between the number of inhabitants of the peninsula, State and jurisdiction to be avoided. Total number of registries was compared with those of the entire country for the 2003-2018 period. Incidence rates annual distribution, as well as weekly averages, were expressed in a line chart.

Ophidian accidents geographical distribution was incorporated into a map using ArcGIS® 10.2 (ESRI®) and the SIGepi program, v. 1.4, for estimating the smoothed incidence rates, with local smoothing being applied with the moving average technique with a vicinity distance of 10 km (smoothing has the purpose to reduce the variability generated by unequal population size between municipalities). For stabilization, municipal rates calculation was carried out with cumulative information of the studied years^{20,21}.

Results

A total of 541 ophidian accident registries were obtained for the 2003-2018 period at the BC peninsula,

out of which 273 occurred in BC and 268 in BCS, with an annual average of 17.06 and 16.75, respectively, which accounted for 0.46 and 0.45% of total cases in Mexico, with an incidence rate for BC of 7.62 and 33.09 for BCS (Table 1). The years with the highest number of registries in BC were 2008 and 2018 with 26 cases, while for BCS it was the years 2003, 2004 and 2018, with 26 and 25 registries. The years with the lowest number of cases were 2004 and 2007 for BC, and 2011 and 2012 for BCS (Table 1).

Although ophidian accidents annual rate was higher in BCS in comparison with BC, it was also higher with regard to the national rate for 2003 and 2004, and equal in 2018 (Fig. 1).

As for distribution of the cases in time in both States, they were constant during all months of the year, with an increase by the end of spring (June) and a decrease in autumn (October) (Fig. 2). On these registries, men were most commonly affected, with a total of 374 cases (69%), while 167 cases (31%) involved women.

Figura 1. Ophidian accidents annual rate in Baja California, Baja California Sur and Mexico.

Figure 2. Ophidian accidents weekly average in Baja California and Baja California Sur.

Regarding cumulative annual incidence rate by BC jurisdiction, the highest was recorded in jurisdiction IV, which corresponded to the south of the Ensenada municipality, with a value of 42.3, while the lowest rate occurred in jurisdiction II, corresponding to the municipalities of Tijuana, Tecate and Playas del Rosarito, with a value of 3.71 (Table 2) (Fig. 3). As for BCS, registries by municipality comprised only the 2003-2005 and 2012-2016 periods, with a total of 132 cases. The highest rate was documented in the Comondú municipality, with a value of 54.04, while the lowest rate occurred in the municipality of Loreto, where there were no cases (Table 3) (Fig. 3).

Discussion

Ophidism is a public health problem in Mexico due to the number of annual cases^{4,5,16}. Its impact on the

health of those who are affected by it depends on several factors, such as the amount and characteristics of inoculated venom, which can vary according to the species involved²², as well as to the promptness of care and access to appropriate treatment²³, which in the BC peninsula depends on the locality the ophidian accident occurs at, since distances to hospital centers can be considerably long, which implies a significant number of hours before being able to receive medical attention.

Interaction between snakes and humans in this region of Mexico occurs mainly in rural areas. In the BC peninsula, epidemiological information on ophidian envenoming is limited, since not all those affected attend medical facilities, due to the remoteness of localities, which is why they are not registered by the health system.

Table 2. Ophidian accident cases and annual incidence rate in Baja California by jurisdiction

Year	Mexicali	Rate	Tijuana, Tecate and Playas de Rosarito	Rate	North of Ensenada	Rate	South of Ensenada	Rate	Total	Rate
2003	2	0.19	5	0.25	5	1.17	2	1.84	14	0.4
2004	3	0.28	0	0	4	0.94	3	2.76	10	0.3
2005	5	0.47	2	0.1	12	2.81	4	3.68	23	0.6
2006	3	0.28	0	0	7	1.64	1	0.92	11	0.3
2007	2	0.19	2	0.1	2	0.47	2	1.84	8	0.2
2008	12	1.14	9	0.45	3	0.7	0	0	24	0.7
2009	8	0.76	2	0.1	1	0.23	1	0.92	12	0.3
2010	7	0.66	3	0.15	5	1.17	2	1.84	17	0.5
2011	4	0.38	14	0.7	4	0.94	4	3.68	26	0.7
2012	8	0.76	3	0.15	5	1.17	8	7.36	24	0.7
2013	7	0.66	4	0.2	10	2.34	4	3.68	25	0.7
2014	4	0.38	6	0.3	2	0.47	1	0.92	13	0.4
2015	7	0.66	5	0.25	6	1.41	6	5.52	24	0.7
2016	4	0.38	7	0.35	1	0.23	1	0.92	13	0.4
2017	6	0.57	7	0.35	2	0.47	0	0	15	0.4
2018	8	0.76	5	0.25	6	1.41	7	6.44	26	0.7
Total	90	8.55	74	3.71	75	17.6	46	42.3	285	8

