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Original Research Article

Ayurveda research: Emerging trends and mapping to sustainable development goals

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ABSTRACT

Ayurveda is India's prominent traditional medical system. The World Health Organization has stated the need for more evidence and data from conventional medicine methods to inform policymakers, regulatory bodies, healthcare stakeholders, and the public about its safe, effective, and equitable use. This study aims to provide a comprehensive analysis of the emerging trends in Ayurveda research, mapping research to the UN Sustainable Development Goals (SDG) and examining the impact of COVID-19. Using bibliometric methods, the researchers analyzed a total of 11,773 publications between 1993 and 2022 to understand the temporal evolution of publications, open-access publications, patterns of author collaboration, top-performing countries, and co-citation networks. The keyword co-occurrence analysis identifies networks of concentrated studies on Ayurveda research themes relating to the four clusters, Alternative and Traditional Medicine, Bioactive Compounds and Biological Activities, Analytical Techniques and Herbal Standardization, and Herbal Medicines and Immunomodulation, reflecting the diverse research areas within Ayurveda. The last cluster included research related to the SARS-CoV-2 virus, suggesting research on herbal approaches to immune modulation in the context of COVID-19. The most prominent SDG among these research themes was Good Health and Well-being (SDG 3), emphasizing the potential of natural products and traditional medicine in promoting holistic health and combating antibiotic resistance.

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1. Introduction

According to the World Health Organization (WHO), 170 member states have reported using traditional medicine and placed a priority request for evidence and data to inform policymakers, regulatory bodies, healthcare stakeholders, and the public about its safe, cost-effective, and fair use [1]. The WHO recently established the Global Centre for Traditional Medicine in India, focusing on innovation and technology, sustainability and equity, evidence and learning, and data and analytics to optimize traditional medicine's contribution to global health and sustainable development [2].

The UN Sustainable Development Goals (SDG) consist of 17 goals and 169 indicators to be attained by 2030 [3]. To meet the increasing demand for value-based healthcare, a unique holistic approach aligned with the SDG agenda emphasizes environmental considerations and societal health and well-being through multidimensional performance indicators [1]. With its well-established practice and research in India, Ayurveda is expected to contribute significantly to SDG 3 (Good Health and Well-being) [4].

Many Ayurvedic research papers about COVID-19 have been published during the recent pandemic [5–7]. This prompted an increased focus on developing Ayurvedic clinical profiling of COVID-19 based on consultation with modern medical doctors treating COVID-19 patients and classical Ayurvedic literature [8]. It also saw

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the development of pragmatic plans in Traditional Medicine to cope with the emergency during the pandemic [9]. The shift from "pathy-based" healthcare to "people-centered holistic healthcare" emphasizes the need for a unified healthcare system [10].

In COVID-19, research has identified potential phytochemicals from in-silico studies, such as *Withaniasomnifera,* with inhibitory effects on the SARS-CoV-2 virus [11]. Some research showed the utilization of telemedicine during the COVID-19 lockdown to enable Ayurveda consultations, highlighting the communication channels and platforms for diagnosing, prescribing, and evaluating patients [12].

Ayurveda is a comprehensive system of natural healthcare that originated in ancient India with an evolutionary history of more than 2000 years. The term "Ayus" in the Sanskrit language translates to "life process" or "life span," whereas the word "Veda" translates to "knowledge" or "science". Usually translated as the 'Science of Life,' Ayurveda's primary emphasis is maintaining health and well-being and preventing disease [13]. Ayurveda is a knowledge system that developed its methods for validating medicines and interventions. Clinical outcomes were analyzed rigorously to rule out chance. Treatment protocols are generated based on rigorous rationale (yukti) based on retrospective (purvavat), prospective (sesavat), and cross-sectional (samanyatodrsta) observational approaches. Cause and effect are to be established by comparing treatment (paksa) to a positive (sapaksa) and negative (vipaksa) control [14]. Ayurveda has a long unbroken evolutionary history with an impressive lineup of textbooks and teachers, constituting perhaps the most extensive medical literature in the world [15]. The earliest texts of Ayurveda date back at least a millennium before the common era.

Ayurveda has been subjected to research methods based on Western science and medicine, and ethnopharmacology represents one of the dominant approaches for studying Ayurveda in modern times. The origins of serious ethnopharmacological studies on Ayurvedic medicinal plants can be traced to the discovery of the antihypertensive properties of Rauwolfia serpentina. It led to the discovery of reserpine, the alkaloid from this plant that was demonstrated to have anti-hypertensive activity [16]. There is much potential for such drug discovery breakthroughs as herbs and formulations of Ayurveda are already being used in humans, and there is empirical knowledge about their clinical efficacy and safety. On the other hand, Ayurvedic formulations have multiple ingredients, and the mechanism of action is complex and depends on the synergy and antagonism of numerous chemical constituents. Hence, modern drug development methods that isolate active molecules from herbs and herbal formulations may not be suitable for Ayurveda.

On the other hand, laboratory research on in silico, in vitro, in vivo, and ex vivo models that address the complexity of Ayurvedic formulations can help understand the mechanism of action and improve the delivery and efficacy of traditional formulations. This is referred to as Reverse Pharmacology or the clinic-to-lab approach and is relevant for the scientific evaluation of ethnopharmacological techniques in conventional systems of medicine [17]. Approaches like network pharmacology are better suited to address the complexity of Ayurvedic formulations. Research has demonstrated the possibility of network pharmacology studies on the Ayurvedic formulation Triphala which is the combination of *Terminalia chebula* Retz, *Phyllanthus emblica* L., and *Terminalia bellirica* (Gaertn) Roxb [18]. Traditional ayurvedic treatment is always personalized, and multimodality treatments administered to different people with the same disease may vary significantly based on the ayurvedic diagnosis. Thus, conducting clinical trials using the Randomized Controlled design can be challenging. Furst et al. [19] demonstrated that it is possible to conduct double-blind, randomized, placebo-controlled clinical trials when personalized pharmacological Ayurvedic treatment is administered to patients with rheumatoid arthritis.

With the increasing interest in Ayurveda and other traditional medicines globally, the pressure to generate scientific evidence of safety and efficacy is also mounting. Bibliometric analysis of research conducted in the field of Ayurveda assumes significance in this context.

A macro-overview of the large academic literature is provided by bibliometrics, which is growing in popularity [20,21]. Over time, it can effectively identify influential studies, authors, journals, research institutions, and countries [21,22]. There is enough evidence for using bibliometric methods in medical science and health, including complementary, alternative, and traditional medicine [23–25]. In the bibliometric study by M.Y et al. [25], PubMed was used to search all acupuncture-related publications between 1995 and 2014. The study analyzed the type/design, clinical condition addressed, country of origin, and journal impact factor. Danell and Danell [23], with help from bibliometric methods, analyzed the publication of complementary and alternative medicine articles, in the Medline database, from 1966 to 2007. They also examined the general content of the articles and in what journals they get published. In the study by Şenel et al. [24], data were obtained from 834 publications across four databases: Web of Science Core Collection, Korean Journal Database, Russian Science Citation Index, and SciELO Citation Index. A total of 834 publications retrieved from 1975 to 2017 were included. Bibliometric networks showing usage density and relationships of the keywords in the documents were generated.

Bibliometrics research in acupuncture includes a systematic review of acupuncture therapy [26], low back pain [27], and complementary and alternative medicine (CAM) (Wieland et al., 2021). Similar studies have been undertaken in the fields of yoga for health [26,28], randomized controlled trials of yoga [29], Naturopathy, and traditional Medicine for stroke [30]. Another research on bibliometrics explains the publication patterns of the literature on the use of complementary and alternative medicine, including Ayurveda, for HIV/AIDS [31]. Original publications are the most prevalent type of document, according to studies. The United States, the People's Republic of China, India, England, and Germany are significant contributors to complementary and Alternative Medicine papers, with India having the highest citations per paper value among the top ten producers of such publications [32]. Network analyses of Hirudotherapy revealed that multicenter studies were scarce in this field, and additional search should be conducted in countries such as Russia, India, and China [24].

