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# Research Implication for Infectious Skin Disease and Phytotherapy in Developing Countries Based on 21st Century Bibliometric Trends

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***Abstract* — Dermatological infectious disease remains one of the least in terms of treatment consideration, especially in developing countries with high prevalence. Based on the World Health Organization initiative towards traditional and complementary medicine (WHA62.13); this study identifies the recent developments in scientific research and gaps in the search for affordable plant-based treatment to combat the threat of infectious skin diseases. Bibliometric methodology was adopted for this study. Relevant research documents were retrieved based on well structured query from the Scopus database. The study covered documents published between the periods 1 January 2001 to 22 November 2022. The preliminary query reviewed all document types and was subsequently limited to original research documents. Excel and VOSviewer were used for bibliometric analysis and visualization. A total of 7,908 articles were retrieved based on the original query input for citation information, with 5,917 being original research articles. The highest number of original research articles was recorded in India (15.28%), followed by the United States (13.81%) and China (9.90%). However, most developing countries in Africa still have lower levels of research output. The combined percentage of original articles published in the top three (3) Journal outlets is 8.26%. The latest 2000 articles identified an extensive 6,108 keywords, most centered on wound healing. The exponential rate of research publications reported in this study shows potential for growth and the need for specialization in this field of phytomedicine in treating skin infections. The results also provide useful information for funding bodies and international health agencies on promoting the international exchange of phytotherapeutic research knowledge, especially in poor developing communities in Africa. If implemented, this will help proffer solutions to the menace of skin infectious diseases reported in the primary health care system of these developing countries.**

***Keywords* — *skin disease, dermatology, phytomedicine, VOSviewer, bibliometric analysis, infectious disease***

## I. Introduction

Skin infections frequently occur secondary to cutaneous structural aberrations or an imbalance in skin microflora interactions [1,2]. Generally, dermatological infections can have a variety of etiological agents, including fungi, bacteria, viruses, and parasites. However, the incidence or prevalence of skin infections has been correlated with countries' economic indices, regional climatic conditions, cultural values, and personal hygiene [3–5]. The present overwhelming burden of microbial resistance to conventional drugs has given rise to intense research in seeking new potent antimicrobials. It is popularly known that the original discovery of most antimicrobials has been from natural sources, which are mostly secondary metabolites from other living organisms such as plants and other microorganisms - produced during competitive relationships [6–8]. The success recorded from the therapeutic use of plants in medieval times is justification for the continuous scientific search for novel antimicrobials from plant natural products [9,10].

Developing countries remain the epicenter for most primary skin infections, as skin diseases come among the top leading causes of nonfatal disease burden worldwide [11,12]. Populations in the tropical and subtropical region with hot and humid climatic conditions are predisposed to several skin diseases and also influences their distribution [13]. Children are the most affected by this clinical condition in these regions, largely due to epidemiological factors like poverty, poor hygiene, and overcrowding [3,14]. Clinical presentation of some skin diseases could include itching, rashes, swelling, pain, boils, skin colour change and structural deformation [15]. Cases of infectious skin-related diseases often reported in most grass-root primary health facilities include tinea infections, pediculosis capitis, scabies, pyoderma and onchodermatitis [16,17]. Nevertheless, based on the poor economic index of communities in these regions, most benign and asymptomatic cases in many patients could be unreported. Despite the global disease burden and the profound impact of infectious skin diseases, there appears to be a lack of commensurate attention globally [18]. Though more serious skin diseases like leprosy have received attention over time, yet a basic knowledge of the simple features for early diagnosis is often lacking at the primary care level [19]. The burden of other lethal diseases such as HIV/AIDS, community-acquired pneumonia, cancer and tuberculosis, seems to overshadow global health attention to skin infections, except in cases of viral skin diseases [20,21]. Nonetheless, the effect of skin infectious diseases related to acne and those secondary to surgical wounds that have negatively impacted the quality of life of people. The burden of these diseases is considerable and affects individuals across different geographical locations and socioeconomic backgrounds 22,23].