Figure 3. Snakebite cases number geographic variation (A) and incidence rate (accidents/100,000 population) (B), during the 2003-2018 period in the Baja California peninsula.

Table 3. Ophidian accident cases and annual incidence rates by municipality in Baja California Sur

Year	Comondú	Rate	Mulegé	Rate	La Paz	Rate	Los Cabos	Rate	Loreto	Rate	Total	Rate
2003	11	13.2	2	2.84	10	3.27	4	1.22	0	0	27	3.33
2004	11	13.2	1	1.42	11	3.6	3	0.91	0	0	26	3.21
2005	2	2.4	0	0	1	0.33	2	0.61	0	0	5	0.62
2012	4	4.8	5	7.1	3	0.98	2	0.61	0	0	14	1.73
2013	4	4.8	3	4.26	2	0.65	7	2.13	0	0	16	1.98
2014	6	7.21	0	0	7	2.29	3	0.91	0	0	16	1.98
2015	3	3.6	1	1.42	2	0.65	4	1.22	0	0	10	1.23
2016	4	4.8	4	5.68	5	1.64	5	1.52	0	0	18	2.22
Total	45	54	16	22.7	41	13.4	30	9.1	0	0	132	16.3

Monthly occurrence of cases in the BC peninsula is similar to that in other regions of the country, with a preponderance during the warmest and rainiest months²⁴⁻²⁶; however, in the peninsula, the occurrence of snakebites is throughout the entire year. Men are more commonly affected than women, which is similar to other regions of Mexico^{1,24-26} and other countries²⁷⁻³⁰.

For the national registry of cases, the Epidemiological Weekly Bulletin, published by the Ministry of Health through the National Epidemiological Surveillance System, is highly useful, because it allows knowing the number of snakebite cases by State; however, there is information that is not considered, but that is collected by the States' Health Services, which classify it at the level of jurisdiction or municipality. Even so, there are important gaps in the collected information, such as the species involved, which could allow the most commonly involved species to be identified. Pictures of the involved snake can be identified by regional specialists. In addition to the person's gender, it is also necessary to record his/her age, anatomical location of the bite, activity the involved person was performing at the time of the bite, time between the bite and anti-venom or faboherapeutic agent application, number of anti-venom applied doses and length of stay at the medical unit.

In this context, epidemiological analyses allow having a better understanding of the problem at the local, state and regional levels, in order to be able to develop efficient action protocols for dealing with an ophidian accident, as well as to determine medical personnel training needs and to establish a support network for the treatment of cases, which is particularly important in the BC

peninsula due to its length of more than one thousand kilometers. Although the main treatment for taking care of an ophidian accident is anti-venom or faboherapeutic agents administration, since after the bite the first two hours are crucial for mitigating the venom effects,²³ there are still doctors who are reluctant about their use.

Although ophidism is relatively low in the BC peninsula, in BCS, the State with the lowest population density in the country, its rate is close to the national mean, and even exceeds it in one year. In BC, despite having almost the same number of cases than BCS, its rate is lower because its population is 3:1 in relation to BCS.

Conclusions

The frequency of ophidian accidents in the BC peninsula is lower than in other States of Mexico; however, in BCS, the incidence rate is high because it is the State with the lowest demographic density.

There are information gaps on each snakebite case cared for at medical services, including the species of the involved snake.

Epidemiological information related to ophidian accidents is essential for the municipal and regional magnitude of the problem to be evaluated in order for guidelines for the management of resources and the training of medical personnel for the treatment of snakebites to be developed.

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Conflict of interests

The authors declare that there are no conflicts of interest related to the statements expressed in this article.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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