Herbal medicine and snakebite research in Southeast Asia: a bibliometric analysis (1974-2024)

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Abstract. This study presents a bibliometric analysis of research on herbal medicine and snakebite in Southeast Asia, focusing on publications from 1974 to 2023. The investigation involved 205 documents selected using specific keywords in the Scopus database. After applying inclusion criteria such as language and regional focus, the final selection yielded 202 documents across 145 sources. The analysis reveals an annual growth rate of 4.25%, indicating a steady increase in research interest over the past five decades. With contributions from 1,049 authors and an average of 6.08 co-authors per document, the field exhibits a high level of collaboration. Notably, nearly half of the publications (49.5%) involve international co-authorship, underscoring the global significance of the research in this domain. Keyword analysis identified "snakebite," "venom," and "medicinal plants" as central themes. The research also emphasizes preclinical studies, which are crucial for understanding the efficacy and safety of herbal remedies for snakebite treatment. The study further identifies key contributors to the field, with prolific authors such as Tan NH, Pithayanukul P, and Gopalakrishnakone P leading the scholarly discourse. Malaysia, Thailand, and Singapore are highlighted as the most productive countries, contributing significantly to the research output and citation impact.

1 Introduction

The burden of snake bites in Southeast Asia represents a significant public health challenge characterized by high morbidity and mortality rates. It is estimated that the region experiences approximately 5 million snake bites annually, with around 100,000 resulting in fatalities [1]. The epidemiological landscape reveals that Southeast Asia, along with South Asia and Sub-Saharan Africa, bears the highest incidence of snake bites globally, primarily due to a combination of factors such as high population density, extensive agricultural practices, and numerous venomous snake species [2]. Notably, the World Health Organization has

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recognized snake bites as a neglected tropical disease, emphasizing the urgent need for improved healthcare access and effective management strategies in rural areas where these incidents are most prevalent [3].

Herbal medicine in Southeast Asia is intricately linked to the region's extensive cultural and ecological variety, reflecting a longstanding practice of utilizing Indigenous plants for medicinal purposes [4-6]. These methods encompass a range of herbal treatments sourced from various plants, targeting conditions from the common cold to chronic diseases. Plants such as *Nelumbo nucifera* are recognized for their astringent qualities and are extensively utilized in traditional medicinal practices throughout Southeast Asia [7]. *Cosmos caudatus* and *Averrhoa bilimbi* are acknowledged as significant sources of bioactive substances, enhancing their utility in functional beverages for the management of diabetes and hypertension [8].

The practice of using herbal medicine as a treatment for snake bites is deeply rooted in the cultural traditions of Southeast Asia, where many communities rely on indigenous knowledge and local flora for managing envenomations. Numerous studies have documented the efficacy of various herbal antidotes against snake venom, highlighting plants such as *Andrographis paniculata*, which has been traditionally employed in several Asian regions for its potential therapeutic effects against snake bites [9]. Ethnobotanical surveys indicate that Indigenous populations utilize a wide array of medicinal plants, with reports of up to 72 different species being used in southern India alone [10]. These herbal remedies are often preferred in rural areas due to their accessibility and cost-effectiveness, especially in regions where modern medical facilities are scarce [11].

The bibliometric examination of herbal medicine indicates a growing body of material underscoring its significance in both traditional and contemporary healthcare systems. A significant study by Delima et al. delineates the patterns of herbal medicine prescriptions among physicians in Indonesia, indicating that herbal remedies are frequently utilized in conjunction with conventional treatments for diverse health concerns [12]. Utomo et al. similarly address the prevalent utilization of herbal treatments among patients with type-2 diabetes mellitus in Indonesia, highlighting advantages such as reduced side effects and more cultural acceptance [13]. Moreover, bibliometric analysis provides essential insights into the quality and impact of research, significantly influencing healthcare funding and policy decisions [14]. By analyzing indicators like citation counts and journal impact factors, researchers can gain insight into the relevance of their work within the broader scientific community [15]. As herbal medicine advances, bibliometric analysis will be essential for directing future research and fostering collaborations that enhance the incorporation of traditional knowledge into contemporary medical procedures [16]. This study seeks to examine the domain of herbal research and leptospirosis in Southeast Asia, focusing on critical inquiries such as I) What are the trends in herbal research pertaining to leptospirosis in Southeast Asia? II) Which writers and institutions are the primary contributors? III) What are the predominant research trends in this domain?