Despite the increasing popularity of organic products in skin care amidst claims that natural products have the potential for treating skin disorders [24,25], issues relating to their effectiveness in infectious skin disease treatment remain largely undermined. Reports on infectious skin diseases in developed countries are often related to secondary infections from surgical sites, wounds and incisions, which is still lower compared to the incidence in developing nations [26–28]. The potent conventional drugs available for the management of these skin diseases require clinical monitoring as they could result in nephrotoxicity among other side effects [29–31]. Furthermore, there are recent evidences on increased cases of resistance to antibiotics used for treating infections [32,33]. Whereas, in developing countries with a higher burden of primary skin infections, the relatively high cost of managing trivial skin complaints is a limiting factor for the treatment of patients [34]. Therefore**,** innovative research involving the use of easily accessible and cheaper effective treatment**,** sourced from plants is relevant in these communities for combating infectious skin diseases. Thus, several original research papers have been published on the treatment of skin infectious disease agents with plant metabolites [35–37]. However, there is limited information as to the impact of relevant research in countries with endemic primary skin infections diseases and the rest of the world. This study is aimed at utilizing bibliometric analysis in evaluating the impact of research in the field of infectious skin diseases and phytotherapy.

## II. Methods

### *A. Literature studies and query formulation*

To assess the relevance of phytotherapy in skin infection and disease treatment, a range of original research and review articles written in English literature was first evaluated. This included prevalence and distribution of primary and secondary skin infectious disease, *in-vitro* and *in-vivo* studies on the use of plant natural products as antimicrobials against skin infectious agents. Relevant keywords were developed during the process for query in the Scopus database. The Scopus abstract and citation database was utilized for this study; compared to other similar research journal repositories, Scopus has a larger collection of research articles and features documentation suitable for bibliometric analysis [38].

### *B. Database querying*

The search query developed and used for this study is: ("skin" OR "dermato*" OR "acne" OR "surgical$wound" OR "wound") AND ("pathogen*" OR "infection*" OR "fungi" OR "bacteria*" OR "virus" OR "parasite") AND ("treat*" OR "anti$microbial" OR "anti$bacteria" OR "anti$viral" OR "anti$parasite") AND ("plant" OR "leave*" OR "herb*" OR "tree" OR "seed" OR "flower" OR "bark" OR "essential oil" OR "plant$extract" OR "plant$metabolite"). To avoid the impact of database updates, all literature/publication search and data collecting was conducted on 22nd November 2022. An initial query of all English language document types found on the database from 1st January 2001 to the date of the query was retrieved for citation information including; author(s), documents title, year, source title, and citation count in CSV file format. Subsequently, the search was limited to original research documents and additional bibliographical information, abstract and keywords were extracted for the most recent 2000 articles in the last five (5) years for further bibliometric analysis and visualization.

### *C. Bibliometric analysis*

Retrieved data were viewed for preliminary screening using the spreadsheet software - Microsoft Excel. Documents not meeting the initial inclusion criteria for the study were eliminated and results of publication output were generated from the first query. Further analysis was carried out using VOSviewer (version 1.6.18) [39], which employs big data facilitating and visualization tools. The data from the second query, which was limited to original research published within the last five (5) years, was examined to identify trends and networks in research collaboration. Using co-occurrence networks, the author's keyword occurrences in various publications were also generated. Graphical representations of each network are presented in colour clusters. A flowchart of the process that was followed is summarized in Fig. 1.

