

A Bibliometric Analysis of Scorpionism Epidemiology in Tropical Health

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ABSTRACT

Scorpionism has driven studies around the world on data relating to epidemiological and clinical aspects in humans. From this perspective, a bibliometric review was carried out to analyze the historical and evolutionary construction of the epidemiology of scorpionism to identify the main authors, journals, countries and years of emphasis, as well as the most cited studies and most frequent terms, through quantitative and qualitative data extracted from the manuscripts. The review also investigated studies that explored the association of the topic with environmental, climatic and anthropogenic factors. The analysis was based on publications indexed in the Scopus database, covering the period from 1952 to 2022. The result of the global analysis, based on 145 articles, demonstrates a growing evolution of the topic. Brazil (17.93%) and Iran (17.24%) emerged as the most productive countries in terms of research production. However, the US, Mexico, Algeria and Canada (11.11%) have the most substantial collaborative efforts. The magazine "Toxicon" stands out as the predominant source of scientific dissemination (25%). Only eight authors have unique authorship and the author Semlali Ilham emerged as the most prominent. Universities were the affiliations with the highest productivity. The results of the metadata extraction analysis, based on a sample of 14 documents, revealed consistent and sustained epidemiological data since 1982. Of these, only one study (7.1%) from French Guiana used environmental variables to elucidate data on the occurrence of scorpion stings. The genera *Tityus*, *Centruroides* and *Androctonus* emerged as the most representative among the works compiled and evaluated.

Keywords: Sting, Envenomation, Scorpion, Bibliometric Methods, Scorpionism.

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INTRODUCTION

Scorpionism refers to poisoning caused by scorpion stings. Investigations in the Scopus database related to the arthropod invertebrate and epidemiology are confirmed in over 300 published articles worldwide. The same report's publications date back to the 1950s, addressing the scorpion issue in Ribeirão Preto São Paulo, Brazil.^[1]

Accidents caused by venomous animals are a global silent threat, included by the World Health Organization (WHO) in the list of Neglected Tropical Diseases, of public health importance due to the increasing number of human injuries resulting in high rates of mortality and morbidity,^[2] as well as epidemiological significance. In 2010, the injury was included in Brazil's List of Compulsory Notifications (LNC) due to the high number of

notifications recorded in the Notifiable Diseases Information System (SINAN), with venomous animal accidents being one of the most reported.^[3]

Targeted searches for studies related to scorpionism epidemiology show that the published literature can provide content related to clinical, epidemiological, and prophylactic aspects,^[4-11] as well as control measures, monitoring, and cases of death caused by scorpionism.^[12-15] However, there needs to be more studies that associate the occurrence of scorpionism with environmental and anthropogenic factors, especially from a bibliometric perspective.

From ancient times to the present day, poisoning resulting from the bite and sting of venomous animals has not lost its significance; quite the opposite, data demonstrate the high and increasing number of cases of scorpion envenomation,^[10] especially in subtropical and tropical regions characterized by high temperatures.^[16,17] Comparative studies aimed at describing symptoms, epidemiological signs, and some common clinical signs among affected humans have become more numerous to analyze, understand, or establish possible patterns for



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occurrences of injuries caused by different scorpion species in various locations around the world.^[18] Compiled case studies demonstrate greater systemic severity of envenomation in children under ten years of age and the elderly, as they associate weight and the strength of the immune system with the amount of injected venom and how harmful the venom of each species is to the human body.^[19-22] Urgency in seeking medical attention within the first few hours and at specialized facilities is crucial to increase the chances of survival.^[8,21] Clinical manifestations are classified as mild, moderate, or severe, with severe cases being rarer, especially among those aged 20 to 50 years, and rarely observed in individuals weighing over 55 kg.^[23,24] The size of the scorpion is also a relevant factor in the aggravation of clinical manifestations.^[23] Studies highlight the importance of species-specific antivenom treatment and the timing of post-sting administration.^[21]

The synanthropic nature and diverse habitats of scorpions, combined with the high incidence of scorpion stings worldwide and the danger of envenomation, demand greater attention from humans in their interactions with these animals.^[25] Therefore, studies draw attention to prevalent and potentially fatal underreporting, especially in remote areas with limited access to healthcare for proper treatment in severe cases.^[26] Additionally, there is a need for educational and informational campaigns for the population regarding early treatment after scorpion stings, which can be potentially valuable in reducing emergency room admissions. The inverse proportion of the number of studies to decipher the clinical characteristics and therapeutic response of available antivenoms in envenomations caused by the abundant and diverse scorpion fauna worldwide constitutes a medical emergency.

Bibliometrics is a critical written communication tool that allows the measurement of scientific production through statistical and mathematical analyses, including author productivity, citation counts, journals with the highest number of publications, frequency of the most commonly used terms, and countries with the highest productivity, among other metrics.^[27] Through this analysis tool, it was possible to quantify the trend in the epidemiological study of scorpionism and identify knowledge gaps related to the metrics in question and those established by the authors. Since the theme of the present study had yet to be explored in the bibliometric context, even though it is a topic of such relevance to public health. This review aims to bring together and present the historical and evolutionary construction of the epidemiology of scorpion injuries through quantitative and qualitative research extracted from manuscripts from the last 70 years, highlighting the need for further studies on the distribution behavior of injuries, the possible factors that may be influencing the high incidence rates, as well as predictive studies

from the perspective of the probability of occurrence of diseases in different scenarios, since the vast majority of studies involve the epidemiological and/or clinical part of scorpionism.

While many studies address the clinical and epidemiological aspects of scorpion envenomation, more significant efforts are needed to understand the importance of environmental and anthropogenic changes in the occurrence and increase of lesions. This review aims to answer questions about the epidemiology of scorpionism described worldwide over the last 70 years, conducting exploratory research based on questions such as: Who are the most prolific authors? In which countries are there more publications on the subject? How many documents?

What is the trend of the most frequent terms over the decades?

METHODOLOGY

Search Strategy

The bibliometric review study was conducted in two stages. The first, conducted in July 2023, involved searching and pre-processing in the electronic database Scopus, including different exploratory searches and defining the best search string containing the following set of keywords and their combinations: TITLE-ABS-KEY ("scorpion*" AND "epidemiology*") AND PUBYEAR>1951 AND PUBYEAR<2023 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (SRCTYPE, "j")), without date restrictions (from 1952 to 2022), language, area, source, keyword, affiliation, sponsor, or country. The returned documents had their titles and abstracts examined, and the screening included only global publications related to scorpionism epidemiology.

The search in the Scopus database was justified by its status as the largest repository of peer-reviewed literature, covering a comprehensive collection of research conducted worldwide in various fields. It also offers intelligent tools for monitoring, analyzing, and visualizing diverse and relevant publications.^[28]

The second stage consisted of a bibliometric analysis of the data from readable documents. As well as using systematic elements, according to criteria, the analysis of the metadata extracted from the complete reading of 10% of the selected manuscripts in descending order based on the number of citations for each decade of the study was carried out, with manuscripts published before 1982 being excluded, as they were not found for full download. The approach resulted in a bibliometric review that, according to Quevedo-Silva and collaborators (2016), aims to quantitatively analyze scientific or technical activity through mathematical and statistical investigations to examine and map the prominent authors, countries, affiliations, funders and address other questions posed by researchers from different areas of study.

Selection and Data Extraction Criteria

The bibliographic software Zotero was used to inventory the preliminary results of the literature search and manage citations. Initially, titles and abstracts relevant to the explored topic were evaluated, followed by defining the search string containing combinations of terms and Boolean operators. Next, the selected documents were inventoried by decades, from 0 to 9, covering the years from 1950 to 2022, with the last decade remaining incomplete. The top 10% of scientific publications with the highest citation counts were listed to extract relevant data.