2 Materials and methods

2.1 Study technique and search strategy

Fig.1 represents a bibliometric workflow for a study on herbal research for snake bites in Southeast Asia. The process follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. The workflow begins with identifying relevant documents by searching a Scopus database using specific keywords related to snake bites and herbal research. Many records were initially found after filtering based on language

(English) and region (Southeast Asia). In the screening phase, articles are filtered by date, and certain documents like reviews, conference papers, and letters are removed. Finally, the remaining articles are included in the bibliometric analysis. This workflow ensures a systematic approach to gathering relevant literature, leading to more accurate insights for the research topic. 205 documents were determined for bibliometrics to ensure relevance, language appropriateness, and regional focus, creating a reliable dataset for analysis.

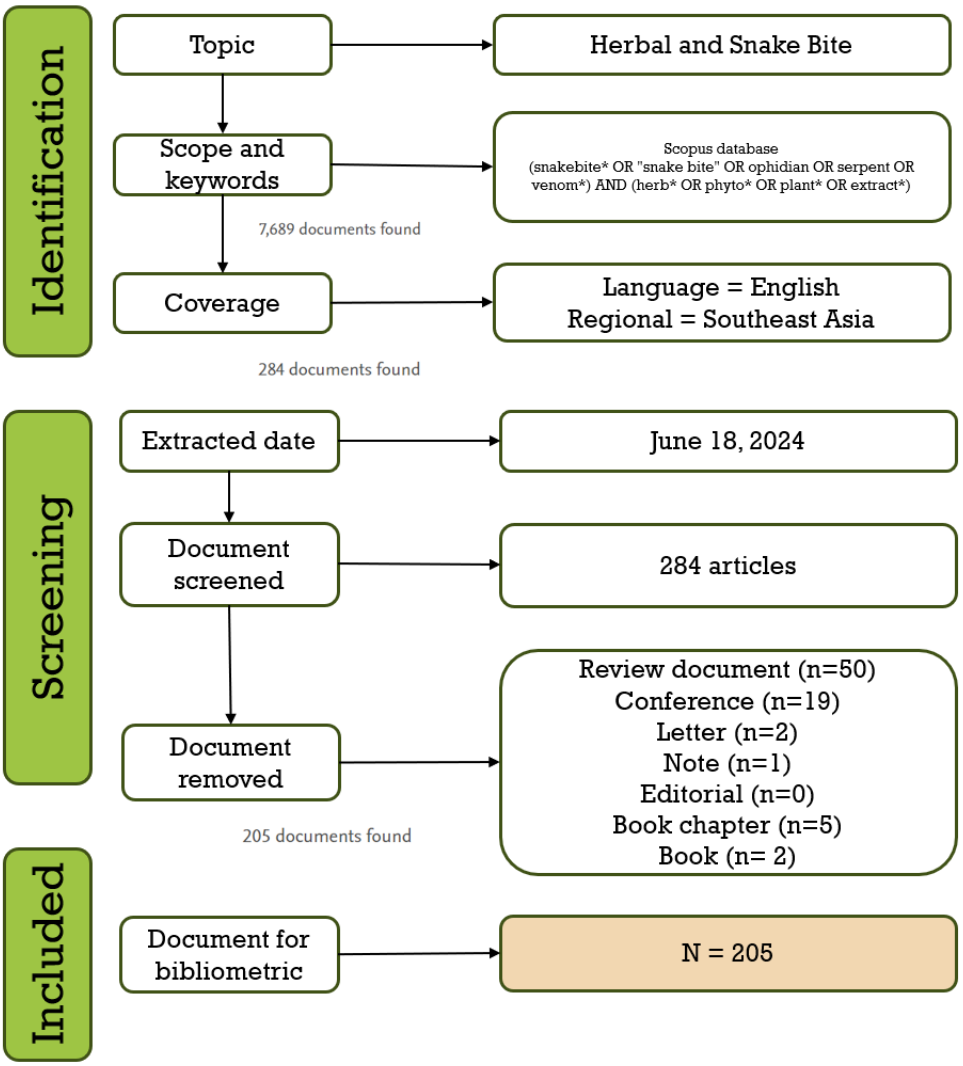

Fig. 1. Bibliometric workflow (adapted from PRISMA protocol).

2.2 Data analysis

The data analysis was performed using RStudio [17], supplemented by Bibliometrics, a software program created by the Department of Economics and Statistics at the University of Naples Federico II, Italy [18]. This study thoroughly analyzed publication trends, focusing on key aspects such as contributing countries, authors, and collaboration networks among researchers in Indonesia.

3 Result and discussion

3.1 General information

Fig.2. offers an overview of bibliometric data related to a study on herbal research for snake bites over 40 years. The data includes 145 different sources and 202 documents, indicating a 4.25% annual growth rate in publications on this topic. The number of authors involved is 1,049, with very few single-authored documents highlighting the collaborative nature of this field. International co-authorship is relatively high at 49.5%, which shows the global interest and collaboration