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Gac Med Mex. 2016;152:511-6



# Epidemiological panorama of venomous snake bites in the state of Yucatan, Mexico (2003-2012)

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## Abstract

*No information has been yet published on the epidemiological panorama of snakebite in the state of Yucatan. The aim of this study was to evaluate the geographic and temporal patterns of this problem in the state. Snakebite data was obtained from the Program of Zoonosis of the Health Services of Yucatan between 2003 and 2012. A total of 821 snakebite cases and an incidence of 41.9 accidents/100,000 inhabitants were recorded during this period. The annual average cases and incidence were 82.1 and 4.1 (bites/100,000 inhabitants), respectively. The highest number of snakebites occurred in 2005, while in 2003 the lowest number was recorded. Geographically, we observed a great disparity between municipalities, some of them reaching very high levels of incidence. This geographical variation may reflect the distribution and abundance of venomous snakes on one hand, and human population densities and their activities on the other. This study will help health authorities to know preliminarily the magnitude of snakebites in Yucatan and improving strategies to mitigate it.* (Gac Med Mex. 2016;152:511-6)

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***KEY WORDS:*** *Venomous snakes. Snakebite. Ophidism. Yucatan.*

## Introduction

Ophidism is regarded by the World Health Organization as a neglected public health problem in spite of its elevated incidence, the number of deaths it causes and the serious and permanent functional sequels that can develop in affected individuals[1-3]. Recent global estimates suggest that the magnitude of the problem is considerably larger than reported by health agencies, especially in tropical developing countries[2-4]. According to Chippaux (2008)[5], up to 5.5 million of venomous snake bite cases could be occurring annually in the world, out of which 2.5 million might involve envenomation, with a toll of around 125 thousand deaths. On the other hand, Kasturiratne et al.[6] estimated that total annual global envenomations might range between 421 thousand and 1.8 million cases, with 20 to 94 thousand deaths. In Mexico, until 1995 there were 27,500 cases reported annually with 136 deceases[7], whereas in the 2003-2006 period, 14,858 cases and a yearly average of 3,714.5 incidents were recorded[8].

Venomous snake bites are less common in the state of Yucatán in comparison with other regions of Mexico (e.g., in the 2003-2006 period, 335 accidents were recorded, whereas in states such as Puebla, Hidalgo, San Luis Potosí, Veracruz and Oaxaca, more than thousand bite cases were reported[8]). Nevertheless, medical complications resulting from these accidents can be severe, since in throughout the state there are very large species distributed whose venom is highly toxic, such as the Yucatan neotropical rattlesnake –*Crotalus tzabcan*[9]– and the *nauyaca* –*Bothrops asper*[10-12]–. The latter causes the majority of accidents in tropical moist

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Date of reception: 21-07-2015
Date of acceptance: 24-07-2015

regions of Mexico, Central America and northern South America, since it is a quite irritable and unpredictable species that can measure up to 250 cm[12,13]. Another medically important venomous species found in the state is the Yucatecan *cantil –Agkistrodon russeolus*[14]–, since even when it is smaller in size than the aforementioned ones, it is relatively common and, according with different authors, it is also of an irritable nature[10].

The Yucatán hognosed pitviper –*Porthidium yucatanicum*– and the variable coral snake –*Micrurus diastema*– complete the list of venomous snakes in the state. However, these are considered to be responsible of much less accidents than those mentioned in the above paragraph. The first one, because it is an uncommon species in the state (although it appears to be abundant in the surroundings of Pisté[10]) and it has a restricted distribution (in fact, it is endemic to the Yucatan Peninsula[15]), and the second, because owing to its biological characteristics, its bite is usually accidental[16], since it dwells in hidden places and it is hardly aggressive[10,15].

The purpose of the present work is to provide updated information on ophidism epidemiological panorama in Yucatan, since the only information available today is the above mentioned work by González-Rivera et al.[8], who only report total figures for the state for the 2003-2006 period. Here, we report the venomous snake bite cases and incidence rate for each municipality of Yucatan in order to describe geographic variation, and analyze this phenomenon in time over a 10-year period (2003-2012). Finally, we discuss the factors potentially determining ophidian accidents in this region and propose some lines of investigation and strategies that could be implemented to mitigate this problem.

## Methods

The information on venomous snake bite cases was provided by the SSY Zoonosis Program State Coordination. The data encompass a 10-year time period (2003-2012) and are grouped by municipalities.

Incidence rates were calculated for the state (the sum of cases of all municipalities divided by Yucatan total population for each 100,000 inhabitants), per year and for the entire period of analysis, by using the population progression provided by the National Institute of Geography and Statistics (INEGI – *Instituto Nacional de Geografía y Estadística*; www.inegi.org-mx/). Their temporal distribution and that of crude cases were analyzed by means of a lines and bars combined graph.