Epidemiological data were extracted, including age groups with higher severity, sting locations, clinical signs, treatment methods, scorpion species, peak attack times, and severity by gender. The methodologies, analyses, and variables used in the study were extracted from manuscripts that relate epidemiological information about scorpionism to environmental, climatic, and anthropogenic factors.

The included documents followed the following criteria: global publications, journal articles published until 2022 in any language, and works focused exclusively on scorpionism epidemiology. Studies that did not meet the selection criteria based on the following principles were excluded: documents without an epidemiological description of scorpions, related to venomous animals, on venom poisoning, as well as duplicated data, studies conducted in 2023, with unavailability for download (criteria used only for the analysis and metadata extraction in open-access articles), and publications classified as gray literature (e.g., reviews, letters, notes, book chapters, books). The extraction of information from all studies, including author names, study years, geographical research locations, journal names, and sample sizes, is presented through graphs, networks, and tables (Figure 1 and Table 1).

Literature Search Results

One hundred and forty-five documents, mainly in English and in the final stages of publication, were retrieved from the Scopus database. General analyzes were carried out on the productivity of publications over the years, authors, sources, affiliations and countries where studies were carried out throughout the entire period. After a manual classification of documents produced in each decade and selection of the 10% of the most cited articles within each decade, 14 articles were chosen (1980-2022) to address and analyze the intended objectives in relation to the epidemiology of scorpionism around the world. Based on the pre-established criteria for selecting documents, from which metadata would be removed, from a total of 140 articles (1980-2022), only one article was selected in the 80s, 90s and the last period of 2020, four articles in the period 2000-2009 and seven documents in the period 2010-2019.

Data Analysis

The total sample of documents retrieved from Scopus and analyzed included the following extracted metrics: the number of publications per year, authors, source, affiliation, and the country of each study. To the data, annual citation counts and the trend of the most frequent terms over the review period were added. The analysis of the documents generated from the electronic database led to the creation of graphs to establish the journals that published the most on the subject, authors, affiliations, and the most cited studies over the review period, using the Bibliometrix software,^[29] developed in the R language. In R Studio, a graph was created to depict the yearly documents produced from 1950 to 2022.

The analysis of trends in the most frequently presented terms related to the explored knowledge, extracted from the titles, abstracts, and keywords of eligible articles over time, was established through the VOSviewer tool (available at www.vosviewer.com).^[30] By forming networks, VOSviewer (van Eck and Waltman, 2023) groups similar items and illustrates the relationships between them, highlighting the most frequent terms aiming for a better visualization of the historical and evolutionary analysis of knowledge produced in the last 70 years. The choice to create a network of co-occurring terms was based on words in the titles, abstracts, and keywords of the documents, adopting the binary method and a minimum number (1) of occurrences for each word. A thesaurus file was developed for this analysis to remove term redundancy and exclude unnecessary or inappropriate terms. Initially, it comprised 3,215 terms for the general network, 214 terms (decade 80-89), 296 terms (decade 90-99), 1,080 terms (decade 2000-2009), 1,988 terms (decade 2010-2019), and 551 terms (decade 2020-2022) for specific networks of each decade.

The items that make up the network are the terms extracted from the studies, called vertices, while the edges or links are structures that establish connections between these vertices (van Eck and Waltman, 2023). The decision to use the global network with title terms, abstracts, and keywords, and the creation of specific networks for each decade, was justified to assess when the subject was first reported, what information and investigations the studies aimed to address more broadly, and to analyze more directly and objectively if the epidemiological profile remained unchanged and what elements were added to the subject. The resolution parameters were adjusted as suggested by the tool's manual.

For the sample based on the reading of the top 10% of the most cited articles in each decade, the following were extracted: title, authors, publication year, and the country where the study was conducted, as well as additional information of interest to the research, including data on scorpions epidemiology, as mentioned in the data extraction criteria, and the methodologies, analyses, and variables used in the study that relate environmental,

Table 1: Description of metadata through the relationship between the questions of the bibliometric review study on the Epidemiology of Scorpionism and the analyzes used together with the data extraction source, for each problem question, in the period from 1952 to 2022.

Questions Analysis	Type Data	Processor	Data extraction source
Which journals publish the most content?	Graph	Bibliometrix	All articles: 145
Which authors publish the most?	Graph	Bibliometrix	All articles: 145
What is the number of documents produced per year?	Graph	R studio	All articles: 145
Which studies are the most cited?	Graph	Bibliometrix	All articles: 145
Who are the major funding sources for the research?	Graph	Bibliometrix	All articles: 145
In which countries is there a higher quantity of publications on the topic?	Graph	Bibliometrix	All articles: 145
What is the trend of the most frequent terms over the decades?	Co-word general network	VOSviewer	All articles: 145
What is the trend of the most frequent terms by decade?	Co-word network	VOSviewer	All articles: 145
Epidemiological data of scorpionism: age group, location of sting, severity, species, between others	Descriptive table	Excel	Post-screening articles: 14
Identify which studies relate scorpion incidents to environmental, climatic, and/or anthropic factors	Descriptive table	Excel	Post-screening articles: 14
Identify the methodologies, analyses, and variables used in the correlational studies	Descriptive table	Excel	Articles with data correlation: 1

climatic, and anthropogenic factors to the incidence of scorpion stings. The results were presented as descriptive tables organized in Excel 2018®.

RESULTS

General productivity analyzes

The linear function graph depicts a consistent upward trend in the studies developed and published from 1950 to 2022. Over the eight decades covered by this review study, there was an average of 18.12 publications per decade and a standard deviation of 24.87. However, a notable publication surge (84.82%) is observed, particularly from the 21st century onward. The decade from 2010 to 2019 stands out as the most prolific, contributing 71 publications (48.9%), whereas the 1950s and 1960s only yielded one publication. Surprisingly, despite being incomplete and spanning only two years, the last decade boasts nearly the same number of publications as the sum of the 1980s and 1990s and represents over a third of the total publications recorded from 2000 to 2009 (Figure 2).

Out of 76 sources of information, the highest number of publications throughout the period was from the journal "Toxicon" (25.0%), accounting for a quarter of all publications during this time frame. Following closely was the "Journal of Venomous Animals and Toxins Including Tropical Diseases"

(15.8%) (Figure 3). Assessing publications by authors and co-authors, 611 researchers were accounted for, including eight single-author publications. Authors Semlali, I. and Soulaymani, A. demonstrated the highest productivity, contributing to 9 (6.2%) and 7 (4.8%) of the documents published throughout the entire period, respectively. Most of these works originated from Morocco and were published in the "Journal of Venomous Animals and Toxins Including Tropical Diseases." Notably, no Brazilian author ranked among the top 10 regarding productivity (Figure 3). Of the 32 countries examined, Brazil and Iran emerged as the leading producers in scorpionism epidemiology, with 26 documents (17.93%) and 25 documents (17.24%) of the publications, respectively. The combined output of the other major countries, including Morocco, Algeria, Turkey, the United States, France, Egypt, Mexico, and Saudi Arabia, totaled 70 documents (48.27%) published throughout the study period. The top 10 most productive countries collectively accounted for 84% of the publications during the review period (Figure 3).

