eCMTA | Evidence-Based Chinese Medicine and Technology Assessment

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Original Research Article

Global trends of traditional, complementary and integrative medicine for musculoskeletal diseases: a bibliometric analysis

Xue-feng Wang[1,§], Zhi-qiang Li[1,§], Heng Yin[1], Trine Stub[2], Jian-ping Liu[1,✉]

[1] *Centre for Evidence-Based Chinese Medicine, Beijing University of Chinese Medicine, Beijing 100029, China*

[2] *National Research Center in Complementary and Alternative Medicine, NAFKAM, UiT The Arctic University of Norway, Tromsø 199008, Norway*

Received: November 15, 2024; **Revised:** January 22, 2025; **Accepted:** February 25, 2025

ABSTRACT

Introduction Musculoskeletal diseases (MSDs) encompass a spectrum of over 150 distinct conditions that impact the musculoskeletal system, affecting people all over the world. Traditional, complementary, and integrative medicine (TCIM) is an integrated healthcare concept that combines conventional therapies with complementary health care. There has been a lack of overarching study to systematically demonstrate the scope of research on TCIM for MSDs. The study aims to explore the patterns and trends in TCIM for MSDs over the last 20 years. **Methods** The Science Citation Index Expanded (SCI-E) in the Web of Science Core Collection (WoSCC) was selected as the data source to identify relevant publications. We included research and review articles published in English from January 1, 2004, to July 29, 2024. The CiteSpace 6.1.R1 software package was used to conduct bibliometric and visual analysis about the number of publications and the distributions of countries/regions, institutions, authors, journals, and their co-occurrence. Microsoft Excel was used to collect information on numbers and frequencies. **Results** A total of 6345 publications were retrieved, including 5559 research articles and 786 review articles. The annual number of publications exhibited an overall upward trend in 20 years. Vitamin D and osteoporosis were the most frequently studied TCIM and MSD, respectively. Research hotspots have gradually shifted from epidemiological investigations of and diagnostic techniques for MSDs to studies of specific populations and disease risk factors and management strategies. Future studies should be conducted to monitor changes in research topics and focus on the prevention and risk recognition of MSDs. **Conclusion** This bibliometric study lays the foundation for further studies in the fields of TCIM and MSDs. Despite the local and indigenous characteristics of TCIM, we encourage international cooperation and interaction. At a time when healthcare needs are shifting toward safety, prevention, and wellness, the role of TCIM should be considered.

KEYWORDS

traditional, complementary and integrative medicine, musculoskeletal diseases, bibliometric analysis, hotspot, trend

CITE THIS ARTICLE

Wang XF, Li ZQ, Yin H, Stub T, Liu JP. Global trends of traditional, complementary and integrative medicine for musculoskeletal diseases: a bibliometric analysis. Evidence-Based Chinese Medicine and Technology Assessment, 2025, 1: 9570001. https://doi.org/10.26599/eCMTA.2025.9570001

1. Introduction

Musculoskeletal health refers to the performance of the locomotor system, which consists of intact muscles, bones, joints, and adjacent connective tissues.[1] Musculoskeletal diseases (MSDs) encompass a spectrum of over 150 distinct conditions that affect the musculoskeletal system via dysfunction of those components, and they affect over 1.71 billion people globally.[1] They result in temporary or enduring functional and participatory restrictions such as persistent joint discomfort, swelling, rigidity, and deterioration, which diminish individuals' capacity to engage in employment and social activities.[2] They can affect individuals from childhood to old age and include acute injuries, such as fractures, sprains, and strains that cause temporary pain and functional impairments, as well as chronic conditions, such as persistent lower back pain and osteoarthritis.[3]

The prevalence of MSDs is increasing worldwide owing to population growth and aging, prompting early retirement and impacting well-being.[1] The International Association for the Study of Pain (IASP) and the National Institute for Health and Care Excellence (NICE) have recommended non-pharmacological approaches as first-line therapy for chronic pain.[4,5] Consequently, individuals who suffer from MSDs pursue complementary modalities.

"Traditional, complementary, and integrative medicine (TCIM)" and its variant names, including "traditional medicine (TM)," "complementary medicine," "complementary and alternative medicine (CAM)," and "integrative medicine (IM)," are modalities not considered "conventional medicine".[6] They are often practiced outside conventional healthcare systems, although some modalities, such as traditional Chinese medicine (TCM) and Ayurvedic medicine, are practiced within the official healthcare system in certain countries.[7] According to the World Health Organization, TM has an extensive historical lineage. It encompasses a collective body of wisdom, expertise, and methodologies that are rooted in the theoretical frameworks, convictions, and empirical knowledge of various cultures, regardless of their explicability. These practices are employed to preserve health and to prevent, diagnose, ameliorate, or treat both physical and psychological ailments.[8] CAM denotes a diverse array of healthcare practices that are not inherent to a nation's indigenous or orthodox medical paradigm and have not been comprehensively incorporated into the prevailing healthcare framework. In certain nations, CAM is synonymous with TM.[8] IM involves practices and beliefs that follow various approaches to combine or integrate elements or systems from TM and/or CAM with conventional medical care and practices.[9] TCIM is also an integrated healthcare concept that combines conventional modalities and complementary healthcare. It prioritizes comprehensive care and addresses an individual's overall well-being by considering their physical, mental, emotional, and spiritual health.

The Social Security Administration of the USA deems back disorders and

✉ Corresponding author.

E-mail address: liujp@bucm.edu.cn (JP. Liu)

§ These authors contributed equally to this work.

osteoarthritis among the most debilitating MSDs.[10] Within the broader classification of "other arthropathies," the relevant committee concurred that inflammatory arthropathies are particularly disabling and that patients may benefit greatly from therapeutic intervention. The purpose of the IASP is to relieve pain (both chronic and acute) caused by MSDs via integrated therapies (at least two types of therapy) according to patient preference.[11] According to the IASP, acupuncture, integrative physical activity, and exercise can be used to treat multiple pain conditions, including osteoarthritis and low back pain.[12] In the NICE recommendations for the management of chronic primary pain, pharmacological choices such as antidepressants (amitriptyline, citalopram, duloxetine, fluoxetine, paroxetine, or sertraline) should only be prescribed for people aged 18 years and over, after full discussion of the benefits and harms. Regarding non-pharmacological therapies, manual therapy (spinal manipulation, mobilization, and soft-tissue techniques, such as massage) is considered part of the treatment package to manage low back pain with or without sciatica.[5]

Bibliometric analysis is used for various reasons, such as to uncover emerging trends in article and journal performance, collaboration patterns, and research constituents, as well as to explore the intellectual structure of a specific domain in the extant literature.[13-15] CiteSpace is a scholarly visualization software tool designed to reveal the intellectual structure and knowledge domains within academic fields. It was developed by Dr. Chaomei Chen at Drexel University and is known for its robust co-citation-analysis capabilities and continuous algorithmic improvements.[13] The key features of CiteSpace include the ability to summarize the existing literature from a big-data perspective, discern the evolution of academic trends over time, identify core research topics through authors and keywords, and reveal the geographic publication patterns of researchers and institutions.[16] Keywords serve as indicators of the research content, aiding in the identification of hotspots and new frontiers through their frequency, centrality, and clustering.[16] Through the analysis of keyword clusters, burst, and timelines and the combination of this quantitative method with qualitative description, conclusions can be drawn regarding the foci, trends, and changes in research over a specific time, potentially leading to new frontiers within various research domains.[16]

