Diversitas Journal
ISSN 2525-5215
Volume 8, Número 4 (out./dez. 2023) p. 3244 – 3254
https://diversitasjournal.com.br/diversitas_journal

Spatio-temporal patterns of scorpionism in Alagoas, northeastern Brazil: ecological study (2007 to 2021)

Padrões espaço-temporais do escorpionismo em Alagoas, nordeste do Brasil: estudo ecológico (2007 a 2021)

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ABSTRACT

The high incidence of scorpionism in public health in Brazil and other developing countries motivated its inclusion in the list of Neglected Tropical Diseases of the World Health Organization (*Organização Mundial de Saúde*). Thus, the aim of the study was to investigate the spatio-temporal dynamics of scorpion accidents reported in the state of Alagoas from 2007 to 2021. This is a mixed ecological study, with data available on the open portal Health Information, regarding the cases of accidents with scorpions confirmed and reported in the Information System of Notifiable Diseases (*Sistema de Informação de Agravos de Notificação*) and the population estimates by municipality in the state. Statistical analyses were performed using the R software (version 4.2.2), analyzing the incidence of cases; temporal evolution; spatial distribution and relative risk. A trend of average annual increase of 1.6 cases per 10 thousand inhabitants in the incidence of scorpionism was identified. The Local Moran Index (*Índice de Moran*) showed significant autocorrelation between the municipalities with the highest incidence as well as their adjacent ones, with Teotônio Vilela, Junqueiro and Campo Alegre presenting high incidence rates in the three cutoff points of the time series studied (2007, 2014 and 2021). The cluster formed by the municipalities of Junqueiro, Teotônio Vilela, Arapiraca and Campo Alegre presented the highest relative risk of scorpionism in almost the entire period studied. The results indicate a trend of annual growth in the number of accidents by scorpions in the state of Alagoas, with this, it will become important that the state and the municipalities develop public health policies aimed at the control of venomous animals of medical importance.

INFORMAÇÕES DO ARTIGO

Histórico do Artigo:
Submitted: 23/07/2023
Approved: 05/10/2023
Published: 14/10/2023

Keywords:
Scorpions, Spatial Analysis, Incidence, Tropical Diseases.

RESUMO

A alta incidência de escorpionismo na saúde pública no Brasil e demais países em desenvolvimento, motivou sua inclusão na lista de Doenças Tropicais Negligenciadas da Organização Mundial de Saúde. Destarte, o objetivo do estudo foi investigar a dinâmica espaço-temporal dos acidentes por escorpiões notificados no estado de Alagoas no período de 2007 a 2021. Trata-se de um estudo ecológico misto, com dados disponíveis no portal aberto Informações de Saúde, a respeito dos casos de acidentes com escorpiões confirmados e notificados no Sistema de Informação de Agravos de Notificação e, as estimativas populacionais por município no estado. As análises estatísticas foram feitas no software R (versão 4.2.2), analisando-se a incidência dos casos; evolução temporal; distribuição espacial e o risco relativo. Identificou-se uma tendência de aumento médio anual de 1,6 casos por 10 mil habitantes na incidência de escorpionismo. O Índice de Moran Local apontou autocorrelação significativa entre os municípios com maior incidência assim como seus adjacentes, com Teotônio Vilela, Junqueiro e Campo Alegre apresentando altas taxas de incidência nos três pontos de corte da série temporal estudada (2007, 2014 e 2021). O cluster formado pelos municípios de Junqueiro, Teotônio Vilela, Arapiraca e Campo Alegre, apresentou o maior risco relativo de escorpionismo em quase todo o período estudado. Os resultados apontam uma tendência de crescimento anual no número de acidentes por escorpiões no estado de Alagoas, com isso, tornar-se-á importante que o estado e os municípios, desenvolvam políticas públicas de saúde que visem o controle de animais peçonhentos de importância médica.

Palavras-Chave:
Escorpiões, Análise Espacial, Incidência, Doenças Tropicais.