The analysis revealed that universities represented 80% of the affiliations. The Ahvaz Jundishapur University of Medical Sciences, a medical school in the Khuzestan province of Iran, was the leading contributor in terms of production on the subject, with 11 documents (7.5%). In Brazil, the Federal University of Minas Gerais represented 2.7% of the documents (4), securing the ninth position in the ranking of top affiliations (Figure 3).

Analysis of frequent terms extracted from text data, as illustrated in Figure 4, displays terms extracted from the titles, abstracts, and keywords of manuscripts published from 1950 to 2022, indicating locations, times of the year, and themes applied by authors. Comprising 1,601 items categorized into 33 clusters, the network features 64,266 links and an edge strength of 92,776. The five most frequently occurring words throughout the study period were "escorpião" (scorpion) with 136 occurrences, "picada" (sting) with 130, "estudo epidemiológico" (epidemiological study) with 114, "estudo de caso" (case study) with 104, and "person" with 90. The prominence of the term "escorpião" highlights its significance in the literature as the primary focus of various researchers. Through the analysis of these terms, significant regions of the world are identified concerning the topic, including Brazil (29 occurrences), Iran (25), Morocco (15), Turkey (9), Argentina (6), Mexico (5), Tunisia (5), the United States (4), Colombia (2), and France (2) (Figure 3).

The top 10 most frequent terms collectively represent approximately 52.8% of the network. The 10 clusters with the highest number of items are color-coded as red (120), green (84), dark blue (82), yellow (80), purple (75), light blue (74), orange (69), brown (64), magenta (64), and pink (60). The three primary clusters address different aspects of scorpionism as follows:

Cluster 1: Concentrates on the geographical distribution, primary months of incidents, scorpionism as a public health issue with high incidence, socioeconomic conditions, anthropogenic factors, and the use of analyses and software.

Cluster 2: Primarily focuses on the results and clinical conditions of individuals affected by scorpion stings.

Cluster 3: Addresses institutions and strategies for monitoring and controlling scorpionism, emphasizing the risk of mortality and morbidity.

Based on the results generated from the co-occurrence networks of terms found in titles, abstracts, and keywords analyzed in

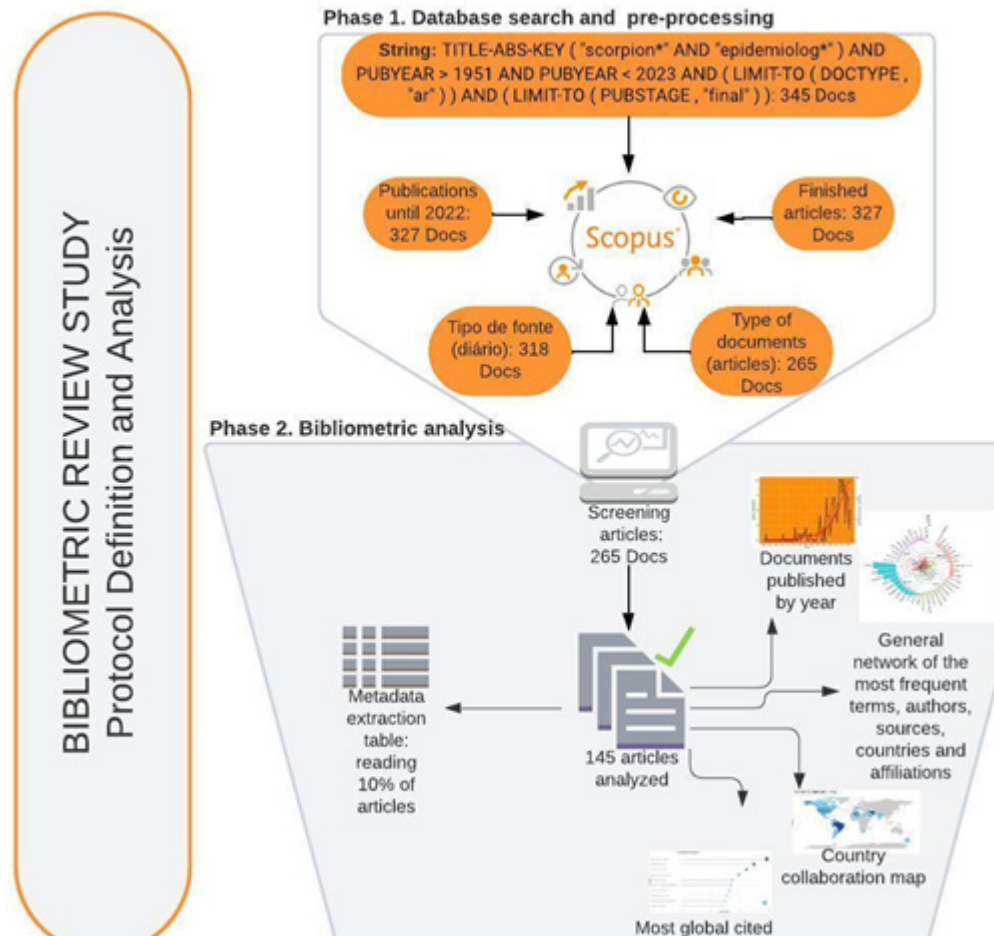


Figure 1: Methodological Approach and Data Analysis Strategy used for the bibliometric review study on the Epidemiology of Scorpionism, conducted in two stages, during the period from 1952 to 2022. Phase I corresponds to carrying out the search and pre-processing in the databases for identification and selection of documents, while Phase II corresponds to bibliometric analysis.

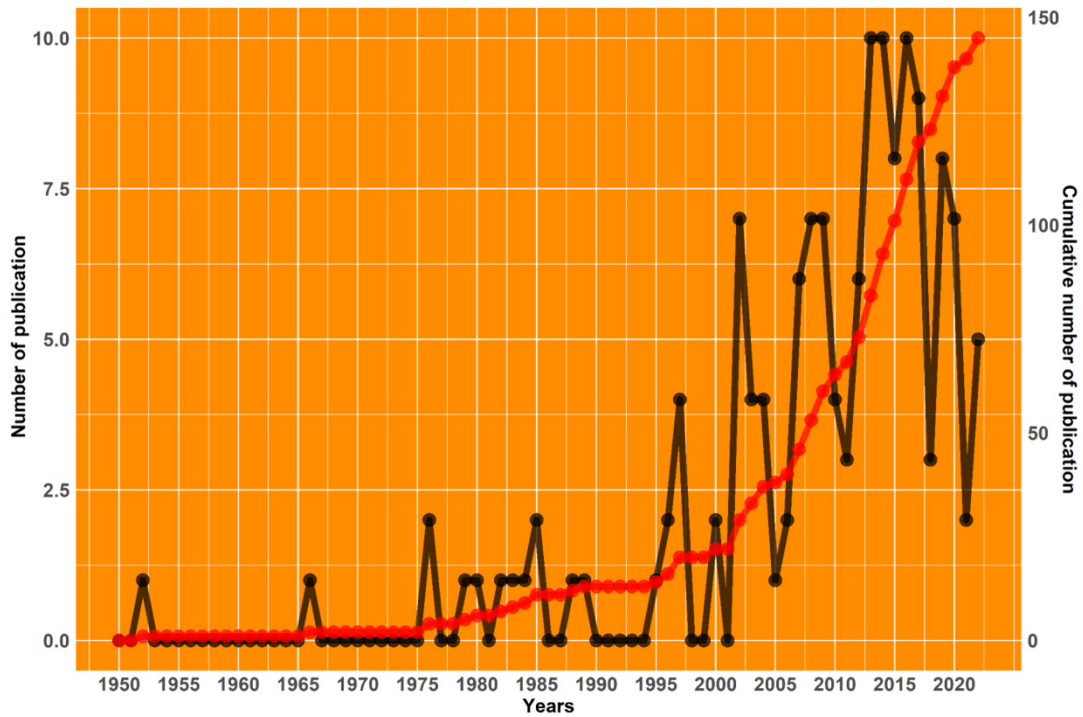


Figure 2: Graphical analysis of the relationship between the number of documents published per year and the absolute frequency of the bibliometric review study on the Epidemiology of Scorpionism, covering the period from 1950 to 2022.

