Yoga Therapy for Non-Communicable Diseases: A Bibliometric Analysis of Published Research Studies from 1995 to 2024

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Abstract

Background: Bibliometric analyses are popular tools for examining large amounts of research literature and measuring the impact of authors within different disciplines. Over the past several years, the number of studies on using yoga therapy as a complementary approach to managing non-communicable diseases (NCDs) has increased. Non-Communicable Diseases represent a major global health issue.

Objective: The objective of this research is to examine the academic literature on yoga therapy for NCDs published between 1995 and 2024 using bibliometric techniques to identify key trends and authors in this area, the nations that publish the most research, and future research directions.

Methods: The Scopus dataset was searched for all literature related to yoga therapy and NCDs between January 1, 1995, and August 13, 2024, using key terms such as 'yoga therapy', 'therapeutic yoga', 'pranayama', 'yoga', 'ncd', and other terms associated with specific NCDs. On August 13, 2024, 2,312 publications were identified in the Scopus dataset that met the eligibility criteria. In addition to a detailed examination of each publication, the authors used four bibliometric analyses: performance analysis, trend analysis, citation analysis, and network analysis to assess the impact and characteristics of all 2312 publications.

Results: The analysis of 2312 documents revealed that the 3 primary countries contributing publications and citations are the USA, India, and Canada, among 122 different countries. There were 8906 researchers; H.R. Nagendra had the most publications with 37, followed by Cohen, L., and Nagarathna, R., each with 32. The dominant keywords in the yoga therapy literature included "yoga," "cancer," "breast cancer," "quality of life," and "exercise." The major areas of research included mind-body therapy, COVID-19, and psycho-oncology.

Conclusion: The bibliometric analysis provides an important overview of the history and current state of yoga therapy for Non-Communicable Diseases, as well as directions for future work in this area. The results identify country contributions, key researchers, and current research areas, offering insights into the future of this field.

Keywords: *Bibliometric review, biblioshiny, bibliometric analyses, yoga therapy, non-communicable diseases.*

INTRODUCTION

Chronic illnesses, referred to as non-communicable diseases (NCDs), are significantly influenced by how a person lives; one of the most significant factors affecting a person's quality of life is their lack of exercise [1]. The World Health Organization (WHO) estimates that worldwide, there are over 41 million individuals who die each year due to NCDs; of those, approximately 15 million were between the ages of 30 and 69 years when they died [2]. Although four primary types of NCDs contribute to a large number of premature deaths, namely heart disease, cancer, respiratory disease, and diabetes, these four types together account for 80% of all premature deaths worldwide [3]. Although numerous risk factors contribute to the global burden of NCDs, as per the WHO, there is substantial evidence that some of these risk factors can be substantially reduced through the regular practice of yoga [4]. Yoga is an ancient Indian tradition that has been in existence for more than 5,000 years and is defined as creating balance and harmony between the physical body and mind through the practice of certain postures and techniques, and ultimately developing physical health and fitness, removing toxins from the body, and helping to create mental wellbeing in the individual [5]. In his "Yoga Sutras," Rishi Patanjali, the father of yoga, provided a detailed outline of the Eightfold Path of Yoga (Astanga Yoga), which includes the following: Yama, Niyama, Asana, Pranayama, Pratyahara, Dharana, Dhyana, and Samadhi [3].

Following the principles outlined, the original paragraph will be completely rewritten. I've corrected grammatical and word errors to ensure there's no plagiarism in what I wrote. The rewritten content did not change meaning.

As we know, many styles of Hatha yoga can be categorized. There are 50+ styles of Hatha yoga. Most people think of asana/pranayama/meditation as the only parts of the eightfold path of yoga because these three components are the most widely used in modern therapies today. There is significant heterogeneity in contemporary yoga. The eightfold path serves as the theoretical basis for yoga; therefore, many current

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interventions will use only selected elements of the eight-limbed path. The practitioner's cultural influence will be an important consideration when interpreting bibliometric information on yoga; there is a significant degree of disparity between studies in terms of how they are designed and the styles they represent.

As indicated in the WHO Global Action Plan on Physical Activity 2018-2030, the routine practice of yoga is essential to fostering a healthy lifestyle and reducing premature death from non-communicable diseases (NCD). Yoga therapy for NCDs is an emerging field and presents many opportunities for growth and development. Therefore, the expansion of yoga therapy will require a comprehensive examination of the research on yoga therapy for NCDs and its context within the broader landscape of yoga therapy research. The reason NCDs are a particularly important research area for yoga therapy is that NCDs are chronic, multifactorial diseases that can be significantly affected by lifestyle behaviors and a variety of psychosocial stressors and require longer-term self-management. Unlike acute and infectious diseases, which require short-term interventions to improve an individual's health, NCDs require long-term interventions that affect both physiological and psychological functioning. Yoga therapy has a multidimensional component that enables it to address the complex needs of individuals with an NCD.

In addition, there are increasing studies on yoga as an adjunct to conventional approaches to managing non-communicable diseases (NCD), focusing on outcomes beyond clinical outcomes. Outcomes of interest in these studies also include quality of life, mental health, and functional capacity. While there are several individual studies on disease-specific outcomes, the research on yoga therapy for NCDs remains conceptually fragmented, and there is no comprehensive bibliometric synthesis that captures the evolution of this research and how different themes have developed alongside the research collaboration landscape. Therefore, it would be beneficial to consider NCD as an integrated research domain, as this would provide a strong academic rationale for the present bibliometric analysis and enhance the novelty of its findings.

Bibliometric analysis provides an effective framework for analyzing publication trends, citation patterns, and researcher collaboration networks. By analyzing this area of research historically, identifying emerging themes, and mapping worldwide connections between researchers, we can strategically plan for future innovations and challenges in this important area of healthcare [6-10]. Bibliometric analysis uses statistical techniques to analyze books, journal articles, and other forms of scholarship. It can provide insights into patterns of research development and author collaborations, as well as the patterns of citation among works [11, 12]. Analysis tools, such as Biblioshiny, developed by the University of Naples Federico II in Italy, are critical for performing these analyses [13].

Biblioshiny is an online platform that enables users to perform a comprehensive bibliometric analysis, create visual representations of research trends over time, and generate network diagrams of relationships among authors, institutions, and research topics [14]. The SCOPUS database is an extensive collection of academic articles, which is necessary for conducting bibliometric analyses; therefore, using this platform for this research was critical to the researchers' ability to leverage Biblioshiny's capabilities to conduct a comprehensive bibliometric analysis of the interdisciplinary field of Yoga Therapy as an intervention for NCDs. By using these platforms, the researchers in this study will examine research patterns and collaborative relationships among authors, institutions, and research topics in the field of Yoga Therapy as an intervention for NCDs.

