

Dengue fever and herbal medicine in Indonesia: Trends, collaborations, and research impact (1985-2023)

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Abstract. The research aims to determine the extent to which herbal research in dengue fever through a bibliometric analysis in Scopus databases from 1985 to 2023. Using RStudio with the Bibliometrix package, this study scrutinizes publication patterns, identifies leading institutions, highlights influential authors, and examines keyword trends. Over this period, 122 documents were published across 88 different sources, revealing an annual growth rate of 8.06%. This growth suggests a rising interest in the intersection of herbal medicine and dengue fever, indicating that the research community is increasingly recognizing the potential of herbal treatments. The collaborative nature of this research is underscored by the fact that the average number of co-authors per document is 5.79. Additionally, 21.31% of these publications involve international co-authorship, reflecting a significant level of global collaboration and a shared interest in addressing this persistent health issue. Leading Indonesian institutions, such as Universitas Airlangga and Gajah Mada University, have been at the forefront of this research, making substantial contributions to the scholarly output in this field. Prominent authors, including Sucipto TH and Yohan B, have emerged as key figures. A keyword co-occurrence analysis identified "Aedes aegypti," "animal model," and "plant extract" as central themes in the research, which highlights a strong focus on preclinical studies and the chemical analysis of plant-based treatments.

1 Introduction

Dengue fever continues to pose a considerable public health problem in Indonesia, marked by its endemic characteristics and the rising occurrence of severe cases, especially dengue hemorrhagic fever (DHF). The country has witnessed a dramatic rise in dengue cases over the past decades, with a reported incidence rate escalating from 0.05 per 100,000 in 1968 to approximately 39.80 per 100,000 by 2014, indicating a growing public health crisis [1, 2]. The primary vectors responsible for transmitting the dengue virus (DENV) are *Aedes aegypti*

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and *Aedes albopictus*, both prevalent across the archipelago [1, 3]. The Indonesian Ministry of Health has implemented various control strategies since 1968, including introducing the 3M Plus program, which emphasizes community involvement in mosquito breeding site eradication [4, 5]. Despite these efforts, the incidence of dengue continues to rise, exacerbated by factors such as urbanization, climate change, and inadequate public awareness regarding prevention measures [6].

Herbal medicine, particularly "jamu," is integral to Indonesia's healthcare system, embodying the nation's profound cultural past and abundant biodiversity. Jamu, a traditional herbal treatment, has been employed for generations and continues to be essential to the everyday lives of many Indonesians. It is often utilized to treat various health concerns, from minor ailments to chronic diseases, and is esteemed for its prospective therapeutic benefits. [7, 8]. Indonesia's abundant Indigenous medicinal plants, exceeding 5,000 species, substantiate the widespread utilization of herbal medicine, positioning it as a prominent global producer of medical plants [9-13].

Using herbal medicine to manage and prevent dengue fever has gained attention in Indonesia, a country rich in biodiversity and traditional medicinal practices. Numerous investigations have recognized multiple Indonesian medicinal plants exhibiting possible antiviral efficacy against the dengue virus (DENV). Extracts from plants such as *Myristica fatua*, *Cymbopogon citratus*, and *Acorus calamus* have exhibited considerable antiviral properties in vitro, indicating their potential as adjunctive therapies for dengue [14]. Furthermore, a review highlighted that natural remedies are increasingly being utilized in developing countries, including Indonesia, where access to expensive medical technologies is limited [15]. This reliance on herbal medicine is particularly relevant in the context of dengue, as severe cases can lead to significant morbidity and mortality, necessitating alternative therapeutic options [16]. Research has also focused on the efficacy of specific plants in treating dengue symptoms. For example, *Carica papaya* leaves have been noted for their ability to increase platelet counts in patients suffering from dengue hemorrhagic fever, which is critical for managing the disease [16, 17]. Additionally, the exploration of other plants, such as *Azadirachta indica* and *Hippophae rhamnoides*, has been encouraged due to their traditional use and emerging scientific evidence supporting their medicinal properties [17]. Incorporating herbal remedies into dengue prevention programs may offer a comprehensive strategy, particularly in remote regions with restricted access to conventional healthcare [18].