However, little comprehensive, systematic research has been conducted to reveal and summarize the current state of TCIM modalities in the MSD domain. Therefore, we conducted a bibliometric analysis with the aim to explore hotspots, topics, and issues in this field that have received widespread attention and discussion over the past >20 years. Additionally, we aimed to investigate the developing trends and changes in research activities in this field. Our main research questions were as follows: 1) Which MSDs have been most frequently studied in the past >20 years? 2) Which TCIM modalities are most commonly employed to alleviate the symptoms induced by these conditions? 3) Which country, institution, journal, and research team are at the forefront of this field, and what is the status of cooperation? 4) What were the hotspots and trends of TCIM for MSDs over time? 5) Based on this information, what should be the focus of future research?

2. Methods

CiteSpace is recognized for its user-friendly interface and ability to transform complex data into insightful and visual representations.[17] Therefore, the Science Citation Index Expanded (SCI-E) in the Web of Science Core Collection (WoSCC) was selected as the data source to identify relevant publications. We used CiteSpace software (V6.1.R1, Drexel University, Philadelphia, PA, USA) to conduct bibliometric and visual analyses of key characteristics of the literature, such as the number of publications, keywords, distributions of countries/regions, institutions, authors, journals, references, and their co-occurrence. Microsoft Excel (Microsoft 365, Microsoft Corporation, Redmond, WA, USA) was used to collect information on numbers and frequencies. We performed a keyword analysis to identify the focus, hotspots, and research trends over the past >20 years. The analysis of keyword frequency was expected to reveal the most studied MSDs and TCIM modalities, and an analysis of strong citation bursts of keywords was used to reflect the focal points and trends of TCIM for MSDs during the past >20 years and identify future research interests. A keyword cluster analysis was conducted to reveal the relationships and connections between the different clusters. We also calculated the publication number, centrality, and/or co-citation of countries/regions, institutions, authors, journals, and references to demonstrate the research distribution and cooperation in TCIM for MSDs.

2.1. Definition and meaning of indicators used in bibliometrics

"Centrality" refers to the number of shortest paths between all pairs of nodes that pass through a particular node in a network.[17] It is a measure of a node's connectivity and importance within the overall network. A high centrality indicates that the node frequently appears on the shortest paths in the overall network, indicating a large influence and importance.

The modularity (Q value) and silhouette (S value) are indicators used to evaluate keyword clusters. The Q value is used to determine the significance of the clustering structure. It often ranges from 0 to 1. A Q value exceeding 0.3 signifies a notable clustering structure, suggesting that the detected community structure is robust and meaningful.[18] The S value is a measure of the clustering quality. Generally, an S value greater than 0.5 indicates reasonable clustering and a value greater than 0.7 indicates convincing clustering.[18]

The strength of a citation burst refers to the degree of a sudden and significant increase in the number of citations a paper or keyword receives within a specific period.[18] It is calculated using the default burst-detection algorithm by Kleinberg, which compares the citation frequency of an article or keyword at different time points. The strength of a citation burst can help researchers identify hot topics and emerging trends in their field of study. A strong burst indicates that the article or keyword has attracted widespread attention in the academic community, possibly heralding the emergence of a new research direction or theory.[17]

"Co-citation" refers to two authors/journals/articles being cited together by a third author, thereby establishing a co-citation relationship. This suggests that the cited works are content-related and often represent high-quality, influential contributions within a particular research domain. Therefore, co-citation analysis of authors/journals/articles plays a vital role in the identification of essential literature.

2.2. Inclusion and exclusion criteria

The inclusion criteria for this study were as follows: (1) articles published from January 1, 2004, to July 29, 2024; (2) research and review articles related to randomized controlled trials, non-randomized controlled trial, cohort studies, case-control studies, case series, and case reports; and (3) articles published in English. Animal, laboratory, and mechanistic studies were excluded. The detailed search strategy and step-by-step selection and identification of the articles are provided in Appendix 1.

3. Results

3.1. Annual publications

A total of 6345 documents were retrieved in the analysis, consisting of 5559 research articles and 786 review articles (Figure 1; Appendix 2). The average number of annual publications was 317 in the past >20 years. From 2004 to 2024, the number of publications on TCIM for MSDs exhibited an overall upward trend. Before 2008, the number of publications fluctuated between 106 (in 2004) and 178 (in 2007). From 2011, a stable increase was observed until 2022, which saw 583 publications. The fastest growth rate of publications occurred from 2020 to 2022. From Figure 1, 334 studies had been published by the first seven months of 2024.

3.2. Keywords

The top 10 keywords during the study period are listed in Table 1. The most frequent keywords were "bone mineral density" (989), "management" (545), "risk" (482), "osteoporosis" (459), "low back pain" (399), "women"

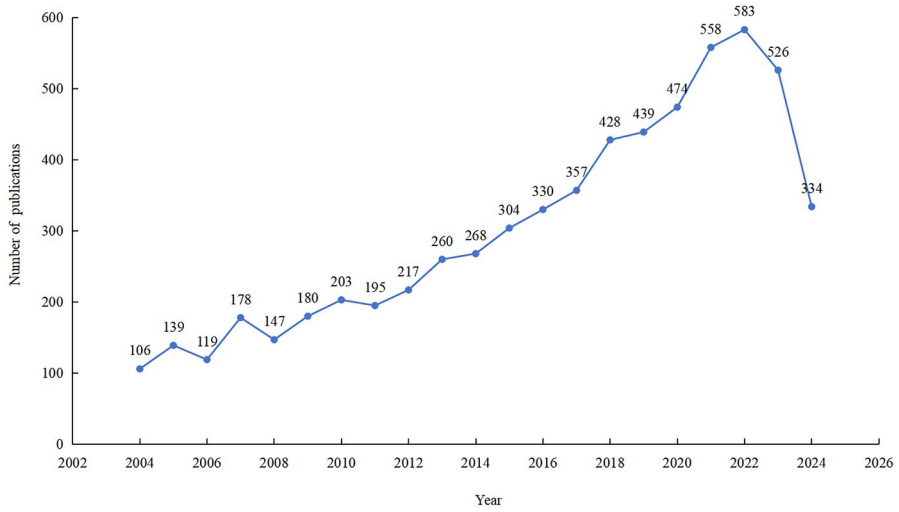

Figure 1 Number of annual publications of research on traditional, complementary, and integrative medicine for musculoskeletal diseases from 2004 to 2024

Table 1 Top 10 keywords in terms of frequency and centrality of TCIM for MSDs in the past >20 years

Rank	Keywords	Frequency	Rank	Keywords	Centrality
1	Bone mineral density	989	1	Bone mineral density	0.27
2	Management	545	2	Low back pain	0.14
3	Risk	482	3	Injury	0.13
4	Osteoporosis	459	4	Management	0.12
5	Low back pain	399	5	Mineral density	0.11
6	Women	368	6	Hip	0.11
7	Postmenopausal women	363	7	Rheumatoid arthritis	0.10
8	Prevalence	353	8	Exercise	0.10
9	Diagnosis	352	9	Double blind	0.09
10	Magnetic resonance imaging	339	10	Reliability	0.09

Notes: MSDs: musculoskeletal diseases; TCIM: traditional, complementary, and integrative medicine.