in this area of research. On average, each document has 6.08 co-authors, pointing to teamwork in producing these publications. The document's average age is 10.5 years, and the average number of citations per document is 27.16, indicating the impact and relevance of these papers in the field. The dataset includes 670 author keywords, helping to identify key topics and trends. This detailed breakdown provides insight into the breadth and collaboration within the study of herbal research for snake bites, emphasizing international cooperation and an increasing trend in publications.

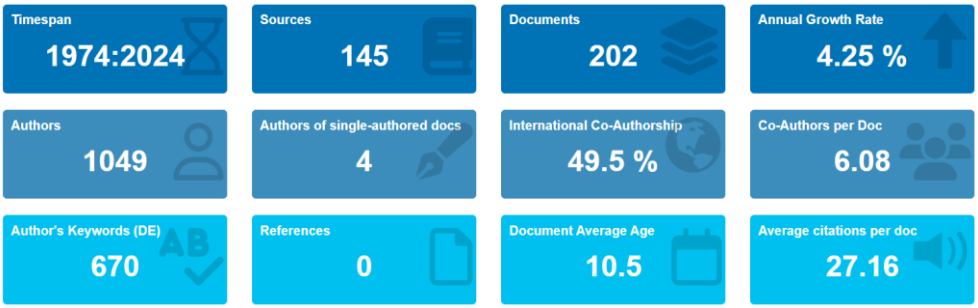

Fig. 2. General information of bibliometric results.

3.2 Trend analysis

Fig.3. illustrates the annual scientific production of herbal research for snake bites, showing a clear upward trend in the number of articles published over time. The early years from the 1970s to the late 1990s exhibit a slow and steady pace of publications, with relatively few articles. However, since the early 2000s, published articles have seen a noticeable rise. By 2017, there appears to be a significant increase in research activity, which has grown sharply in recent years, especially after 2017. Although the Mann-Kendall test result shows a slight upward trend in publications, it is weak, suggesting a long-term increase in research. Pettitt's test identifies 2017 as a critical year when the publication rate changed, likely due to a heightened interest in the field or significant advancements. The overall growth rate of publications is relatively steady, indicating sustained interest and expansion of research on this topic. The sharp rise in recent years could be linked to growing awareness of the need for effective herbal research in response to snake bites, particularly in regions where such therapies are crucial. It suggests that more research is being conducted to explore herbal solutions for snakebite management, perhaps driven by increasing global health concerns or advances in herbal medicine research.