Bibliometric analysis has emerged as an essential instrument in medical research, allowing researchers to statistically evaluate and illustrate the landscape of scientific literature across many fields. This method employs statistical and mathematical techniques to assess published works, providing insights into research trends, collaboration networks, and the impact of certain studies or publications. [19]. Bibliometric analysis systematically examines extensive datasets to identify significant contributions, including prominent authors, institutions, and nations, thereby elucidating worldwide research trends and focal areas [20].

Bibliometric analysis is essential for delineating the progression of research trends and illustrating the integration of historic techniques into contemporary healthcare systems. It has been notably efficient in monitoring the proliferation of material on herbal remedies for diverse disorders, including infectious diseases such as dengue [21, 22]. This quantitative method identifies key study domains and reveals knowledge gaps necessitating additional investigation [23].

Moreover, bibliometric analysis provides critical insights into the quality and effect of research, which are vital for informed decision-making concerning funding and healthcare policies [24]. By studying indicators like citation counts and journal impact factors, researchers acquire a more profound comprehension of the relevance of their work within the

broader scientific community [25]. As the domain of herbal medicine evolves, employing bibliometric analysis will be essential for directing future research trajectories and facilitating collaborations that promote incorporating traditional knowledge into modern medical procedures [26]. This study seeks to investigate the realm of herbal research on dengue in Indonesia, focusing on essential inquiries: I) What are the tendencies in herbal research for dengue in Indonesia? II) Who are the principal authors and institutes contributing to this work? III) What are the principal research trends in this domain?

2 Materials and methods

2.1 Study technique and search strategy

Fig.1 delineates a systematic bibliometric workflow grounded in the PRISMA protocol, showcasing the methodical approach employed to find and evaluate pertinent material about herbal therapies for dengue fever. The procedure commences with the identification step, during which a search is performed in the Scopus database utilizing keywords pertinent to dengue fever and herbal medicines. The preliminary results are filtered by language (English) and geographic focus (Indonesian) to guarantee the documents' relevance. During the screening phase, the retrieved records are evaluated for appropriateness, and specific publication types—such as reviews, conference proceedings, surveys, editorials, and book chapters—are removed to enhance the selection process. After eliminating extraneous papers, a conclusive collection of articles is preserved for a comprehensive bibliometric study. This method guarantees the inclusion of only documents directly relevant to the study objectives, enabling a thorough and targeted examination. The workflow delineates each phase, from topic definition to evaluating the final quantity of documents for bibliometric analysis. This study focuses on herbal treatments for dengue fever, yielding an initial 4,151 documents, then refined to 194 articles. After further filtering, 122 documents remain for final analysis, ensuring relevance and accuracy in the review process.

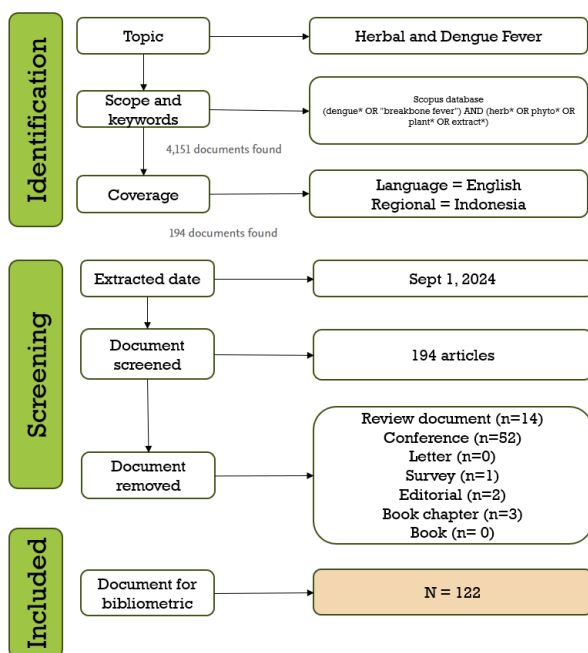


Fig. 1. Bibliometric workflow (adapted from PRISMA protocol).

2.2 Data analysis

The data analysis was performed using RStudio [27], with additional support from Bibliometrics, a software developed by the Department of Economics and Statistics at the University of Naples Federico II, Italy [28]. This study thoroughly analyzed publication trends, highlighting significant elements such as contributing nations, prominent authors, and collaborative networks among researchers in Indonesia.