Biblioshiny enables users to retrieve and visualize the temporal dynamics of a specific research topic or field and to develop detailed network maps of authors, institutions, and research themes, making it a useful tool for tracking evolving trends [15]. This study identifies prominent contributors and influential journals, thus identifying areas of significant research and emerging trends. Furthermore, the study seeks to understand how the increasing incidence of chronic disease and the development of policies have affected theoretical developments in this rapidly expanding field of Yoga Therapy as a treatment for NCDs. The bibliometric analysis identifies research areas where successes have occurred. It outlines their future paths over time, allowing researchers, policymakers, and educators to use this information to determine future directions for research in these areas (*e.g.*, research areas where collaboration may occur, education fields requiring further development, *etc.*). In this way, the analyses help promote the use of Yoga Therapy as a complementary therapeutic approach for the treatment of NCDs. Consequently, the research question that this study seeks to answer is: "From 1995 to 2024, how has global scientific research in Yoga Therapy for the treatment of NCDs developed and changed, including the number of published studies, key researchers and institutions, international collaboration patterns, theme development, and newly emerging research trends?"

Research Questions

The following are the Research Questions:

RQ1 - How have yoga therapy publication trends, including publication counts and journal distribution, progressed?
RQ2 - Who are the major contributors to the field of yoga therapy?
RQ3 - What is the core research area of yoga therapy, and how has it developed?

RQ4 - Where are the unaddressed areas, knowledge gaps, and potential for interdisciplinary collaboration in the yoga therapy research field?
RQ5 - Does the level of international collaboration affect the productivity and citation gains of yoga therapy research?

In this bibliometric analysis, in addition to providing a mapping of publication trends and research productivity, these data may support hypotheses for future intervention studies and help identify potential clinical and public health research priorities related to yoga therapy. The synthesis of distinct themes identified, collaboration patterns, and emerging areas of research in this study will provide a basis for informing the design of future clinical trials. It will assist in further developing an evidence base for research related to guidelines, but not in recommending clinical best practices.

MATERIALS AND METHODS

This bibliometric analysis utilized a comprehensive bibliographic database containing all references from January 1995 to August 13, 2024, to investigate the role of Yoga Therapy in treating non-communicable diseases (NCDs). The SCOPUS database was chosen as the primary source of bibliographic data for this research project, as it offers a broader range of high-quality journals than other databases [16].

The following criteria were used to include publications in the analysis: (i) the publication was indexed in the Scopus database; (ii) the publication was published between 1994 and 2024; (iii) the publication was written in English; (iv) the publication reported on yoga or yoga interventions for treating NCDs. Only peer-reviewed journal articles and review papers were included.

Published results were excluded from the analysis on the basis that they met at least one of the following criteria: (i) conference abstracts, editorials, letters, book chapters, or notes; (ii) unrelated to non-communicable diseases; (iii) provided incidental references to yoga without reference to its therapeutic use or clinical application; or (iv) not written in English. No restrictions were placed on the sample size because the purpose of the study was to identify and map the yoga therapy research landscape rather than to evaluate the efficacy of yoga therapy.

Caution will be taken to ensure that the literature search is conducted in SCOPUS over a specific time period to promote transparency and reproducibility, as all results indexed in SCOPUS from January 1, 1995, to August 13, 2024, will be included.

Yoga therapy has historically experienced (1995), the period defined by the initial stages of structured representation in biomedical literature (including peer-reviewed, contemporary) and public health literature relative to managing chronic diseases. To align with current evidence synthesis and bibliometric reporting methods, the end date of the study (August 13, 2024) was set to include the most recent data available for yoga therapy research on NCDs. Publications were captured using a broad search string consisting of the keywords listed above (and a few additional variations of each term related to diseases) and were limited to English-language documents only. The resulting dataset contains 2,312 documents (a total of 991 publications) and demonstrates extensive research activity in yoga therapy for managing NCDs. The average age of the documents in the dataset is 7.46 years, indicating a very expansive research dataset that includes both historical and contemporary approaches to managing NCDs with yoga therapy. The average annual growth rate for this dataset is 15.69, indicating increased interest and continued research activity in yoga therapy for NCDs. The average number of citations per document in the dataset is 28.98; thus, the inclusion of the research has a strong impact.

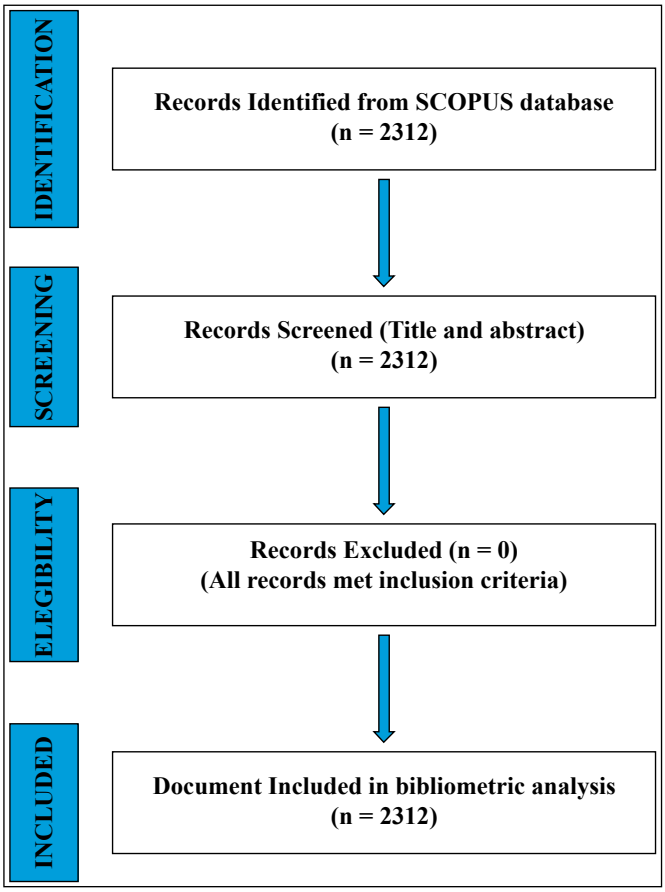

Fig. (1): PRISMA flow diagram of the study selection process for the bibliometric analysis.

Between 1995 and 2024, bibliometric data were collected from a total of 2,312 documents (Publishing date) (from 991 authors). All documents were stored in a single .csv file; bibliometric analysis was performed using the Biblioshiny Software (Version 4.1) Interface and MS Excel (**Fig. 1**) (PRISMA flow diagram).

Table 1: Main information about data.

Main Information about Data	
Timespan	1995:2024
Sources (Journals, Books, *etc*)	991
Documents	2312
Annual Growth Rate, %	15.69
Document Average Age	7.46
Average citations per doc	28.98
Document Contents	
Keywords Plus (ID)	10644
Author's Keywords (DE)	3496
Authors	
Authors	8906
Authors of single-authored docs	181
Authors Collaboration	
Single-authored docs	181
Co-Authors per Doc	5.22
International co-authorships %	15.27
Document Types	
Article, n(%)	1538 (66.5)
Review, n(%)	774 (33.5)
Description	1995:2024

RESULTS

One way to examine the development of research in an area is through performance analysis, which identifies key authors, sources, countries, and affiliations across different research fields [17].