Using the ArcGIS® v.10.2 (©ESRI) software, ophidian accidents geographic distribution was determined by incorporating them to a vectorial layer of Yucatan state municipalities developed by the INEGI that contains each municipality's population size. Subsequently, the SIGepi v. 1.4 program was used to estimate smoothed incidence rates by applying local smoothing with the mobile mean technique with a distance in the vicinity of 10 km (smoothing has the purpose to reduce variability generated by uneven population size between municipalities). For stabilization, municipal rates calculations calculation was carried out by accumulating the information of the studied years[17,18].

## Results

A total of 821 cases of venomous snake bites and an incidence of 41.9 accidents per 100,000 population in the state of Yucatan were obtained for the period from January 2003 through December 2012. Annually, the number of cases and the incidence rate fluctuated, but in relative terms they remained stable (Fig. 1), with an average of 82.1 bites and 4.1 incidents per 100,000 population being recorded. The highest number of accidents was observed in 2005, whereas the lowest figure was recorded in 2003 (Fig. 1, Table 1).

In the geographic analysis, it is important to highlight municipalities such as Xocchel and Mocochá, where incidence rates of more than 3,000 bite cases of bite per 100,000 population were recorded. In the former there was also the highest number of crude cases recorded (151), whereas the latter occupies the third position on this subject (104). Tzucacab was second place in the number of accidents (124) and fourth place with regard to rates (885 cases/100,000 population), in this last subject only below the previously mentioned municipalities and below Mayapán, where a rate of 1,070 cases per 100,000 population was estimated (Table 2).

In the geographic analysis it is also possible observing municipalities that recorded an elevated number of cases, but a low incidence rate. For example, Kanasín, Progreso, Tixkokob and Tekax are among the 20 municipalities with the highest number of cases, but are not among those with the highest incidence rates. On the other hand, in Kopomá, Yaxkukul, Sinanché and Sudzal, elevated incidence rates were estimated in spite of not having as many cases as other municipalities (Fig. 2).

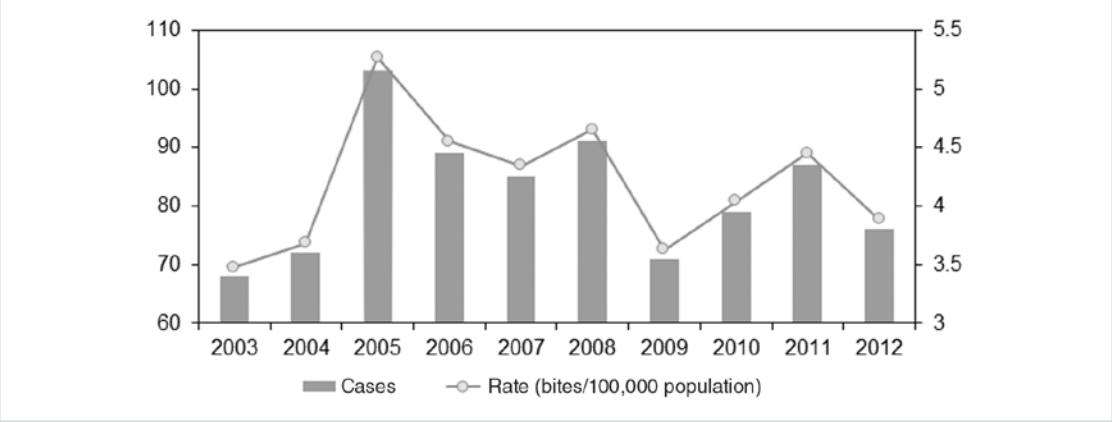


**Figure 1.** *Number of cases and incidence rate (accidents/100,000 population) of venomous snake bites during the 2003-2012 period in the state of Yucatan, Mexico.*

## Discussion

The present work represents the first epidemiological analysis on ophidism in the state of Yucatán. Our main objective was to carry out a longitudinal retrospective study to describe temporal and geographic patterns of this phenomenon.

The only previously published information on the subject corresponds to the work by González-Rivera et al.[8], who conducted a nation-wide analysis and report an average of 83.7 bites for the state of Yucatán from 2003 to 2006, a figure slightly higher than the

**Table 1. Records of cases and incidence rate (accidents/100,00 population) of venomous snake bites in the state of Yucatán, México, distributed by year (2003-2012)**

| Year | Cases | Rate |
|---|---|---|
| 2003 | 68 | 3.5 |
| 2004 | 72 | 3.7 |
| 2005 | 103 | 5.3 |
| 2006 | 89 | 4.6 |
| 2007 | 85 | 4.3 |
| 2008 | 91 | 4.7 |
| 2009 | 71 | 3.6 |
| 2010 | 79 | 4.0 |
| 2011 | 87 | 4.4 |
| 2012 | 76 | 3.9 |