Our paper is organized as follows. First, we list the research questions, then the bibliometrics study methodology, including the data source. This is followed by the results section, where the temporal evolution of publications, citations, open access trends, and science mapping analysis is investigated. Finally, we discuss our findings, conclusions, and recommendations for future research based on thematic areas.

2. Research questions

This study aims to investigate the following questions about Ayurveda research.

1. What is the trend of research productivity and influence over time?
2. How has collaboration impacted research, both nationally and internationally?
3. Who are the leading countries, institutions, and funders of Ayurveda research?

4. What are the main thematic research areas of Ayurveda research?
5. How well is Ayurveda research aligned with the UN Sustainable Development Goals (SDG)?
6. What has been the impact of COVID-19 on Ayurveda research?

3. Study methodology and data

3.1. Bibliometric analysis

This study uses performance analysis and science mapping techniques [33] to examine the most influential publications, authors, journals, and keywords in Ayurveda through bibliographical coupling, co-citation networks, and analysis of keyword co-occurrences [34]. Co-citation is the frequency with which two publications are cited together by other publications [35,36], while bibliographic coupling occurs when two publications reference a common publication in their bibliographies [37]. Visualizing network analysis is essential in determining the hotspots and evolution of the study field while providing insights into emerging research areas [38]. A co-occurrence network of keywords can show the research organization and the relationships of themes [34]. The keywords' organization shows the thematic cluster's scope and essence [39]. VOS viewer [34] has been used in this study to create scientific landscapes, networks, and cluster analysis [40] and illustrate the structural and dynamic aspects of scientific research [33]. The number of references is often used to judge publications, creating pressure on authors, editors, stakeholders, and funders [41,42].

3.2. Data source

An extensive review of the literature from the Scopus database from 1993 to 2022 was used for this study. Scopus has peer-reviewed quality requirements, comprehensive coverage across themes and sources, and quality requirement inclusion criteria [43].

The PRISMA framework, used in several bibliometrics studies [44], was used in the process of identification, screening, eligibility, and final selection of publications (Fig. 1) [45]. The search terms (Ayurveda OR Ayurved OR Ayurvedic) were applied in the title, abstract, and keywords of Scopus publications for 1993 through 2022. The publications tagged retraction or errata were excluded. The source type was limited to journals.

The metadata of the final publications was generated in MS Excel format. The number of publications (total and per year), authors, journals, countries, institutional affiliations, funding sponsors of publications, journal quartiles, most productive authors, and publications with the highest citation counts were among the bibliometrics data gathered and analyzed. Scopus classifies all publications into four quartiles, and some are not ranked due to insufficient data or being a newer entry to Scopus.

The entire data set was analyzed in this study, and the results were presented in the results section. The subset of the dataset containing the top two quartiles was used in some analyses to see if there is a varying trend in higher quartile publications [46].

As the 2030 target date for the Sustainable Development Goals (SDG) approaches, there is a growing urgency to accomplish these goals, leading to increased research efforts across various fields, including Ayurveda. While many bibliometric studies have focussed on mapping research areas to SDG [47–49], there is a noticeable research gap in systematically aligning individual Ayurveda publications with the SDG. Our research aims to address this knowledge gap by utilizing the Elsevier SDG Mapping Initiative, offering a novel perspective on the discipline [50]. Elsevier SDG Mapping Initiative is integrated within the Scopus database, employing specific SDG

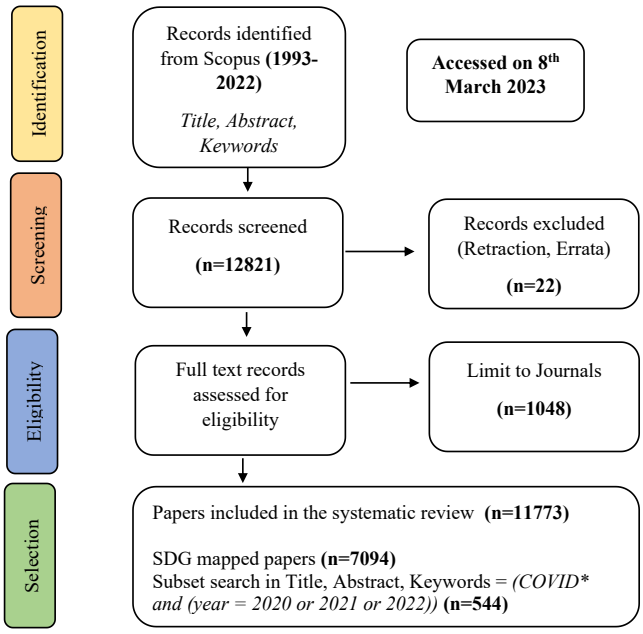

Fig. 1. PRISMA framework.

queries developed based on targets and sub-targets. Through rigorous review and feedback, these queries have been refined and supplemented by a machine learning model to maintain precision above 80%. The Scopus database further facilitates the research process by providing pre-set search queries for each SDG.

Additionally, the finally selected data set was further searched for the term (COVID*) in title, abstract, and keywords with years limited to 2020 to 2022. * means any number of characters that may follow the term COVID. For e.g COVID-19, COVID19, COVID etc... This way we can catch all variations of the term COVID used by the researchers.

4. Results

4.1. Publications and citations trends

Fig. 2 illustrates the annual distribution of the publications and the cumulative citations from 1993 to 2022. The blue bars depict the total annual publications (TP), while the orange bar is the subset of total publications in the first two quartiles (TPQ). We find that the TP stagnated between 2014 and 2020; similarly, TPQ has a similar trend of reduced or stagnating between 2014 and 2020. The publications in both groups increased to their highest levels during the COVID-19 pandemic years of 2021 and 2022. The gray curve represents total cumulative citations (TCC), while the yellow curve represents the cumulative total citations of the two quartile publications (TCCQ).

The Ayurveda research development in Table 1 is divided into three decades. The TP and the TPQ increased over three decades. The total citations of TC and TCQ increase from the first decade to the second and then decrease in the last decade. Similarly, from the first to the second decade, the TC/TP and TCQ/TPQ improved, then fell in the last decade.

4.2. Impact of collaboration

Authors may collaborate on global, local, organizational, and individual levels [51]. Depending on the affiliation data, each article is mapped to one of the four collaboration levels. A single report

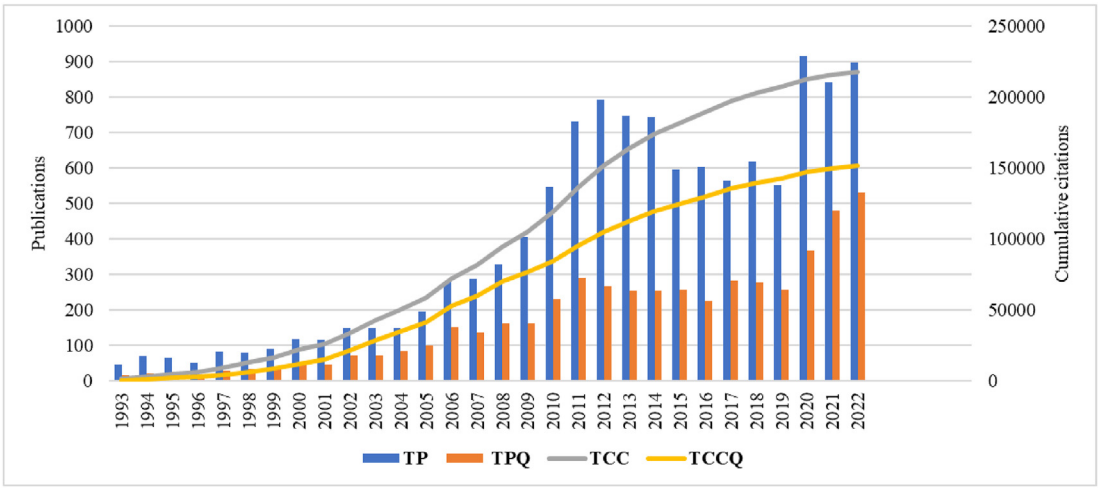

Fig. 2. Publications and citations trends. Note: TP – total publications; TPQ – total publications in top quartiles, TCC – total cumulative citations; TCCQ – total cumulative citations based on top quartiles.

could also highlight the global, local, and organizational levels of data in its associates. Regardless, a single corporation level is assigned to ascertain that the total of all the publications across the four levels totals 100%. Citation Impact (CI) considers the disparity in research behavior across specific fields. CI is obtained from SciVal (2022) and shows the number of citations from specified publications compared to the standard citations allocated to similar themes in the Scopus database. Table 2 indicates the type of collaboration in Ayurveda research. The organizational and national collaboration lead with shares of 41.8% and 35.3%, respectively. While international affiliation has the smallest percentage of 14%, it has the largest TC/TP and CI of 9.6 and 1.09, respectively. National and institutional affiliations follow TC/TP of 6.6 and 4.6. They also have a moderate CI. Institutional collaboration has the least CI, while single authorship has the least TC/TP.