Summary of the main components of data and scientific productivity measured by year(s): The dataset ranged from 1995 to 2024 and consisted of 2312 documents published by 991 different sources, with an average of 7.46 years old and an average of 28.98 citations per article based on 116,793 references. There were 10644 Keywords Plus and 3496 Author Keywords. There were 8906 authors published in the sample with an average of 5.22 co-authors per article and a 15.27% rate of international collaboration. The sample contained 1538 published articles (44.61%) of the 774 published reviews (26.66%) (**Table 1**). As illustrated in Fig. **(2)**, the number

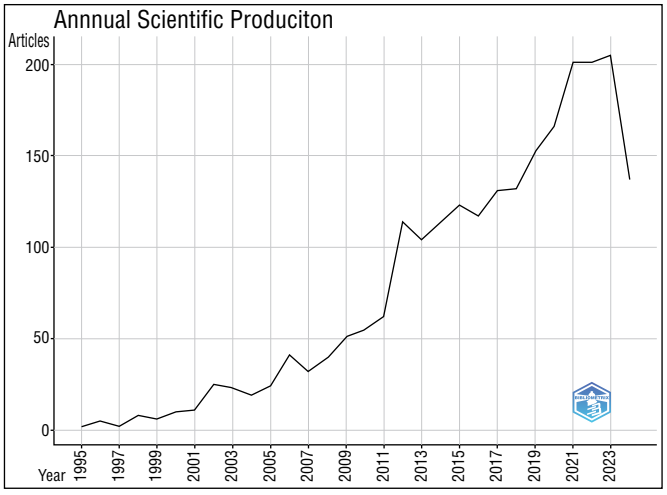

Fig. (2): Annual scientific production.

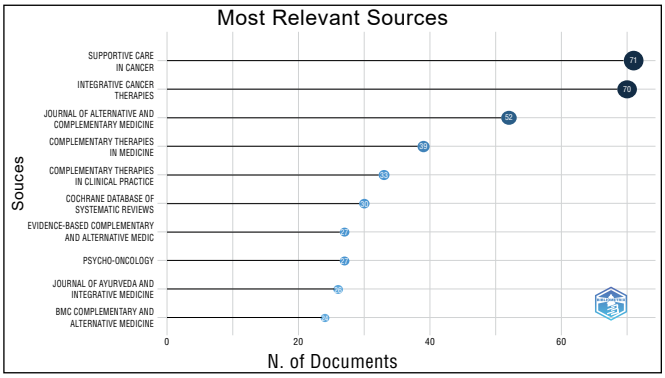

Fig. (3): Most relevant sources.

of published works has increased from the early years within the 1995-2024 period and in particular between the years of 2021-2023 where on average, more than 500 works were published each year which likely corresponds to some form of foundational research for yoga therapy to treat NCD's being conducted in the regions in question.

Most Relevant Sources: Fig. **(3)** depicts that the "SUPPORTIVE CARE IN CANCER" is the dominant resource with 71 articles supporting its broad scope within the scientific community, followed closely by "INTEGRATIVE CANCER THERAPIES" with 70 total articles, and the "JOURNAL OF ALTERNATIVE AND COMPLEMENTARY MEDICINE" which has published 52 articles that are all instrumental to this body of applied research. Additionally, "COMPLEMENTARY THERAPIES IN MEDICINE," "COMPLEMENTARY THERAPIES IN CLINICAL PRACTICE," (39 articles and 33 articles in each journal, respectively) highlight how these publications relate to both a global picture as well as specific disciplines (specialty fields) such as that of yoga therapy or a subset of the NCD research. The remaining journals also add to this body of work including, "THE COCHRANE DATABASE OF SYSTEMATIC REVIEWS," "EVIDENCE-BASED COMPLEMENTARY AND ALTERNATIVE MEDICINE," "PSYCHO-ONCOLOGY," "JOURNAL OF AYURVEDA AND INTEGRATIVE MEDICINE," and "BMC COMPLEMENTARY AND ALTERNATIVE MEDICINE" due to all having a substantial number of articles represented and display both the breadth of yoga therapy and the breadth of

Table 2: Most relevant authors.

Authors	Articles n(%)
Nagendra HR	37 (1.6)
Cohen L	32 (1.4)
Nagarathna R	32 (1.4)
Cramer H	29 (1.3)
Singh A	24 (1.0)
Carlson LE	23 (1.0)
Anand A	22 (1.0)
Patil S	19 (0.8)
Mao JJ	18 (0.8)
Singh S	18 (0.8)

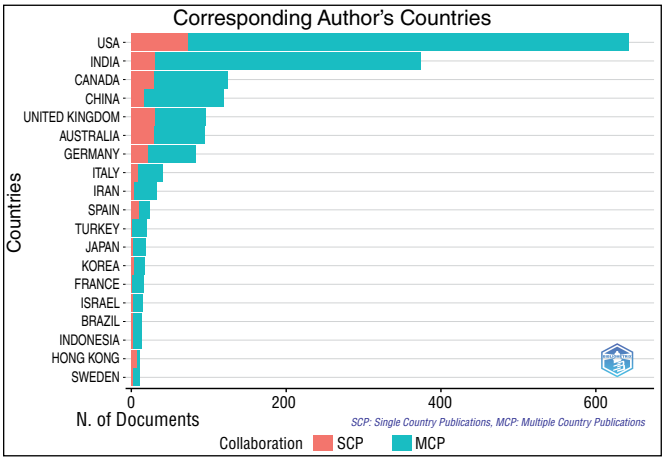

Fig. (4): Corresponding author's country.

NCD research being explored through interdisciplinary avenues.

Most relevant Authors: The top contributors to Yoga Therapy for NCDs research are represented in Table **2**. The authors who have contributed to the body of research are as follows (with the No. of articles published in parentheses): H.R. Nagendra - 37; L. Cohen - 32; R. Nagarathna - 32; H. Cramer - 29; A. Singh - 24; L.E. Carlson - 23; A. Anand - 22.

Most relevant countries: Fig. **(4)** shows the first ten countries/regions that have had the highest productivity in this domain. It represents the contributions of both individual countries (depicted by the blue box) and the collaboration of several countries (depicted by the red box) from 1995 through 2024. The database consists of both independent publications and publications resulting from country collaborations. The USA and India are the two countries that have produced the most; therefore, they must have begun their research much earlier than most other countries.