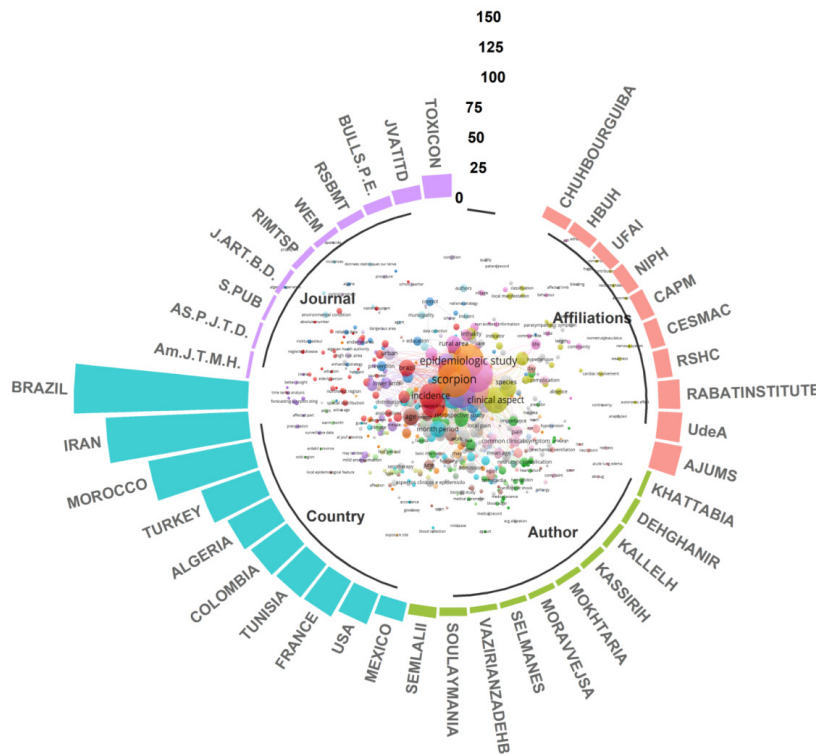


Figure 3: Network of co-occurrence of words presented in titles, abstracts and keywords, with 1,601 terms and general information (regarding the top 10 journals, authors, countries and affiliations with the highest productivity) of articles published and selected for the bibliometric review study on the Epidemiology of Scorpionism, during the period from 1952 to 2022.

each decade, a clear upward trend in the number of terms used is evident, consistently maintaining scorpion, sting, and epidemiological study as the focal points in scorpionism-related research (Figure 4).

The co-word network for the 1980s consisted of 141 terms distributed across 7 clusters, with the most frequent terms being "sting" (8), "scorpion" (7), and "epidemiological study" (5). The top 5 clusters with the highest number of items are color-coded in red (32), green (25), dark blue (25), yellow (18), and purple (16) (Figure 4a).

The co-word network for the 1990s comprises 200 terms distributed among 6 clusters, with the most frequent terms being

"scorpion" (7), "sting" (6), and "case study" (6). The top 5 clusters with the highest number of items are color-coded in red (61), green (41), dark blue (32), yellow (27), and purple (23) (Figure 4b).

The co-word network for the 2000s is composed of 592 terms spread across 19 clusters, with the most frequent terms being "scorpion" (38), "sting" (34), and "epidemiological study" (30). The top 5 clusters with the highest number of items are color-coded in red (44), green (44), dark blue (42), yellow (41), and purple (39) (Figure 4c).

The co-word network for the 2010s comprises 1033 terms distributed among 23 clusters, with the most frequent terms

Table 2: Documents selected for metadata extraction (title, authors, year and country) based on reading 10% of the articles, for each decade, on the Epidemiology of Scorpionism, covering the period from 1982 to 2022.

	Title	Authors	Year	Country
1	Epidemiological and Clinical Characteristics of The Scorpion Envenomation in Tunisia	M, Goyffon, M. Vaehon. and N, Broglio	1982	Tunisia
2	Clinical description of <i>Parabuthus transvaalicus</i> scorpionism in zimbabwe	NILS J. BERGMAN*	1997	Zimbabwe
3	An epidemiological and a clinical study on scorpionism by the Iranian scorpion <i>Hemiscorpius lepturus</i>	Mohammad H. Pipelzadeha, Amir Jalalib,-, Mohammad Tarazb, Roya Pourabbasb, Abbas Zaremirakabadic	2007	Iran
4	Epidemiological and clinical aspects of scorpionism by <i>Tityus trivittatus</i> in Argentina	Adolfo R. de Roodta*, Susana I. Garcí ab, Oscar D. Salomó nc, Liliana Segrea, Jorge A. Dolaba, Raúl F. Funesa, Ernesto H. de Tittob	2003	Argentina
5	Epidemiological, clinical characteristics and outcome of severe scorpion envenomation in South Tunisia: Multivariate analysis of 951 cases	Mounir Bouaziz, Mabrouk Bahloul*, Hatem Kallel, Mohamed Samet, Hichem Ksibi, Hassan Dammak, Mohamed Nouri Ben Ahmed, Kamilia Chtara, Hedi Chelly, Chokri Ben Hamida, Nouredine Rekik	2008	Tunisia
6	Epidemiological and clinical survey of scorpionism in Khuzestan province, Iran (2003)	Delavar Shahbazzadeh a*, Aref Amirkhani b, Navid Dinparast Djadid a, Shahla Bigdeli c, Abolfazl Akbari d, Hamed Ahari a, Hossein Amini, Rouhullah Dehghani e	2009	Irã
7	Classification of clinical consequences of scorpion stings: consensus development	Asmae Khattabi a,b,*, Rachida Soulaymani-Bencheikha,c, Sanae Achour b,d, Louis-Rachid Salmi	2011	Marrocos
8	Scorpion Envenomation Among Children: Clinical Manifestations and Outcome (Analysis of 685 Cases)	Mabrouk Bahloul,* Imen Chabchoub, Anis Chaari, Kamilia Chtara, Hatem Kallel, Hassen Dammak, Hichem Ksibi, Hedi Chelly, Nouredine Rekik, Chokri Ben Hamida, and Mounir Bouaziz	2010	Tunisia
9	Scorpionism in Brazil in the years 2000 to 2012	Guilherme Carneiro Reckziege 1,2* and Vitor Laerte Pinto Jr3	2014	Brasil

	Title	Authors	Year	Country
10	Scorpion fauna and epidemiological aspects of scorpionism in southeastern Iran	Jalil Nejati ¹ , Ehsan Mozafari ² , Abedin Saghafipour ^{3*} , Malek Kiyani ⁴	2014	Iran
11	Epidemiological and clinical characteristics of scorpionism in Shiraz (2012-2016); development of a clinical severity grading for Iranian scorpion envenomation	Hossein Sanaei-Zadeh, Sayed Mahdi Marashi, Rouhullah Dehghani	2017	Iran
12	Pediatric epidemiological aspects of scorpionism and report on fatal cases from Tityus stigmurus stings (Scorpiones: Buthidae) in State of Pernambuco, Brazil	Cleide Maria Ribeiro de Albuquerque ^[1] , Pedro de Lima Santana Neto ^[2] , Maria Lucineide Porto Amorim ^[2] and Sofia Campos Vidal Pires ^[2]	2013	Brasil
13	SCORPION STINGS IN TURKEY: EPIDEMIOLOGICAL AND CLINICAL ASPECTS BETWEEN THE YEARS 1995 AND 2004	Yıldırım CESARETLI (1) & Ozcan OZKAN (1)	2010	Turquia
14	Pediatric scorpionism in northern Amazonia: a 16-year study on epidemiological, environmental and clinical aspects	Jules Vaucel ^{1,2,*} , Remi Mutricy ² , Maëlle Hoarau ² , Jean-Marc Pujo ² , Narcisse Elenga ³ , Magali Labadie ¹ , Hatem Kallel ⁴	2020	French Guiana

being "scorpion" (68), "sting" (67), and "epidemiological study" (61). The top 5 clusters with the highest number of items are color-coded in red (81), green (71), dark blue (66), yellow (66), and purple (64) (Figure 4d).