DOI: 10.48017/dj.v8i4.2751

Introduction

The Notifiable Diseases Information System (SINAN) classifies animals of clinical interest as those that cause mild, moderate or severe accidents and among them are scorpions (Information System of Notifiable Diseases [SINAN], 2019). Thus, the term scorpionism refers to accidents by venomous animals that culminate in poisoning of the victims, caused by the bite of scorpions. These animals are terrestrial arthropods of the class Arachnida that have a body divided into cephalothorax and abdomen, a region in which the telson is located, the last segment of the metasoma (tail), in which the venom-producing glands are present, next to the sting (stinger) through which it´s inoculated (Ministério da Saúde [MS], 2009; Lisboa et al., 2021).

As of 2020, 2,544 scorpion species have been described worldwide (Pimentel & Claine, 2020). However, only a few species of the genus *Tityus* are among the main causes of accidents by venomous animals in Brazil, such species of medical interest are: *Tityus serrulatus* (yellow scorpion); *Tityus bahiensis* (brown scorpion); *Tityus stigmurus* (northeastern yellow scorpion); *Tityus obscurus* (Amazon black scorpion) and *Tityus silvestris*. Among these, *T. serrulatus* and *T. stigmurus* occur in the Brazilian Northeast, the latter being the main responsible for scorpion accidents in this region of the country (Gomes et al., 2022).

Of nocturnal habits, scorpions are commonly found most often in vacant lots or places with food availability such as sewage networks, dumps, cemeteries, yards with rubble or rest of construction material. They are carnivores, feed on small insects such as cockroaches, crickets, spiders and other invertebrates, and in the absence of food carry out cannibalism (Candido & Wen, 2019). It´s noteworthy that due to the increasingly close contact of man with these animals lead to the occurrence of accidents by poisoning more often.

Thus, among the clinical manifestations that can be observed in victims of scorpion poisoning are: Pain, edema, erythema and sweating at the site of the bite. In addition to these, nausea, vomiting, hyper- and hypotension, cardiac arrhythmia, pulmonary edema and shock can be observed (Santana et al., 2015). It´s important to note that in cases of accidents, the victim should be immediately referred to a health unit for appropriate care, avoiding homemade measures such as: Tying or tourniquet at the site of the bite or even using substances that may infect the affected area, such as coffee powder, tobacco, alcohol among others (MS, 2021).

The high incidence of this type of public health problem in Brazil and other developing countries motivated the World Health Organization (WHO) to include accidents by venomous animals in the list of Neglected Tropical Diseases (NTDs). In Brazil, scorpion accidents represent the second leading cause of poisoning in humans, second only to drug intoxication. Between 2003 and 2018, more than two million accidents were reported by venomous animals,

and of these, 59% correspond to scorpionism (Dourado et al., 2019; Lisboa et al., 2021; Machado, 2016).

In the period between 2009 and 2019, the number of accidents by scorpions in the Brazilian Northeast region was 457,341 cases, especially the state of Bahia, with 28.62% (130,907) of the notifications. In addition, regarding the age group, individuals from 20 to 39 years old were the most affected. However, children up to 4 years of age and elderly over 70 years of age represent the population group most susceptible to severe complications due to scorpionism, due to the vulnerability of their immune system (Oliveira et al., 2021).

In the state of Alagoas, between 2018 and 2021, 40,590 cases of scorpionism were reported, so that the two most populous municipalities in the state, Maceió (10,766 cases) and Arapiraca (5,061 cases) respectively, had the highest number of notifications, with one death in 2019 and three in 2021 (Oliveira et al., 2022).

In this perspective, in view of the relevance of scorpionism in public health, and that studies on this problem can subsidize the development of public policies that potentially contribute to the control of scorpionism, this study aimed to investigate the spatio-temporal dynamics of scorpion accidents reported in the state of Alagoas in the period from 2007 to 2021.

Methodology

Type of study

This is a mixed ecological study regarding the occurrence of cases of accidents caused by scorpions in the state of Alagoas, notified in the period from 2007 to 2021.