3 Results and discussions

3.1 General information

Fig.2. presents a detailed summary of the bibliometric analysis, including essential parameters about publications on herbal therapies for dengue disease. The data covers multiple decades, demonstrating consistent expansion in the field, with an annual growth rate of 8%, indicating heightened interest and research activity. The analysis encompasses contributions from about 600 writers, highlighting the collaborative essence of research in this domain, as evidenced by a significant average of co-authors per document. Although most works are cooperative, a limited quantity of single-authored papers exists. International collaboration is crucial in research since over 20% of publications arise from international co-authorship, demonstrating substantial worldwide involvement. The publications originate from many journals and channels, emphasizing the extensive distribution of research across multiple platforms. The comparatively youthful average document age indicates a lively field characterized by numerous recent publications contributing to continuing discourse. The average citation count per document indicates a moderate impact within the scientific community, signifying that the research is achieving recognition and importance as the area evolves. The picture depicts a dynamic, collaborative field that perpetually enhances its knowledge base and research influence.

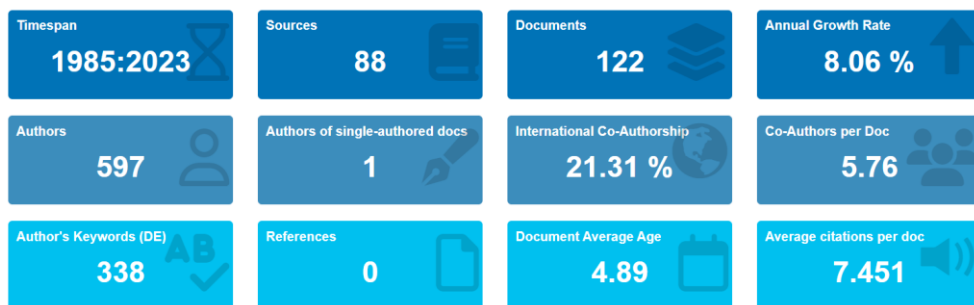


Fig. 2. General information of bibliometric results.

3.2 Trend analysis

Figure 3 depicts the annual scientific output regarding herbal therapies for dengue illness, highlighting substantial growth over recent decades. Initially, publications were relatively sparse, exhibiting modest activity before the 2000s. The graph demonstrates a significant rise in output commencing around 2010, succeeded by a pronounced escalation in recent years.

This growing trend indicates that the topic has garnered considerable attention within the scientific community, possibly propelled by heightened awareness of alternate treatments and the global impact of dengue fever in tropical areas.

The findings of the Mann-Kendall and Pettitt tests further substantiate the relevance of this growth pattern, indicating that the increase in publications is statistically validated. The growth rate demonstrates persistent momentum, signifying that the field is expanding, with an increasing number of scholars and institutions contributing to the literature. This increased research activity may be ascribed to progress in herbal medicine and a rising interest in traditional remedies as feasible alternatives or supplements to current medical treatments. The graph highlights the growing significance of this study domain, indicating that it will probably persist in garnering attention and investment.

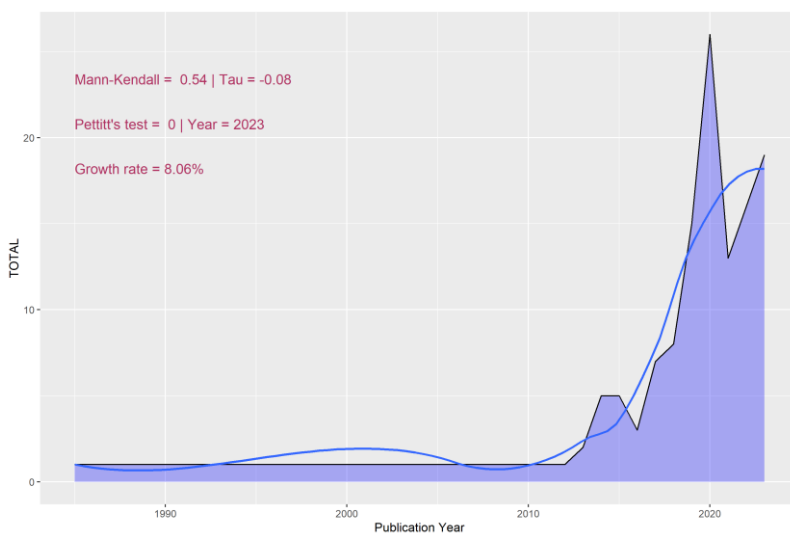


Fig. 3. Annual scientific production.