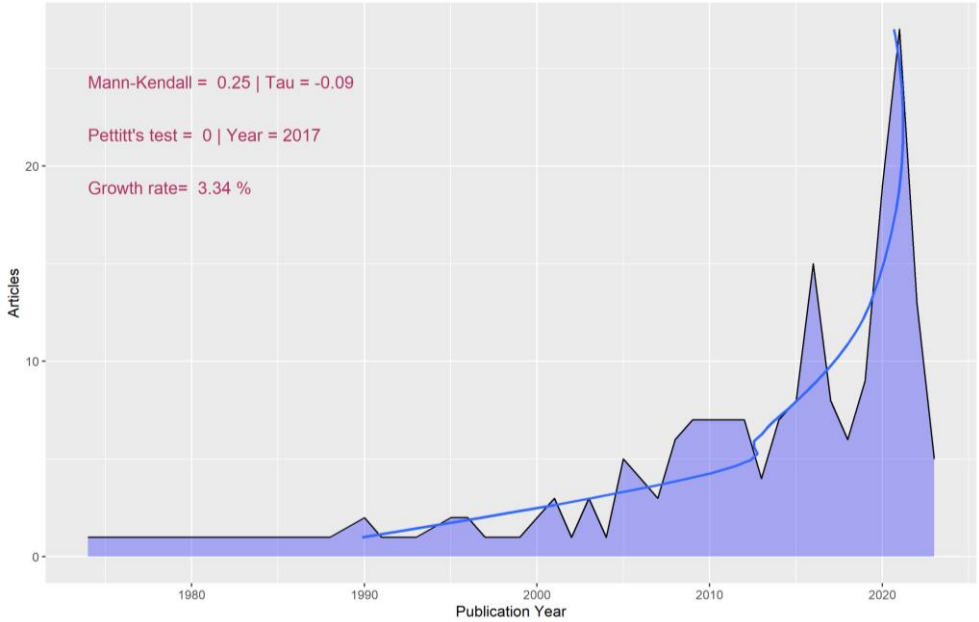

Fig. 3. Annual scientific production.

3.3 Authors analysis

Fig.4 displays the most productive authors in herbal research for snake bites, ranked by the number of published documents. The top three authors, marked in blue, stand out for their higher contributions. These authors are highlighted for their output and based on "fractionalized publication," which likely refers to the adjusted share of authorship when multiple authors contribute to a single paper. Tan NH ranks with the highest fractionalized contribution, followed by Pithayanukul P and Tan CH, which also have many publications. The other authors listed have contributed fewer papers but still need to rank among the top ten. The fractionalized values suggest that some authors may have worked on larger collaborative projects where their contributions are substantial, even if they authored fewer total papers. This chart highlights the importance of collaboration and consistent productivity in advancing this field. The dominance of certain authors also indicates the potential for expertise clustering, where a few researchers are driving much of the research on this topic. It may suggest that these leading authors are key figures in advancing herbal research for snake bites and that their work is likely shaping the direction of the field.