Area of study

The state of Alagoas is located in the Northeast region of Brazil, is the second smallest state in the region and one of the states with the lowest Human Development Index (*Índice de Desenvolvimento Humano*) (0.631) in the country. Alagoas has an estimated population of 3,365,351 inhabitants, a population density of 12.33 inhabitants/km², and is composed of 102 municipalities, most of which have considerable indices of social vulnerability (Bezerra et al., 2020; Instituto Brasileiro de Geografia e Estatística [IBGE], 2023).

Data collection

The data refer to cases confirmed and reported in the Information System of Diseases of Notification of Accidents by Venomous Animals in the state of Alagoas, from 2007 to 2021. Only accidents with scorpions were selected. To calculate the incidence, we used the population

estimates by municipality, carried out by the Federal Court of Auditors. All data were obtained from the open portal Health Information (TABNET) - DATASUS (https://datasus.saude.gov.br/informacoes-de-saude-tabn), and organized in Microsoft Excel software.

Statistical analysis

All statistical analyses were performed on the free software R, version 4.2.2 (The R Core Team, 2022). The level of significance adopted was 5%. The incidence of cases was calculated as the total number of cases observed in a given year, divided by the total population estimated for the same year, and multiplied by 10,000 (De Oliveira Filho, 2015). For the analysis of the temporal evolution of these variables, the series were represented in a line graph, and the trend was evaluated using Simple Linear Regression (Gujarati, 2011).

In the Spatial Analysis, we mapped the incidence coefficient per 10 thousand inhabitants, using the cartographic base of Alagoas (obtained from the IBGE Map Portal - https://portaldemapas.ibge.gov.br/portal.php), divided by municipalities. The K-means grouping technique (Hair et al., 2009), with the Hartigan-Wong algorithm was used for the stratification of the municipalities. Crude data rates were smoothed by the Local Empirical Bayesian Estimator (Yamamoto & Landim, 2013) to minimize instability caused by random fluctuation.

For both, the Moran Global Index (Moran, 1948) was calculated to identify spatial autocorrelations and, when identified, the Local Index of Spatial Association (LISA) was used (Andriotti, 2013; Yamamoto & Landim, 2013) with the objective of quantifying the degree of spatial association to which each location of the sample set is submitted as a function of a neighborhood model. LISA generated the Moran scatterplot to identify critical or transition areas, in which the value of each municipality is compared with the values of neighboring municipalities. The generated quadrants will be interpreted as follows: Q1-High/high (positive values and positive means); Q2-Low/low (negative values and negative means); Q3-High/low (positive values and negative means); Q4-Low/high (negative values and positive means).

The Moran Map considers only those areas whose Local Moran indices were significant. The formation of clusters, as well as the Relative Risk of infection within each cluster was verified through the Spatial Scan technique (Andriotti, 2013; Yamamoto & Landim, 2013).

Ethical aspects

Because it´s a study developed with secondary data in the public domain, without any personal identification of the victims of the accidents, it was not necessary to approve a

Research Ethics Committee (CEP), thus respecting the ethical precepts of resolution No. 466/12 of the National Health Council (CNS).

Results and Discussion

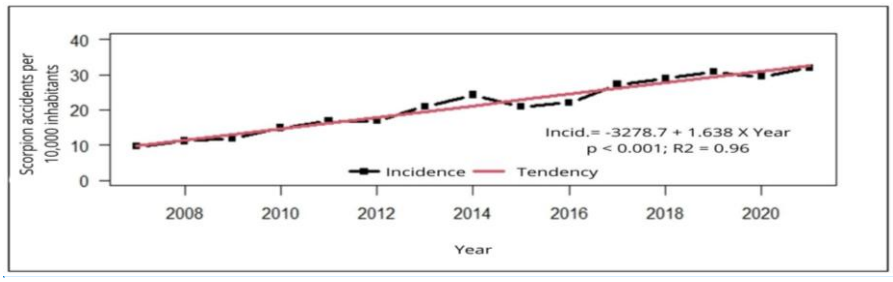
Temporal analysis

The temporal analysis shows a trend towards an average annual increase of 1.6 cases per 10,000 thousand (10 thousand) inhabitants (inhab) in the incidence of scorpion accidents over the time series. Indicating that, on average, there was an increase of 8.45% in the incidence of scorpion accidents each year (**Figure 1**). Corroborating this, between the years 2018-2021, 40,590 scorpion accidents were reported in Alagoas, and the year in which there was the highest number of records was 2021, with 10,766 cases (Oliveira et al., 2022).

