Herbal and filariasis in Indonesia: a citation network analysis

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Abstract. This study examines the role of herbal medicine, deeply rooted in Indonesia's rich culture, as a potential solution for filariasis. The primary goal is to analyze the extent of herbal research related to filariasis through a citation network analysis of studies published in Scopus databases from 1980 to 2023. The study uses RStudio and the Bibliometrix package to assess publication trends, key contributing institutions, influential authors, and keyword patterns. One hundred eighteen documents have been published in 90 sources, with an annual growth rate of 5.95%, indicating a growing interest in herbal filariasis research. The average number of co-authors per document is 4.64, and 34.75% of the publications involve international collaboration, underscoring significant global involvement. Universitas Negeri Surabaya, Universitas Indonesia, and Universitas Gadjah Mada are leading the research efforts in this field, contributing notably to the body of knowledge. Prominent authors like Maizels RM, Djati MS, and Yazdanbach SH play a key role in shaping the academic discourse. The analysis of keyword co-occurrence reveals that "brugia malayi," "controlled study," and " extract" are central themes, reflecting a strong focus on preclinical research and the extraction procedures of plant-based treatments.

1 Introduction

Filariasis, especially lymphatic filariasis (LF), continues to pose a considerable public health concern in Indonesia, which is endemic in several locations. The ailment is chiefly induced by the parasitic nematodes *Wuchereria bancrofti* and *Brugia malayi*, conveyed via mosquito bites. According to the Ministry of Health of the Republic of Indonesia, 337 out of 401 districts/cities in Indonesia remain endemic for filariasis [1]. The transmission dynamics of filariasis are affected by several environmental conditions, such as temperature, humidity, and rainfall, which are associated with the occurrence of lymphatic filariasis cases [2]. Furthermore, human activities, including outdoor pursuits and the application of insect

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repellents, considerably influence exposure to mosquito vectors, thereby affecting transmission rates [2].

Herbal medicine, especially as "jamu," plays a crucial role in Indonesia's healthcare system, reflecting the country's rich cultural heritage and extensive biodiversity. Jamu, a traditional herbal treatment, has been utilized for generations and continues to be integral to the daily lives of several Indonesians. It is frequently used to address a range of health issues, from minor ailments to chronic diseases, and is esteemed for its possible therapeutic benefits [3-7]. Indonesia's extensive array of Indigenous medicinal plants, exceeding 5,000 species, enhances the prevalent utilization of herbal medicine, establishing the nation as a leading global producer of medicinal flora [8, 9].

Herbal medicine has been recognized as a potentially complementary approach to managing filariasis, particularly in regions like Indonesia, where the disease is endemic. Various studies have highlighted the efficacy of local plants in controlling mosquito vectors, which are crucial in transmitting lymphatic filariasis. For instance, research has shown that methanol extracts from plants such as Jatropha curcas and *Bacillus thuringiensis israelensis* exhibit promising larvicidal properties against Culex quinquefasciatus, a primary vector for filariasis [10]. This eco-friendly approach not only aids in vector control but also aligns with traditional practices that utilize local flora for medicinal purposes. Moreover, the antifilarial activity of certain plants has been documented, contributing to the exploration of herbal remedies as potential treatments for filariasis. For example, *Vitex negundo* has demonstrated significant anti-filarial effects in vitro, suggesting its potential as a natural therapeutic agent [11]. Such findings are crucial as they provide a basis for integrating herbal medicine into the broader strategy for filariasis management, particularly in areas where access to conventional pharmaceuticals may be limited. The use of herbal medicine is also supported by ethnobotanical surveys documenting traditional practices among communities affected by filariasis. These surveys reveal a wealth of knowledge regarding the application of various plants in treating symptoms associated with filariasis, such as lymphoedema and skin infections [12]. This traditional knowledge can be invaluable in developing culturally acceptable and effective treatment protocols incorporating modern and traditional medicine.