The results indicate that among the 643 total articles published from the USA and India, India, as the second most productive country, produced 374 articles; however, this number is significantly lower than the USA's total. Canada produced 125 articles, which is almost one-fifth of the USA's total production. China and the UK are other countries that contributed to the total number of publications produced for NCD's Yoga Therapy and will be discussed later in this article. Other countries (*i.e.*, Australia, Germany, Italy, and Iran) produced 95, 83, 41, and 32 articles, respectively. Based on these findings, it can be concluded that the USA has produced more research on Yoga Therapy for NCDs than any other country that contributed to this research; however, India is the second most productive country and therefore shows a significant interest in this area.

Most Relevant Affiliations: The study also included a review of the top institutions with the most relevant engagement in Yoga Therapy for Chronic Non-

Table 3: Most relevant affiliations.

Affiliations	Publications n(%)
The University of Texas MD Anderson Cancer Center	52 (2.2)
All India Institute of Medical Sciences, New Delhi	48 (2.1)
University of Calgary	47 (2.0)
Harvard Medical School	40 (1.7)
Memorial Sloan-Kettering Cancer Center	39 (1.7)
University of California, San Francisco	38 (1.6)
Swami Vivekananda Yoga Anusandhana Samsthana	30 (1.3)
University of Toronto	29 (1.3)
Universität Duisburg-Essen	28 (1.2)
Mayo Clinic	2 (0.1)

Communicable Diseases (NCD) research. The ranking of the top institutions was based on their volume of published articles and research output associated with Yoga Therapy for NCD. The United States ranks among the top countries in the number of published papers in the field, as shown in Table **3**. Of the key institutions in Yoga Therapy for NCDs, the MD Anderson Cancer Center of the University of Texas is ranked number one in the total number of published articles with a total of 52 published articles, the All India Institute of Medical Sciences, New Delhi with a total of 48 published articles, the University of Calgary, Canada with a total of 40 published articles, Harvard Medical School, USA with a total of 39 published articles, and the Sloan-Kettering Cancer Center, USA with a total of 38 published articles are also significant institutions in terms of published articles, however there are multiple other institutions with fewer published articles than the top 5 institutions. The top five institutions are located in the U.S., India, and Canada.

Trend Analysis: Analysis of trends over time involves studying changes in an area of study and their relationships to other factors, based on data collected through October 2023 [17].

Word Cloud of Keywords: Fig. **(5)** provides a visual representation of the 50 most frequently used keywords (word cloud) for authors in the Yoga Therapy for NCDs (non-communicable diseases) literature from 1995-2024, with keyword size denoting frequency of occurrence [18]. 'Cancer' was the most frequently referenced

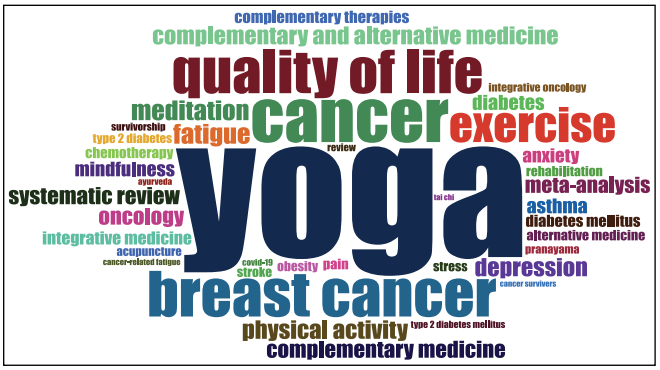

Fig. (5): Word cloud of keywords.

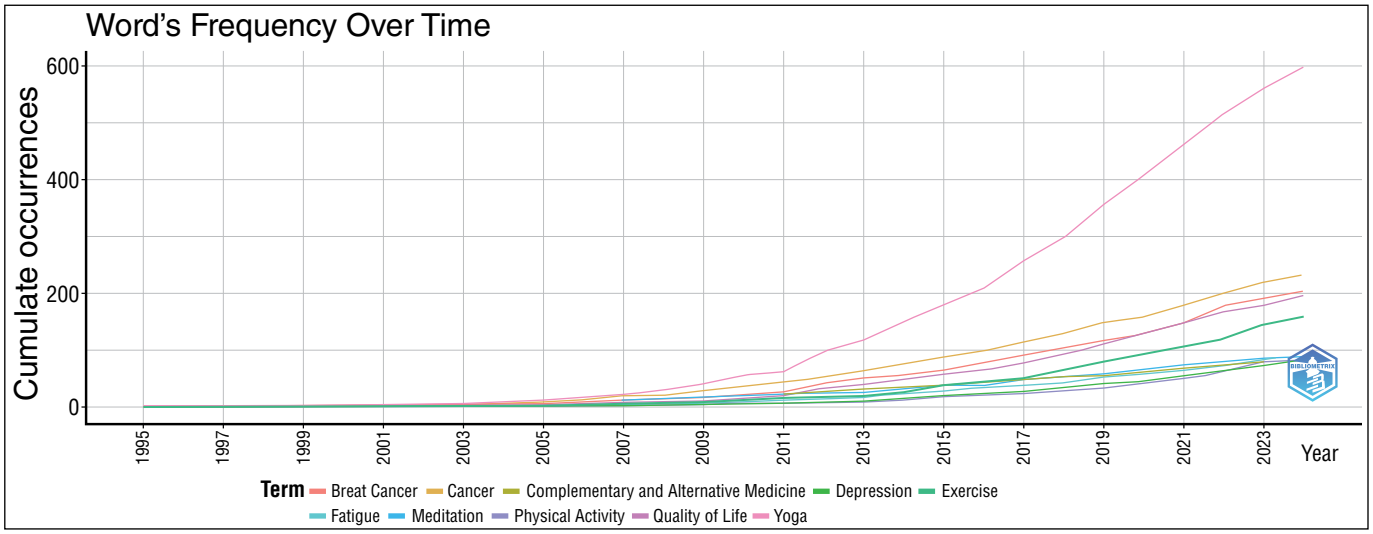

Fig. (6): Words frequency over time.

keyword in relation to Yoga Therapy for NCDs during this time, followed by 'Breast Cancer.' Other related but less frequently used keywords included 'Exercise,' 'Depression,' 'Fatigue,' and 'Complementary & Alternative Medicine.' Other keywords listed in the word cloud and numerous occurrences of those keywords occur as well.