In the study by Freire et al. (2021) conducted in the city of Estância, Sergipe, 476 accidents with scorpions were reported, between the years 2015 to 2019, the highest number of records was observed in the year 2019 with 152 cases (31.93%).

Figure 1.

Time trend of the incidence of accidents with scorpions in Alagoas (2007 a 2021).



Comentado [1]: Tradução dos textos do gráfico:
Scorpion accidents per 10,000 inhabitants
Incidence
Year
Incidence
Tendency
Year

Source: Prepared by the authors (2023).

In a national context, in the period from 2017 to 2019, the number of cases of accidents by venomous animals throughout Brazil was increasing, highlighting the year 2019 with the highest number of occurrences in that period (Lima et al., 2022).

Bayesian estimator

Corroborating with the temporal analysis, it´s observed that the incidence of scorpion accidents increased over time. At the beginning of the time series (2007), no municipality in Alagoas had an incidence above 52.6/10 thousand inhab, so that the highest incidence

recorded for the period was 49.43/10 thousand inhab in the municipality of Teotônio Vilela. In 2014, half of the time series studied, Arapiraca and Teotônio Vilela had incidences greater than 52.6/10 thousand inhab, and in 2021, Junqueiro, Paripueira, Pilar, Matriz do Camaragibe and União dos Palmares were added to Arapiraca and Teotônio Vilela with the highest incidence rates (>52.6/10 thousand inhab) (**Figure 2.A, B, C**).

Cases of scorpionism in urban centers have become increasingly common, in the municipality of Jaboatão dos Guararapes, Pernambuco, there was a higher notification of cases in the urban area (76.9%), when compared to the rural zone (0.4%), a fact related to the growing deforestation and densely populated regions, which provide the intra-household spread of scorpions (Dias et al., 2020).

It´s important to note that the growing number of these registries is associated with the implementation of the Hospital Epidemiology Centers from the year 2009. Thus, the notifications began to be evaluated more carefully, in addition, the increase in the search for health services due to the awareness of the population about the severity that a scorpion accident can have, probably contributes to an improvement in the quality of scorpion notifications (Carmo et al., 2019).

Spatial autocorrelation

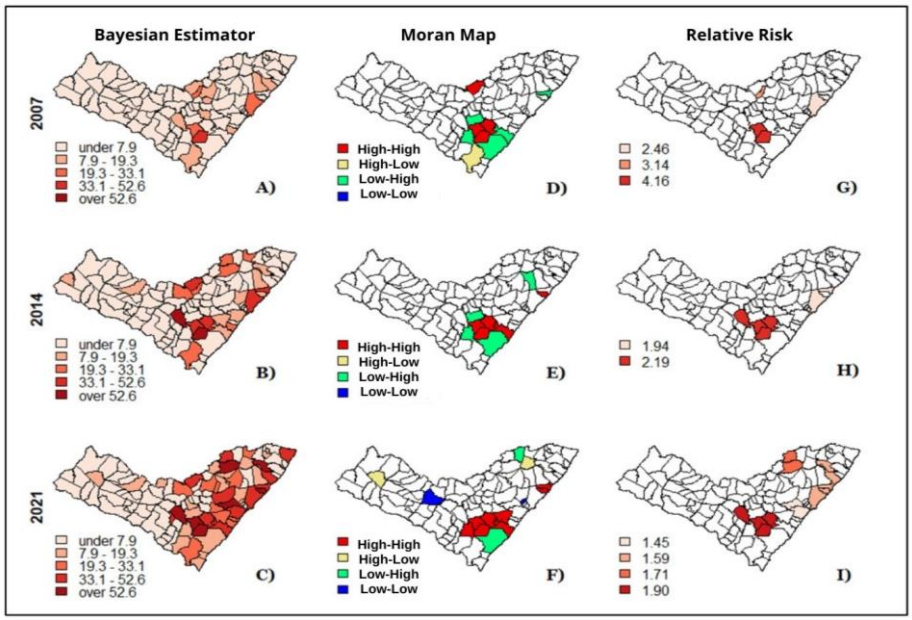
In 2007, the Moran Global Index showed a significant global autocorrelation among the municipalities with the highest incidence rates (I = 0.24; p-value = 0.002), indicating that these are adjacent. When analyzing locally, the Local Moran Index indicated significant autocorrelation in 10 municipalities, 4 of which were classified with higher incidence rates (High-High) in 2007, namely: Teotônio Vilela (49.43/10 thousand-inhab), Junqueiro (22.58/10 thousand-inhab), Quebrangulo (8.40/10 thousand-inhab) and Campo Alegre (5.09/10 thousand-inhab), which implies that, in addition to these, its neighboring municipalities also had considerable incidence rates (**Figure 2.D**).