(368), "postmenopausal women" (363), "prevalence" (353), "diagnosis" (352), and "magnetic resonance imaging" (339). "Bone mineral density" was the keyword with both the highest frequency and the highest centrality, indicating that bone mineral density was an area of interest and in-depth research in the past >20 years.

The most frequently studied MSDs and TCIM modalities over the past >20 years are listed in Figure 2. The most frequently studied MSD was osteoporosis, which was often associated with topics such as bone mineral density and bone health in older women. Low back pain, a disease of great concern worldwide, was the next most frequently occurring condition. Different types of fractures, including vertebral, general, osteoporotic, and hip fractures, were also common MSDs in TCIM research. Vitamin D, the most frequently studied TCIM modality, plays an important role in the support of the immune system and bone health, and it may mitigate the risk of certain chronic diseases. It was followed in frequency by exercise, physical activity, spinal manipulation, and acupuncture. Of note, in the top 10 most studied TCIM modalities, only vitamin D and TCM belonged to pharmaceutical therapies, whereas the others were all non-pharmaceutical interventions. This analysis revealed that the effectiveness and safety of exercise and manual therapies for MSDs received much attention.

Figure 3 demonstrates the top 25 keywords with the strongest citation bursts. Several keywords were in the list from the start of the study period and remained in the list for nearly 10 years; these included keywords related to skeletal health, such as "cervical spine" (strength = 14.81), "spinal cord" (strength = 13.4), and "spinal cord compression" (strength = 7.51), as well as

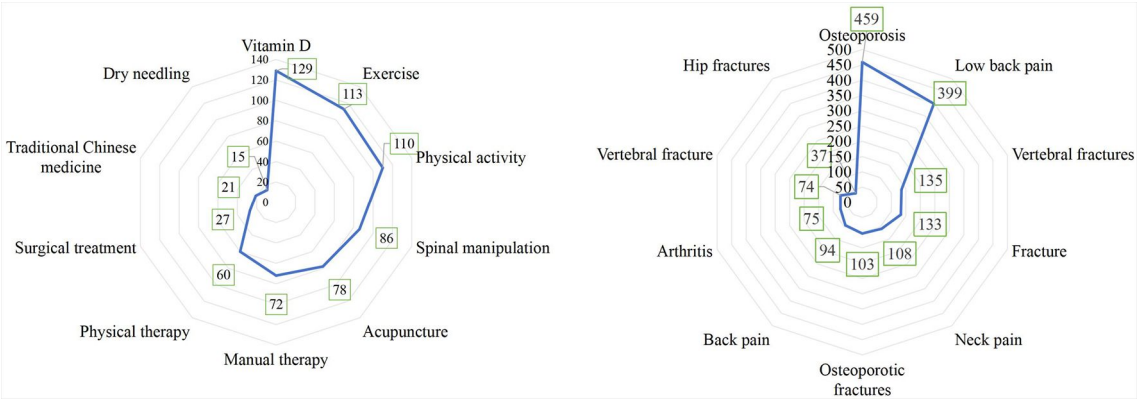

Figure 2 Frequency of the most studied musculoskeletal diseases and traditional, complementary, and integrative medicine modalities in the past >20 years

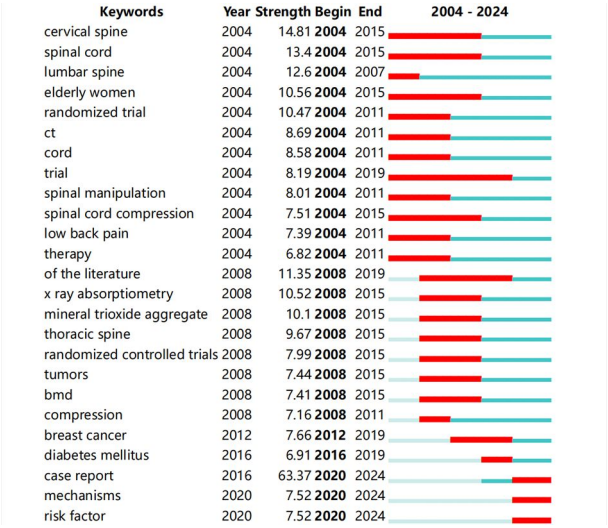

Figure 3 Top 25 keywords with the strongest citation bursts of TCIM for MSDs

Notes: MSDs: musculoskeletal diseases; TCIM: traditional, complementary, and integrative medicine. The whole line means the time span. The cyan part indicates that the keywords have weak burst intensity in this time period, while the red part indicates that the keyword has a strong burst intensity in this time period.

those related to demographics, such as "elderly women" (strength = 10.56). The keyword "trial" had the longest duration in the list, 15 years, and its strength was 8.19. We deemed keywords that received increased attention since 2020 representative of the current focus of research in the field. Thus, "case report" (strength = 63.37), "mechanisms" (strength = 7.52), and "risk factor" (strength = 7.52) are the weathervanes in this field.

In this study, 232 nodes and 561 links between keywords were identified and clustered into nine research clusters by using CiteSpace software (Figure 4): cluster 0: "knee osteoarthritis" (red), cluster 1: "hip fracture" (orange), cluster 2: "magnetic resonance imaging" (green), cluster 3: "low back pain" (grass green), cluster 4: "osteoporosis" (dark green), cluster 5: "postmenopausal women" (blue), cluster 6: "lumbar spinal stenosis" (dark blue), cluster 7: "total hip arthroplasty" (indigo blue), and cluster 8: "clinical trials" (purple).

In Figure 5, the horizontal axis indicates the period from 2004 to 2024. The research activities on the different topics changed over time. For example, studies on "knee osteoarthritis" and "hip fracture" peaked in around 2015, whereas studies of "postmenopausal women" increased significantly during 2020–2023. Larger nodes and thicker lines in the graph indicate potential research hotspots or frontier areas. For example, "knee osteoarthritis" and "hip fracture" have larger nodes in the figure, indicating that they are research hotspots in this field. The evolution of the research topic can be analyzed by observing the activity in different periods. "Magnetic resonance imaging" was more active early on, whereas "clinical trials" became more important toward the end of the study period.

3.3. Distribution of countries/regions and institutions

From 2004 to 2024, articles about MSDs by 266 institutions from 111 countries/regions were published. The top 10 countries/regions with publications on TCIM for MSDs are listed in Table 2. The USA made the most substantial contribution with 1259/6345 publications, followed by China (1136/6345). These two countries published over 2000 articles, accounting for 37.7% of the total publications. They were followed by Japan (564/6345, 8.89%), South Korea (480/6345, 7.57%), England (408/6345, 6.43%), and Taiwan, China (260/6345, 4.10%).