A Citation Network Analysis (bibliometric analysis) has emerged as a crucial instrument in medical research, enabling scientists to quantitatively assess and visualize the scientific literature landscape across diverse disciplines. This methodology employs statistical and mathematical approaches to analyze published works, providing insights into research trends, collaboration patterns, and the influence of particular studies or journals [13]. Through the systematic evaluation of extensive datasets, bibliometric analysis can identify prominent authors, institutions, and nations contributing to a topic, thereby elucidating worldwide research dynamics and focal regions [14].

In herbal medicine, bibliometric analysis is essential for tracking the evolution of research trends, illustrating the growing incorporation of ancient techniques into contemporary medical systems. It has demonstrated efficacy in monitoring the increase of literature concerning herbal remedies for many ailments, including chronic and infectious diseases like filariasis [10, 12]. This quantitative approach identifies significant research domains and uncovers knowledge gaps necessitating future investigation [15].

Moreover, bibliometric analysis offers essential insights into the quality and influence of research outputs, which are pivotal for informing financing and policy decisions in healthcare [16]. Researchers attain a greater comprehension of their work's significance within the broader scientific community by studying publishing indicators such as citation counts and journal impact factors [17]. As herbal medicine advances, employing bibliometric analysis will be essential in guiding future research trajectories and promoting collaborations that facilitate incorporating traditional knowledge into modern medical practice [18]. This study aims to examine the domain of herbal research and filariasis in Indonesia, focusing on critical

inquiries: I) What are the developments in herbal research concerning filariasis in Indonesia? II) Who are the principal authors and institutions contributing significantly? 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, demonstrating the methodical approach employed to discover and evaluate pertinent material about herbal therapies for filariasis. The workflow commences with the identification step, wherein a search is performed in the Scopus database utilizing keywords pertinent to filariasis and herbal medicines. The preliminary search results are filtered by language (English) and geographic focus (Indonesian) to guarantee relevancy. During the screening phase, the retrieved documents are evaluated for appropriateness, with specific publication types, including reviews, conference proceedings, and book chapters, being removed to enhance the selection process. After eliminating irrelevant documents, a conclusive set of articles is available for comprehensive bibliometric study. This methodology guarantees the inclusion of only publications closely associated with the study objectives, facilitating a thorough and concentrated examination. The figure distinctly delineates each phase, from topic selection to the ultimate quantity of documents preserved for examination.

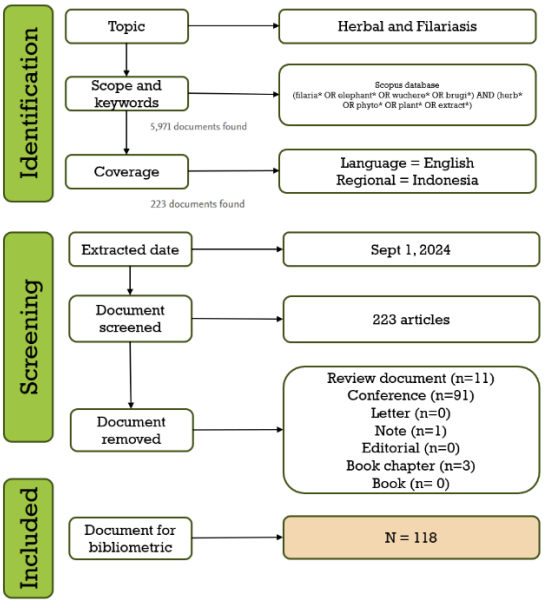

Fig. 1. Bibliometric workflow (adapted from PRISMA protocol)

2.2 Data analysis

The data analysis was performed using RStudio [19], augmented by Bibliometrics, a software package created by the Department of Economics and Statistics at the University of Naples Federico II, Italy [20]. This study meticulously examined publishing trends, emphasizing

critical elements such as contributing nations, authors, and collaborative networks among scholars in Indonesia.