The co-word network for the 2020s consists of 321 terms distributed across 11 clusters, with the most frequent terms being "scorpion" (14), "sting" (12), and "case study" (12). The top 5 clusters with the highest number of items are color-coded in red (39), green (37), dark blue (34), yellow (33), and purple (33) (Figure 4e).

Based on the analysis of collaboration between countries/territories of 145 documents, the collaboration map among countries highlights Brazil as the primary producer and disseminator of scientific content on the topic at hand, closely followed by Iran. Interestingly, the United States and Mexico (11.11%), as well as Canada and Algeria (11.11%), are the countries with the most significant collaborative efforts (Figure 5).

This exchange of knowledge involves 17 countries. For instance, Algeria collaborates with Benin and France, Brazil similarly cooperates with Argentina, Spain, and Venezuela, Colombia establishes relations with France and Mexico, and France collaborates with Mali and Mexico. Iran teams up with the United Kingdom, Morocco, and France, while Turkey collaborates with the United States, and the United States also engages with Egypt. Venezuela shares a collaborative relationship with Spain. It is worth noting that all these collaborations occur with a frequency of 1 (5.5%).

According to the analysis of the Most Cited Studies, the study entitled "An epidemiological and clinical study on scorpionism by the Iranian scorpion *Hemiscorpius lepturus*", published in 2007, authored by Mohammad H. Pipelzadeh, Amir Jalali, Mohammad Taraz, Roya Pourabbas and Abbas Zaremirakabadi, obtained the highest number of citations (146). Followed by "Epidemiological and clinical characteristics of scorpion envenomation in Tunisia" published in 1982, by authors M. Goyffon, M. Vachon and N. Broglio, with 124 citations, and "Epidemiological and clinical aspects of scorpionism by *Tityus trivittatus* in Argentina" 2003, published by Adolfo R de Roodt, Susana I García, Oscar D Salomón, Liliana Segre, Jorge A Dolab, Raúl F Funes and Ernesto H de Titto, with 111 citations. The result of the analysis of the most cited works throughout the period represented in the figure below by the top 10, had 70% of publications in the source "Toxicon" (Figure 6).

Analysis of Journals on Scorpionism Epidemiology and Associated Environmental, Climatic, and Anthropogenic Factors

Based on the analysis of data extracted from the reading of 14 articles (9.65%) on scorpion epidemiology and associated environmental, climatic and anthropogenic factors, which were examined proportionally (10% of documents) for each decade, it is evident that the Epidemiological aspects of scorpion sting poisoning in different global settings present standardized patterns (Table 2). Almost all studies (92.8%), except for "Classification of Clinical Consequences of Scorpion Stings: Consensus Development," which focuses solely on clinical symptoms, emphasize the significance of severe clinical

symptoms in children under ten and adults over 60. However, mild cases with more frequent local symptoms than systemic ones predominate across all studies. Most articles (85.7%) categorize clinical symptoms into three stages, while only two (14.3%) divide them into four classes, indicating increasing severity yet not necessarily constituting a progression from one to another (Table 3).

The most commonly reported symptoms in stage 1 were pain (60%), erythema, and edema (40%). Symptoms like nausea, vomiting, headache, pallor, hyperthermia, sweating, and restlessness were noted in patients at this stage but were less frequent. Nevertheless, two publications (14.3%) describe case studies with clinical symptoms of severity 2 and 3, and two studies (14.3%) do not mention clinical symptoms resulting from scorpion envenomation (Table 3).

Table 3: Documents selected for metadata extraction (age group of the injury, location of the bite, clinical signs, treatment, species of scorpion, period of the year of notification and severity by sex) based on reading 10% of the articles, for each decade, on the Epidemiology of Scorpionism, covering the period from 1982 to 2022.

	Title	Authors	Year	Country	Age group	Sting location	Clinical signs	Treatment	Species	Period of the year	Severity by sex
1	Epidemiological and Clinical Characteristics of The Scorpion Envenomation in Tunisia	M, Goyffon, M. Vaehon. and N, Broglio	1982	Tunisia	UNDER 15 YEARS OF AGE MORE SEVERITY AND EVEN DEATH	EXTREMITIES	Stage 1, Stage 2 and Stage 3 - described in the study	antivenin	Androctonus australis; Androctonus aeneas; Buthus occitanus; Scorpio maurus; Eusaorpius carpathicus	JUNE TO OCTOBER (SUMMER)	EQUALLY AFFECTED
2	Clinical description of <i>Parabuthus transvaalicus</i> scorpionism in zimbabwe	NILS J. BERGMAN*	1997	Zimbabwe	UNDER 20S HAVE MORE ACCIDENTS	EXTREMITIES	Stage I, II and III report	All severe cases were treated with species-specific antivenin. Local anesthesia was used only in cases of localized pain.	Parabuthus transvaalicus	SUMMER (OCTOBER TO APRIL)	Females were bitten more frequently than males, and bites were more common in adolescents.
3	An epidemiological and a clinical study on scorpionism by the Iranian scorpion <i>Hemiscorpius lepturus</i>	Mohammad H. Pipelzadeha, Amir Jalalib, -, Mohammad Tarazb, Roya Pourabbasb, Abbas Zaremirakabadic	2007	Iran	The most frequently inflicted age was between 1 month to 10 years and 11 to 20 years, observed in 39.6% and 26.8% victims, respectively. Most cases were children under 12 years of age	EXTREMITIES	Clinical signs and symptoms were local and systemic. Local symptoms ranged from erythema to severe necrosis without immediate sensation of pain.	antivenin	Hemiscorpius lepturus	mild/warm months between April and October	EQUALLY AFFECTED
4	Epidemiological and clinical aspects of scorpionism by <i>Tityus trivittatus</i> in Argentina	Adolfo R. de Roodta*, Susana I. Garcí ab, Oscar D. Salomó nc, Liliana Segrea, Jorge A. Dolaba, Rau'l F. Funesa, Ernesto H. de Tittob	2003	Argentina	More than 50% of accidents involved children and adolescents.	EXTREMITIES	<i>T. trivittatus</i> poisoning was characterized mainly by local symptoms. Neurological, cardiovascular and respiratory disorders were unusual.	antivenin	Tityus trivittatus	NOVEMBER-APRIL (HOT MONTHS)	EQUALLY AFFECTED
5	Epidemiological, clinical characteristics and outcome of severe scorpion envenomation in South Tunisia: Multivariate analysis of 951 cases	Mounir Bouaziz, Mabrouk Bahloul*, Hatem Kallel, Mohamed Samet, Hichem Ksibi, Hassan Dammak, Mohamed Nouri Ben Ahmed, Kamilia Chtara, Hedi Chelly, Chokri Ben Hamida, Noureddine Rekik	2008	Tunisia	severe scorpion accident, age under 5 years	EXTREMITIES	Grade II e III	NOT REPORTED	UNAVAILABLE (most common scorpions <i>A. australis</i> and <i>B. occitanus</i>)	JUNE AND SEPTEMBER (SUMMER)	EQUALLY AFFECTED