Centrality is also an important indicator of a country's impact and contribution to the field. England had the highest centrality (0.22), followed by the USA (0.20), showing their vital role and great influence in the field of research on TCIM for MSDs. Further, the analysis demonstrated that Singapore (0.16), Scotland (0.16), and Germany (0.16) had an equal influence on the field. Figure 6 shows the connections, cooperation (including the starting time), number of publications, and centrality among the different countries. The analysis revealed a relatively close and early cooperation network among England, Brazil, Denmark, Australia, the Netherlands, Germany, and Spain. Notably, although the USA and China had substantial numbers of publications, they exhibited little academic communication and cooperation with other influential countries.

Table 3 shows the top 10 institutions in terms of publication and centrality. The University of California (148/6345) topped the list, followed by Harvard University (137/6345) and the University of Southampton (90/6345).

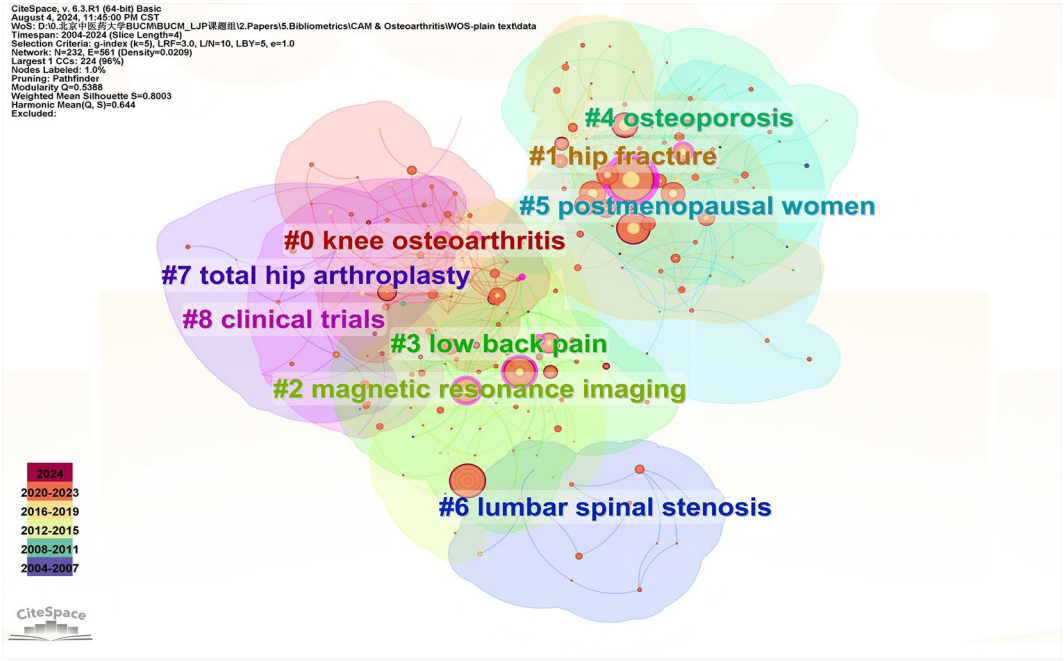

Figure 4 Keyword clusters of traditional, complementary, and integrative medicine for musculoskeletal diseases

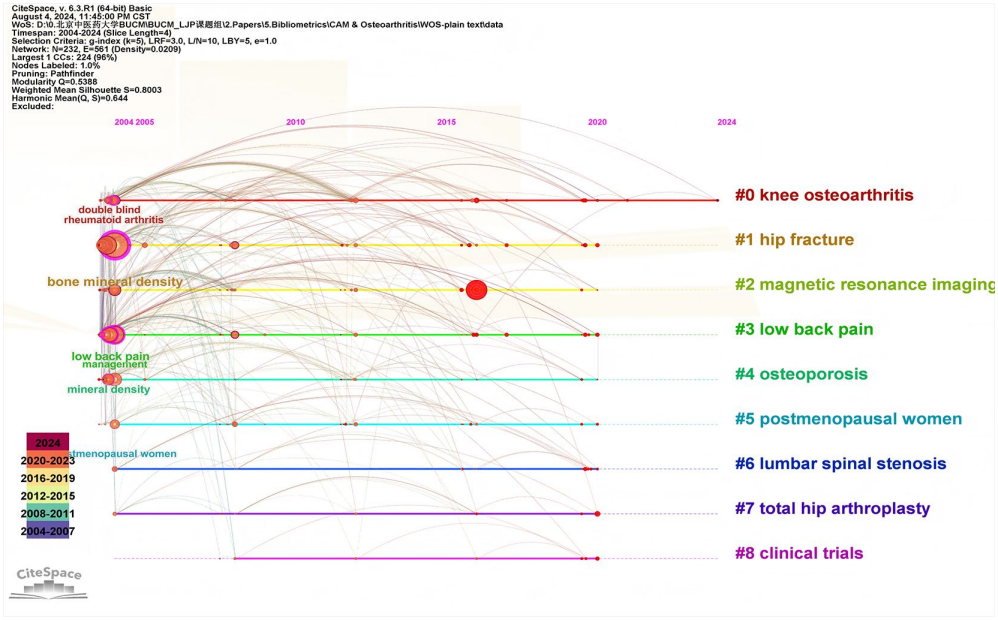

Figure 5 Timeline of cluster keywords of traditional, complementary, and integrative medicine for musculoskeletal diseases

Table 2 Top 10 countries/regions in terms of publications and centrality of traditional, complementary and integrative medicine for musculoskeletal diseases

Ranking	Country/Region	Publications	Percentage	Ranking	Country/Region	Centrality
1	USA	1259	19.84% (1259/6345)	1	England	0.22
2	China	1136	17.90% (1136/6345)	2	USA	0.20
3	Japan	564	8.89% (564/6345)	3	Singapore	0.16
4	South Korea	480	7.57% (480/6345)	4	Scotland	0.16
5	England	408	6.43% (408/6345)	5	Germany	0.16
6	Canada	313	4.93% (313/6345)	6	Russia	0.15
7	Italy	298	4.70% (298/6345)	7	Australia	0.13
8	Australia	283	4.46% (283/6345)	8	Netherlands	0.13
9	Taiwan, China	260	4.10% (260/6345)	9	Iceland	0.11
10	Spain	255	4.02% (255/6345)	10	Austria	0.11