4.3. Open access trends

Fig. 3 shows the Open Access (OA) and OA publications from the two quartile sources (OAQ) increased from 1993 to 2022. OA publications are expected to have more significant citations than close-access publications [52]. The percentage of OA and OAQ publications increased from 2% in 1993 to a massive 57% and 50% in 2022.

Table 1
Publications and citations trends across three decades.

Metric	1993–2002	2003–2012	2013–2022
TP	854	3859	7075
TPQ	331	1650	3179
TC	33,234	117,740	65,872
TCQ	21,383	83,541	46,345
TC/TP	38.9	30.5	9.3
TCQ/TPQ	64.6	50.6	14.6

Note: TP – total publications; TPQ – total publications from Q1, Q2 journals; TC – total citations; TCQ – total citations from publications in Q1, Q2 journals; TC/TP – average citations per publication; TCQ/TPQ – average citations per publication based on Q1, Q2 journals.

Table 2
Research collaborations.

Type of collaboration	% Share	TC/TP	CI
International collaboration	14%	9.6	1.09
Only national collaboration	35.3%	6.6	0.84
Only institutional collaboration	41.8%	4.6	0.50
Single authorship (no collaboration)	8.8%	3.4	0.55

Note: TC/TP – average citations per publication; CI – collaborative index.

4.4. Most contributing countries

Table 3 illustrates the most contributing countries with publications and High Impact Journals to Ayurveda research. India, the United States, and the United Kingdom have the highest TC, TCQ, TP, and TPQ. India takes up 65.91% of the TP, 52.93% of the TPQ, 46.06% of the TC, and 43.03% of the TCQ. The US follows with 9.26% of TP, 14.48% of TPQ, 18.52% of TC, and 20.16% of TCQ. The citations per publication (TC/TP) are higher for the US. The US and UK have TC/TP values of 42.8 and 48.

4.5. Bibliographic coupling of countries

The bibliographic coupling of the countries is presented in Fig. 4 with network visualization. Only countries with a minimum of 5 publications and 500 citations were used, leading to 27 countries. The bubble size represents the total publication from the country, and the link's width represents the connection's strength. The biggest bubble is India, with strong links to China, Saudi Arabia, Bangladesh, and Pakistan, and is connected to nearly all the countries. The United States has strong links with Canada, Sri Lanka, and Japan. The United Kingdom has strong ties with France, Italy, Spain, and several other European countries.

4.6. Most productive institutions

Table 4 shows the most productive institutions in Ayurveda research. Datta Meghe Institute of Medical Sciences and the Academy of Scientific and Innovative Research are the leading organizations with the highest TP (178) and TC (989), respectively. Banaras Hindu University and the University of Pune are second and third in citations, with TC of 874 and 837, respectively. Banaras Hindu University and Manipal Academy of Higher Education are the second and third in productivity, with TP of 159 and 103, respectively. All these ten leading institutions from India are private. Most of the institutions are focused on Ayurveda practice and research. Banaras Hindu University is in the lead since it has a specialized Ayurveda department other than medical institutions.

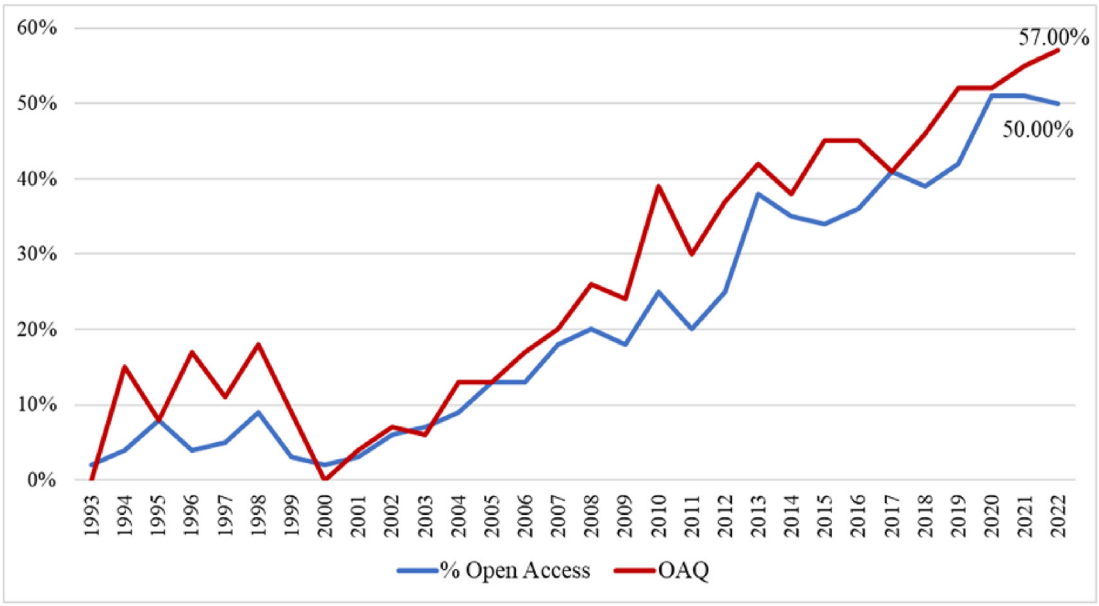

Fig. 3. Open access publication trends.

Table 3
Most contributing countries.

Rank by publications						Rank by citations					
Rank	Country	TP	%TP	TPQ	%TPQ	Rank	Country	TC	%TC	TCQ	%TCQ
1	India	15,227	65.91%	5989	52.93%	1	India	228,017	46.06%	151,430	43.03%
2	United States	2140	9.26%	1638	14.48%	2	United States	91,679	18.52%	70,955	20.16%
3	United Kingdom	473	2.05%	359	3.17%	3	United Kingdom	22,715	4.59%	16,402	4.66%
4	Japan	364	1.58%	269	2.38%	4	Italy	15,370	3.10%	9735	2.77%
5	Germany	357	1.55%	214	1.89%	5	Japan	10,205	2.06%	9531	2.71%
6	China	309	1.34%	235	2.08%	6	China	10,163	2.05%	8789	2.50%
7	Australia	280	1.21%	215	1.9%	7	Germany	9450	1.91%	6993	1.99%
8	Malaysia	276	1.19%	135	1.19%	8	Australia	8540	1.73%	6558	1.86%
9	Italy	26	1.14%	229	2.02	9	Norway	6188	1.25%	974	1.25%
10	Norway	40	0.17%	30	0.27	10	Malaysia	5554	1.12%	3419	1.14%

Note: TP – total publications; TC – total citations; TPQ – total publications in Q1 & Q2 journals; TCQ – total citations from publications in Q1 & Q2 journals.