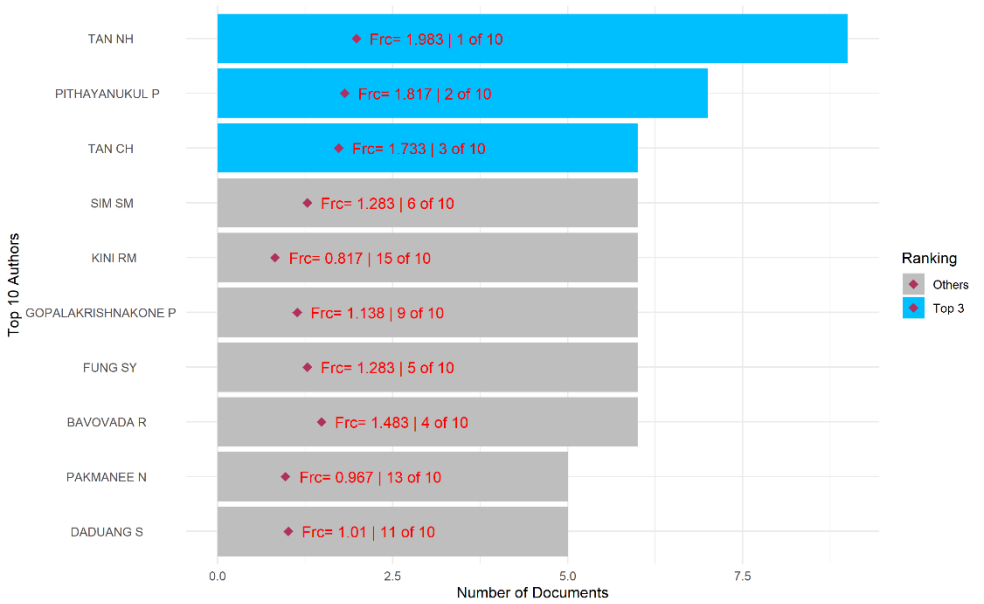

Fig. 4. The most productive authors (total and fractionalized publication).

Fig.5 presents the production of the top 10 authors in herbal research for snake bites over time, showing the number of articles each author publishes annually. The size of the circles represents the number of articles, while the shading (from light to dark blue) indicates the total citations (TC) per year, with darker shades corresponding to higher citation counts. Authors like Pithayanukul P. and Gopalakrishnakone P. show consistent contributions over multiple years, with some peaks in the early 2000s when their work received more citations. This suggests that their research gained significant attention and influenced subsequent studies. On the other hand, some authors, such as Tan NH and Kini RM, show more steady output over a more extended period, without prominent citation peaks, indicating consistent but perhaps less impactful production in terms of citations. This visualization highlights the diversity in research patterns—some authors contribute a few highly cited works, while others maintain steady productivity over time. It also shows how certain years, especially around 2005 and 2017, saw concentrated contributions from these authors, which could reflect periods of increased interest or breakthroughs in the field.

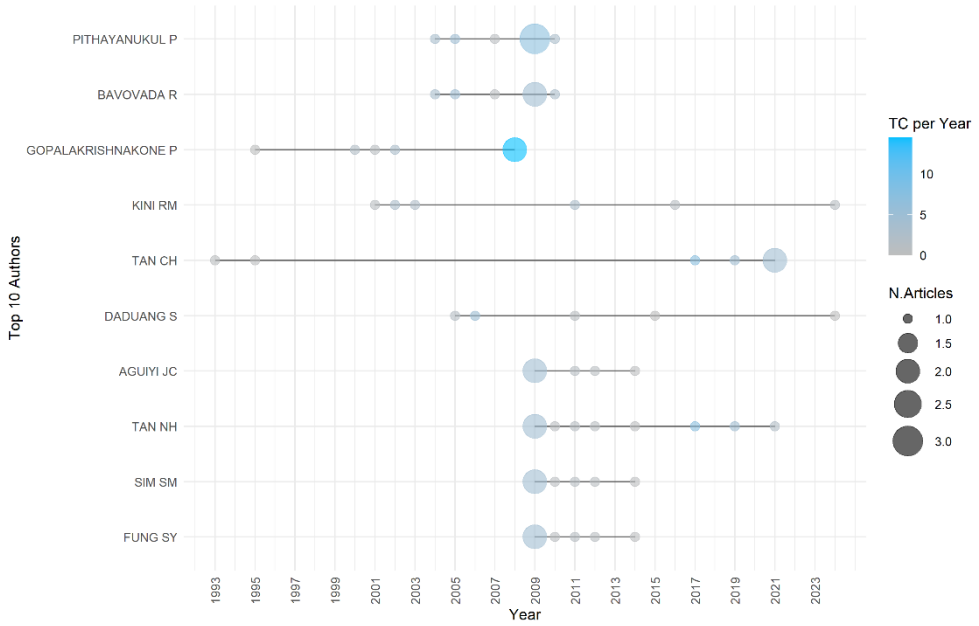

Fig. 5. The most productive authors over time.