3.3 Authors analysis

Fig.4 illustrates the most prolific writers in herbal treatment research for dengue fever, with contributions quantified in total and fractional publications. The primary authors are ranked according to the number of documents they have generated, with fractional numbers reflecting their contributions to collaborative efforts. The leading three writers are eminent, indicating their significant contributions to advancing research in this domain. The illustration shows that few exceptionally productive authors have contributed substantially to the corpus of knowledge, with some participating in a larger share of joint study. This illustrates the collaborative essence of the discipline, wherein teamwork and collective endeavors are crucial for advancing inventions and discoveries. The existence of specific authors with elevated fractionalized ratings indicates that while some writers significantly contribute to various projects, others spearhead their study, rendering both individual and collaborative efforts equally vital in this field. The distribution of authorship and participation reflects a robust equilibrium between autonomous research initiatives and collaborative endeavors, essential for advancing the depth and scope of research on herbal remedies for dengue fever. The preeminence of leading authors indicates their authority and impact in shaping the research agenda and progressing the discipline, as evidenced by their substantial publication output.

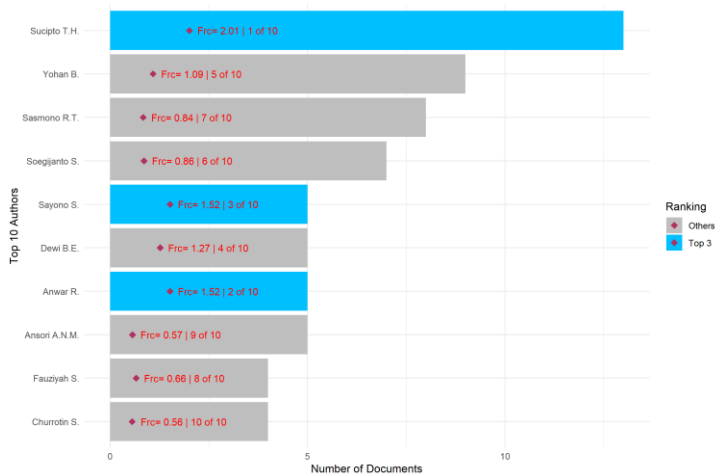


Fig. 4. The most productive authors (total and fractionalized publication).

Fig.5 illustrates the publication tendencies of the most prolific authors, providing insight into the number of published works and their citation influence. Each circle symbolizes an article, with the circle's size reflecting the quantity of articles authored by that individual in a specific year. The color intensity corresponds to the annual citation count. The graphic illustrates differing degrees of productivity and impact across the authors. Individuals such as Sasmono and Yohan have exhibited enduring contributions throughout the years, continually publishing research and amassing citations. This continuous output signifies their sustained involvement and leadership in the domain. Individuals like Ansori have exhibited increased productivity in recent years, evidenced by a substantial volume of publications and considerable citation effect, indicating an expanding influence within the community. The image underscores the variety in research impact, with certain authors exhibiting elevated citation rates, indicative of the significance and relevance of their contributions. This suggests that although several authors contribute to the discipline, a few pivotal personalities propel substantial scientific progress and exert a lasting influence. The picture illustrates the impact of prominent writers on the evolution of herbal treatment research for dengue fever, highlighting certain authors as particularly influential over time.