4.7. Highly cited journals

Table 5 shows the leading journals on Ayurveda research based on citations. The Journal of Ethnopharmacology and Phytotherapy Research has the highest number of citations, 26782 and 7412, respectively. The Journal of Ayurveda and Integrative Medicine and The Journal of Ethnopharmacology has the highest publications, 613 and 446, respectively. Biochemical Pharmacology and Alternative Medicine Review have the highest high citations per publication. Seven of the top fifteen journals are in Q1, while four are in Q2. The two-year journal impact factors are for the year 2022, published by Clarivate Analytics in July 2023.

4.8. Bibliographic coupling of journals

Bibliographic coupling links are similarity approaches used in the frameworks of science mapping [53]. It measures the journal–journal relationships considering the number of references they share [54,55]. The bibliographic coupling of journals is highlighted in Fig. 5. To reduce clutter, as inclusion criteria, the journal's minimum number of publications with our search criteria was set to be greater than 10, and the total citations to greater than 500. Forty-seven journals met the threshold.

Journal of Ethnopharmacology and Phytotherapy Research has the highest publication and citation (TP:446, TC:26782) in cluster 1, followed by the journal Evidence-based Complementary and alternative medicine (TP:125). In cluster 2, pharmacognosy reviews have the highest citation (TC:2531), and the second is the Asian pacific journal of tropical biomedicine (TP:1711). Journal of Ayurveda and integrative medicine has the highest publication (TP:613), followed by the Journal international journal of Research in Ayurveda and Pharmacy (TP:2866) and citation (TC:574) in Cluster 3, followed by evidence-based complementary and alternative medicine (TP:125, TC:5003). The links show how closely the journals have cited each other.

4.9. Influential authors

Table 6 shows the ten most influential authors in Ayurveda research based on TP and TC. The top authors are Patwardhan B and Prajapati PK, while the top three cited authors are Patwardhan B, Aggarwal B.B, and Mukherjee P.K. All the top authors based on publications originate from India. In contrast, three authors ranked by citations are from the US, and five are from India. Interestingly, there are five authors with single-digit publications in the ranking by citations.

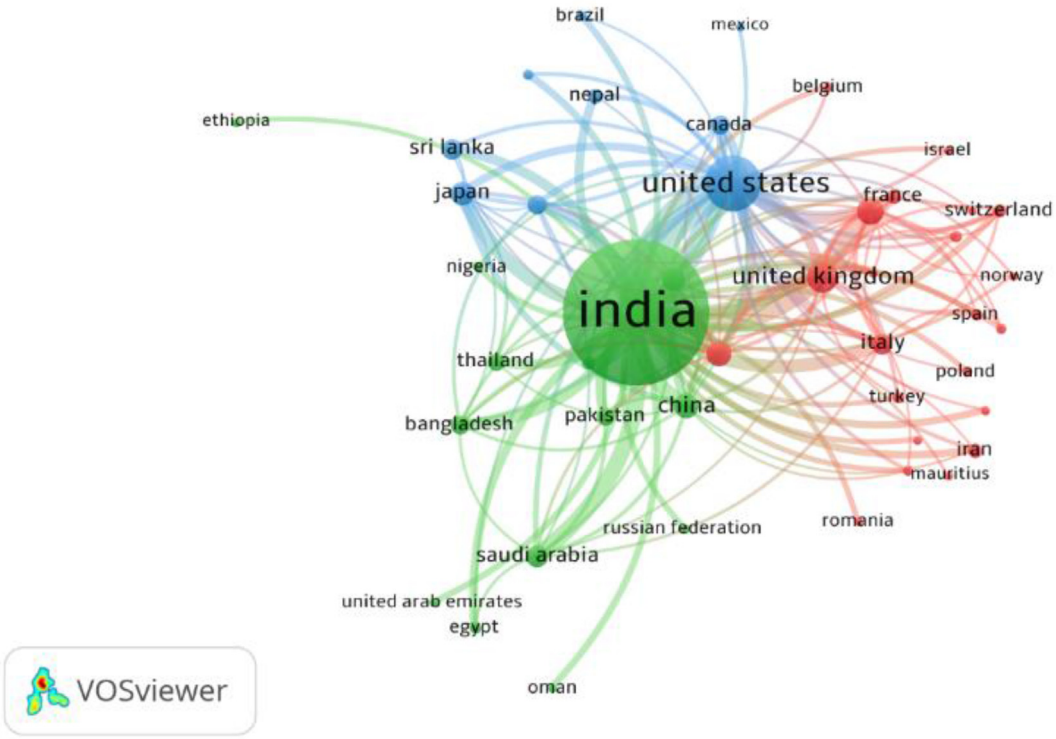

Fig. 4. Bibliographic coupling of countries.

Table 4
Most productive institutions

Institution	TC	TP	Type
Datta Meghe Institute of Medical Sciences	161	178	Private
Banaras Hindu University	874	159	Public
Manipal Academy of Higher Education	309	103	Private
University of Pune	837	81	Public
Amrita Vishwa Vidyapeetham	317	77	Private
Saveetha Institute of Medical and Technical Sciences	49	73	Private
Lovely Professional University	316	62	Private
Bharath Institute of Higher Education and Research	365	60	Private
Academy of Scientific and Innovative Research	989	60	Public
Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha, Sowa Rigpa and Homoeopathy	357	57	Public

\Note: TP – total publications; TC – total citations (All institutions are from India).

Table 5
Top cited Journals.

Journal	TP	TC	TC/TP	Impact Factor (2 year, 2022)	Scopus Quartile
Phytomedicine	43	3029	70.44	7.9	Q1
Phytotherapy Research	137	7412	54.1	7.2	Q1
Biochemical Pharmacology	10	2895	289.5	5.8	Q1
Journal of ethnopharmacology	446	26782	60.05	5.4	Q1
Molecules	34	2035	59.85	4.6	Q1
BMC complementary and alternative medicine	69	2339	33.9	3.9	-
PLOS one	58	2215	38.19	3.7	Q1
Journal of Alternative and complementary medicine	115	3594	31.25	2.6	Q1
Journal of Ayurveda and integrative medicine	613	3795	6.19	2.4	Q2
Indian Journal of Pharmacology	71	2766	38.96	2.4	Q2
Asian pacific journal of tropical biomedicine	28	1711	61.11	1.57	Q2
Indian Journal of experimental biology	129	4472	34.67	0.6	-
Evidence-based complementary and alternative medicine	125	5003	40.02	-	Q2
Alternative Medicine Review	13	2855	219.62	-	-
Pharmacognosy Reviews	42	2531	60.26		-

*Note: TP – total publications; TC – total citations; TC/TP – average citations per publication (The two-year journal impact factors are for the year 2022, published by Clarivate Analytics in July 2023).

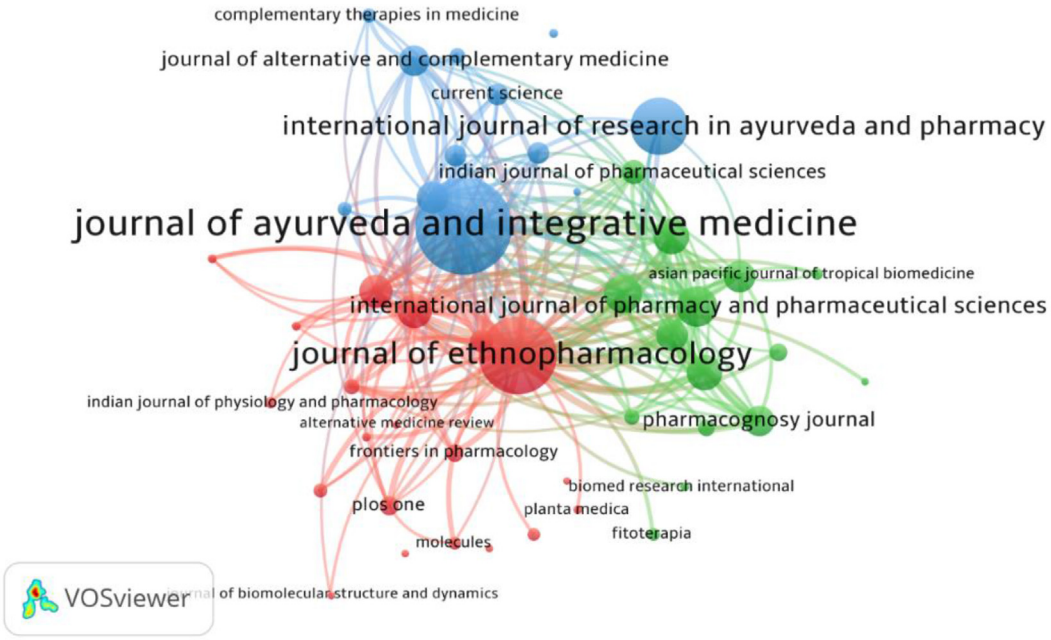

Fig. 5. Bibliographic coupling of journals.