3 Results and discussions

3.1 General information

Fig.2. provides a comprehensive summary of the bibliometric analysis, emphasizing essential indicators about publications on a particular research area from 1980 to 2023. The picture illustrates multiple components, such as the number of sources, documents, and contributing writers. The data indicates substantial international collaboration, with 34.75% of articles featuring cross-border co-authorship. This highlights the global significance and cooperative essence of research in this domain. The data indicates a consistent yearly growth rate of 5.95% in publications and an average of 4.64 co-authors per document, reflecting a dynamic and collaborative research environment. The chart displays the diversity of keywords utilized, with 486 different keywords discovered, facilitating the tracing of research trends and emphasizing significant areas of interest. The mean document age is 8.06 years, suggesting that a substantial proportion of publications is comparatively recent, aiding the field's continuous advancement. The mean citation count per document is 12.81, indicating the research's significant visibility and influence. The substantial rate of international co-authorship and a robust average of co-authors per publication suggests that research in this domain is highly collaborative and often transcends geographical boundaries. This global partnership highlights the significance and growing acknowledgment of the subject. The continual increase in publication volume underscores heightened academic interest, while the considerable citation rate further illustrates the research's importance within the scientific community. These measures signify a dynamic research environment that persistently generates valuable insights for the field.

Fig. 2. General information of bibliometric results.

3.2 Trend analysis

Fig.3. depicts the yearly scientific output in the domain, highlighting the trends in publication volume over time. The data reveals a progressive rise in scientific production in the late 1990s, succeeded by a significant surge post-2015. This increase indicates an expanding interest and intensified research efforts in the field. The line graph illustrates annual variations in publication numbers while indicating an overall upward trajectory over time. The graph demonstrates a notable increase in scientific productivity, especially over the past decade, signifying that the subject has garnered considerable attention. The growth rate of 5.95%, together with the outcomes of the Mann-Kendall and Pettitt tests, substantiates the increasing significance and emerging prominence of this research within the scientific

community. The significant increase in publications post-2015 may be ascribed to breakthroughs in the discipline or heightened global awareness of the subject. The current trend indicates that the research domain is poised for expansion, resulting in enhanced collaboration activities, augmented financing prospects, and forthcoming advances.

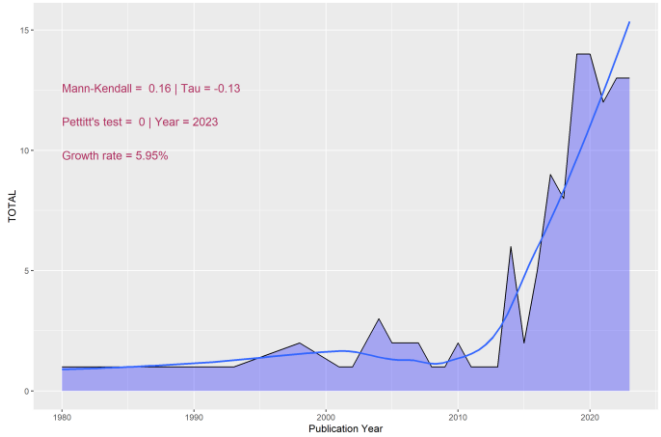

Fig. 3. Annual scientific production.

3.3 Author productivity analysis

Fig.4 illustrates the ten most prolific authors according to their aggregate and fractional publishing outputs in the discipline. The ranking is based on the quantity of documents each author has submitted, with fractional numbers indicating the extent of their contributions to joint research. The three authors highlighted in blue are distinguished for their significance in the scientific field, whereas the others, noted in gray, also make substantial contributions. This chart clearly illustrates individual contributions within the field. The existence of prolific authors suggests that a limited cohort of scholars significantly propels advancements in the discipline. The fractionalized scores underscore the collaborative essence of this research, indicating that leading authors are engaged considerably in cooperative endeavors. This trend of collaboration, especially among prominent authors, highlights the significance of teamwork in furthering knowledge in this field. The predominance of a limited number of principal contributors indicates a concentration of leadership or competence in specific areas of the study, potentially impacting the field's trajectory and policy-making decisions. Recognizing these principal contributors and their influence may yield significant insights for promoting future collaboration and enhancing research initiatives.