Growth of Top 10 Author's Keywords: The growth over the 30 years (1995-2024) can be seen in Fig. **(6)**, which provides a breakdown of the top 10 author keywords that have been used to represent yoga therapy for NCDs and includes the keywords 'yoga,' 'cancer', 'breast cancer', 'quality of life', 'exercise', 'fatigue', 'meditation', 'physical activity', 'depression', and 'complementary and alternative medicine.' Based on the data, all 10 keywords demonstrate significant and consistent increases in growth rates during the years reported. Each keyword demonstrates annual growth in occurrences, indicating that this growth helps prove that researchers need to remain knowledgeable of recent advances in their respective fields. The x-axis of Fig. **(6)** is representative of years, while the y-axis represents the cumulative number of occurrences of the keyword [19]. The growth trajectory of 'cancer' was the most significant in yoga therapy for NCDs, as evidenced by the 231 occurrences at the end of 2022. Of the available 10 keywords, 'cancer' was first used as an author keyword in 2001, except for 'yoga'. With the early years of analysis occurring before 2001, all other keywords, except 'meditation' and 'physical activity', were published after 2001. In 2003, 'breast cancer' was a new author keyword that has since seen the 2nd largest increase in occurrence, with a total of 203, which is relatively small when compared to the growth of the word 'cancer'. By 2024, 'quality of life' was used as often as either 'exercise' or 'fatigue,' making them the 3rd-fastest-growing keywords; however, they exhibited nearly identical growth rates. The remaining keywords 'meditation,' 'physical activity,' 'depression,' and 'complementary and alternative medicine' have similar growth curves.

Trending Topics: Yearly changes in research trends to help define areas within academia that are of interest. The data shown in Fig. **7** illustrates the different trending topics surrounding Yoga Therapy for NCDs for the years 1995-2024. For ease of understanding, the identified trending topics could be generally categorized into two thematic areas. The first area of interest is related to the actual components of Yoga therapy, being asana-based practices, pranayama, meditation, relaxation, and mind–body therapies, or in other words, operational factors of Yoga intervention studies over time. The second area of interest is related to NCDs and the outcomes associated with them, including cancer, diabetes, quality of life, fatigue, and physical activity. This generalized grouping suggests that research trends may differ across different yoga-based practices and specific clinical conditions targeted for clinical interventions. Further evidencing this point is the overall size of each of the blue circles located in Fig. **(7)**, which indicates how many times each topic has been studied, with a minimum of 10 for the smallest circle (as defined in the key) and a maximum of 50 for the largest circle [20]. Between 2002 and 2007, the number of studies focusing on different yoga asanas was very high, whereas between 2013 and 2021, research focus

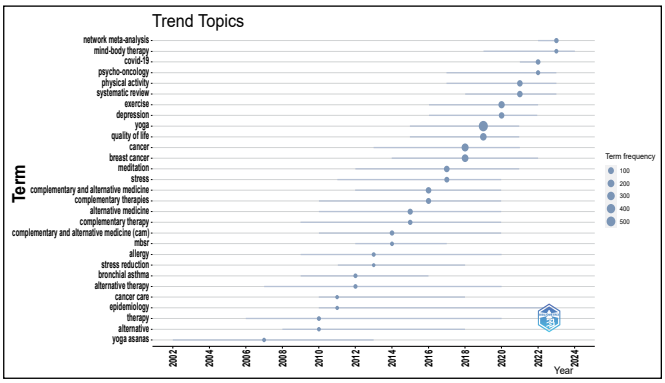

Fig. (7): Trending topics.

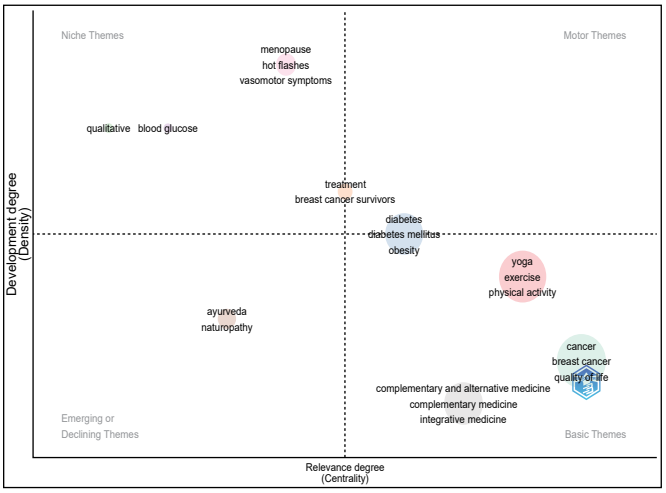

Fig. (8): Thematic map.

shifted towards 'cancer'. From 2009 to 2013, several topics related to NCDs were studied, including 'bronchial asthma', complementary and alternative medicine (CAM), meditation, 'cancer', and 'allergy', with 'cancer' becoming the most studied topic overall.

Between 2015 and 2022, there has been very little academic work related to the three topics; however, there has been a substantial amount of research into 'COVID-19, ' physical activity, and COVID-19. For the 2024 network meta-analyses, the top topic will be 'network meta-analysis and mind-body therapies'. It is expected that both 'physical activity' and mind-body therapies, as well as those related to psycho-oncology, will continue to gain visibility, as they have only begun to emerge as an area of research in 2021. Also, an examination shows that 'classification of beats' has been of interest for an extended period.

Thematic map: Fig. **(8)** presents a thematic map illustrating the overall layout of the research area, showing how the different topic types in this area are developed and their relative importance. The themes are organized into four quadrants: (a) basic/top of the list; (b) niche/bottom-right; (c) emerging/declining; (d) motor [21]. On the map, we can clearly see distinct divisions for each theme type—basic, niche, and motor.

For example, basic themes such as Cancer, Breast Cancer, Yoga, Exercise, Physical Activity, Complementary and Alternative Medicine, and Integrative Medicine have long been established; in other words, there is extensive research on these topics. These basic themes are also located at the center of the Yoga Therapy research related to NCDs. Niche themes (*e.g.*, menopause: hot flashes, & vasomotor symptoms; & qualitative blood glucose) are very well developed but are not at all central; this indicates that while many research articles reference these themes, the audience for these themes is usually limited to a very small pool of researchers who have developed a specific expertise with respect to niche topics. Emerging and declining themes (*e.g.*, Ayurveda, Naturopathy) are both relatively underdeveloped and low on the map; this indicates that only a small number of researchers are conducting research using these themes, and therefore, the volume/level of research generated is low. Still, they may be sources of future directions for these researchers, either as they begin to gain interest or as they begin to decline because they are nearing full development.

The dynamic theme quadrant of the motor theme, highly developed and central to areas such as Diabetes, Diabetes Mellitus, Treatment, and Breast Cancer Survivor; these motor themes facilitate both research and collaboration in this area and help generate new ideas and foster interdisciplinary collaboration among researchers involved in these themes. Therefore, the current theme map of Yoga Therapy for NCDs research represents its current stage of research and offers strategic guidance to domains that could impact its future direction.

Citation Analysis: This provides an assessment of the impact and importance of the research by identifying the number and types of sources and the contexts from which citations arise. Citation analysis provides a way to evaluate an author's contributions, the quality of their research, and the relevance of their research to the topic [17].