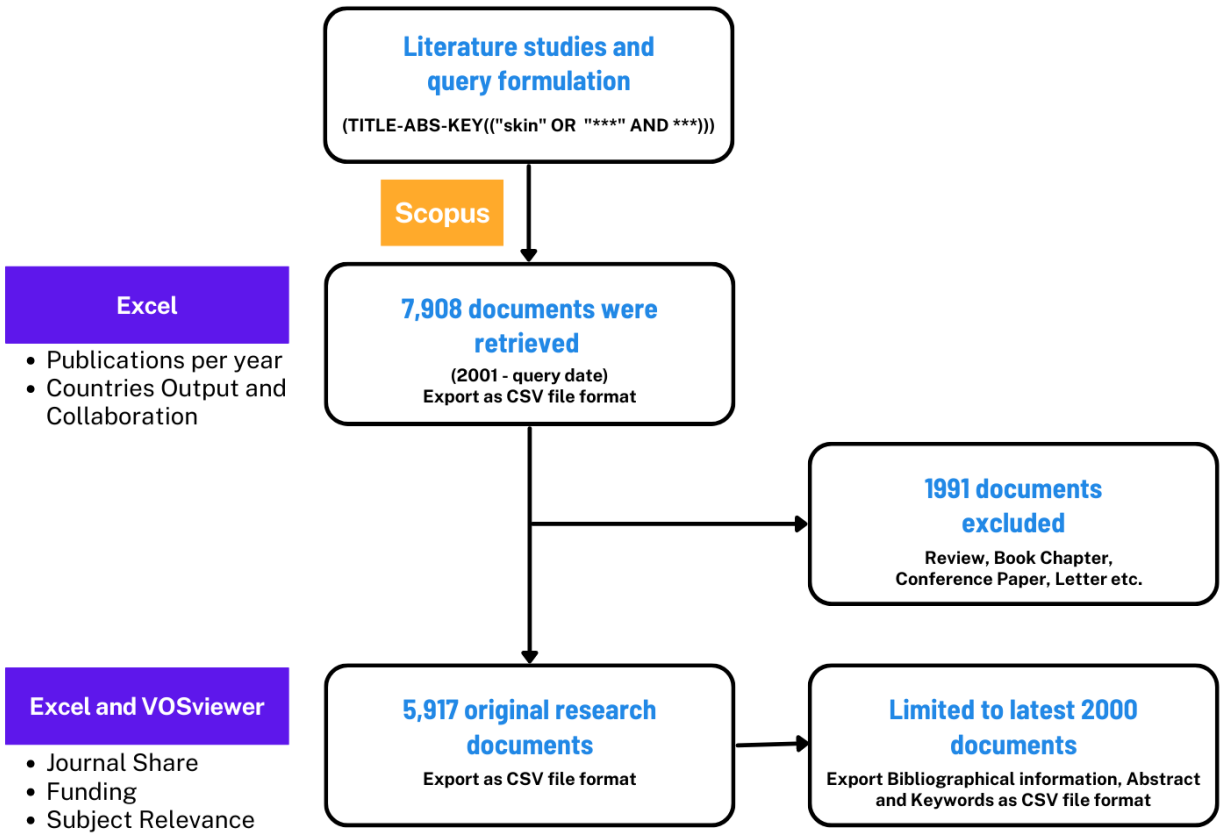


Fig. 1: Flowchart of bibliometric analysis - literature review, data collection and analysis

## III. Results

In this study, 7,908 documents were retrieved on 22nd November, 2022 from the Scopus collection database from 2001 on phytotherapy and skin diseases. The documents included 74.82% original research articles, 19.03% review papers and the remaining 6.15% were other forms of publications including book chapters, conference papers and letters as shown in Fig. 2 (A, B). There was an exponential increase in related publications output with original research articles rising from 53 in 2001 to 590 documents by 2021. In terms of subject relevance shown in Fig. 2 (C), 26.17% of original articles are related to "Medicine", 17.80% "Pharmacology, Toxicology and Pharmaceutics", 13.47% "Biochemistry, Genetics and Molecular Biology", 12.20% "Agricultural and Biological Sciences" and 6.93% "Immunology and Microbiology".