Notably, the incidence of accidents by scorpions has intensified in recent years. In urban areas, this fact is directly related to the high adaptation of these animals to the anthropic environment, where they can develop their biological activities and reproduce without control due to the lack of natural predators in this environment (Lofego, 2019).

Figure 2.

Spatial analysis of accidents with scorpions in Alagoas (2007 to 2021).

Comentado [2]: Tradução dos textos do gráfico que ainda não estão traduzidos:
Bayesian Estimator
Relative Risk
High-High
High-Low
Low-High
Low-Low



Source: Prepared by the authors (2023).

In 2014, the global autocorrelation was significant (I = 0.25; p-value = 0.003), with 9 municipalities significant for local autocorrelation, in which Teotônio Vilela (60.34/10 thousand inhab), Junqueiro (44.43/10 thousand inhab), Campo Alegre (35.78/10 thousand inhab), Jequiá da Praia (9.94/10 thousand inhab) and Paripueira (9.94/10 thousand inhab) presented high incidence rates (High-High), along with their neighboring municipalities. Moreover, in 2021, significant global autocorrelation was also observed (I = 0.45; p-value < 0.001), in which the higher value of the Moran Index indicates greater intensity of this autocorrelation. In the local analysis, significance was observed in 14 municipalities, eight of which were classified as High-High. They were: Teotônio Vilela (96.92/10 thousand inhab), Junqueiro (58.01/10 thousand inhab), Paripueira (57.42/10 thousand inhab), Campo Alegre (45.38/10 thousand inhab), Barra de Santo Antônio (40.41/10 thousand -inhab), Jequiá da Praia (37.13/10 thousand inhab), São Miguel dos Campos (22.08/10 thousand inhab) and São Sebastião (18.54/10 thousand inhab) (**Figure 2.E, F**).

Corroborating with the aforementioned line of reasoning, it should be taken into account that urban growth is often not accompanied by a sanitation infrastructure, resulting in garbage accumulation and proliferation of cockroaches. These end up attracting scorpions into homes, and consequently increasing the number of accidents (Reis et al., 2017). Reaffirming this, Lisboa et al. (2021) point out that the increase in cases of scorpionism is

directly related to the disorderly growth of cities, the inadequacy of household infrastructure and environmental imbalance.

It´s important to note that municipalities whose incidence of scorpionism is low (Low-High), however they are close to a cluster with high incidence (High-High), should remain alert, because this geographical proximity can provide the expansion of the occurrence of accidents in these areas of low incidence. This fact was observed in the municipality of Jequiá da Praia, which in 2007 (0.57/10 thousand-inhab) was low-high, and rose to high-high in 2014 (9.94/10 thousand-inhab) and 2021 (37.13/10 thousand-inhab) due to the increase in the incidence of cases (**Figure 2.D, E, F**).