**Table 2. Municipalities of the state of Yucatán, Mexico, with the highest number of cases and with the highest smoothed rate (accidents/100,000 population) of venomous snake bites (2003-2012)**

| Municipality | Cases | Municipality | Rate |
|---|---|---|---|
| Xocchel | 151 | Xocchel | 4,666.3 |
| Tzucacab | 124 | Mocochá | 3,386.5 |
| Mocochá | 104 | Mayapán | 1,070.7 |
| Acanceh | 63 | Tzucacab | 885.0 |
| Kanasín | 46 | Timucuy | 541.5 |
| Timucuy | 37 | Quintana Roo | 530.8 |
| Mayapán | 35 | Telchac Pueblo | 506.0 |
| Progreso | 28 | Acanceh | 410.8 |
| Panabá | 22 | Panabá | 294.9 |
| Telchac Pueblo | 18 | Ixil | 210.4 |
| Akil | 14 | Dzemul | 172.0 |
| Opichén | 10 | Kopomá | 163.3 |
| Teabo | 9 | Opichén | 159.1 |
| Ixil | 8 | Teabo | 145.0 |
| Samahil | 7 | Samahil | 139.8 |
| Dzemul | 6 | Yaxkukul | 139.5 |
| Huhí | 6 | Akil | 135.1 |
| Tixkokob | 6 | Sinanché | 128.0 |
| Quintana Roo | 5 | Huhí | 123.9 |
| Tekax | 5 | Sudzal | 118.4 |