3.4 Country Analysis

Fig.6 illustrates the most productive countries in publishing research on herbal research for snake bites. The countries are ranked by the number of documents they have produced, with the bars segmented into two categories: single-country publications (SCP), where the research was conducted within one country, and multiple-country publications (MCP), which involve international collaboration. Blue diamonds represent the total number of citations for each country's research output. Malaysia leads in the number of publications and total citations, combining single-country and collaborative efforts. Thailand and Singapore follow closely behind, with substantial contributions, though Thailand has a higher proportion of internationally collaborative works. Other countries, such as the Philippines and India, show a balance between national and international research contributions. In contrast, countries like the USA and the United Kingdom have more internationally co-authored works. This chart highlights the importance of global collaboration in the field, especially for countries like Thailand, where multiple-country publications are significant. It also emphasizes the robust research output from Southeast Asian countries like Malaysia, Thailand, and Singapore, which are likely central to advancing research on herbal research for snake bites in the region, both in terms of volume and influence through citations.

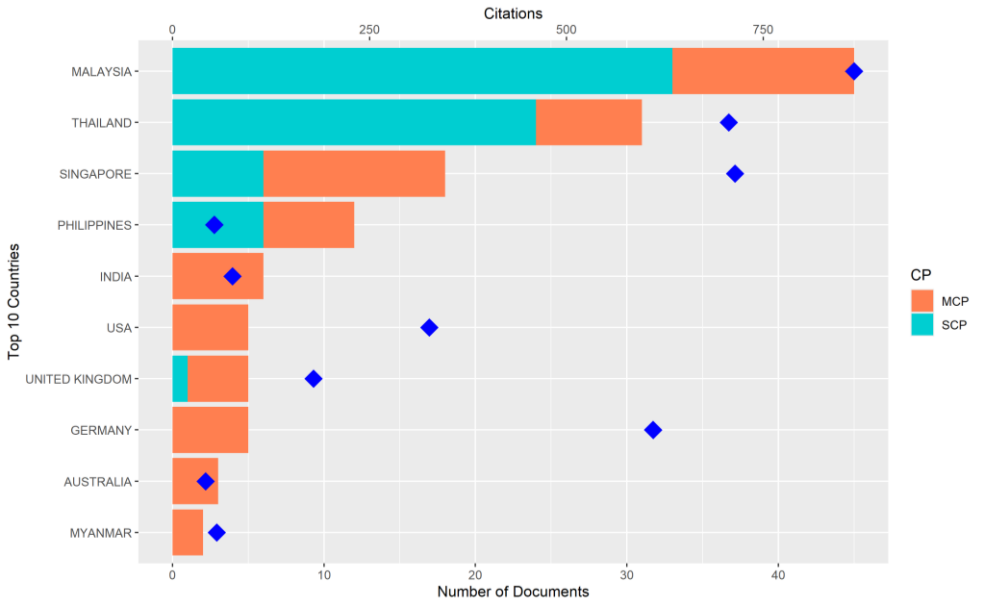

Fig. 6. The most productive country (total document and citation); blue diamond represents total citations.