Most frequently cited countries: Citation analysis also offers a meaningful means to evaluate the research impact of articles [22]. Fig. **(9)** shows the top ten most frequently cited countries worldwide. Most articles on Yoga Therapy for NCDs have been published in the U.S., receiving the most citations, reflecting their value and applicability to the yoga therapy community. The U.S. had 25,534 citations, which is a sizable difference compared to India's second place (5,690 citations). Other significant contributors to this body of research are Canada (4,578 citations), Germany (3,670 citations), and the UK (3,455 citations). Finally, Mexico, with only 1,035 citations, is included in the top ten overall but has the highest average citation count per article (147.90) among the countries on this list.

Most globally cited Document: The most globally cited documents are those with the highest overall citation counts (*i.e.*, articles with a high citation count, without

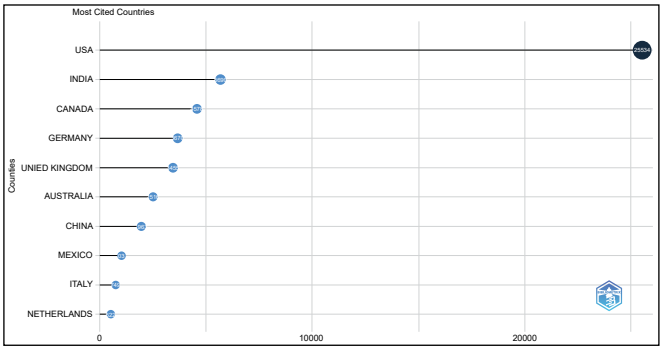

Fig. (9): Most cited countries.

Table 4: Most globally cited documents.

Paper Details	DOI	Total Citations	TC per Year 1995 to 2024	Normalized TC
NA, 2003, Am J Respir Crit Care Med [24]	10.1164/rccm.168.7.818	879	39.95	6.91
Cohen SP, 2021, Lancet [25]	10.1016/S0140-6736(21)00393-7	874	218.50	56.61
Chou R, 2007, Ann Intern Med [26]	10.7326/0003-4819-147-7-200710020-00007	768	42.67	6.49
Mosca L, 2007, Circulation [27]	10.1161/CIRCULATIONAHA.107.181546	624	34.67	5.27
Mishra SI, 2012, Cochrane Database Syst Rev-A [28]	10.1002/14651858.CD008465.pub2	617	47.46	11.65
NA, 2015, Obstet Gynecol [29]	10.1097/AOG.0000000000001214	591	59.10	19.45
Bisht S, 2017, Nat Rev Urol [30]	10.1038/nrurol.2017.69	562	70.25	14.63
Carlson LE, 2003, Psychosom Med [31]	10.1097/01.PSY.0000074003.35911.41	554	25.18	4.36
Greenlee H, 2017, Ca Cancer J Clin [32]	10.3322/caac.21397	513	64.13	13.35
Carlson LE, 2007, Brain Behav Immun [33]	10.1016/j.bbi.2007.04.002	491	27.28	4.15

any filtering based on subject domain) [23]. In other words, the total number of times a document is cited is considered to be its total number of global citations, regardless of whether that document has been cited within a particular subject domain or otherwise. The ten most globally cited documents may also be considered the ten most highly cited. They can be found in articles related to NCDs and non-NCDs; the ten most influential papers are discussed in Table **4** and include: paper details, DOI, total number of citations, total number of citations in that document, and the normalized total number of citations.

Network Analysis: Studies of network analysis focus on understanding the relationships among academic journals, research affiliations, and countries by examining co-citation and co-authorship networks to identify areas for collaborative research and teamwork in related fields [17].

Co-Author Collaboration Network: The co-author collaboration network depicts the nature of collaboration among authors working within a given research area [34]. Fig. **(10)** presents the co-author collaboration network for Yoga Therapy for NCDs. There are four distinct clusters representing various authors, each with a different color. The size of each node in the network indicates the extent to which each author has contributed to the research area. The four clusters are indicated by blue, green, orange, and purple. The purple group, which is the largest group with five authors, appears to be the most prominent contributor to Yoga Therapy for NCDs, followed by Nagendra HR and Nagarathna R. Cohen L contributed to Yoga Therapy for NCDs and is part of the orange group, which is made up of three authors (Cohen L, and 2 unnamed authors). Other clusters are proportional to their representation in the co-author collaboration network. The blue group is the smallest collaborating cluster, with only two authors (Culos-Reed SN and Carlson LE). This study demonstrates that the purple group has developed a strong collaborative network for the authors in this area, and that Nagendra HR is the most active author within this group.

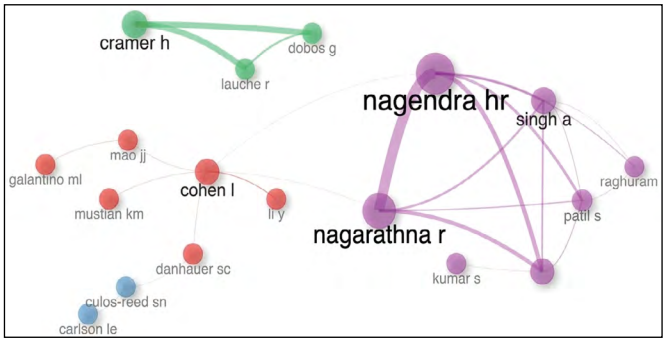

Fig. (10): Collaboration network of authors.

Collaboration Network of Countries: A collaboration network of countries that are engaged in Yoga Therapy research for the treatment of NCDs is presented in a visual format in Fig. **(11)**. In the graphic, each of the three different colors (red, blue, and green) represents the collaborative relationship of countries with one another. The collaboration exists between countries of the same color. The thickness of the connecting line between two countries also indicates the strength of the collaboration. Furthermore, the size of each circle indicates the number of collaborations. Fig. **(11)** also indicates that the USA and China have the most collaboration partners among countries and the strongest level of collaboration with them. Of importance is that the level of collaboration among the ten countries that form the largest collaboration network (green) on Yoga Therapy/ NCDs is much higher than in other countries (red = 7; blue = 3). In conclusion, the green color cluster has the

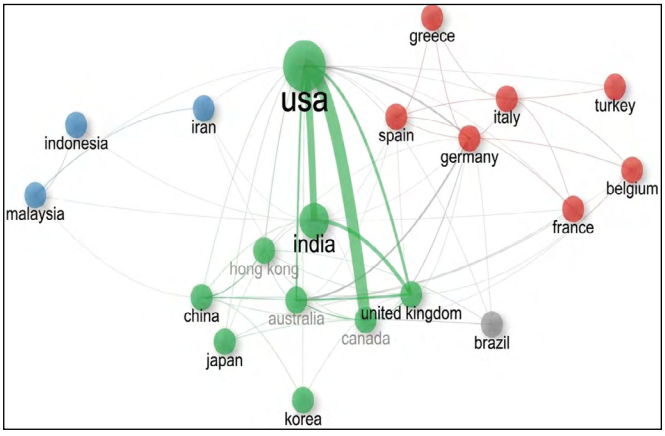

Fig. (11): Collaboration network of countries.