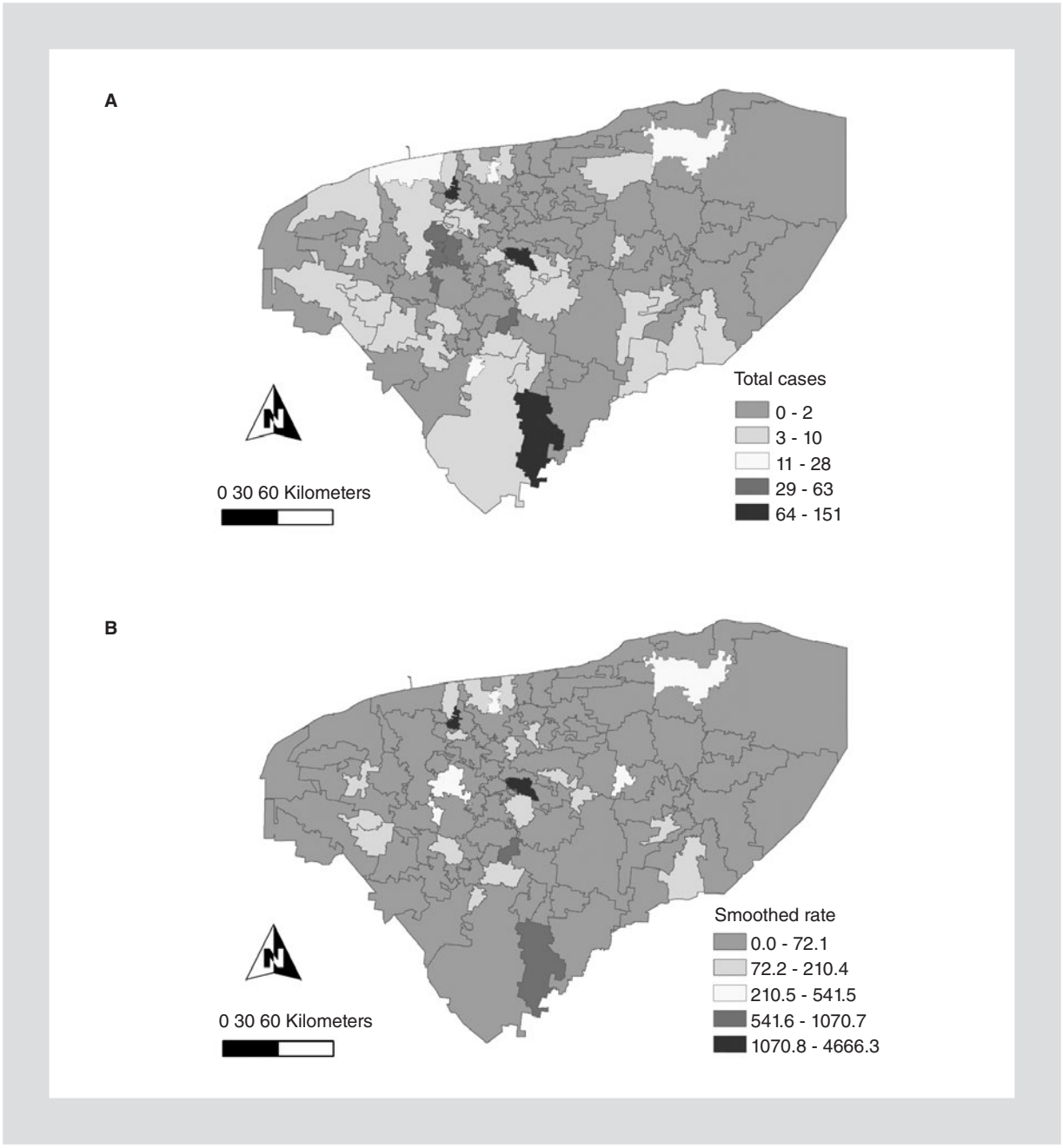


**Figure 2.** *Geographic variation of cases **(A)** and incidence rates (accidents/100,000 population) **(B)** of venomous snake bites during the 2003-2012 period in the state of Yucatán, Mexico.*

average (82.1) estimated in our study for the 2003-2012 period. These authors also report total cases per year and for the entire study period (335 total cases), which has enabled for us to identify discrepancies with the sum of cases we obtained for the same period based on data provided by the SSY Zoonosis Program State Coordination. Although these discrepancies are subtle, they indicate errors in the recording of this information, either due to overestimation in González-Rivera et al.[8] work or due to omission of some cases in the database provided by the SSY. Different authors have emphasized that in many tropical and developing countries, official figures reported by health agencies on ophidian accidents should be taken with caution, since in these regions, people who suffer accidents in marginal rural communities often die before being able to have access to some healthcare center, or primarily resort to healers or traditional doctors[19-22]. In Yucatán, although

growing modernization is having a strong impact on traditional medicine, healers currently continue playing an important and necessary role within the communities healing, by means of medicinal plants, different ailments, including venomous snake bites[23].

In spite of the limitations there might be in hospital and health centers databases and reports, it is important using this information to describe venomous snake bite geographic and temporal patterns in this region as a first step to understand the magnitude of the problem in the state and locally. For example, estimated incidence for some municipalities of the state is considerably higher than in any municipality of the state of Veracruz[24], which is considered the second state with the highest number of ophidian accidents in the country[25]. Specifically, 4 municipalities in Yucatán have incidence rates higher than the highest rate estimated in Veracruz, which is 541.4 bites per 100,000 population. The Xocchel and Mocochá municipalities stand out, where we estimated a rate approximately 6 and 8-fold higher, respectively, than the highest rate reported for Veracruz, which is rather surprising. Such a high incidence results from the large number of reported cases combined with a small population size, whereas the elevated number of cases could be the consequence of an interaction of factors such as the presence and abundance of venomous snake species on one hand, and the density and activities of the human populations in the region on the other.

With regard to the temporal analysis, the highest number of bites was recorded in 2005, which is consistent with the path across the state of category IV hurricane "Emily", which made landfall in the vicinity of Tulum, Quintana Roo, and after advancing across the northeastern part of the Yucatán Peninsula, it exited to the Gulf of Mexico. That year, Yucatán was also crossed by the "Stan" tropical storm and the "Cindy" tropical depression, which caused intense rainfall, affecting the state with floods. In addition, category IV hurricane "Wilma", the most intense ever recorded for the Atlantic basin, severely impacted the Quintana Roo coasts also bringing damages and increased rainfall in Yucatán[26-30]. In other regions of the world, an increased incidence of ophidian accidents has been documented following extreme natural events such as cyclones, hurricanes, typhoons and storms[31-35]. This is owing to the fact that rainfall and floods generally affect snakes' normal habitat, which are forced, due to the water level, to migrate and leave their pits, which increases the likelihood of encounters with people[36].

Finally, we consider important mentioning that, to better understand ophidism in the state of Yucatán, as well as in other regions of the world, it is crucial on one hand for more specific information to be digitalized by government health agencies on temporal (e.g., hour, month) and geographic (e.g., geo-referenced or approximate location where the accident occurred and the clinic or health center where it was attended to) conditions under which the accidents occur, as well as social characteristics (e.g., gender, age, occupation) of affected individuals, and on the other hand, for information obtained by means of other methodological approaches to be incorporated, including:

- Venomous snakes geographic distribution and environmental favorability modelling[24].
- Estimation of potential future changes in distribution ranges as a consequence of climate change[37,38].
- Spatial modeling of recorded cases probable under-representation by clinics and health centers[39].
- Identification, by means of geographic information systems, of regions at high ophidian risk where increasing accessibility of their population to health centers where they can receive attention is required[40].

## Acknowledgements

We thank the SSY Zoonosis Program Coordination for providing the databases on ophidism. We also thank Karla Rodríguez Medina, MSc, for the review of the present manuscript.

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