Table 6
Influential authors.

Ranked by TP (research productivity)					Ranked by TC (research influence)				
Name	Country	TP	TC	TC/TP	Name	Country	TC	TP	TC/TP
Patwardhan B.	India	103	4047	39.29	Patwardhan B.	India	4047	103	39.29
Prajapati PK.	India	67	525	7.84	Aggarwal B.B.	India	3990	18	221.67
Mukherjee, P.K.	India	55	2684	48.80	Mukherjee P.K.	India	3137	55	57.04
Balkrishna, A.	India	51	325	6.37	Bhattacharya S.K.	India	2181	27	80.78
Prabhu, K.	India	48	407	8.48	Grover J.K.	Belgium	2162	9	240.22
Rao, M.R.K.	India	46	384	8.35	Vats V.	United States	2062	8	257.75
Rastogi, S.	India	43	231	5.37	Kunnumakkara A.B.	India	2021	4	505.25
Ravishankar, B.	India	42	436	10.38	Goel A.	United States	1804	8	225.50
Tripathi, Y.B.	India	40	1161	29.03	Phillips R.S.	United States	1632	6	272.00

Note: TP – total publications; TC – total citations.

4.10. Top cited publications

Table 7 highlights the top-cited Ayurveda publications. Regarding the citation, each article is associated with a set of Medical Subject Headings (MeSH) terms. While citations indicate the core structure of research, MeSH terms represent relevance to current research options [56]. Goel et al. [57] evaluated Curcumin transmission from the kitchen to the clinic among the top-cited papers. Gurib-Fakim [58] discussed the use of medicinal plants, while [59] investigated Curcumin as India's asset. The three leading papers originated from Biochemical Pharmacology, Journal of Ethnopharmacology, and Molecular Aspects of Medicine. Grover J.K. had the second-highest annual TC of 1304. The last two publications evaluated heavy metals in organisms [60] and assessed *Curcuma longa* [61].

4.11. Funding agencies

Table 8 illustrates the top ten funding agencies in Ayurveda research. Six are from India, and three are from the US, showing the dominance of these two countries in funding most of the research in Ayurveda.

4.12. Fields of research

Table 9 describes the ten leading fields of research in Ayurveda. Pharmacology, Toxicology, and Pharmaceutics have the highest TP and TC. Medicine has the Second-largest TC. The average citation per paper is the highest in Immunology and Microbiology (30.1), followed by Multidisciplinary (17), Biochemistry, Genetics and Molecular Biology (16.5), and Chemistry with a TC/TP of (15.3).

4.13. Keyword co-occurrence analysis

Table 10 lists the top keywords for each cluster based on the minimum occurrence criterion. The research themes and hot topics were identified using a keyword co-occurrence network analysis [62,63], using keywords that occurred a minimum of 50 times (Fig. 6). The networks of concentrated studies on Ayurveda research themes relating to the four clusters, Alternative and Traditional Medicine, Bioactive Compounds and Biological Activities, Analytical Techniques and Herbal Standardization, and Herbal Medicines and Immunomodulation.

Table 7
Top cited publications.

Title	TC	Year	TC/Year	Journal	Mesh Terms	Authors
Curcumin as "Curecumin": From kitchen to clinic	1725	2008	123.21	Biochemical Pharmacology	Anticancer; Curcumin; Natural products	Goel A et al.
Medicinal plants of India with anti-diabetic potential	1304	2002	65.2	Journal of Ethnopharmacology	Ayurveda; Diabetes mellitus; Herbal medicine; Indian; Plants; Review	Grover J.K et al.
Medicinal plants: Traditions of yesterday and drugs of tomorrow	1260	2006	78.75	Molecular Aspects of Medicine	Drug discovery; Ethnobotany; Medicinal plants; Pharmacognosy; Traditional medicine; Validation	Gurib-Fakim A.
The anti-infective potential of natural products: How to develop a stronger in vitro 'proof-of-concept.'	1082	2006	67.63	Journal of Ethnopharmacology	Antibacterial; Antifungal; Antiparasitic; Antiviral; Natural products; Screening	Cos P et al.
Anti-inflammatory properties of curcumin, a major constituent of *Curcuma longa*: A review of preclinical and clinical research	1055	2009	81.15	Alternative Medicine Review		Jurenka J.S.
Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): A review of recent research	1027	2008	73.36	Food and Chemical Toxicology	Anti-emetic; Anti-inflammatory; Anti-oxidant; Anti-tumorigenic; Ginger; Gingerols	Ali B.H et al.
Herb-drug interactions	1021	2000	46.41	Lancet		Fugh-Berman A.
Silver nanoparticles: The powerful nano weapons against multidrug-resistant bacteria	1000	2012	100	Journal of Applied Microbiology	Antimicrobial; Methicillin-resistant *Staphylococcus aureus*; Multidrug resistance; Nanoweapon; Silver nanoparticles; Vancomycin-resistant *Staphylococcus aureus*.	Rai M.K et al.
Traditional medicine and modern medicine from natural products	919	2016	153.17	Molecules	Chemodiversity; Drug discovery; Natural products; Traditional medicines; Traditional uses	Yuan H et al.
Use of opioid analgesics in the treatment of cancer pain: Evidence-based recommendations from the EAPC	883	2012	88.3	The Lancet Oncology		Caraceni A et al.

Note: TC – total citations; TC/Y – average citations per year.

4.13.1. Cluster 1: alternative and traditional medicine (red)

This cluster involves traditional and alternative approaches to healthcare, including herbal remedies, complementary therapies, and cultural-specific practices such as yoga. It also includes concepts like cancer, diabetes mellitus, and toxicity in the context of alternative treatments.

Studies in this cluster investigate these alternative therapies' efficacy, safety, and mechanisms of action through clinical trials, observational studies, and laboratory research. Researchers draw knowledge from multiple disciplines, collaborating with fields like pharmacology, ethnobotany, and anthropology to study the cultural context and health benefits.

Table 8
Funding agencies based on publications.

Institution	Country	TP
University Grants Commission	India	171
Council of Scientific and Industrial Research, India	India	171
Department of Science and Technology, Ministry of Science and Technology, India	India	111
Indian Council of Medical Research	India	119
Department of Biotechnology, Ministry of Science and Technology, India	India	118
National Institutes of Health	United States	79
National Center for Complementary and Integrative Health	United States	67
National Cancer Institute	United States	62
University Grants Commission	India	60
Bangladesh Council of Scientific and Industrial Research	Bangladesh	51

Note: TP – total publications.

Table 9
Fields of research.

Fields of research	TP	TC	TC/TP
Pharmacology, Toxicology, and Pharmaceutics	5660	104,668	18.49
Medicine	5273	95,121	18.03
Biochemistry, Genetics, and Molecular Biology	2148	57,481	26.76
Agricultural and Biological Sciences	1144	20,776	18.16
Chemistry	734	15,519	21.14
Environmental Science	409	4373	10.69
Social Sciences	384	4306	11.21
Health Professions	310	2927	9.44
Nursing	283	6125	21.64
Immunology and Microbiology	281	8344	29.69

Note: TP – total publications; TC – total citations; TC/TP – average citations per publication.

Table 10
Thematic areas of research from keyword co-occurrence analysis.