3.5 Structure analysis

Fig.7 reveals a keyword co-occurrence network, where frequently used terms in the research on herbal research for snake bites are visualized as nodes connected by lines (edges). The size of the nodes represents the frequency of the terms, with larger nodes indicating more common keywords. The proximity and connections between nodes reflect how often these terms appear together in the literature. The terms are grouped into clusters, marked by different colors, suggesting thematic areas in the research. For example, "venom" and "snake" are central terms, likely reflecting the core focus of the studies. Around them, clusters related to "plant," "extract," and "study" emphasize the herbal and experimental focus of the research. Other terms like "results," "potential," and "activity" suggest that much of the research investigates the effects and efficacy of various plant-based treatments. Additionally, "mice" and "protein" clusters indicate that some studies involve lab testing on animals and biochemical analysis. This co-occurrence map provides insight into the primary research areas and methods being explored. It highlights the interconnectedness between herbal treatments, venom studies, and experimental results, showing that the field explores various aspects of herbal solutions, from traditional knowledge to modern scientific validation.

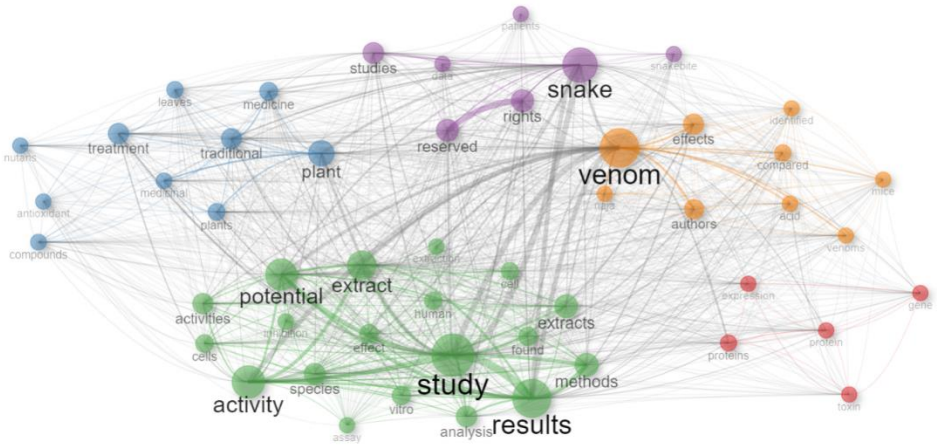

Fig. 7. Co-occurrence network of herbal and snakebite bibliometric.

The bibliometric analysis provides valuable insights into the research landscape of herbal research for snake bites, revealing trends in publication growth, author productivity, international collaboration, and thematic focus areas. **First**, The analysis shows a steady increase in publications over time, with a significant uptick starting around 2017. This growing interest can be attributed to a combination of factors, including the increased recognition of traditional herbal remedies, the need for affordable and accessible treatments in snakebite-endemic regions, and advancements in the study of plant-based compounds. The growth rate suggests that more researchers are exploring the potential of herbal therapies in combating the effects of venom, reflecting an expanding field with broader scientific and clinical interest. **Second**, Malaysia, Thailand, and Singapore emerge as the most productive countries regarding research output, with Malaysia taking the lead. These Southeast Asian countries are rich in biodiversity, making them prime regions for studying plant-based therapies. Additionally, their high citation counts suggest that the research produced in these regions is highly impactful. The significant proportion of multiple-country publications (MCP) for countries like Thailand highlights the importance of international collaboration in advancing this research field. Collaborations across borders enhance the quality of research by pooling expertise, resources, and access to diverse plant species, leading to more comprehensive studies on herbal research for snake bites.