	Title	Authors	Year	Country	Age group	Sting location	Clinical signs	Treatment	Species	Period of the year	Severity by sex
6	Epidemiological and clinical survey of scorpionism in Khuzestan province, Iran (2003)	Delavar Shahbazzadeh a,* , Aref Amirkhani b, Navid Dinparast Djadid a, Shahla Bigdeli c, Abolfazl Akbari d, Hamed Ahari a, Hossein Amini a, Rouhollah Dehghani e	2009	Irā	highest incidence rate of scorpion stings fell in group from 6 to 45 years old	EXTREMITIES	Local symptoms were more frequent than systemic ones. The most reported signs were pain and edema. Neurological symptoms such as spasm were also observed, while central symptoms such as hyperthermia, sweating, vomiting, restlessness were less frequent. Other reported symptoms such as tachycardia, semi-consciousness and local necrosis were also observed.	antivenin	Escorpiões amarelos (Mesobuthus eupeus, Hottentotta saulcyi, Odonthobuthus doriae e Hemiscorpius lepturus), e preto (Androctonus crassicauda e Hottentotta schach), e de cor desconhecida	Most bites occurred throughout the year, however, the highest and lowest frequencies occur in June and February, respectively.	EQUALLY AFFECTED
7	Classification of clinical consequences of scorpion stings: consensus development	Asmae Khattabi a,b,*, Rachida Soulaymani-Bencheikha, c, Sanae Achour b,d, Louis-Rachid Salmi	2011	Marrocos	NOT REPORTED	NOT REPORTED	4 classes were established: local manifestations; minor systemic manifestations; main systemic manifestations; lethal poisoning.	NOT REPORTED	NOT REPORTED	NOT REPORTED	NOT REPORTED
8	Scorpion Envenomation Among Children: Clinical Manifestations and Outcome (Analysis of 685 Cases)	Mabrouk Bahloul, * Imen Chabchoub, Anis Chaari, Kamilia Chtara, Hatem Kallel, Hassen Dammak, Hichem Ksibi, Hedi Chelly, Noureddine Rekik, Chokri Ben Hamida, and Mounir Bouaziz	2010	Tunisia	Children aged 0 - 15 years (higher risk in children under 5 years of age)	May frequency in feet and hands	grade II and III	antivenin	NOT REPORTED	Greater frequency in summer (June to September)	Male (431) and Female (315)
9	Scorpionism in Brazil in the years 2000 to 2012	Guilherme Carneiro Reckziegel1,2* and Vitor Laerte Pinto Jr3	2014	Brasil	About half of the accidents (47%) occurred in age group of 20 to 49 years, and the proportion of deaths was higher in victims up to nine years old (53.9%). Individuals up to four years had the highest risk of death, which was 10.09 times higher than that of victims aged 15 or more.	May frequency in feet and hands	NOT REPORTED	NOT REPORTED	NOT REPORTED	Accidents were less frequent in the months of June (7.3%) and July (7.7%), with a peak in October (9.7%), except in the northern region of the country, where the accidents peaked in May (10.1%) and the lowest rate was recorded in December (6.6%) in the urban area. In the northern regions, accidents were more frequent in the months of June and July and in rural areas.	The highest frequency of accidents was recorded in males. There were no significant differences between the sexes.

	Title	Authors	Year	Country	Age group	Sting location	Clinical signs	Treatment	Species	Period of the year	Severity by sex
10	Scorpion fauna and epidemiological aspects of scorpionism in southeastern Iran	Jalil Nejati1, Ehsan Mozafari2, Abedin Saghafipour3*, Malek Kiyani4	2014	Iran	higher frequency in ages 15-24	hands and legs equally	NOT REPORTED	antivenin	Two families (Buthidae and Scorpionidae). Five species, including <i>Odontobuthus odonturus</i> , <i>Hottentotta (Buthotus) jayakari</i> , <i>Compsobuthus matthiesseni</i> , <i>Scorpio maurus</i> and <i>Orthochirus scrobiculosus</i> are reported for the first time in this area. <i>Androctonus crassicauda</i> was the dominant species.	highest occurrence in July (highest between June and August) summer	majority female, but without significant differences
11	Epidemiological and clinical characteristics of scorpionism in Shiraz (2012-2016); development of a clinical severity grading for Iranian scorpion envenomation	Hossein Sanaei-Zadeh, Sayed Mahdi Marashi, Rouhollah Dehghani	2017	Iran	age between 8 and 63 years	most prevalent in the lower extremities followed by the upper extremities	Stage I, II and III report	antivenin	yellow scorpions (<i>Mesobuthus eupeus</i> , <i>Mesobuthus caucasicus</i> and <i>Compsobuthus matthiesseni</i>) and <i>Hottentotta scorpions (Hottentotta jayakari</i> and <i>Hottentotta zagrosensis</i>)	The season for <i>Hottentotta</i> scorpion poisoning was summer in all cases, but yellow scorpion poisonings were seen throughout the year.	Around 59% (n=74) were male
12	Pediatric epidemiological aspects of scorpionism and report on fatal cases from <i>Tityus stigmurus</i> stings (Scorpiones: Buthidae) in State of Pernambuco, Brazil	Cleide Maria Ribeiro de Albuquerque[1], Pedro de Lima Santana Neto[2], Maria Lucineide Porto Amorim [2] and Sofi a Campos Vidal Pires [2]	2013	Brasil	Children up to 12 years old (under 5 most affected)	areas most frequently affected of the body were the hands/arms	Grade 1, 2 and 3 reported	antivenin	<i>Tityus stigmurus</i>	June to August	Small difference in patient sex was observed
13	SCORPION STINGS IN TURKEY: EPIDEMIOLOGICAL AND CLINICAL ASPECTS BETWEEN THE YEARS 1995 AND 2004	Yıldırım CESARETLI (1) & Özcan OZKAN(1)	2010	Türquia	Age group 20 to 29 years old	NOT REPORTED	Grade 1 and 2 reported	antivenin	<i>Androctonus crassicauda</i> , <i>Leiurus quinquestriatus</i> , <i>Mesobuthus gibbosus</i> and <i>M. eupeus</i> species,	June to August	Gender distribution was 0.22% female and 45.48% male
14	Pediatric scorpionism in northern Amazonia: a 16-year study on epidemiological, environmental and clinical aspects	Jules Vaucel1,2,*, Remi Mutricy2, Maëlle Hoarau2, Jean-Marc Pujo2, Narcisse Elenga3, Magali Labadie1, Hatem Kallel4	2020	Francia Guiana	From 0 to 18 years old. With those aged 0 - 9 years being the most severe group	EXTREMITIES	Grade 1, 2 and 3 reported	no case used antivenom	<i>Tityus em</i> 30 casos (22%) e <i>Tityus obscurus</i> especificado em 18 casos (13%).	April... followed by June and July	63% were male