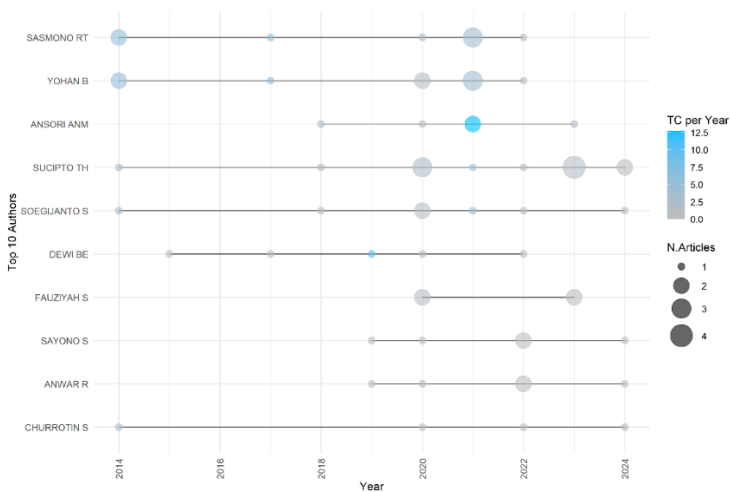


Fig. 5. The most productive authors over time.

3.4 Affiliation analysis

Fig.6 illustrates the most prolific colleges according to their total document publications and the citations garnered by those documents. Leading institutions like Universitas Airlangga, the Institute of Tropical Disease, and the Eijkman Institute stand out for their high volume of publications and substantial citation impact. These top universities are represented by blue bars and have significantly influenced the research landscape, driving much of the progress in herbal treatments for dengue fever. While producing fewer documents, other institutions still show notable citation counts, suggesting that their research is of high quality or significant importance even with a smaller output. For instance, universities like Universitas Gadjah Mada and Universitas Indonesia have contributed fewer papers but achieved high citation numbers, indicating that their work is well-regarded and impactful within the scientific community. The presence of red diamonds, representing total citations, highlights the balance between quantity and quality in academic contributions. While some universities lead in the research volume, others achieve strong academic influence with fewer publications. This statistic highlights the significance of extensive research output and the enduring impact of high-caliber studies, establishing these universities as pivotal contributors to advancing herbal treatment research for dengue fever.

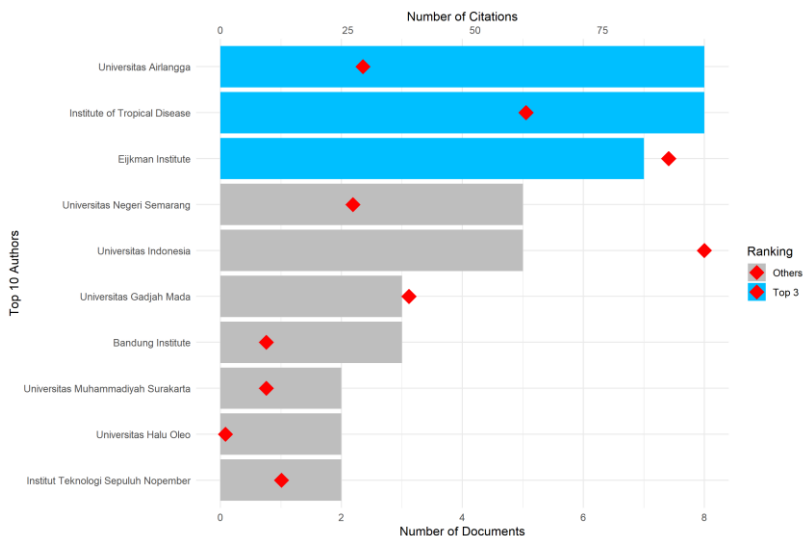


Fig. 6. The most productive university (total document and citation); red diamond represents total citations.

3.5 Structure analysis

Fig.7 illustrates a co-occurrence network of pivotal phrases associated with herbal and dengue research, demonstrating the frequency of simultaneous appearances of specific concepts in the literature. The larger nodes represent often occurring terms, while the connections between nodes indicate their co-occurrence in research articles. At the center of the network, terms like "article" and "controlled study" dominate, suggesting that much of the research is focused on structured studies involving herbal treatments, often targeting dengue. The network is divided into clusters, with red nodes representing terms related to preclinical or experimental studies, such as those involving "nonhuman" subjects and "controlled trials." These indicate a strong focus on experimental research to validate the efficacy of herbal treatments in controlled environments. Terms related to "antiviral activity"