Third, The analysis of author productivity shows that a small group of researchers, including Tan NH, Pithayanukul P, and Tan CH, are responsible for a substantial portion of the literature. These key researchers likely serve as leaders in the field, driving much of the scientific inquiry and exploration of herbal research. The co-authorship network reveals that the field is highly collaborative, with most papers being multi-authored, suggesting that research in this domain benefits from a multidisciplinary approach, combining expertise in toxicology, botany, pharmacology, and clinical medicine. **Fourth**, The keyword co-occurrence network reveals the core themes of the research, with "venom," "snake," "extract," and "study" being the central concepts. This indicates that most of the research focuses on the potential efficacy of plant extracts in neutralizing snake venom. Other prominent terms, such as "activity," "potential," and "results," suggest that much of the work is experimental in nature, aiming to assess the bioactive properties of these extracts. Clusters related to terms like "mice," "protein," and "effects" suggest that researchers are also investigating the

biochemical mechanisms by which these plant-based research act against venom toxins, often using animal models for preclinical testing.

3.6 Limitations and Future Research Directions

While the bibliometric analysis provides essential insights into the research landscape of herbal research for snake bites, several limitations should be acknowledged. The results show that most research is concentrated in Southeast Asian countries like Malaysia, Thailand, and Singapore. While these regions are rich in biodiversity, the lack of research from other snakebite-endemic areas, such as Africa and Latin America, limits the global applicability of the findings. This geographical concentration could hinder a more comprehensive understanding of worldwide plant-based research for snake bites. The analysis focuses solely on English-language publications from the Scopus database. This could exclude significant research published in other languages or indexed in different databases, such as Web of Science or PubMed. Consequently, the full breadth of research, particularly regional studies published in non-English journals, might need to be captured. The keyword analysis focuses on experimental studies, often involving animal models or in vitro assays. However, the research needs more clinical trials or studies that assess the efficacy of herbal research in humans. This limitation means that while many plant-based compounds may show promise in the lab, their real-world applicability remains to be determined. Although international collaboration is evident in many publications, the partnership tends to be concentrated among specific countries and research groups. This fragmented nature of collaboration may limit the cross-fertilization of ideas from diverse regions and expertise that could lead to breakthroughs in the field. The analysis needs to address the challenges associated with the variability in the composition and potency of herbal extracts. The lack of standardization in herbal medicine remains a significant issue, as differences in plant species, harvesting methods, and preparation techniques can result in inconsistent efficacy across studies.

Given the limitations identified, several critical areas of future research are recommended. (1) Future research should include more collaboration with countries from Africa, Latin America, and other snakebite-endemic regions. These areas often rely on traditional medicine, and incorporating their knowledge systems could provide new perspectives and solutions. Expanding research to underrepresented areas would enhance the global relevance and impact of the findings. (2) While laboratory studies provide a foundation, future research should prioritize clinical trials to validate the safety and efficacy of herbal research in human populations. With clinical data, it will be easier to integrate these remedies into mainstream medical practice. Research should focus on translating promising results from experimental models into clinical applications. (3) One of the significant challenges in herbal medicine is ensuring consistent quality and potency. Future research should work toward developing standardized extraction methods and dosage guidelines for herbal research, particularly those targeting snake venom. This will enhance the reproducibility of studies and improve the reliability of herbal remedies. (4) To advance the scientific understanding of how herbal compounds neutralize snake venom, further research should focus on the underlying biochemical mechanisms. This could involve exploring the molecular interactions between venom components and plant extracts, identifying active compounds, and testing their potential for pharmaceutical development. (5) Future research should encourage broader multidisciplinary collaboration involving botanists, pharmacologists, clinicians, toxicologists, traditional healers, and public health experts. This would foster more holistic approaches to snakebite management, blending traditional knowledge with modern science. (6) Finally, research should also focus on integrating herbal research into public health strategies in snakebite-endemic regions. This

could involve working with local communities, health systems, and policymakers to create frameworks for the safe and effective use of herbal remedies as part of a broader snakebite treatment protocol.

4 Conclusion

In conclusion, while herbal research for snake bites is growing, several limitations still need to be addressed, including regional bias, a lack of clinical trials, and standardization issues. Addressing these gaps through expanded collaboration, clinical validation, and standardized practices will be crucial for advancing the field and ensuring that herbal remedies can play a meaningful role in global snakebite management.

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