A similar situation occurred in Barra de Santo Antônio, in 2007 (0.51/10 thousand-inhab) it was classified as low-high, however in 2021 (40.41/10 thousand-inhab), it was the fourth municipality with the highest incidence rate of scorpionism in Alagoas. In turn, São Sebastião was classified as low-high in the years 2007 (0.23/10 thousand-inhab) and 2014 (7.14/10 thousand-inhab), but in 2021 (18.54/10 thousand-inhab), it was among the eight municipalities that form the cluster with the highest incidence of scorpion accidents in the state (**Figure 2.D, E, F**).

Situations such as these, in which there is an increase in the incidence of scorpionism, were observed in other regions of the country. In the municipality of Roraima, between the years 2011 and 2017, 348 cases of accidents involving scorpions were found, with an increase in cases over the years, where the highest frequency was recorded in 2017, with 84 cases (Teixeira et al., 2020). In turn, the city of Colatina, in Espírito Santo, recorded an average annual incidence of 162.5 cases per 100,000 inhabitants between 2009 and 1019. Thus, the incidence rate of scorpionism had a growth of 125% in the general population of this region in the period studied (De Paula Júnior, 2021).

Relative Risk (RR)

When it comes to the relative risk, the cluster formed by the municipalities of Junqueiro, Teotônio Vilela, Arapiraca and Campo Alegre, presented the highest RR of scorpionism in almost the entire period studied. Junqueiro and Teotônio Vilela stood out in 2007 (RR = 4.16), 2014 (RR = 2.19) and 2021 (RR = 1.99), with Arapiraca and Campo Alegre joining them in 2014 (RR = 2.19) and 2021 (RR = 1.99). We also emphasize that Maceió, the state capital, was present in the cluster of lowest RR in 2007 (RR = 2.46) and 2014 (RR = 1.94), and joins two municipalities (Barra de Santo Antônio and Paripueira) of its metropolitan region in 2021 (RR = 1.59) with the second lowest RR, as well as Matriz de Camaragibe and Passo de Camaragibe (**Figure 2.G, H, I**).

Thus, considering the risk that scorpionism represents for public health, which can cause from temporary sequelae to deaths, scorpionism should be a constant object of public

actions, aiming mainly at greater clarification and change of behavior of the population for the prevention of accidents. For this, it´s of paramount importance to know about this disease, in order to offer scientific support that can subsidize the development of public policies that contribute to the control of scorpionism (Rossi, 2020).

Conclusion

There was an annual growth trend in the number of accidents by scorpions in the state of Alagoas. Although the distribution of cases is heterogeneous in most of the state, there is a concentration of high incidence rates and high relative risk in certain municipalities and their adjacent, which are located mainly in the regions of Agreste and East Alagoas.

Thus, it will become important that the state and municipalities develop public health policies aimed at the control of venomous animals of medical importance, in a multisectoral way involving collaboration between zoonosis control centers, cleaning agencies and urban development, sanitation, health and education, aiming at greater effectiveness of control measures.

The data used for the development of this study were obtained from secondary sources, which may be subject to errors, such as underreporting of cases. In addition, there is a lack in the literature of studies that allow the identification of risk areas of the state, therefore, we see the need for research that investigates such phenomena.

REFERENCES

Andriotti, J. L. S. (2013). *Fundamentos de estatística e geoestatística*. UNISINOS.

Bezerra, R. P., de Souza, C. D. F., & dos Santos, C. B. (2020). Dinâmica espaço-temporal da Esquistossomose Mansônica em Alagoas (2007-2017). *Diversitas Journal*, *5*(3), 1738-1749. DOI: https://doi.org/10.17648/diversitas-journal-v5i3-1056

Carmo, E. A., Nery, A. A. Sobrinho, C. L. N., Casotti, C. A. (2019). Clinical and epidemiological aspects of scorpionism in the interior of the state of Bahia, Brazil: retrospective epidemiological study. *Sao Paulo Medical Journal,* 137(2), 162-8. https://www.scielo.br/j/spmj/a/VZJPPhtGKrGzd94jVxbmfPF/?format=pdf&lang=en

Candido, D. M., & Wen, Fan Hui (2019). Controle de escorpiões de importância em saúde. Repositório Butantan. https://repositorio.butantan.gov.br/handle/butantan/3363