The body areas at the highest risk of being affected are the extremities, hands, and feet (85.7%). Some studies indicate equal involvement in these areas (42.85%), while others show a more significant occurrence in the feet (57.14%). One study (7.1%) reports the hands and arms being more affected than the legs, and two studies do not provide this information (14.3%). The clinical

symptoms are categorized as follows: I. Mild-characterized by local symptoms (pain, swelling, paresthesia, local sweating); II. Moderate-characterized by local symptoms and systemic manifestations such as sialorrhea, sensation of a foreign body (hair) in the throat, generalized sweating, nausea, vomiting, abdominal pain, tachycardia, tachypnea, mild hypertension,

DISCUSSION

The analysis of publication trends by year and term co-occurrences has revealed a notable increase in publications from 1982 to 2022, particularly after 2000. This surge in interest regarding scorpions and technological processes for antivenom production can be attributed to the health risks posed by scorpions (Chippaux *et al.*, 2020; Silva *et al.*, 2005). Additionally, the World Health Organization (WHO) classifies accidents caused by venomous animals, including scorpions, spiders, and snakes, as Neglected Tropical Diseases (NTDs), owing to their impact on socially vulnerable populations with limited access to essential healthcare services.^[31] These findings suggest that the subject is rapidly expanding, indicating a growing need for research to address its associated challenges and concerns.

The review identified Brazil and Iran as the leading contributors to scientific research on scorpion-related topics, including the prevalence of scorpion genera.^[32,21] Countries located in tropical regions experience a high incidence of scorpion envenomation cases.^[22,33-35] Scorpions are predominantly found in tropical and subtropical zones characterized by high temperatures and humidity.

Iran is home to a wide variety of scorpion species, with different genera and species found throughout the country. It is estimated that Iran hosts scorpions from at least five genera, including *Mesobuthus*, *Compsobuthus*, *Hottentotta*, *Orthochirus*, *Androctonus*, and *Hemiscorpius*. Among these, *Hemiscorpius lepturus* is particularly significant, as it is one of the main species responsible for stings and envenomations in the country (Radmanesh, 1990). The geographic distribution of these scorpions varies depending on environmental factors such as temperature, humidity, and soil characteristics, which

support the survival of these animals. In addition to *Hemiscorpius lepturus*, other scorpion species such as *Androctonus crassicauda*, *Mesobuthus eupeus*, *Odontobuthus doriae*, *Hottentotta saulcyi*, *Hottentotta schach*, *Compsobuthus matthiesseni*, *Orthochirus scrobiculosus*, *Apistobuthus pterigocercus*, and *Olivierius caucasicus* are also among the leading causes of scorpion envenomations in Iran.^[32,21] These species are found in various regions of the country, often associated with hot and dry climates typical of arid and semi-arid zones.

In Brazil, scorpion envenomation ranks as the second most frequently reported epidemiological condition, with over 140,000 cases reported across the country's regions in recent years, surpassing snakebite cases.^[36] Brazil is a country with a great diversity of ecosystems, which supports the presence of various scorpion species. These animals are predominantly found in tropical and subtropical regions, such as the North, Northeast, and Southeast, but they are also present in other parts of the country, including urban areas.

The most important species in terms of envenomation in Brazil is *Tityus serrulatus*, a yellow scorpion known for its highly toxic venom. This species is responsible for the majority of severe scorpionism cases in the country. *Tityus serrulatus* is primarily found in urban and suburban areas, where the warm and humid conditions favor its proliferation. Other species of the *Tityus* genus, such as *Tityus bahiensis* and *Tityus stigmurus*, are also common and can cause envenomations, although with fewer fatal cases. Scorpionism in Brazil has become a public health concern, particularly due to the rising number of reported cases and the high incidence in urban areas. This trend is attributed to uncontrolled urban growth, which alters the natural habitats of these animals and increases human-scorpion contact. Epidemiological studies indicate that scorpion envenomations

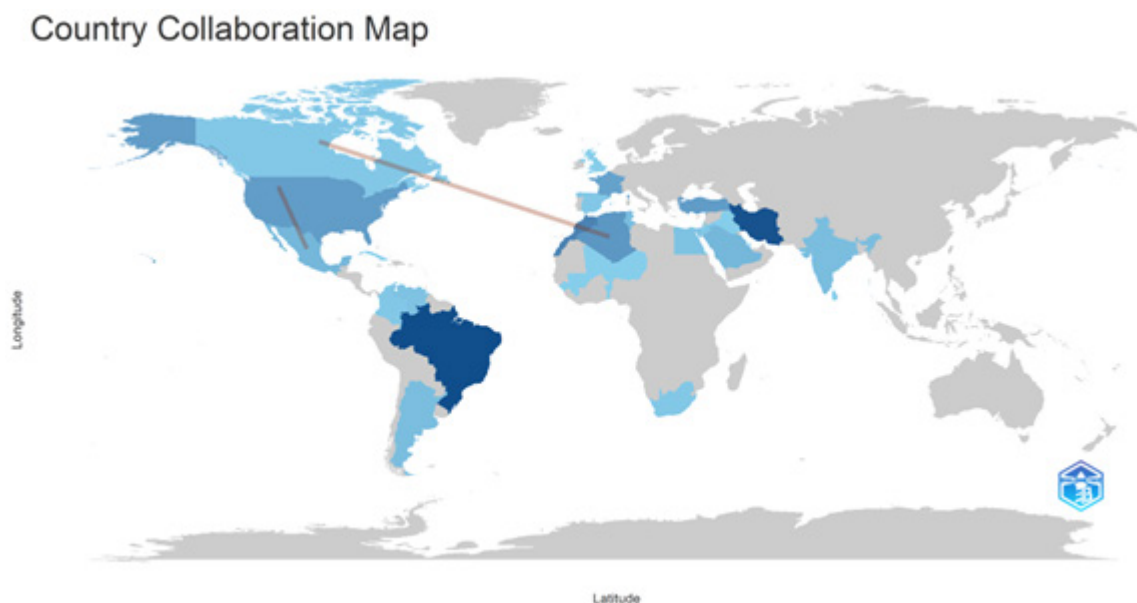


Figure 5: Map of Collaboration between countries that protect knowledge about the Epidemiology of Scorpionism, extracted from bibliometric analysis, during the period from 1950 to 2022.