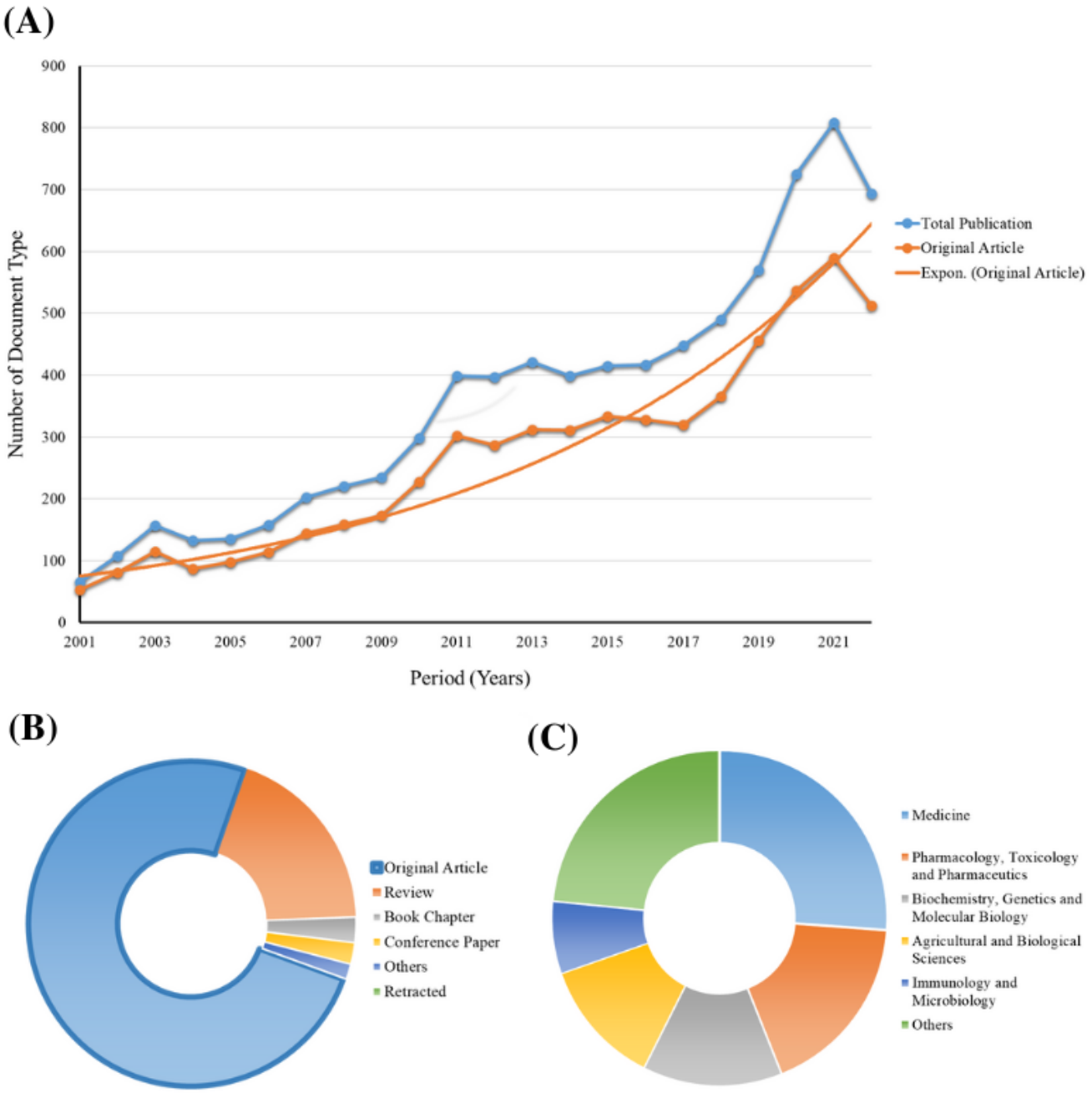


Figure 2: (A) Rate of publication per year with original article exponential trendline (B) Share of document type (C) Share of original article publication based on subject relevance

The Journal of Ethnopharmacology (n = 346), Molecules (n = 73), and Evidence Based Complementary and Alternative Medicine (n = 70) were the top three (3) journals outlet with cumulative 8.26% in the share of original articles published (Table 1).

TABLE I. TOP 12 JOURNALS IN DERMATOLOGICAL RESEARCH AND PLANT NATURAL PRODUCT BASED TREATMENT

| Journal | Studies (n) | CiteScore | SJR | SNIP |
|---|---|---|---|---|
| Journal of Ethnopharmacology | 346 | 6.9 | 0.801 | 1.578 |
| Molecules | 73 | 5.9 | 0.705 | 1.267 |
| Evidence Based Complementary and Alternative Medicine | 70 | 3.2 | 0.461 | 0.901 |
| BMC Complementary and Alternative Medicine (BMC Complementary Medicine and Therapies) | 65 | 6.2 | 0.674 | 1.471 |
| Plant Disease | 53 | 4.0 | 0.654 | 1.234 |
| PloS One | 49 | 5.6 | 0.852 | 1.368 |
| South African Journal of Botany | 44 | 4.3 | 0.479 | 0.997 |
| *American Eurasian Journal of Sustainable Agriculture | 38 | N/A | 0.125 | 0.781 |
| Biomedicine and Pharmacotherapy | 38 | 11.6 | 1.194 | 1.517 |
| Phytomedicine | 35 | 9.6 | 0.981 | 1.549 |
| Phytotherapy Research | 35 | 9.3 | 1.046 | 1.732 |
| Pharmaceutical Biology | 30 | 4.8 | 0.663 | 1.175 |