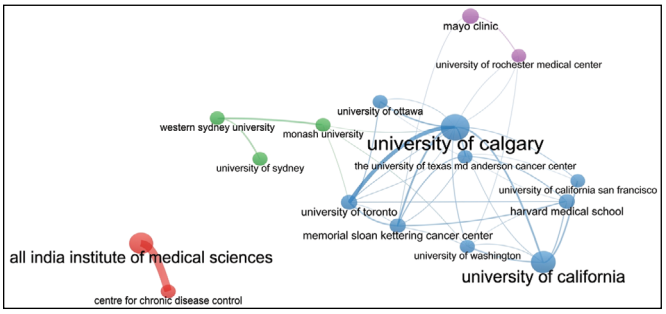

Fig. (12): Collaboration network of institutions.

largest collaboration network of the three countries, with a total of (10) countries (*i.e.*, USA, India, Canada, China, Australia, UK, Japan, Hong Kong, Korea, and Brazil).

Collaborative Network of Institutions: The Collaborative Network of Institutions engaged in Yoga Therapy for NCDs is depicted in Fig. **(12)**. Institutions are represented as colored circles, and the size of each circle indicates the number of publications from that institution [35]. Institutions are connected by lines of the same color (representing collaborative institutions). Four clusters (red, blue, green, and purple) can be distinguished by the varying degrees of collaboration among the institutions within them. The institutions in each cluster collaborate, regardless of whether they are located in close geographic proximity to one another. The largest cluster consists of the blue cluster, which includes eight universities that are located in different geographical locations, including the University of Calgary and the University of California, with the University of Texas MD Anderson Cancer Centre, Memorial Sloan Kettering Cancer Centre, the University of Toronto, Harvard Medical School, the University of Washington, the University of Ottawa, and the University of California, San Francisco being examples of large cooperative institutions. The largest is Calgary and has been involved in the most extensive collaboration. In the red cluster, the All-India Institute of Medical Sciences and the Center for Chronic Disease Control are among the two largest collaborating institutions, both located in India. The other clusters show a similar pattern. Generally, the blue cluster demonstrates a particularly high level of collaboration.

DISCUSSION

The trend topic and thematic map analyses provide a clearer understanding of how the focus of yoga research has evolved. The findings from these analyses also highlight potential research gaps and provide direction for future studies.

The data demonstrate that most research on yoga interventions has been driven by clinical indicators of need, primarily high symptom burden and a lack of supportive services for the patient. Research on yoga practice in oncology, cardiometabolic disorders, and mental health aligns with previous reviews of the literature and reflects current clinical use of yoga in patients (yoga is primarily used as an adjunctive therapy to manage symptoms related to disease, rather than to modify disease).

2002-2008: Establishing a Foundation and Exploring Potential: Research on yoga has mainly focused on foundational themes (*e.g.*, asanas) from 2002 to 2008, with an increasing recognition of the use of yoga (*e.g.*, as a complementary therapy) to support physical health, improve quality of life, and reduce stress. However, there has been a recognized absence of acceptable evidence (*e.g.*, many investigations are not rigorously scientifically validated), especially about the use of yoga asanas in relation to chronic diseases and mental health [36]. In addition, few studies have provided information about the mechanisms underlying how and why yoga produces effects. This lack of evidence underscores a serious need for ongoing/or substantial long-term research to build credibility, establish standardized protocols, evaluate clinical outcomes, and strengthen scientific support for the therapeutic use of yoga [37].

2010-2014: The Evolution of Yoga as a Therapeutic Modality: During this period, a shift towards greater research into therapeutic applications of yoga began. Between 2010 and 2014, the number of studies investigating alternative therapies, cancer therapy, the epidemiology of bronchial asthma, allergy management, stress relief, and complementary and alternative medicine (CAM), as well as Mindfulness-Based Stress Reduction (MBSR) [38, 39]. These studies provide growing evidence supporting the role of yoga in preventing and/or managing NCDs and achieving total health and wellness.

There remain many important research gaps, especially in integrating holistic and preventive practices. There remains limited evidence regarding the specific effects of yoga in both preventing and treating the following chronic illnesses: cardiovascular disease, diabetes, and chronic respiratory diseases [40]. In addition, long-term studies across different ethnic groups are needed, and further research is required on how yoga can be used as part of a public health strategy and how it might help lower health care costs and improve the overall quality of life for those with non-communicable diseases.

2015-2018: Alternative and Complementary Treatment Integration: Between 2015 and 2018, there was substantial progress in complementary and alternative medicine. The volume of published studies on alternative therapies, meditation, stress management, cancer, and breast cancer increased markedly. During this time, yoga also gained greater recognition as part of a larger system of complementary and integrative therapies. Despite these positive developments, significant gaps remained in research on yoga. For example, there is little comparative research on how yoga compares with or complements the management of non-communicable diseases (NCDs), such as cancer, and the majority of published research on yoga is classified under broad

categories of "alternative medicine" and "complementary therapies." There is very little research that examines the unique or combined effects of yoga and other therapies. In addition, the questions of whether or not yoga has long-term efficacy against NCDs—both for the prevention of NCDs and for reducing stress and improving quality of life for cancer patients—remain largely unanswered. Therefore, many future research opportunities could answer these questions.

2019-Present: Focus on Personalization and Holistic Health: The Focus has shifted to Personalization and Holistic Care. In the past several years, researchers have increasingly moved toward more personalized and holistic approaches to improving individual health. As a result, topics such as yoga, quality of life, exercise, depression, and physical activity, as well as systematic reviews related to depression and physical activity, have become much more popular [41]. However, there is still a significant research gap regarding the ability of personalized yoga interventions, developed specifically for individuals and tailored to their individual characteristics, to positively impact long-term outcome measures in patients with non-communicable diseases (NCDs). Although many studies have demonstrated the benefits of yoga on an individual's quality of life, physical activity level and mental health (particularly related to depression), there are very few studies assessing the impact of custom yoga programs (based upon the individuals; genetics, mental health & lifestyle) on the results related to NCDs over time. Likewise, Mind-Body therapies' potential to impact disease progression and help prevent disease before any residual disease after COVID-19 (or psycho-oncologically), *etc.*, continues to represent a significant research gap. NCD's are currently a major burden on global health (more than communicable) and continue to be and will remain the leading cause of death and impairment.