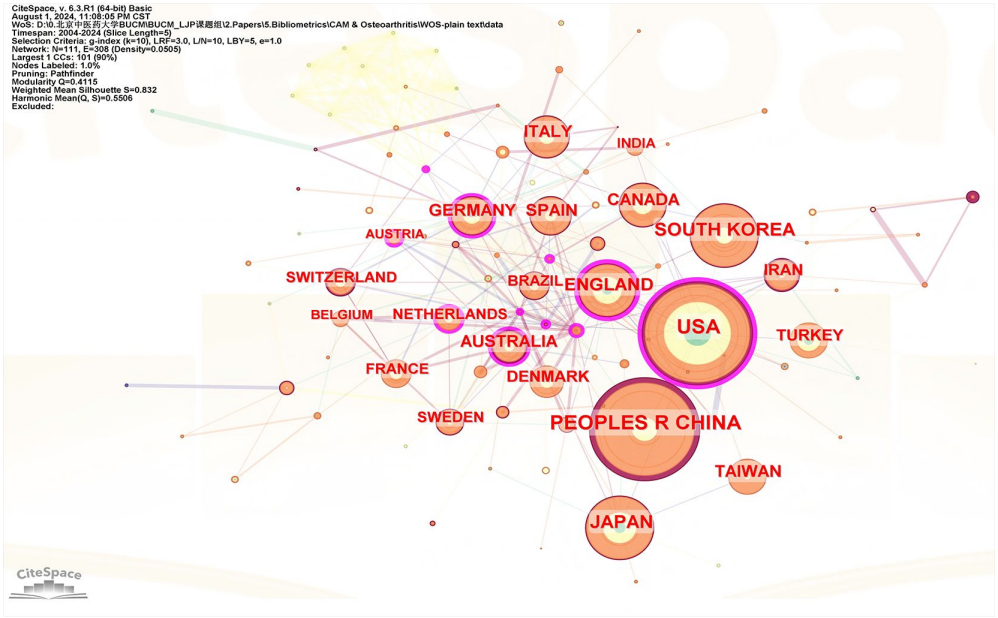

Figure 6 Cooperation network of research on traditional, complementary, and integrative medicine for musculoskeletal diseases among countries/regions

Table 3 Top 10 institutions in terms of publications and centrality regarding traditional, complementary, and integrative medicine for musculoskeletal diseases

Ranking	Institutions	Publications (%)	Country/Region	Ranking	Centrality	Institutions	Country/Region
1	University of California System	148 (2.33)	USA	1	0.21	Institut National de la Santé et de la Recherche Médicale	France
2	Harvard University	137 (2.16)	USA	2	0.18	Université de Montréal	Canada
3	University of Southampton	90 (1.42)	UK	3	0.16	Harvard University	USA
4	Harvard Medical School	86 (1.36)	USA	4	0.16	Beth Israel Deaconess Medical Center	UK
5	University of Southern Denmark	81 (1.28)	Denmark	5	0.15	University of Leeds	UK
6	Pennsylvania Commonwealth System of Higher Education	75 (1.18)	USA	6	0.14	Assistance Publique Hopitaux Paris	France
7	University of London	75 (1.18)	UK	7	0.13	University System of Ohio	USA
8	University of Copenhagen	74 (1.17)	Denmark	8	0.13	Harvard Medical School	USA
9	University of Oxford	74 (1.17)	UK	9	0.13	Capital Medical University	Beijing, China
10	University of Toronto	74 (1.17)	Canada	10	0.13	National Taiwan University Hospital	Taiwan, China

These institutions are located in countries that have higher centrality rankings, as the top three most prolific institutions were located in the USA or UK. The institutions with the most publications did not have equal centrality. Of the top 10 institutions in terms of centrality, 4 were located in the USA, 2 in France, 2 in China, 1 in the UK, and 1 in Canada.

Institut National de la Santé et de la Recherche Médicale (Inserm) in France had the highest centrality (0.21), followed by Université de Montréal (0.18), a Canadian institution, and Harvard University (0.16). Capital Medical University (0.13) and National Taiwan University Hospital (0.13), two Chinese academic institutions with the same centrality as Harvard Medical School (0.13), had an influence and notable academic status on a level of institutions. However, the connections and cooperation among Western institutions were much closer than those between Chinese and Western institutions (Figure 7).

3.4. Distribution of authors and co-cited authors

The top 10 authors in terms of publication volumes are listed in Table 4. Table 5 demonstrates author centrality in the field. In terms of the first working unit, these authors were affiliated to Canada (3/10), Australia (2/10), the UK (2/10), Denmark (1/10), South Korea (1/10), and Spain (1/10), and the top six most prolific authors each had more than 20 published articles.

The co-occurrence analysis demonstrated cooperation among the authors, including 275 nodes and 501 links (Figure 8). Professor Cicuttini Flavia M, from Monash University in Australia, who had the highest centrality, and therefore had a notable academic influence, was located far from the dense areas in the academic network. The analysis showed that she had formed a relatively independent research network much earlier than other research groups. Similarly, Professor Jones Graeme, affiliated with the University of Tasmania in Australia, has demonstrated longstanding experience in all areas

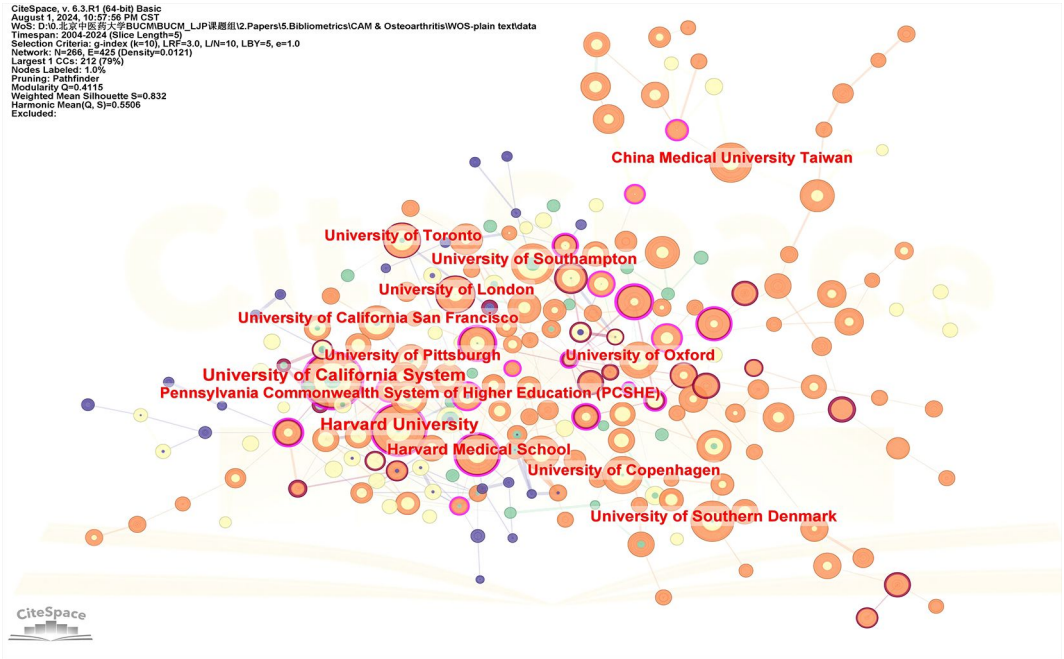

Figure 7 Institutions and their cooperation networks regarding publications of traditional, complementary, and integrative medicine for musculoskeletal diseases

Table 4 Top 10 authors in terms of publications regarding traditional, complementary, and integrative medicine for musculoskeletal diseases