De Oliveira Filho, P. F. (2015). *Epidemiologia e Bioestatística: Fundamentos para a leitura crítica*. (1. ed.). Rubio.

de Paula Júnior, R. A. (2022). Acidentes por escorpião no município de Colatina, Espírito Santo, no período de 2009 a 2019. *Revista Brasileira De Pesquisa Em Saúde/Brazilian Journal of Health Research*, *23*(4), 78–84. https://doi.org/10.47456/rbps.v23i4.37472

Dias, R. F. F., Moura, C. M. C., Sobral, D. M., Fonseca, S. S., Brito, C. C., Melo, K. R. T. A., Luna R. O., Santa Maria, L. F. B., & Brandespim, D. F. (2020). Perfil dos acidentes escorpiônicos, no período de 2007 a 2019 no município de Jaboatão dos Guararapes, Pernambuco, Brasil. Periódicos Brasileiros em Medicina Veterinária e Zootecnia. 36(1), 032-039. https://www.bvs-

vet.org.br/vetindex/periodicos/ars-veterinaria/36-(2020)-1/perfil-dos-acidentes-escorpionicos-no-periodo-de-2007-a-2019-no-munici/

Dourado, F. S., Alves, R. V., Pereira, L. R. M., Costa, V. M., & Croda, J. H. R. (2019). Boletim Epidemiológico Especial set. 2019-Vigilância em Saúde no Brasil 2003-2019 Acidentes por animais peçonhentos. https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/a/animais-peconhentos/acidentes-por-abelhas-1/arquivos/boletim-epidemiologico-especial-set-2019-vigilancia-em-saude-no-brasil-2003-2019-acidentes-por-animais-peconhentos.pdf/view

Freire, A. R. de J, de Andrade, E. M., De Jesus, L. A. S., & Santos, D. M. S. (2021). Panorama epidemiológico dos acidentes com escorpião no município de Estância - SE entre 2015 e 2019. *Brazilian Journal of Development, 4*(1), 3081-3092. file:///C:/Users/GAMER/Downloads/admin,+bjhr+245.pdf

Gomes, A. C. M., Campos, G. P., Rodrigues, R. R., Parrela, A. F. B., Rodrigues, B. S. S. L., Melo-Braga, M. N., Junior, A. N. R., & Siqueira-Batista, R. (2022). Escorpiões do gênero *Tityus* no Brasil: biologia, bioquímica da peçonha e fisiopatologia do escorpionismo. *Scientia Vitae*, 13(36), 1-14.

Gujarati, D. N. (2011). *Econometria Básica*. (5. ed.). Mc Graw Hill.

Hair, J. F., Black, W. C.; Babin, B. J.; Anderson, R. E., Tatham, R. L. (2009). *Análise multivariada de dados*. (6. ed.). Bookman.

Ibge. Instituto Brasileiro de Geografia e Estatística. (2023). Alagoas- Cidades e Estados. https://www.ibge.gov.br/cidades-e-estados/al.html

Lima, G. O., Santos, M. R. S., Fernandes, C. F., Uesugi, J. H. E., Silva, J. C. C., Souza, L. C. R., Cabral, L. C. P, Silva, A. V. N., Nascimento, B. R. S., Silva, A. G., Ferreira, L. A., & Trindade, E. L. (2022). Análise do perfil epidemiológico de acidentes por animais peçonhentos no Brasil entre 2010 e 2019. *Saúde Coletiva, 12*(76), 10406-10417. https://doi.org/10.36489/saudecoletiva.2022v12i76p10406-10417.

Lisboa, N. S., Boere, V., & Neves, F. M. (2021). Índice de Vulnerabilidade Socioambiental à acidentes Escorpiônicos: análise a partir do caso do município de Teixeira de Freitas, Bahia, Brasil. *Saúde e Desenvolvimento Humano*, *9*(1). DOI: http://dx.doi.org/10.18316/sdh.v9i1.6584

Lofego, A. C. (2019). SBMT – Sociedade Brasileira de Medicina Tropical. *Acidentes com escorpiões: aumento expressivo preocupa autoridades e população*. https://sbmt.org.br/accidents-with-scorpions-significant-increase-worries-authorities-and-population/

Machado, C. (2016). Um panorama dos acidentes por animais peçonhentos no Brasil. *Journal Health NEPEPS*, v.1, n.1, p. 1-3.