CiteScore, SCImago Journal Rank(SJR) and Source Normalized Impact per Paper (SNIP) were for 2021 and retrieves from the Scopus database; * coverage discontinued in 2017 by Scopus; N/A – not assigned

Fig. 3 shows research output based on country contribution. India has the high turnover in the amount of published original research in respect to Infectious Skin Disease and Phytotherapy, this amount to a total of 904 documents of the 5,917 original research articles, followed by the United States (n=817), China (n=586), Brazil (n=351) and Iran (n=287). The collaboration network between countries shows that the strongest research co-authorship in this field was between China and the United State.

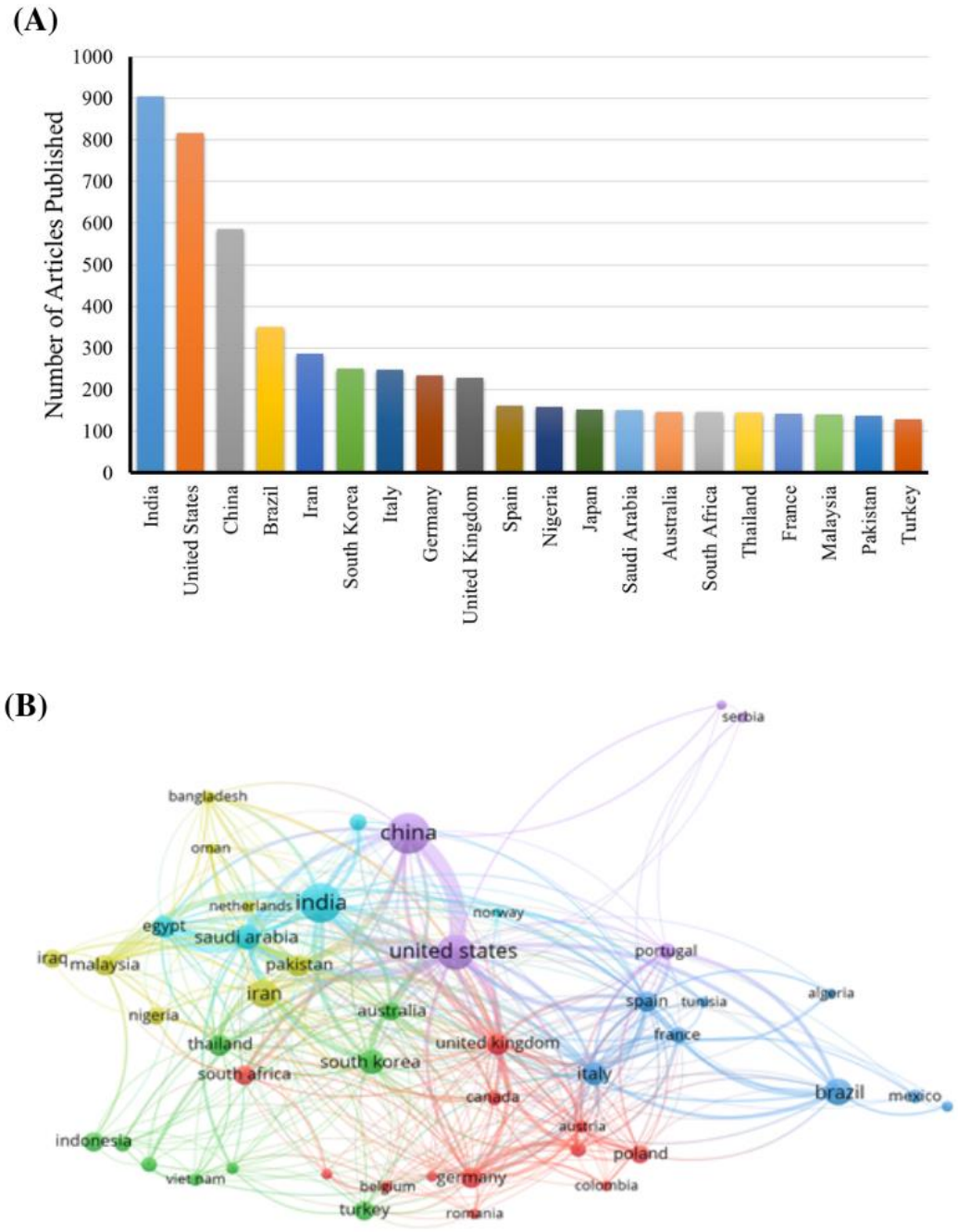


Figure 3: Global trends in Country's research output for (A) publication and (B) collaboration