Ranking	Authors	Publications	Country/Region
1	Cooper, Cyrus	50	University of Southampton, Southampton, UK
2	Cicuttini, Flavia M	25	Monash University, Alfred Hospital, Melbourne, Victoria, Australia
3	Leslie, William D	25	University of Manitoba, Winnipeg, MB, Canada
4	Prieto-Alhambra, Daniel	22	University of Oxford, Oxford, UK
5	Fernandez-de-las-penas, Cesar	21	Universidad Rey Juan Carlos, 28933 Alcorcón, Spain
6	Abrahamsen, BO	16	University of Southern Denmark, Odense, Denmark
7	Lix, Lisa M	16	University of Manitoba, Winnipeg, MB, Canada
8	Morin, Suzanne N	15	McGill University, Montreal, Canada
9	Jones, Graeme	13	University of Tasmania, Hobart, Tasmania, Australia
10	Chang, Min Cheol	13	Yeungnam University, Taegu, South Korea

Table 5 Top 10 authors in terms of centrality regarding traditional, complementary, and integrative medicine for musculoskeletal diseases

Ranking	Centrality	Author	Country/Region
1	0.05	Cicuttini, Flavia M	Monash University, Alfred Hospital, Melbourne, Victoria, Australia
2	0.05	Jones, Graeme	University of Tasmania, Hobart, Tasmania, Australia
3	0.03	Cauley, Jane A	University of Pittsburgh, Pittsburgh, Pennsylvania, USA
4	0.03	Abrahamsen, Bo	University of Southern Denmark, Odense, Denmark
5	0.02	Leslie, William D	Department of Internal Medicine, University of Manitoba, Winnipeg, MB, Canada
6	0.02	Yoshimura, Noriko	The University of Tokyo, Tokyo, Japan
7	0.01	Kanis, John A	Australian Catholic University, Melbourne, Australia
8	0.01	Harvey, Nicholas C	University of Southampton, Southampton, the UK
9	0.01	Johansson, Helena	Australian Catholic University, Melbourne, Australia
10	0.01	Jones, G	University of Edinburgh, Edinburgh, UK

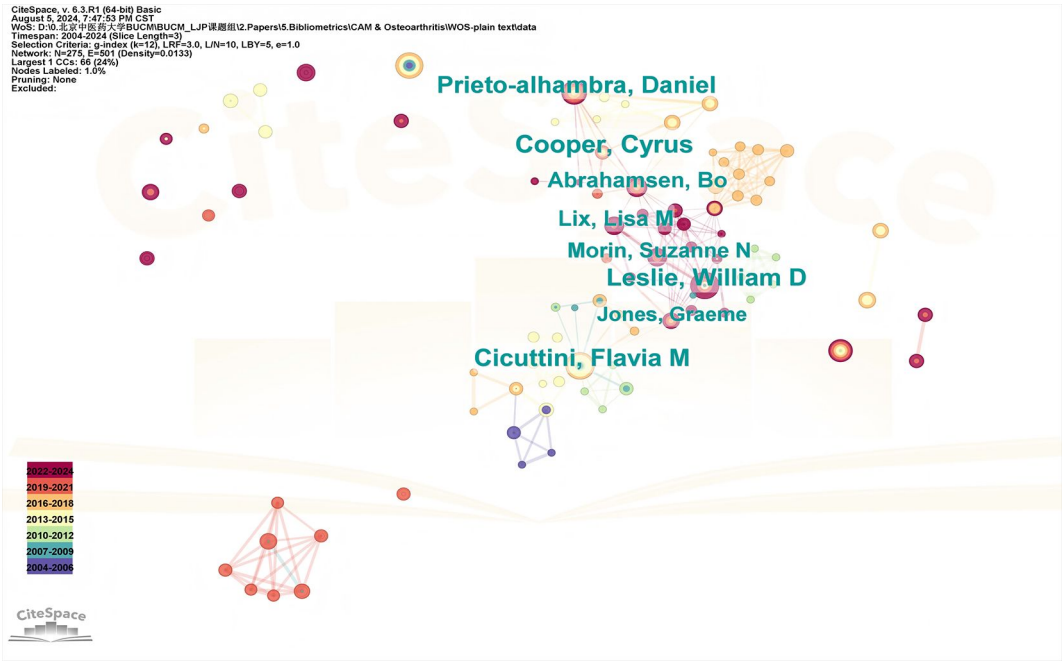

Figure 8 Cooperation network of authors regarding traditional, complementary, and integrative medicine for musculoskeletal diseases

of rheumatology, including biological therapy, as well as a wide range of autoimmune conditions and osteoporosis.

The authors with the highest centrality who were also cited more than 80 times in the research field were Kanis John A (970 times), Cummings Steven R (282 times), Johnell Olof (189 times), Cooper Cyrus (164 times), and Black Dennis M (162 times) (Figure 9). The figure demonstrates the numerous direct and indirect partnerships among them. Other researchers, such as Chou Richard C, although outside the co-occurrence network, have established a relatively independent and stable, small research collaboration network. All these researchers have made considerable contributions and achievements in the field of TCIM for MSDs.

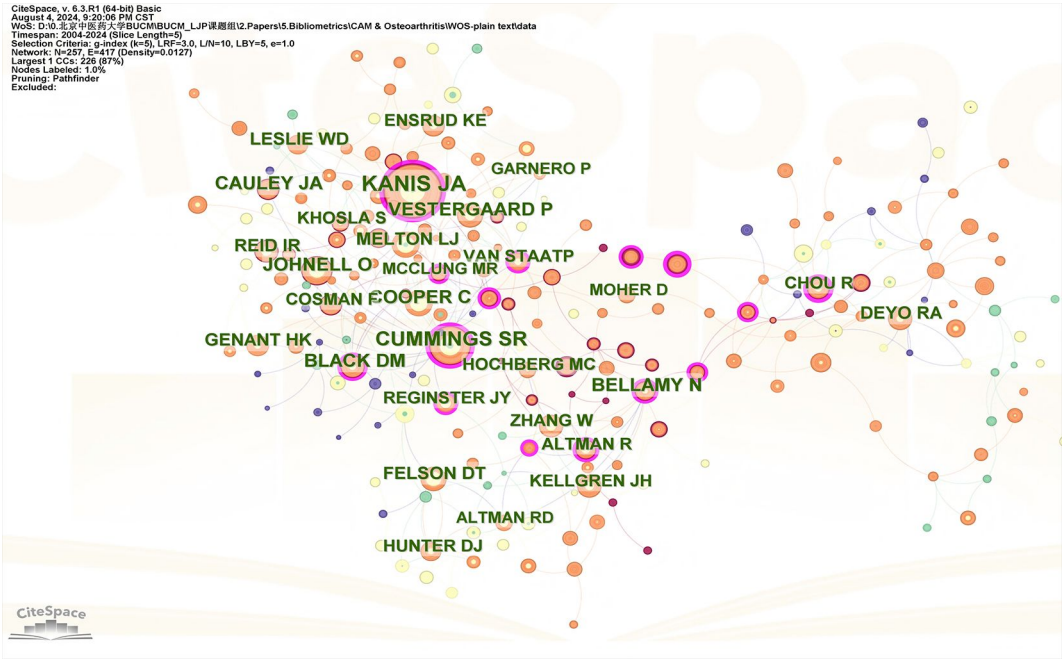

Figure 9 Co-citation network of authors regarding traditional, complementary, and integrative medicine for musculoskeletal diseases

3.5. Distribution of journals

The top 10 journals in terms of publications in the field were *Medicine*, which was accountable for the most publications on TCIM for MSDs (381), followed by journals specializing in the MSD field, including *Osteoporosis International* (192), the *Journal of Bone and Mineral Research* (157), and *BMC Musculoskeletal Disorders* (154). Most of these journals are published in the USA or UK. Undoubtedly, the USA has a leading position in the field, from research to publishing. These journals cover a wide range of fields, from medicine (general and internal medicine, endocrinology and metabolism, and orthopedics) to surgery, TCIM, and multidisciplinary sciences (Table 6).