and "*Aedes aegypti*" also appear frequently in this cluster, reflecting the exploration of how herbal compounds may combat dengue and its vectors. On the other hand, the blue cluster focuses more on human studies and the broader context of the disease. Terms like "dengue virus," "human," and "Indonesia" are central, showing the regional focus and the human-centered nature of many studies in this area. The presence of terms related to polymerase chain reaction (PCR) and other diagnostic methods suggests that the research also explores advanced methods for detecting and analyzing the effects of herbal treatments. This network highlights the interdisciplinary nature of research in this field, bridging clinical studies, diagnostics, and experimental research. It also reveals areas of intense research focus, such as controlled studies of herbal efficacy, while indicating the potential for more human-centered studies and exploring the under-researched regions in diagnostics and public health interventions.

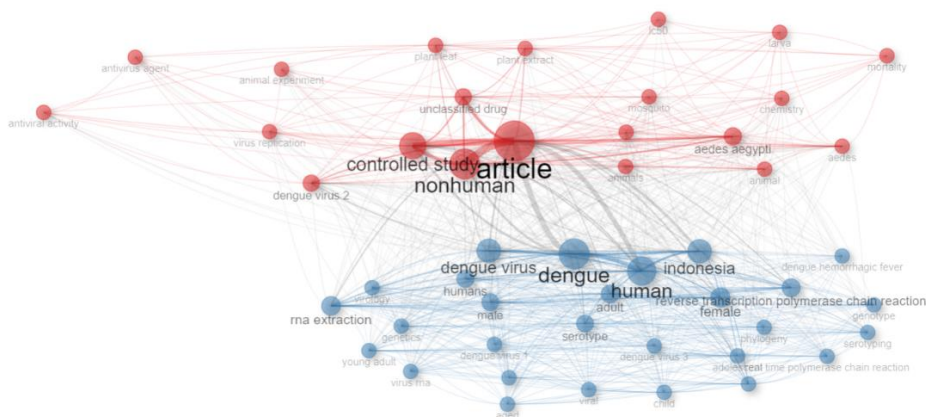


Fig. 7. Co-occurrence network of herbal and dengue bibliometric.

The bibliometric analysis indicates a substantial rise in research about herbal remedies for dengue, underscoring a distinct progression toward evidence-based validation of traditional medicine. The co-occurrence network and productivity figures emphasize the central role of controlled studies and collaboration among key institutions and researchers. However, despite these advances, the field still faces challenges, and gaps warrant further exploration.

The dominance of terms such as "controlled study" and "nonhuman" in the co-occurrence network suggests a firm reliance on preclinical research. This focus on animal models and controlled experiments is critical for establishing the efficacy of herbal treatments before they are tested in human trials. However, the limited presence of human-centered research terms, such as "clinical trial," indicates that there may be a gap in translating these preclinical findings into real-world applications. One possible explanation could be the complexity of clinical trial approval processes or the challenges of conducting large-scale trials in regions with limited resources. Consequently, there is an urgent want for additional human-centered research to connect preclinical discoveries with actual healthcare implementations.

Furthermore, the concentration of research activity around certain institutions, as seen in the institutional productivity figures, suggests that only a few universities and research centers are driving much of the research on herbal treatments for these diseases. While these institutions are leaders in the field, this concentration may limit the diversity of perspectives and approaches to solving the problem. An opportunity exists for expanded collaboration among more institutions, particularly in areas where dengue is endemic yet underrepresented in research. Expanding research links could lead to more innovative and regionally relevant solutions, leveraging local knowledge and resources in new ways.

The co-authorship data reflects strong collaboration, with many publications involving multiple researchers. While collaboration is a positive indicator of knowledge-sharing and resource pooling, the relatively low percentage of international co-authorship suggests that research in this area still needs to be more regionally focused. Given the global burden of dengue, international collaboration could bring in new technologies, perspectives, and methodologies that may accelerate progress. Encouraging more international partnerships, especially with institutions with expertise in herbal medicine or infectious diseases, could help diversify and strengthen the research landscape. The focus on key terms, such as "antiviral activity" and "polymerase chain reaction," points to a growing interest in using advanced diagnostic and therapeutic techniques to study herbal treatments. However, it also suggests that some research areas, such as prevention strategies and public health interventions, may need to be explored. While antiviral activity is a critical aspect of treatment, broader prevention efforts—such as vector control and community-based health strategies—should also be integrated into the research agenda to offer a comprehensive plan for addressing dengue.