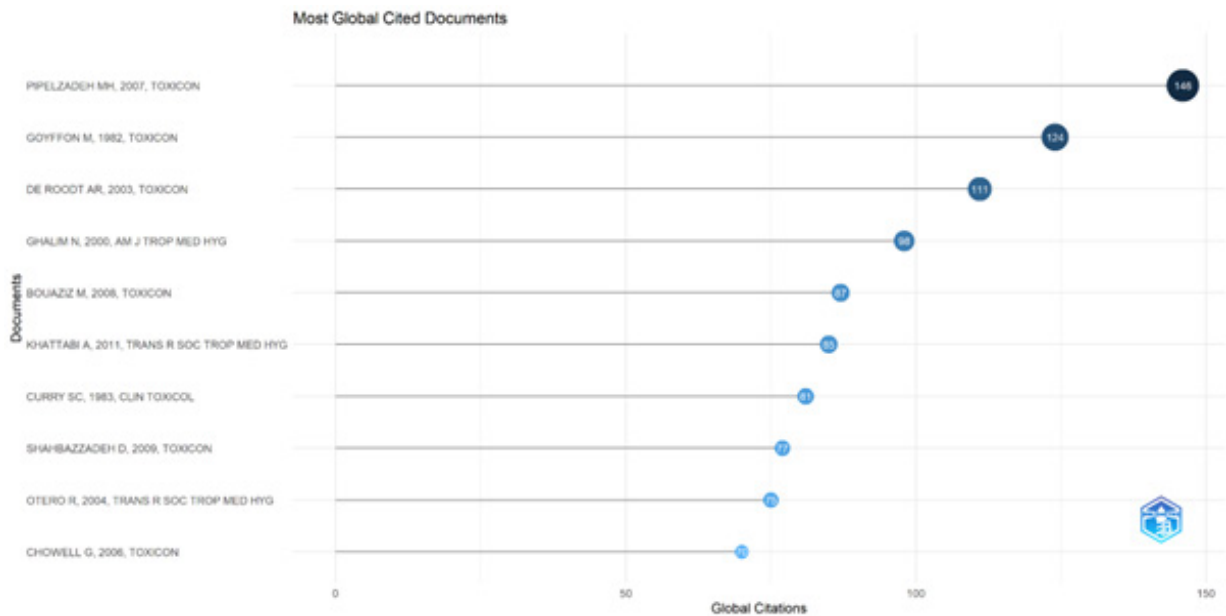


Figure 6: Analysis graph of the top 10 cited studies on the Epidemiology of Scorpionism, based on bibliometric analysis, referring to the period 1950-2022.

are one of the leading causes of incidents involving venomous animals in Brazil, second only to snakebites. In 2019, over 140,000 cases of scorpion stings were recorded in the country, surpassing the number of incidents involving snakes and spiders, according to data from the Notification of Injury Information System (SINAN).

Scorpionism has a significant impact on global health systems, primarily due to the large diversity of venomous scorpions and the high incidence of accidents involving these animals. Scorpion stings are common, especially in rural areas and arid climates, where scorpions find shelter in dark, warm places such as burrows, rocks, and poorly maintained structures. The severity of scorpion envenomations can range from mild to severe, depending on the species, the amount of venom injected, and the victim's overall health. In some cases, the effects of the venom can be fatal, particularly if there is no quick access to antivenom or proper medical treatment. Additionally, extreme weather conditions and environmental changes can worsen the situation. Human populations in rural areas, who often live in poor infrastructure conditions and have limited access to healthcare services, are the most vulnerable.

Toxicon is a highly relevant scientific journal in the field of studies on toxins derived from animals, plants, and microorganisms. Published by Elsevier since 1962, with Ray Norton as the editor-in-chief, the journal serves as an international platform for disseminating original research, innovative discoveries, and reviews on the properties and effects of natural toxins. With an impact factor of 3.033 in 2020, according to the Journal Citation Reports, *Toxicon* has become one of the main sources of information for scientists and professionals in the field of toxicology. The journal covers a wide range of topics, including

venoms from scorpions, snakes, spiders, and other venomous animals, making it a key reference for studies on scorpionism and its medical and therapeutic implications. Among the most cited and significant articles in the journal are those that address the characterization of specific toxins, the development of antivenoms, and the impact of toxins on various biological systems, which have greatly contributed to the advancement of applied toxicology and the treatment of envenomations.

An analysis of the authorship of publications identified Ilham Semlali as the most prolific author in the field of scorpionism epidemiology. Semlali, affiliated with the Centre Anti venin et pharmacovigilance de Maroc in Agdal Rabat, Morocco, is followed by Abdelmajid Soulaymani from the Université Ibn Tofail, Kenitra, Morocco. The significant contributions of these researchers, demonstrated by the high number of citations in related studies, highlight the importance of collaboration in advancing research in this field. It is noteworthy that only eight researchers are responsible for individual studies, indicating a strong culture of collaboration and a highly cooperative research environment within this scientific domain.

The analysis of scientific publications on scorpionism highlights the importance of universities in both Iran and Brazil as key research centers for advancing knowledge in this field. In Iran, the Ahvaz Jundishapur University of Medical Sciences stands out for its strong contribution to studies on scorpionism, particularly regarding endemic species such as *Hemiscorpius lepturus*, which causes numerous envenomations in the country. A significant example of this contribution is the study "An Epidemiological and Clinical Study of Scorpionism by the Iranian Scorpion *Hemiscorpius lepturus*," published by Pipelzadeh *et al.*, (2007), which has received a high number of citations, demonstrating

its impact on the field of toxicology and scorpion envenomation epidemiology in Iran. In Brazil, the Federal University of Minas Gerais ranks ninth among the leading affiliated institutions, also standing out for its relevant scientific research on scorpionism. Although the volume of publications is smaller compared to Iran, Brazil has proven to be an important contributor, with a focus on studies related to urban scorpionism and species responsible for envenomations, such as *Tityus serrulatus*. Cooperation between researchers from different countries is evident, as many publications, including those on Iranian and Brazilian scorpions, are published in prominent journals like *Toxicon*, which has served as a key platform for disseminating new findings on venoms and antivenoms, publishing 27 of the most cited manuscripts. These observations emphasize international collaboration and the central role of universities in both Iran and Brazil in generating scientific knowledge on scorpionism, while also highlighting the importance of specialized journals such as *Toxicon* and the *Journal of Venomous Animals and Toxins* in disseminating critical discoveries for the treatment and prevention of scorpion envenomations in both countries.

When reviewing the literature on scorpionism epidemiology, certain aspects warrant further investigation, particularly the association between environmental, anthropogenic, and climatic variables that may influence the increasing incidence of scorpion-related diseases over the decades. Additionally, it is crucial to explore other factors that may play a role in the evolutionary patterns of scorpion stings. Another consideration is the methodological limitation related to the number of documents from which metadata was extracted, which necessitates a more comprehensive analysis of the documents retrieved. However, the increase in publications between 1950 and 2022, particularly from 2000 onwards, may reflect the growing global interest in scorpionism due to the rising number of reported cases.

CONCLUSION

In this proposed article, statistical and mathematical analyses have revealed a progressive trend in scorpionism epidemiology worldwide over the past 70 years, primarily associated with clinical aspects in children. This assertion is substantiated by the increasing publication of articles, especially since 2000. Moreover, this article is a pioneering work in employing bibliometric tools to assess the construction and evolution of scientific production concerning scorpionism. It is worth noting, however, that there needs to be more research productivity concerning environmental, climatic, and anthropogenic factors associated with scorpionism. These factors provide additional insights into these creatures, including their distribution and behavior, crucial for effective prevention and treatment measures. The growing application of bibliometric tools in studies has contributed to the dissemination of knowledge, simultaneously highlighting research efforts and facilitating global access to the work conducted.

Scorpionism in Brazil and Iran is a significant public health issue, impacting various regions of both countries, particularly those that are tropical and subtropical. The distribution of scorpions is closely linked to climatic and environmental conditions such as heat, humidity, and unchecked urbanization. The high incidence of scorpion accidents, combined with increasing urbanization and the growing vulnerability of populations in peripheral areas, underscores the importance of public policies focused on prevention, early diagnosis, and treatment of envenomations, as well as public awareness campaigns. Ongoing research on species distribution and venom effects is crucial for developing more effective control strategies and producing appropriate antivenoms.

This comprehensive review underscores the growing concern over scorpion-related incidents worldwide, reaffirming the imperative need to comprehend the underlying causes and establish new preventive measures and policies to reduce the incidence, prevalence, morbidity, and mortality rates attributable to these venomous arachnids. Given the high occurrence rates of scorpion envenomations and the insights gained from this study, we reiterate the importance of seeking early medical assistance in such cases. This not only helps alleviate the suffering of the affected individuals but also plays a pivotal role in minimizing the overall impact of scorpionism on public health.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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