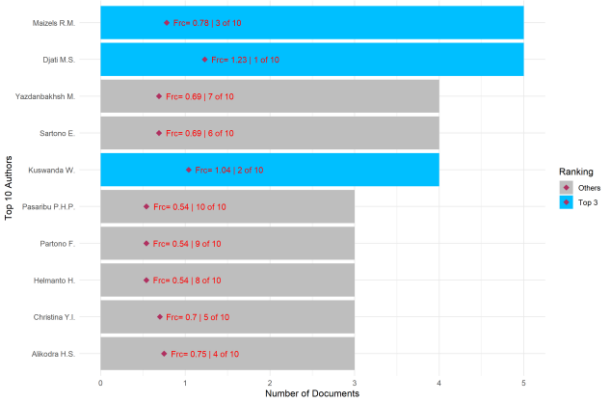

Fig. 4. The most productive authors (total and fractionalized publication).

Fig.5 illustrates the publication trends of the most prolific authors, depicting the annual number of articles produced and the citations earned by these authors. The diameter of the circles indicates the number of published papers, while the color intensity reflects the annual citation count. Authors with regular publications and elevated citation rates are readily discernible, highlighting their productivity and enduring influence. The figure illustrates the variety of research activities among leading contributors. Certain authors demonstrate sustained publication endeavors throughout numerous years, whereas others have suddenly attained notoriety. Some writers exhibit elevated citation rates, signifying that their work has garnered significant attention in the scientific community. This pattern of consistent contributions, particularly with elevated citation rates, illustrates the enduring impact of these authors on the discipline. The data indicates intervals of heightened research output, potentially aligning with improvements in the discipline or changes in research objectives. These oscillations offer insight into the evolution of research trends and the pivotal role of significant authors in instigating those changes. The image demonstrates the distinct influence of authors and the overarching changes in the research landscape.

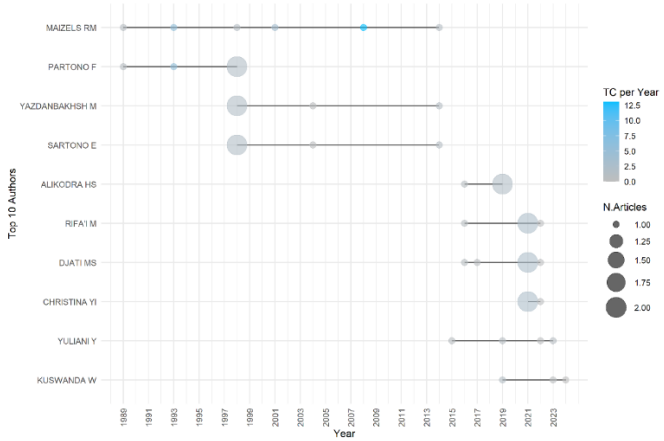

Fig. 5. The most productive authors over time.

3.4 Affiliation analysis

Fig.6 depicts the universities with the highest productivity, as determined by their total publications and citations. The three leading universities are emphasized, indicating their

significance in research productivity. Red diamonds represent the total citations of each university, providing a comparative analysis of their academic influence on their document count. The data indicates that some colleges, especially those ranked highest, have generated numerous publications and attained substantial citation metrics, signifying a significant impact in the discipline. This suggests that these institutions excel in producing considerable research. Institutions like Universitas Negeri Surabaya, Universitas Indonesia, and Universitas Gadjah Mada are pivotal in advancing knowledge in this domain through their prominence and impact. Conversely, several colleges with a limited number of publications still attain significant citation counts, indicating their research's high caliber or relevance. This underscores the significance of quantity and quality in scholarly output and the impact of institutional reputation and research emphasis on citations and influence.

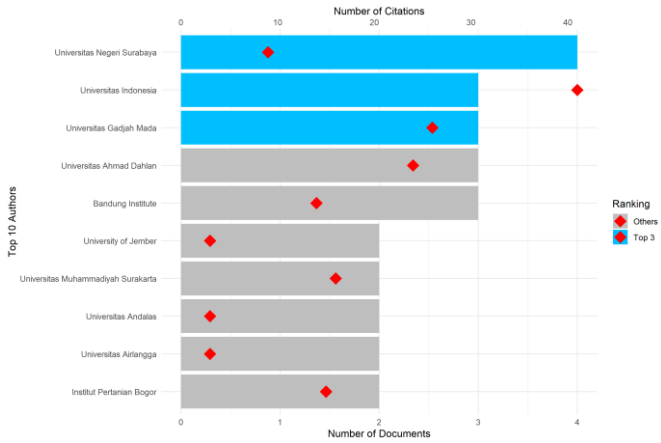

Fig. 6. The most productive university (total document and citation); red diamond represents total citations.