Ministério da Saúde. (2021). Saúde e Vigilância Sanitária. Com a chegada do verão, Brasil registra maior número de acidentes com animais peçonhentos; saiba como prevenir. https://www.gov.br/saude/pt-br/assuntos/noticias/2021-1/novembro/com-a-chegada-do-verao-brasil-registra-maior-numero-de-acidentes-com-animais-peconhentos-saiba-como-prevenir

Ministério da Saúde. (2009). Secretaria de Vigilância em Saúde. Departamento de Vigilância Epidemiológica. Manual de controle de escorpiões. https://bvsms.saude.gov.br/bvs/publicacoes/manual_controle_escorpioes.pdf

Moran, P. (1948). The Interpretation of Statistical Maps. *Journal of the Royal Statistical Society*, v. 40, p. 283–294.

Oliveira, S. S., Cruz, J. V. F. & Silva, M. A. (2021). Perfil Epidemiológico do Escorpionismo no Nordeste Brasileiro. *Brazilian Journal of Development*, v.7, n.2, p.11984-11996.

Oliveira, T. L. R., dos Santos, C. B., Figueiredo, M. T. S., da Silva, D. K., & dos Santos, M. H. (2022). Incidência de acidentes por escorpiões no Estado de Alagoas, nordeste do Brasil. *Research, Society and Development*, 11(6), e51411629484-e51411629484. https://doi.org/10.33448/rsd-v11i6.29484

Pimentel, A., & Claine, J. (2020). Escorpiões e escorpionismo: análise de conteúdos e imagens em livros didáticos de biologia do ensino médio. *International Journal Education and Teaching* (PVDL), v.3, n.3, 117-136.

Reis, A. S., Nunes, A.T., Monte, G. M. S., Oliveira, V. C. A. S., & Cayana E. G. (2017, 14 de junho). Perfil socioeconômico e distribuição geográfica das vítimas de acidente com escorpião da cidade de Campina Grande-PB [Comunicação Oral]. II Congresso Brasileiro de Ciências da Saúde, Campina Grande – PB. https://editorarealize.com.br/artigo/visualizar/29518

Rossi, A. (2020). Perfil epidemiológico e manifestações clínicas e laboratoriais dos acidentes escorpiônicos atendidos em hospital de referência do Tocantins [Dissertação de mestrado, Universidade Federal do Tocantins]. Repositório Institucional da UFT. https://repositorio.uft.edu.br/bitstream/11612/2208/1/Alexsandra%20Rossi%20-%20Disserta%c3%a7%c3%a3o.pdf

Santana, V. T. P., Barros, J. O., & Suchara, E. A. (2015). Aspectos clínicos e epidemiológicos relacionados a acidentes com animais peçonhentos. *Revista de Ciências Médicas e Biológicas*, v.14, n.2, p.153-159.

Sinan. Sistema de Informação de Agravos de Notificação. (2019). Acidentes por animais peçonhentos. http://www.portalsinan.saude.gov.br/acidente-por-animais-peconhentos

Teixeira, S. T., Figueiredo, D. B., Freitas, A. G., Bertelli, E. V. M., & Costa, E. R. (2020). Distribuição Geográfica dos acidentes escorpiônicos ocorridos nos Municípios de Roraima entre 2011 a 2017 / Geographical distribution of scorpion accidents in the Municipalities of Roraima between 2011 and 2017. *Brazilian Journal of Health Review*, *3*(4), 10928–10307. https://doi.org/10.34119/bjhrv3n4-296

The R Core Team. (2022). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing.

Yamamoto, J. K., Landim, P. M. B. (2013). *Geoestatística: conceitos e aplicações*. Oficina de Textos.