3.6. Analysis of co-cited references

The top five most cited references are listed in Table 7, and Figure 10 shows the co-cited references, which encompassed 265 nodes and 666 links between them. Among these references, 3/5 were published in top medical journals, including *The Lancet* and the *Annals of Internal Medicine*, and 2/5 were from two other journals (*Osteoporosis International* and *Arthritis Care & Research*). The analysis revealed that half of these references were guidelines and half were reviews or research articles. Several scholars who started to conduct research in this field from 2002 to 2014 formed relatively independent co-citation networks. Further, from 2017 to 2020, the co-citation networks became gradually denser. However, the high co-citation rate indicates that these references laid the foundation for subsequent research and played important roles in guiding future research.

4. Discussion

This is the first bibliometric study to cover the two wide-ranging concepts of TCIM and MSDs. Five main results were obtained. 1) Osteoporosis was the most frequently studied MSD over the past >20 years, followed by low back pain, vertebral fractures, fractures, and neck pain. 2) Vitamin D was the most commonly employed TCIM modality for the alleviation of symptoms induced by MSDs, followed by exercise, physical activity, spinal manipulation, and acupuncture. 3) The USA is clearly on the forefront of research on TCIM for MSDs according to publication numbers and centrality. China, Japan, and South Korea also had considerable numbers of publications, but their academic influence and pioneering status were not on the same level as those of the USA. The UK had the fifth-highest number of publications but ranked second highest for centrality. Accordingly, the USA and UK had the most prolific institutions and journals. Authors from the UK, Australia, and Canada were at the forefront of the research field. A close, early cooperative network had formed between the UK, Brazil, Denmark, Australia, the Netherlands, Germany, and Spain, while little academic communication and

Table 6 Top 10 journals in terms of publications on traditional, complementary, and integrative medicine for musculoskeletal diseases

Ranking	Journal	Publications	Country	IF (2023)	Categories	JCR
1	*Medicine*	381	USA	1.3	Medicine, general & internal	Q2
2	*Osteoporosis International*	192	UK	4.2	Endocrinology & metabolism	Q1
3	*Journal of Bone and Mineral Research*	157	USA	5.1	Endocrinology & metabolism	Q1
4	*BMC Musculoskeletal Disorders*	154	UK	2.2	Orthopedics	Q2
5	*World Journal of Clinical Cases*	111	USA	1	Medicine, general & internal	Q3
6	*Spine*	106	USA	2.6	Orthopedics	Q1
7	*World Neurosurgery*	85	USA	1.9	Surgery	Q2
8	*Journal of Manipulative and Physiological Therapeutics*	84	USA	1.2	Integrative & complementary medicine	Q3
9	*Bone*	82	USA	3.5	Endocrinology & metabolism	Q2
10	*PLoS One*	65	USA	2.9	Multidisciplinary sciences	Q1

Table 7 Top 5 co-cited references for publications on traditional, complementary, and integrative medicine for musculoskeletal diseases

Title	Co-cited counts	Type	Year	Journal	JCR category	IF (2023)	DOI
Noninvasive treatments for acute, subacute, and chronic low back pain: a clinical practice guideline from the American College of Physicians	33	Guideline	2017	*Annals of Internal Medicine*	Medicine, general & internal	19.6	10.7326/M16-2367
What low back pain is and why we need to pay attention	27	Review	2018	*Lancet*	Medicine, general & internal	98.4	10.1016/S01406736(18)30480-X
2019 American College of Rheumatology/Arthritis Foundation Guideline for the management of osteoarthritis of the hand, hip, and knee	27	Guideine	2020	*Arthritis Care & Research*	Rheumatology	3.7	10.1002/acr.24131
Clinician's guide to prevention and treatment of osteoporosis	26	Guideline	2014	*Osteoporosis International*	Endocrinology & metabolism	4.2	10.1007/s00198-014-2794-2
Osteoporosis	24	Review	2019	*Lancet*	Medicine, general & internal	98.4	10.1016/S01406736(18)32112-3

Notes: JCR: journal citation reports; IF: impact factor.

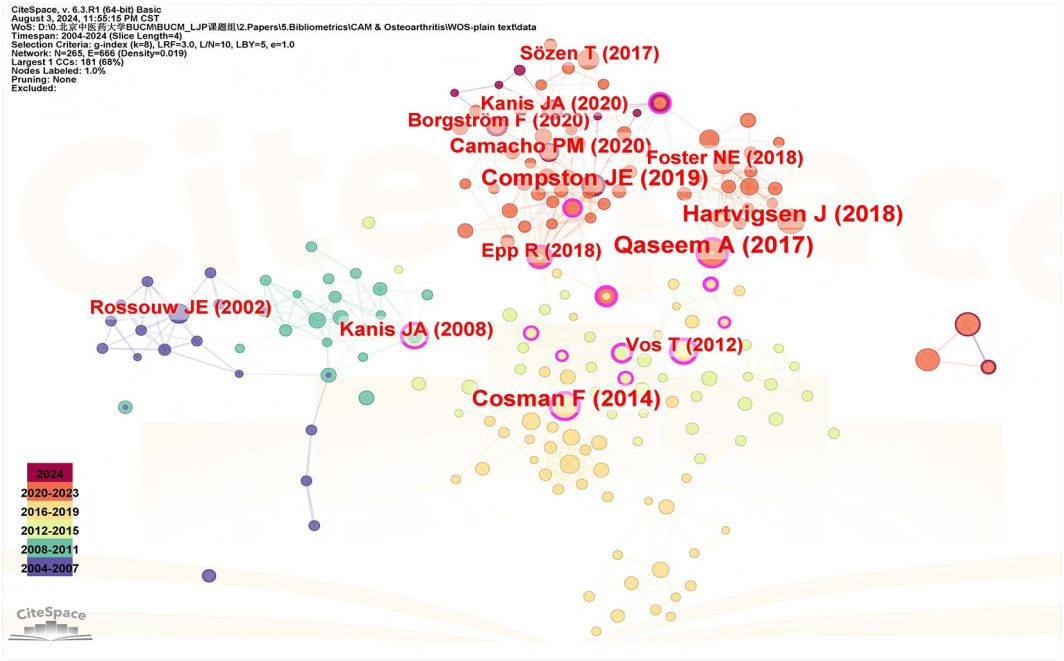

Figure 10 Co-citation network of publications on traditional, complementary, and integrative medicine for musculoskeletal diseases

cooperation were observed among the USA, China, and other influential countries. 4) For specific MSDs, such as knee osteoarthritis and low back pain, study designs, such as clinical trials, and diagnostic techniques, such as magnetic resonance imaging, have been research hotspots in this field. Case reports, mechanisms, and risk factors have recently received increasing attention in this field. 5) Future studies should be conducted according to the reported change in focus in the research topic and focused more on the prevention and risk recognition of MSDs.