3.6 Limitations and future research directions

This bibliometric analysis offers significant insights into the research landscape of herbal remedies for dengue, although it is crucial to acknowledge its limits. The study is based solely on data obtained from the Scopus database, potentially overlooking pertinent research from other significant databases such as PubMed, Web of Science, or regional repositories. The study should have addressed significant contributions from non-English-speaking regions and lesser-known journals, potentially biasing the findings in favor of more prominent international publications. A further issue is the dependence on citation metrics and publication quantities as indicators of research impact. Although these indicators offer a broad indication of research impact, they may need to adequately reflect the quality or practical relevance of the study outcomes. Prominently referenced studies may infrequently result in clinical or public health progress, particularly in herbal medicine, where cultural and local norms profoundly affect acceptance and execution. Furthermore, the emphasis on institutional and author production, although beneficial for identifying prominent figures in the field, may obscure the contributions of smaller research groups or institutions that generate fewer yet significantly relevant papers. The concentration of research within a limited number of institutions may result in a restricted diversity of research methodologies, hindering the investigation of innovative or alternative approaches in herbal medicines.

To mitigate these limits and enhance the domain of herbal therapies for dengue, certain prospective research avenues should be contemplated: 1) **Expanding Database Coverage:** Subsequent studies ought to incorporate data from a wider array of databases, including PubMed, Web of Science, and regional repositories, to get a more exhaustive perspective of the research landscape. This will assist in identifying underrepresented studies and offer a more comprehensive perspective on contributions to the discipline. Incorporating grey literature, governmental reports, and NGO studies may provide significant insights into herbal remedies' practical, community-oriented applications. 2) **Promoting International Collaboration:** Despite robust regional cooperation, the comparatively low incidence of international co-authorship underscores a potential to enhance global relationships. International cooperation provides varied viewpoints, approaches, and resources, potentially expediting the advancement of herbal therapies. Researchers should establish collaborations with institutions possessing complementary expertise, especially in nations where dengue is common. 3) **Transitioning from Preclinical to Clinical Research:** Most contemporary research emphasizes preclinical investigations, including animal models and controlled procedures. Subsequent research should emphasize converting these discoveries into human-

centric clinical trials. This necessitates overcoming regulatory obstacles and obtaining financing, although it is crucial for substantiating the effectiveness and safety of herbal therapies in practical environments. 4) Expanding Research Topics: The present emphasis on antiviral efficacy and controlled trials, although essential, neglects other domains, including preventive methods, vector management, and community-based initiatives. Future studies should investigate the integration of herbal remedies into comprehensive public health programs, including the reduction of mosquito populations and the enhancement of local health systems. Investigating the preventive efficacy of herbal therapies, particularly in high-risk populations, may offer a more comprehensive strategy for managing dengue. 5) Integrating Cultural and Societal Contexts: Given that herbal medicine is profoundly embedded in cultural traditions, subsequent research should investigate the impact of cultural elements on the acceptance and utilization of herbal therapies. Comprehending community attitudes, indigenous knowledge systems, and traditional healing practices will be essential for formulating successful and culturally appropriate therapies. Researchers must collaborate intimately with local communities to ensure discoveries are converted into significant, contextually relevant health interventions. 6) Augmenting Data Sharing and Open Access: The discipline would gain from enhanced data sharing and unrestricted access to research outcomes. Future research initiatives should promote transparency and the open dissemination of data and findings, facilitating a more collaborative and efficient research process. The establishment of open-access databases or repositories for herbal medicine research can facilitate accelerated progress and broader distribution of knowledge within the scientific community.

4 Conclusion

This bibliometric analysis yields significant insights into the present research landscape about herbal remedies for dengue. Despite substantial advancements in controlled studies and collaborative initiatives, notable deficiencies persist, especially in translating preclinical discoveries to human trials and diversifying research institutions and viewpoints. Enhancing international collaboration, prioritizing human-centered research, and intensifying public health initiatives would progress the field and facilitate the practical implementation of herbal medicines in global health.

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