Cluster Title	#Keywords	Top Keywords
Alternative and Traditional Medicine	18	Alternative medicine, ayurvedic medicine, cancer, complementary and alternative medicine, complementary medicine, diabetes mellitus, herbal medicine, herbs, homeopathy, India, integrative medicine, medicinal plants, natural products, Siddha, toxicity, traditional medicine, yoga.
Bioactive Compounds and Biological Activities	13	Anti-inflammatory, anticancer, antidiabetic, antimicrobial, antioxidant, apoptosis, curcumin, diabetes, flavonoids, inflammation, lipid peroxidation, oxidative stress, and phytochemicals.
Analytical Techniques and Herbal Standardization	10	Antioxidant activity, gallic acid, HPLC, HPTLC, pharmacognosy, pharmacology, phytochemical, phytochemistry, standardization.
Herbal Medicines and Immunomodulation	7	SARS-CoV-2, *Withania somnifera*, COVID-19, immunomodulation, rasayana, ashwagandha, *Tinospora cordifolia*,

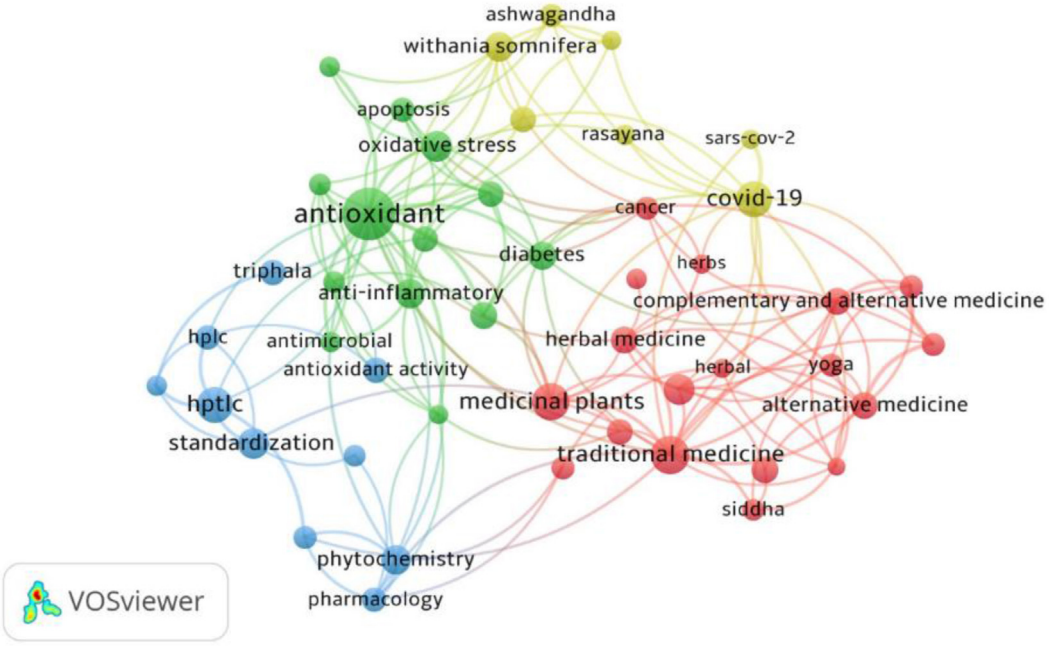

Fig. 6. Keyword co-occurrence analysis.

4.13.2. Cluster 2: bioactive compounds and biological activities (green)

This cluster involves the development of dietary supplements, pharmaceuticals, or functional foods derived from bioactive compounds to promote health and manage specific conditions. It focuses on bioactive compounds with antioxidant, anti-inflammatory, and anticancer properties, including curcumin, flavonoids, and other compounds. It also explores apoptosis, lipid peroxidation, and oxidative stress processes.

Research in this cluster investigates these compounds' mechanisms, bioavailability, and therapeutic applications, particularly in inflammation, cancer, diabetes, and related conditions. It involves in vitro and in vivo experiments, clinical trials, and epidemiological studies. Researchers in this cluster collaborate across disciplines such as biochemistry, pharmacology, and medical sciences to understand bioactive compounds' biochemical and physiological effects and their potential applications in medicine.

4.13.3. Cluster 3: analytical techniques and herbal standardization (blue)

The concepts in this cluster relate to the practical aspects of analyzing and standardizing natural products, ensuring their quality and safety. It involves applying analytical techniques in identifying, quantifying, and characterizing compounds in herbal products. It focuses on analytical techniques such as HPLC and HPTLC, antioxidant activity, pharmacognosy, pharmacology, phytochemicals, and herbal standardization.

Research in this cluster involves developing and standardizing analytical methods for studying natural products, identifying bioactive compounds, and evaluating their pharmacological properties. It aims to improve quality control and ensure the safety and efficacy of herbal medicines. Researchers in this cluster collaborate across fields such as analytical chemistry, pharmacology, and botanical sciences to develop robust analytical techniques and ensure the safety and efficacy of herbal products.

4.13.4. Cluster 4: Herbal Medicines and Immunomodulation (yellow)

The concepts in this cluster pertain to the practical use of herbal products for immune support and adjunctive therapy in COVID-19 patients or individuals with immune-related conditions. It focuses on specific herbal medicines such as Ashwagandha and *Tinospora cordifolia*, immunomodulation, and their potential effects on immune function. It also includes concepts related to COVID-19 and the SARS-CoV-2 virus, suggesting research on herbal approaches to immune modulation in the context of COVID-19.

Research in this cluster investigates the potential effects of herbal medicines and bioactive compounds on immune function,

including their role in COVID-19 and immunomodulation. It involves in vitro studies, animal models, and clinical trials to explore the therapeutic applications of these herbal interventions. Researchers in this cluster collaborate across fields such as virology, immunology, pharmacology, and infectious diseases to explore the potential benefits and mechanisms of action of herbal interventions in viral infections and immune modulation.

4.14. Key phrases analysis

To identify recent trends, the top 50 key phrases were identified using Scival for 2018–2022 (Fig. 7). Scival uses text mining to extract and standardize keyphrases from titles and abstracts. Keyphrase analysis can identify research hotspots [64]. The size of the keyphrases represents their relevance or the number of times they occur, and the color of the keyphrases indicates if they are growing, declining, or stable in the period. The key phrases that are both highly relevant and growing are Ayurvedic Medicine, Formulation, Medicinal Plant, Phytochemicals, and Traditional Medicine. The key phrases with low relevance scores but are growing include Gas Chromatography–Mass Spectrometry, Curcuma, Drugs, Case Report, Anti-inflammatory Activity, *Withania somnifera* L., Chemical Constituents of Plants, Phytochemicals, and Leaf Extracts.

The key phrases that have low relevance and are decreasing include High-Performance Thin Layer Chromatography, Alternative Medicine, Ayurvedic Drugs, Complementary and Alternative Medicine, Root extracts, and Bacoppa Monnieri. COVID-19 is a new keyphrase that is growing and relevant during this period.

4.15. Mapping to sustainable development goals

Table 11 illustrates the distribution of publications mapped to the SDG. Good Health and Well Being (SDG 3) have the most publications and citations. Ayurveda is a traditional system of medicine that emphasizes the importance of maintaining balance in the body, mind, and spirit to achieve good health and well-being. It promotes healthy lifestyle practices, such as regular exercise, a healthy diet, and stress management techniques, and uses natural remedies, such as herbs and oils, to prevent and treat illness. By promoting healthy lifestyle practices and using natural remedies, Ayurveda will be able to contribute to the achievement of SDG 3. A unique holistic approach that aligns with the UN SDG focuses on environmental considerations and societal health and well-being through multidimensional performance indicators [1]. An integrative approach to cancer management can support SDG 3 and substantially contribute to its prevention and treatment to reduce this burden [3]. Practical approaches are explored to involve SDG 3, "Health for all" by defining responsibilities and preparing the healthcare system, emphasizing traditional healthcare like Ayurveda in an unequal world [65].

Table 11
Ayurveda research mapped to SDG.