3.5 Structure analysis

Fig.6 illustrates a densely interwoven array of study themes about herbal therapies and filariasis. The key phrases, including "article," "human," and "controlled study," suggest that a significant portion of the research is on clinical studies with human participants. The concentrated aggregation of red nodes indicates that clinical trials and research into the efficacy of therapies for illnesses such as filariasis are primary areas of emphasis. The green cluster on the left, comprising phrases such as "plant extract" and "flavonoid," signifies another important study domain concerning the pharmacological properties and prospective applications of particular herbal substances. The correlation among these clusters indicates a link between herbal therapies and empirical research, illustrating the scientific endeavors to substantiate conventional herbal cures. The blue nodes labeled "Animalia" and "Elephantidae" indicate more specialized or potentially ecological investigations, which may be tangential to the primary emphasis on human clinical studies yet remain integral to the broader study network. This image indicates a comprehensive research initiative integrating clinical trials, pharmaceutical studies, and other pertinent domains.

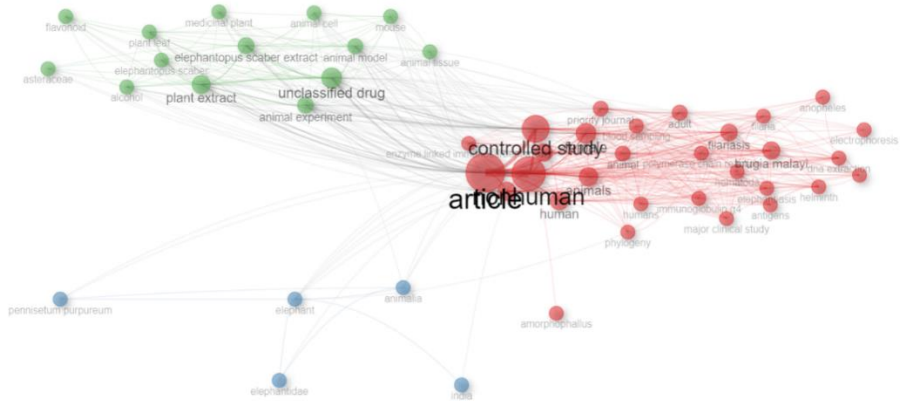

Fig. 7. Co-occurrence network of herbal and filariasis bibliometric.

The increase in research production, especially post-2015, can be attributed to the global health environment. Filariasis and similar diseases persist as endemic in numerous countries, especially in tropical and subtropical settings with restricted access to conventional care. Herbal remedies provide a more accessible and culturally endorsed alternative. The demand for economical, sustainable, and locally sourced medicines undoubtedly propels much of the research in this domain. Countries such as Indonesia confront ongoing difficulties with parasite infections, necessitating the urgent development of alternative, cost-effective therapies. The heightened focus on herbal remedies signifies the expanding worldwide acknowledgment of traditional medical systems. Entities like the World Health Organization (WHO) have underscored the incorporation of traditional medicine into national healthcare frameworks, particularly in nations where it constitutes a substantial component of healthcare practices [11, 12]. This support stimulates further academic investigation into herbal remedies, enhancing research productivity. The substantial degree of international collaboration (34.75% of documents have international co-authorship) indicates increased global focus—and potential funding—on neglected tropical illnesses such as filariasis. International research collaborations frequently address global funding initiatives or public health campaigns to combat diseases that disproportionately impact low-resource areas. The involvement of several nations and organizations in these initiatives enhances expertise and resources, hence expediting scientific advancement [21].