The list of top 15 institutions funding research in Skin Infections Disease and Phytotherapy is shown in Table 2. Four (4) of these institutes are in India, while Brazil and the United States had 3 institutions each that have funded research in this area of study. However, the National Natural Science Foundation of China has the highest number of articles (n = 213) supported by funding institutions.

TABLE II. TOP 15 FUNDING BODIES THAT PROVIDED FUNDING FOR SKIN INFECTIONS DISEASE AND PHYTOTHERAPY

| **Funding Body** | **Articles (n)** | **Country** |
|---|---|---|
| National Natural Science Foundation of China | 213 | China |
| Conselho Nacional de Desenvolvimento Científico e Tecnológico | 135 | Brazil |
| Coordenação de Aperfeiçoamento de Pessoal de Nível Superior | 118 | Brazil |
| National Institutes of Health | 71 | United States |
| National Research Foundation of Korea | 60 | South Korea |
| Department of Science and Technology, Ministry of Science and Technology, India | 46 | India |
| National Research Foundation | 43 | South Africa |
| National Key Research and Development Program of China | 39 | China |
| Japan Society for the Promotion of Science | 38 | Japan |
| Fundação de Amparo à Pesquisa do Estado de São Paulo | 37 | Brazil |
| University Grants Commission | 32 | India |
| National Institute of Allergy and Infectious Diseases | 29 | United States |
| Council of Scientific and Industrial Research, India | 28 | India |
| Fundação para a Ciência e a Tecnologia | 28 | Portugal |
| Consejo Nacional de Ciencia y Tecnología | 24 | Mexico |
| European Regional Development Fund | 24 | Europe |
| National Science Foundation | 24 | United States |
| Department of Biotechnology, Ministry of Science and Technology, India | 22 | India |
| Ministry of Science, ICT and Future Planning | 22 | South Korea |
| Ministry of Science and Technology, Taiwan | 21 | Taiwan |

The analysis of the keyword frequency used by authors is shown in Fig. 4. Close co-occurrence is indicated by similar colours, and the nodes' sizes in the networks represent the items' total link strengths. A total of 6,108 keywords were identified, with wound healing having the highest number of occurrences (n=159), antibacterial, antimicrobial, essential oils and antioxidant following successively n = 80, 78, 75 and 62 in order of author's keyword use. *Staphylococcus aureus* was high in the frequency of hotspot test microbial isolates followed by *Candida albicans* and *Pseudomonas aeruginosa*.