SDG	TP	TC	TC/TP
3 Good health and well-being	6898	15,3876	22.31
2 Zero hunger	38	491	12.92
11 Sustainable cities and communities	20	679	33.95
12 Responsible consumption and production	20	186	9.30
16 Peace, justice and strong institutions	19	221	11.63
13 Climate action	17	173	10.18
7 Affordable and clean energy	14	264	18.86
15 Life on land	14	430	30.71
8 Decent work and economic growth	13	132	10.15
6 Clean water and sanitation	11	163	14.82
5 Gender equality	10	26	2.60
9 Industry, innovation and infrastructure	8	58	7.25
10 Reduced inequalities	5	186	37.2
4 Quality Education	4	15	3.75
1 No Poverty	2	59	29.5
14 Life below water	1	0	0.00

Note: TP – total publications; TC – total citations; TC/TP – average citations per publication.

Table 12 lists highly cited publications mapped to SDG. Highly cited articles are mapped to Good Health and Well-Being (SDG 3).

SDG 11(Sustainable cities and communities) and SDG 15 (Life on land) have high citations per publication. The principles of Ayurveda, such as the importance of eating a balanced diet that is appropriate for an individual's unique constitution and needs and the use of locally grown and seasonal whole foods, may contribute to the goals of Sustainable Development Goal 2 (SDG 2), which aims to "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture." By promoting the use of whole, unprocessed foods and advocating for individualized approaches to diet and nutrition, Ayurveda may help to improve the overall nutrition and health of populations, reducing the burden of malnutrition and other diet-related health problems. Ayurveda promotes the importance of self-care and self-knowledge and encourages individuals to take an active role in their health and well-

Fig. 7. Word cloud visualization of key phrases.

Table 12
Highly cited publications mapped to SDG.

SDG mappings	TC	Title	Journal	Year	Authors
3 Good Health and Well Being	939	Silver nanoparticles: the powerful nano weapon against multidrug-resistant bacteria	Journal of Applied Microbiology	2012	Rai, M.K. et al.
	922	Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): A review of recent research	Food and Chemical Toxicology	2007	Ali, Badreldin H. et al.
	904	The Traditional Medicine and Modern Medicine from Natural Products	Molecules	2016	Yuan, Haidan et al.
15 Life on Land	127	*Asparagus racemosus*—Ethnopharmacological evaluation and conservation needs	Journal of Ethnopharmacology	2007	Bopana, Nishritha et al.
	62	*Leptadenia reticulata* (Retz.) Wight & Arn. (Jivanti): Botanical, Agronomical, Phytochemical, Pharmacological, and Biotechnological Aspects	Molecules	2017	Mohanty, Sudipta Kumar et al.
	50	Traditional knowledge of zootherapeutic uses by the Saharia tribe of Rajasthan, India	Journal of Ethnobiology and Ethnomedicine	2007	Mahawar, Madan Mohan et al.
2 Zero Hunger	230	Indian Traditional Ayurvedic System of Medicine and Nutritional Supplementation	Evidence-based Complementary and Alternative Medicine	2013	Pandey, M. M. et al.
	26	Functional Fungal Endophytes in Coleus forskohlii Regulate Labdane Diterpene Biosynthesis for Elevated Forskolin Accumulation in Roots.	Microbial Ecology	2019	Mastan, Anthati et al.
	25	*Morus alba* L. Plant: Bioactive Compounds and Potential as a Functional Food Ingredient	Foods	2021	Chen, Centhyea et al.
4 Quality Education	40	The Ayurveda Education in India: How Well Are the Graduates Exposed to Basic Clinical Skills?	Evidence-based Complementary and Alternative Medicine	2011	Patwardhan, Kishor et al.
	25	Global challenges of graduate level Ayurvedic education: A survey	International Journal of Ayurveda Research	2010	Patwardhan, Kishor et al.
	15	Government policies and initiatives for the development of Ayurveda	Journal of Ethnopharmacology	2016	Katoch, Dinesh et al.

Note: TC – total citations.

being through mindfulness and self-observation. These principles may be incorporated into education and lifelong learning opportunities. They may be particularly relevant in SDG 4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

4.16. Impact of COVID-19

Table 12 shows that from 2020 to 2022, there were 544 publications related to Ayurveda and COVID-19, demonstrating significant collaboration among multiple authors and institutions. The top five publications included three that focused on docking studies to identify phytochemicals in plants used in Ayurveda that may have activity against SARS-CoV-2 viruses.

The highest-ranked article explored ligands on SARS-CoV-2 variants. Two other papers focused on Ayurvedic clinical interventions for COVID-19 patients, with one categorizing patient into four groups based on severity and the other discussing prophylactic measures from Ayurveda and yoga for preventing COVID-19. Another discussed the Indian government's promotion of Ayurveda during the pandemic and its potential positive influence on immune function and mental health [66].t

The second article identified a plan for using Ayurveda to manage COVID-19 symptoms ranging from mild to severe. The authors highlighted knowledge and practices from Ayurveda that may help manage COVID-19, including using *W. somnifera* and yoga for mental health. The article lists specific herbs and formulations that may be used to treat patients in each category and recommends adjusting the dosage of individual formulations based on the patient's strength and the severity of the disease. Other studies have suggested that Ayurvedic care may be a cost-effective first-line treatment in an integrative setting for patients with persistent hypoxia in the post-hospitalization phase [67,68]. A machine-based topic modeling study found that messages about “Yoga and Ayurveda for immunity” had a significant herd effect [69].

Tillu et al. [70] investigated the use of yoga and Ayurveda to improve the health of COVID-19 patients. Shree et al. [71] studied the potential of using phytochemicals from Ayurvedic herbal plants to treat COVID-19 and identified six potential inhibitors against SARS-CoV-2. Maurya et al. [72] evaluated the use of natural drugs from Ayurveda to target the COVID-19 glycoprotein. They suggested that curcumin and nimbi may interact highly with the spike glycoprotein and ACE2 receptor. In silico studies have also identified several potential inhibitors of SARS-CoV-2, including *W. somnifera* L, *T. cordifolia* (Wild) Hook. f. & Thomson, *Asparagus racemosus* Wild. [73], Amalaki (Emblica officinalis Gaertn. is synonymous with *P. emblica* L.), and *Cinnamomum zeylanicum* (synonymous with *Cinnamomum verum* J.Presl.) [11]. Compounds of *Citrus medica* and *Zingiber officinale* have also shown potential against the SARS-CoV-2 virus in an in-silico study [74] and a clinical study [75] (see Table 13).

5. Discussion and conclusion

This bibliometric study aimed to examine the research trends in Ayurveda over the past three decades, assessing its growth and identifying potential areas for future investigation. The findings revealed a substantial increase in Ayurveda research regarding publications and citations during the studied period. Notably, there was exponential growth from 1993 to 2012, followed by a tapering off until 2019. However, the onset of the COVID-19 pandemic resulted in a surge in Ayurveda research, with the highest number of annual publications occurring in 2020 and 2022, even in higher-quality journals within the top two quartiles.

The study also highlighted the prevalence of institutional collaborations, with approximately half of the research involving such

Table 13
Top cited Ayurveda research and COVID-19.