3.6 Limitations and future research directions

Notwithstanding this bibliometric analysis's promising trends and insights, many limitations must be recognized. The study predominantly depends on data from a singular source, thereby constraining the breadth of the research landscape represented. Databases such as Scopus, although extensive, may not encompass all pertinent studies, particularly those published in local journals or other regional databases. This may exclude substantial research contributions from non-English speaking or lesser-known publications. Furthermore, the focus on co-authorship and institutional output may distort the research impact assessment. Although the quantity of documents and levels of co-authorship serve as useful markers of collaboration, they do not inherently signify the quality or practical utility of the study outcomes. Certain extensively referenced studies may not immediately enhance clinical outcomes or public health initiatives. The dependence on citation counts advantages older publications, perhaps neglecting current yet significant works that have not yet garnered numerous citations. Furthermore, although useful for finding study patterns, the co-

occurrence network must comprehensively reflect the level of interactions between concepts. The phrase "controlled study" in conjunction with "plant extract" does not inherently signify successful clinical trial outcomes but indicates the frequency of their co-occurrence. This may provide a cursory comprehension of advancements in the therapeutic utilization of herbal therapies.To mitigate these restrictions and propel the field forward, other prospective research avenues may be contemplated: 1) Broadening the Database Parameters: Subsequent bibliometric studies ought to incorporate data from supplementary databases, including PubMed, Web of Science, and regional sources, to furnish a more exhaustive perspective of the research scene. This may assist in identifying geographically noteworthy studies that could have been overlooked owing to language or database limitations. Incorporating grey literature, including official papers and NGO studies, may yield insights into the practical applications of herbal remedies for filariasis. 2) Emphasizing Research Quality and Outcomes: Although this analysis highlights publication quantity and citations, subsequent studies should concentrate on assessing the quality and impact of the research. Metrics, including clinical trial success rates, the implementation of discoveries in endemic areas, and the long-term health outcomes of herbal medicines, should be evaluated to enhance understanding of how research translates into tangible benefits. Furthermore, emphasis should be placed on evaluating the reproducibility and scalability of promising herbal therapies across diverse demographic groups and settings. 3) Enhancing Connections Between Preclinical and Clinical Research: The co-occurrence network reveals a disparity between pharmacological investigations and clinical trials. Subsequent studies must concentrate on integrating these two domains, guaranteeing that encouraging outcomes from preclinical investigations (e.g., plant extracts exhibiting significant antibacterial efficacy) are methodically transitioned into clinical trials. Enhanced collaboration between pharmacologists and physicians will be crucial for translating laboratory discoveries into viable, evidence-based therapies for filariasis. 4) Long-Term and Preventive Research: Present investigations emphasize the treatment of existing infections. Nonetheless, there exists an opportunity to broaden research on the preventative efficacy of herbal treatments, particularly when integrated with public health initiatives such as vector control. Research investigating the potential of certain herbal compounds as prophylactics for filarial infections or their usage in conjunction with other treatments, such as mosquito repellents, may offer a more comprehensive strategy for addressing filariasis. 5) Examining Socio-Cultural Impacts and Acceptance: Given that herbal medicine is intricately woven into cultural traditions, the forthcoming study may investigate how socio-cultural elements affect the adoption and effectiveness of these therapies. Comprehending community perceptions and utilization of herbal treatments may inform more efficacious public health campaigns and interventions. Furthermore, a more profound exploration of traditional knowledge systems may reveal novel herbal remedies that require scientific investigation. 6) International Collaboration: While the data indicates substantial global cooperation, forthcoming studies should strive to encompass a broader array of nations, especially those where filariasis is endemic yet inadequately documented in scholarly literature. Enhancing research networks throughout Asia, Africa, and Latin America can promote increased information exchange and guarantee that discoveries are broadly relevant and culturally attuned to local requirements.

4 Conclusion

The bibliometric analysis reveals a growing and collaborative research environment surrounding herbal treatments for filariasis. While the progress is encouraging, particularly with the rise in international collaborations and clinical trials, the limitations suggest room for a more nuanced approach. Expanding the database scope, focusing on research outcomes, and strengthening links between different research stages will be crucial for the field's

continued development. Moreover, integrating socio-cultural understanding with scientific research can create holistic solutions to combat filariasis in endemic regions. The future holds promise, and with targeted research efforts, herbal treatments for filariasis could become more mainstream in global public health strategies.

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