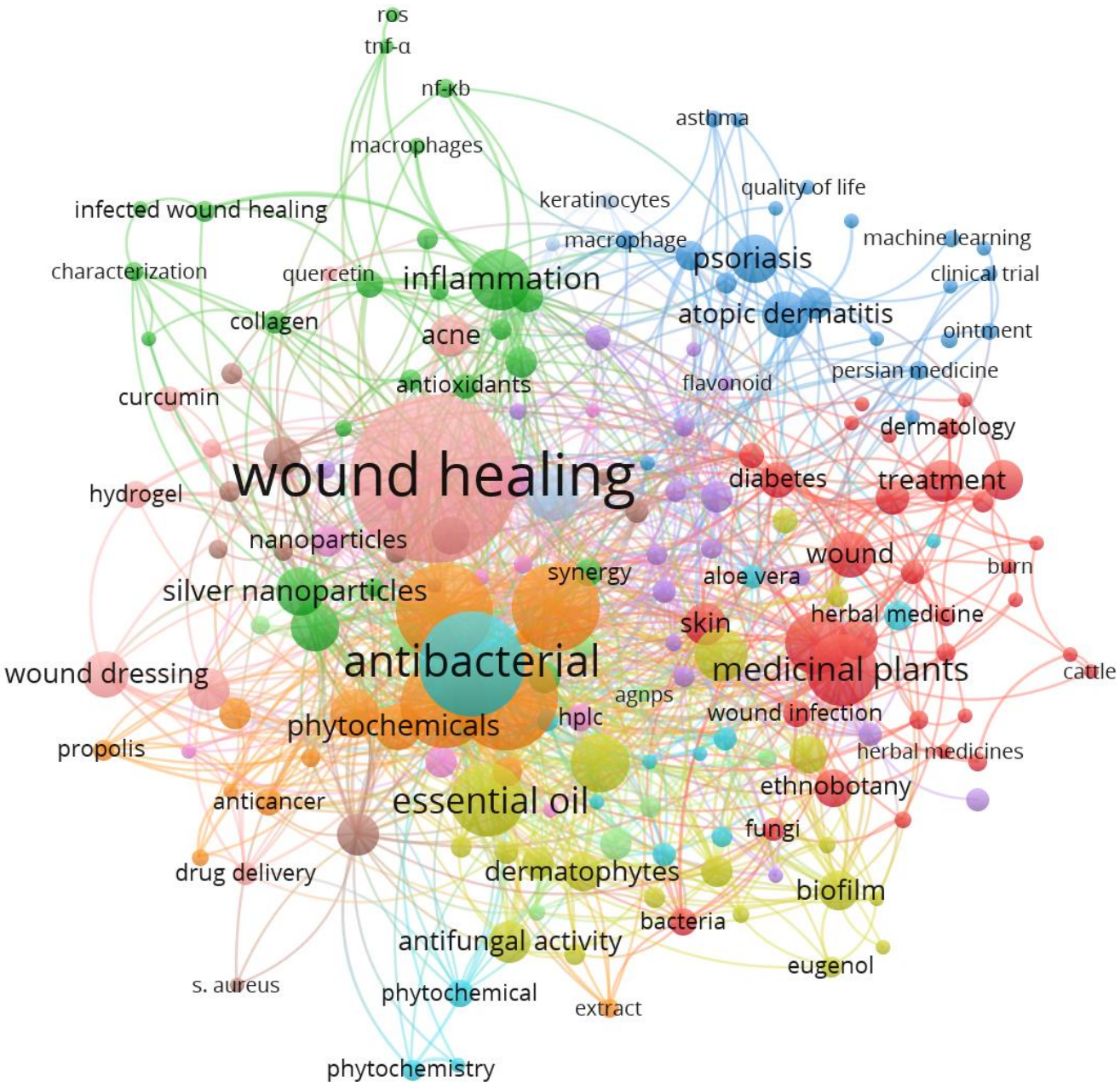


Figure 4: Author's keywords trend for the past five years

## IV. Discussion

The use of computational methods has become an integral part of research in all fields. In keeping with the large information and publication records in recent years, novel tools such as Bibliometric analysis among others [40] have aided in huge data summaries, identifying trends and research gaps. In this study, the amount of documents generated in the field of phytotherapy and skin infectious disease show a significant amount of research output, which will be burdensome to study and create summaries utilizing traditional literature review reports. Likewise, this Bibliometric method aided in streamlining article focus to original research rather than a review of other review articles. The exponential rate of research publications reported in this study shows the potential for growth and the need for specialization in this field of phytomedicine. Based on this bibliometric study, the quality of each research article is

difficult to access. The top research journals accessed are of high research impact in the field of Pharmacotherapy and Complementary medicine (Table 1). Specifically, prior studies have identified the Journal of Ethnopharmacology as having a high-impact publication output, especially in complementary medicine and phytotherapy [41,42]. Discussion on the subject matter shows that a significant amount of work done in Phytotherapy is in Medicine, Pharmacology and Drug discovery. Phytotherapy remains an integral part of complementary medicine, which has subsequently influenced the progress in allopathic medicine [43,44].