Yoga has become a viable method of preventing and managing stress-related illnesses and injuries that are common among individuals living sedentary lifestyles who have unhealthy diets. The practice of yoga (which involves breath control, physical postures, and meditation) has been used for centuries; as such, it offers a holistic approach to the rising prevalence of non-communicable diseases (NCDs) due to sedentary lifestyles, poor nutrition, and chronic stress in modern society. Yoga also closely relates to the overall goal of the Global Action Plan on Physical Activity (GAPPA), which aims to increase the number of people participating in physical exercise to improve the health of humanity between 2018-2030 and beyond. Recently, a growing body of evidence supports the use of Yoga Therapy as an effective tool for improving health outcomes and enhancing quality of life in people with chronic illness/ disease. These findings have led to a call from the medical community for the integration of Yoga Therapy (on a structured basis) into multidisciplinary NCD treatment strategies, and particularly those that seek to improve quality of life, decrease fatigue and increase physical activity levels among patients with limited exercise tolerance. The low cost, flexibility and minimal risk associated with yoga make it a practical option for both medical and community-based programs.

This study provides an updated analysis of the literature on Yoga Therapy and its connection to non-communicable diseases, using a comprehensive bibliometric analysis. In addition, three different types of analysis were completed (performance analysis, science mapping, and network analysis). This involved analysing the publication of literature, citation of articles, and the key contributors to the literature. The study included 2312 articles published between 1995 and 2024. Results indicate that the United States is the leading country in publications on Yoga Therapy and NCDs, followed by India, Canada, China, and many other countries worldwide, demonstrating global interest in the subject. The significant number of publications from India shows that both India and the USA have distinct sociocultural and institutional influences. The historical and cultural connection of yoga to India, along with the support of the Indian government through the Ministry of AYUSH and other governmental agencies, fostered a sustained publishing trend with Indian researchers. On the other hand, in the USA there is substantial funding for integrative medicine research, especially from the National Institutes of Health (NIH), and a high level of patient acceptance of complementary and alternative modalities.

H.R. Nagendra of India is the author with the greatest influence on the total knowledge base created in this area. The journal with the most articles on Yoga Therapy for NCDs is *Supportive Care in Cancer*. The University of Texas MD Anderson Cancer Center in the United States is the institution that has produced the most research in this area. Frequently cited keywords in the literature related to Yoga Therapy for NCDs include "cancer," "breast cancer," "quality of life," "exercise," "physical activity," "depression," "fatigue," and "complementary and alternative medicine." The presence of these themes is due, in part, to the many common clinical difficulties faced by individuals with NCDs, including chronic fatigue, limitations in functional ability, and emotional distress. The experience of cancer survivors, particularly those with breast cancer, who often suffer from fatigue and depression after completing their treatment and are thus good candidates for yoga as an intervention that addresses both their physical needs for rehabilitation and the psychological needs for improved mental health.

Recent research has shown a shift toward greater awareness of the mind-body experience that can occur through yoga practice. Key areas driving the current interest in yoga therapy, as well as other forms of body-based therapy, are mind-body, psycho-oncological and physical activity (fitness). Network mapping

methods have been used to visually represent the complex interrelationships among authors, countries, institutions, and journals in yoga therapy research. For example, through a collaboration/partnership analysis of 25 countries, three clusters were identified, with the strongest linkages between the United States and India, which together represent the largest research base in yoga therapy for non-communicable diseases. A review of the collaborative networks of 16 participating institutions from different countries identified four separate institutional clusters, with the University of Calgary representing the largest cooperative research network, collaborating with seven other research institutions. The mapping of journals, institutions and countries through citation and collaboration networks in our study demonstrates that yoga therapy is a global undertaking with yoga researchers worldwide working together to expand the body of knowledge. The results of this study not only highlight the contributions of top authors, institutions, and journals, but also provide insight into how well established these fields have become over time. The results of this study also assist today's researchers, authors, and stakeholders in identifying contemporary trends and historical developments, and they represent a solid foundation upon which to develop stronger collaborative relationships.

Many new avenues are opening up for the future of research. A potential area for future research involves the development of customized yoga programs that take into account each individual's health characteristics (*e.g.*, genetic makeup, lifestyle choices, and psychological issues). Long-term studies will therefore be necessary to evaluate the sustainability of the various benefits provided by yoga and to compare them with those of other complementary therapies. The mental health benefits of yoga are particularly important in this context. Yoga represents a whole-body (*i.e.*, somatic) therapy that combines body movement, breath control, and meditation—the three key components of all currently established psychotherapeutic modalities. Research indicates that the benefits of yoga on mental health may occur through activation of the vagus nerve, regulation of the hypothalamic-pituitary-adrenal axis, and improved balance of the autonomic nervous system, all of which may contribute to its effectiveness as an adjunct to the treatment of depression and psychological distress in individuals with chronic diseases (NCDs). Given that yoga has been shown to help reduce stress, anxiety, and depression in individuals with chronic diseases, it is likely that yoga will have a significant role in psycho-oncology settings. Yoga-based community programs could also help reduce the incidence of NCDs and lower healthcare expenditures. Studies evaluating the cost-effectiveness of these programs could inform the development of policies for their implementation.

We need to look at cultural and socioeconomic factors as well. Research that includes diverse populations in low- and middle-income countries can help ensure that yoga programs are accessible and effective. We can also look to technology; today's digital health tools and wearables will make it easier to help individuals with personalized yoga practices. Special consideration should also be given to elderly persons, as well as children, and even people who are living with multiple chronic diseases; there need to be yoga programs that are designed specifically to address their different needs. More studies on the biological processes underlying yoga's effects would help us explain how yoga improves the mind-body connection overall. From there, studies on cardiovascular disease or diabetes could inform more specific recommendations. By collaborating with conventional medicine and therapy practitioners, we could develop broader and more sustainable solutions to health care that integrates yoga and yoga/wellness professionals into health care. By doing this, we can elevate our understanding of yoga's impact on the management and prevention of chronic illnesses and lead us toward a more effective, individualized, and comprehensive approach to health care.

CONCLUSION

This bibliometric study provided a broad picture of yoga therapy research on NCDs and non-NCDs across the globe, conducted between 1995 and 2024. As shown in the data collected and analyzed, the quantity of scientific research on yoga therapy for NCDs is gradually increasing, as is the average number of NCDs studied. The primary NCD researched is cancer (with breast cancer being the focus), followed by research related to quality of life, physical activity, fatigue, and mental health. The U.S. and India are the top 2 countries in yoga therapy research, and both countries have strong institutional support/financial resources, as well as sociocultural factors, that enable the integration of yoga into healthcare systems. Several influential authors, journals, and institutions have been identified that form collaborative networks that shape the field's direction. The science mapping/network analyses also indicate a shift in the focus of yoga therapy research from traditional/conventional yoga practices towards integrative, mind-body, and psycho-oncology research. Therefore, the research findings are consistent with the study's objectives and provide a solid empirical basis for new research, integrating clinical research into practice, and developing policies for yoga therapy in the treatment of people living with NCDs.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

Alok & Sudip Bhattacharya were involved in conceptualization, study design and methodology, data collection, data analysis and visualization, interpretation of results, and drafting and critical review of the manuscript.

Akanksha Singh contributed to data collection, data analysis and visualization, interpreting results, and drafting the manuscript, as well as the critical review of the manuscript.

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