Rank	TC	Year	Authors	Country	Publication Title
1	212	2020	Esakandari H.; Nabi-Afjadi M.; Fakkari-Afjadi J.; Farahmandian N.; Miresmaeili S.-M.; Bahreini E.	Iran	A comprehensive review of COVID-19 Characteristics
2	212	2020	Joshi R.S.; Jagdale S.S.; Bansode S.B.; Shankar S.S.; Tellis M.B.; Pandya V.K.; Chugh A.; Giri A.P.; Kulkarni M.J.	India	Discovery of potential multi-target-directed ligands by targeting host-specific SARS-CoV-2 structurally conserved main protease
3	107	2020	Maurya V.K.; Kumar S.; Prasad A.K.; Bhatt M.L.B.; Saxena S.K.	India	Structure-based drug designing for potential antiviral activity of selected natural products from Ayurveda against SARS-CoV-2 spike glycoprotein and its cellular receptor
4	101	2022	Shree P.; Mishra P.; Selvaraj C.; Singh S.K.; Chaube R.; Garg N.; Tripathi Y.B.	India	Targeting COVID-19 (SARS-CoV-2) main protease through active phytochemicals of ayurvedic medicinal plants—*Withania somnifera* (Ashwagandha), *Tinospora cordifolia* (Giloy) and *Ocimum sanctum* (Tulsi)—a molecular docking study
5	90	2020	Tillu G.; Chaturvedi S.; Chopra A.; Patwardhan B.	India	Public Health Approach of Ayurveda and Yoga for COVID-19 Prophylaxis
6	80	2022	Rastogi S.; Pandey D.N.; Singh R.H.	Nepal	COVID-19 pandemic: A pragmatic plan for Ayurveda intervention
7	70	2021	Khanna, K., Kohli, S.K., Kaur, R., (...), Bhardwaj, R., Ahmad, P.	India	Herbal immune-boosters: Substantial warriors of the pandemic Covid-19 battle

partnerships. Notably, publications with international collaborations demonstrated the highest impact regarding citations, followed by national collaborations. However, a significant portion of the publications (55.5%) involved single or institutional collaborations. The study suggests that fostering increased international and national collaborations could enhance the impact of Ayurveda research. Furthermore, the percentage of publications in open-access journals rose to 50% in 2022, exceeding the average. This substantial increase may be attributed to improved visibility, higher citation rates, quicker review processes, and the growing emphasis on open science. It also suggests a rising interest in funding Ayurveda research.

Regarding global contributions, the countries with the highest number of citations for Ayurveda research were India, the United States, and the United Kingdom. India, the primary hub for Ayurveda practice, had the highest number of publications (65.9%) and total citations (46%). Among the contributing institutions, Banaras Hindu University emerged as the top institution regarding publications and citations. The Journal of Ethnopharmacology had the highest number of publications on Ayurveda. At the same time, Phytotherapy Research, Evidence-based Complementary, and Alternative Medicine, the Indian Journal of Experimental Biology, and the Journal of Ayurveda and Integrative Medicine demonstrated the highest ratio of citations to publications. These journals and their research themes may serve as valuable considerations for future work.

Regarding funding, the study identified the top two funders for Ayurveda research in India as CSIR, DST, and DBT. Among the top 10 funders, five were from India, and three were from the United States, reflecting the dominance of these two countries in funding Ayurveda research. Noteworthy authors in this field during the studied period included Patwardhan B. and Prajapati P.K., while Patwardhan B., Aggarwal B.B., and Mukherjee P.K. garnered the highest number of citations.

The keyword co-occurrence analysis in this bibliometrics study uncovers distinct research clusters within Ayurveda, showcasing its diverse areas of study. These clusters are Traditional Ayurvedic Practices and Therapies, Bioactive Compounds and Biological Activities, Analytical Techniques and Herbal Standardization, and Herbal Medicines and Immunomodulation. This reveals that Ayurvedic research extends beyond traditional practices and incorporates modern scientific approaches, including exploring bioactive compounds, developing analytical techniques, and investigating immunomodulatory effects. These interdisciplinary clusters demonstrate collaborations between various fields, such as virology, immunology, pharmacology, and infectious diseases, advancing Ayurvedic research.

Ayurveda shows great potential in promoting holistic well-being by integrating traditional wisdom with scientific methodologies. The identified keyword clusters indicate that Ayurvedic practices and therapies are being explored to enhance immunity alongside studying the mechanisms of action by characterizing bioactive compounds. There is also a concerted effort to improve the quality of Ayurvedic medicines through phytochemical studies. Notably, research related to the SARS-CoV-2 virus in the Herbal Medicines and Immunomodulation cluster suggests that Ayurveda, like other traditional medical systems, aimed to modulate the immune response even in the context of COVID-19.

This study maps Ayurveda research to the Sustainable Development Goals (SDG), finding a significant focus on SDG 3 (Good Health and Well-being). Highly cited publications in Ayurveda primarily address SDG 3, highlighting the potential of natural products and traditional medicine in combating antibiotic resistance, improving health, and promoting holistic health through balanced lifestyle practices and natural remedies. Additionally, Ayurveda research contributes to SDG 2 (Zero Hunger) by exploring nutritional supplementation and SDG 4 (Quality Education) through education, self-care approaches, and training in Ayurveda.

5.1. Recommendations for future research

1. Increase funding & Capacity Building for Ayurveda research: There is a need for increased funding for Ayurveda and integrative medicine research, particularly in Europe and other countries. According to this study, the United Kingdom, Italy, Germany, and Norway are among the top 10 countries in terms of publications or citations in the field of Ayurveda. However, the European Commission is the only European funding agency among the top 10 funders for Ayurveda research. Collaborative projects should be encouraged to support further development and implementation of Ayurvedic practices. Moreover, it is essential to provide training in research methods to enhance the research capabilities of the Ayurveda community, ensuring high-quality research outcomes and attracting global funding opportunities.
2. Translate preclinical findings into clinical evidence: The keyword co-occurrence analysis shows that preclinical studies in pharmacology and pharmaceuticals dominate the field of

Ayurveda. This suggests a need for further research to translate preclinical studies and these findings into clinical evidence. This will contribute to a better understanding of the efficacy and safety of Ayurvedic substances.

3. Explore the phytochemistry of Ayurvedic herbs and formulations: The Analytical Techniques and Herbal Standardization cluster in Ayurveda research is relatively small, indicating a potential opportunity for further exploration of the many formulations mentioned in classical texts and used in Ayurvedic clinical practice. Conduct research using advanced techniques such as network pharmacology, metabolomics, and high throughput screening to explore the complex pharmacological activity of Ayurvedic substances. This will enable the standardization of multi-ingredient formulations and support their clinical use.
4. Utilize the "reverse pharmacology" approach: The "reverse pharmacology" or "clinic-to-lab" approach can be employed to understand the mechanisms of action of Ayurvedic substances and enhance their delivery and efficacy. This approach involves starting with the clinical use of these substances and then conducting laboratory research to uncover their underlying mechanisms. Increasing the number of high-quality preclinical experiments and clinical trials can contribute to developing preventive and treatment protocols based on phytochemical screening of Ayurvedic formulations.
5. Conduct ethnopharmacological studies for new drug discovery: Ethnopharmacological studies focusing on medicinal plants and formulations used in Ayurveda can help identify promising natural products that have the potential to overcome challenges in drug development and contribute to the discovery of new medicinal products.
6. Investigate the role of Ayurveda in integrated medicine approaches: Research on Ayurveda's potential role in integrated medicine approaches, particularly in the context of addressing the COVID-19 pandemic, should be further explored. Understanding the synergistic effects of combining Ayurveda with allopathic medicine can help enhance treatment effectiveness and explore strategies for strengthening immunity.
7. Address sustainability challenges: Ayurveda heavily relies on natural resources and biodiversity for its medicines. Considering the increasing demand for these products and the challenges of deforestation and climate change, research on Sustainable Development Goals (SDG) 12 (Responsible Consumption and Production) and 13 (Climate Action) is crucial. This research will contribute to sustainable practices, ensuring the availability of raw materials and promoting responsible production in Ayurvedic medicine.

5.2. Limitations

Using Scopus as the source database for this review has limitations that may affect the study findings. Other databases like Web of Science and PubMed have different inclusion criteria and domain focuses. However, Scopus is widely used for ranking purposes and includes only peer-reviewed publications. To address this limitation, the researchers analyzed only the Scopus journal publications and, in some cases, the journals in the top two quartiles. While some publications from other traditional medicine systems may have been included if they mentioned Ayurveda, the extensive analysis of numerous publications and keywords reduces the impact of this potential issue on the overall trends in Ayurveda research.

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PN and RR conceived the work, analyzed the data, and wrote the manuscript. VKN curated and analyzed the data, and SS, RP, CK, and BP provided detailed input on the development of the field. All authors critically reviewed the work. All authors have approved the final content of the manuscript.

Declaration of competing interest

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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