Research focus in countries often varies based on local needs for development, politics and international relations. The study sufficiently captures the research contribution from developing countries, thereby justifying the consideration of the study. While the turnover rate of research might not equate to an impact on societal issues, the quantitative analysis reflects awareness and high consideration for research implementation. In this study, of the top 5 countries that have made substantial contributions to this field of phytomedicine and skin infectious disease research, India and China are known key players due to renowned cultural influences [45]. The United States is largely a significant partner with these other countries. Brazil in South America is known for its plant diversity and this could have as well translated to the focus on the area of phytomedicine research [46–48]. Of the four countries earlier mentioned, a key part of their research has been the contribution of research funding institutions (Table 2). This is in sharp contrast to African developing countries, only South Africa's National Research Foundation has been a funding partner. Interestingly, Nigeria in Western Africa is reported as 11th in research output regardless of little to no funding partnership within the country. So far, no data (positive or negative) or report is made on these countries until now; considering the focus of this study. It should be noted that the burden of primary skin infections and diseases is higher in these low and middle income developing countries. And compared to western developed countries, the medical facilities and healthcare framework of developing countries are still relatively lagging behind [49,50]. Therefore in order to achieve the sustainable development goal (SDG 3) relating to good health and well-being, there is a need for international assistance and collaboration from upper and middle income countries (SDG 17).

Based on the analysis of the author's keyword, "wound healing" takes the central focus on the use of plant-based complementary treatment for infectious skin disease research (Fig. 5). The global burden of infectious skin disease is closely associated with injuries. Nevertheless, across different traditional cultures, people have employed the use of plant parts, especially herbs to treat cuts, wounds, and burns [51]. Complications are known to arise from some other diseases such as diabetes which predispose to lethal infection such as in non-healing wounds [52]. Studies have shown that medicinal plants improve wound healing in diabetic, infected and opened wounds [53]. However, new knowledge has shown the possibility of skin pathogens employing evasive methods such as the formation of biofilms [54,55]. Some of these phytochemicals have been reported to work in synergy with standard antibiotics [56]. Some present widely studied subjects in the use of phytochemicals are leveraging modern optimization techniques, such as green synthesis of nanoparticles. Green synthesized nanoparticles could employ diverse mechanisms, such as improving collagen deposition, increasing fibroblasts and fibrocytes during wound healing, while inhibiting microbial pathogenesis [57,58]. The identification of this trend can be beneficial for researchers in designing future studies. Considering the potential of phytotherapy in health care and the WHO Traditional Medicine Strategy promotion, there is immense opportunity for research scientists to improve traditional medical practices to manage illnesses in local communities [59–62]. Infectious skin plant-based treatment provides a low barrier to the implementation of experimental research outputs and products in addressing the health concerns of developing communities.

*Limitations*

Due to the bibliometric approach to this study, the quality of the publications was not considered, and all documents were treated equally regardless of their research impact. This may hamper the comprehensive inference of our analysis and the features of visualization. Likewise, of the 5,877 publications in original research articles reported in this study, there is no significant networking of co-authorship, co-citation and bibliographic coupling. This gives the notion that this field of research remains a passive subsect of phytomedicine research, as no research group has specialization on the subject of plant-based treatment of skin infections. The selection of only English articles may have introduced a language bias, and may therefore have impact on the result of analysis.

## V. Conclusion

In summary, this study identified a specific area of research within phytomedicine, namely the treatment of skin infectious diseases, that requires specialization and attention. Developing countries remain top contributors in the field of phytotherapy in the treatment of skin infectious diseases. However, there is a lack of funding and strong collaboration for researchers in low and middle income countries, where primary infectious skin disease are endemic. The significant research contribution by developing countries in this field of research shows that the WHO (WHA62.13) initiative towards T&CM gained attention. As the 2014 -2023 strategy is coming to an end, this study will assist in appraising the impact of research in review for the next T&CM initiative.

Besides the aforementioned limitation, the literature-based visual analysis offers an updated standpoint on phytotherapy in skin infection and serves as a basis for scholars to understand the research overview, hotspots, and trends. With the use of emerging techniques, there is opportunity for researchers and research teams to specialize investigating the use of natural product from plant in treatment of skin infectious disease. Other researchers may find it useful to conduct similar analysis in Phytotherapy in respect to their medical field of diseases treatment in primary health care and to promote innovation/collaboration.

This study is novel in its use of bibliometric investigation of Phytomedicine to a specific infectious disease condition, viz Skin infection. We envisage that future research will validate the quantitative trends reported in this study. Therefore, a need for research scholars and groups to collaborate, and extend the horizon of emerging technologies in plant bioactivity for dermatological treatment. The results in this study will remain useful for funding agencies, donors, and other international health agencies interested in promoting healthcare among poor developing countries.

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