Over the last 20 years, scholarly interest in TCIM for MSDs has continued to rise because an increasing number of studies have demonstrated positive outcomes. Acupuncture reportedly leads to overall improvement of patients with low back pain compared with sham acupuncture and nonsteroidal anti-inflammatory drugs (NSAIDs).[19] Similarly, the short-term benefits of acupuncture in the relief of chronic pain caused by osteoarthritis, symptomatic osteoarthritis, and fibromyalgia have been demonstrated.[20] Mechanistic research has also revealed that TCM, including acupuncture, moxibustion, and massage, are effective in the treatment of knee osteoarthritis via inhibition of inflammatory factors and promotion of the secretion of antioxidants, among others.[21] In terms of non-pharmaceutical therapies, the use of dietary, nutritional, and herbal interventions based on the philosophy and methodology of CAM may overcome the detrimental adverse effects induced by the continuous intake of NSAIDs and steroids for the alleviation of rheumatoid arthritis.[22] Several herbal medicines and dietary supplements reportedly lessen the pain associated with osteoarthritis and rheumatoid arthritis, improving patients' overall physical and mental health.[23] TCIM supports the integration of indigenous medicine, exotic medicine, conventional medicine, and TM to safeguard human welfare in a comprehensive and multi-dimensional way.[8] Therefore, a worldwide increase in research on the use of TCIM as treatment for physical and mental discomfort caused by MSDs is understandable.

The institutions with the largest numbers of related publications were located in countries that had higher centrality rankings; the top three were located in the USA or UK. The University of California, for example, is known for its cutting-edge biomedical research. The Osher Center for Integrative Medicine, founded by the University of California in 1997, prioritizes rigorous scientific research to demonstrate the most effective treatments for patients, which will facilitate the evaluation of CAM and the integration of proven therapies into patient care. Its goal is to evaluate not only whether treatments are effective but also the degree of effectiveness. The TCIM used in the center include acupuncture and TCM, yoga, bio-reflexology, medical consultation, cancer care, psychiatric and psychological therapy, women's

health care, spinal compressions, physical training, and therapeutic massage.[24] Thus, the University of California has a reputation as an academic research institution that pioneers research and application of TCIM therapy.

East Asian countries such as China, South Korea, and Japan have a long history of CAM, which raises the question, why are they not included in cooperation networks of Western countries such as Australia and the UK? This may be because the concept of evidence-based medicine was introduced relatively late to Asia, and the methodological quality of research still has to be improved. A systematic review of trials of Chinese herbal medicine as treatment for rheumatoid arthritis pointed out that most trials fail to meet the expected methodological criteria.[25] This may also be because developed countries have paid more attention to the underlying mechanism of TCIM therapies than to their theoretical basis, which is a historically important part of research in Asian countries, especially in China. In the future, researchers in Asian countries should focus on international cooperation, strengthening their academic interactions and connections.

Professor Cooper Cyrus, one of the most prolific and influential scholars, is highly regarded in the field of rheumatology; his research is focused on osteoporosis.[26] The research fields of the authors overlap, and they have all made important contributions and advancements in the field of MSD. As TCIM has its origin in specific locations and is associated with distinct research interests, the historical lack of cooperation among high-yield or high-impact research teams is understandable. However, the field may stand to benefit if experts with high volumes of publications and strong centrality set an example by cooperating with one another.

Based on keyword frequency, we discovered that the focus of research has gradually shifted from the epidemiological investigation and diagnostic techniques of MSDs to the study of specific populations such as postmenopausal women.[27], more common MSDs (low back pain and osteoporosis).[27, 28], and disease risk factors and management.[29] One reason for this change may be the gradual recognition of sex differences in the presentation of MSDs.[30] Second, the relative neglect of women's healthcare needs in public healthcare systems might have contributed to the fact that women, to a higher degree than men, turn to CAM and related products.[31] Thus, more attention should be directed toward female musculoskeletal health.[32,33] Additionally, the development of medical science and technology and improvements in people's understanding of diseases likely explain why research in this field has gradually shifted from diagnosis and treatment to prevention and control.

5. Strengths and limitations

We conducted a comprehensive search on this topic in the Web of Science Core Collection with the aid of CiteSpace, an authoritative, statistically reliable tool in the field of bibliometrics. Therefore, we believe that the research hotspots, future trends, and academic dynamics in the field revealed in this study are credible.

Of note, however, the inclusion of two such large concepts results in certain shortcomings. For instance, the accuracy of the search process to identify publications is questionable, despite our refinements of the search strategy. Second, despite efforts to incorporate numerous search terms related to TCIM and MSDs into the search strategy, we might have overlooked terms that could have revealed certain research trends. Third, our search was restricted to publications in English, and we used data exclusively from the Web of Science Core Collection. Although English may be the dominant language in which articles are published in this field, we cannot guarantee that the general trend of research published in other languages is the same as those that we revealed. Although the Web of Science Core Collection is recognized as one of the most authoritative scientific literature retrieval tools, renowned for its stringent selection process, and frequently serves as a cornerstone for bibliometric studies, rendering it a world-class platform for journals.[34], we acknowledge that it does not encompass all research on TCIM for MSDs. Within the domain of TCIM research, the reliability of bibliometric analyses is greatly influenced by the appropriateness of the selected database. For instance, the exclusion of non-English literature may subtly skew the analysis. Although the use of a single database is generally recommended to minimize errors associated with data integration, future research incorporating additional databases, such as PubMed, may broaden the scope and enrich the results.

6. Conclusion

This bibliometric analysis provides an overview of studies on TCIM for MSDs, answering various research questions regarding these two broad health concepts. Although TCIM has certain local and indigenous characteristics, international exchanges and cooperation are necessary to promote knowledge exchange and implementation of TCIM research. At a time when healthcare needs are shifting toward safety, prevention, and wellness, the role of TCIM should be considered. Neglected aspects of MSDs should be investigated to meet these changing societal needs; for example, the prediction and prevention of MSDs, as well as the distribution and prevention of such diseases between the sexes, warrant thorough investigation in the future.

Funding

This work was supported by the Innovation Team and Talents Cultivation Program of the National Administration of Traditional Chinese Medicine (grant no.: ZYYCXTD-C-202006).

Author Contribution Statement

Xue-feng Wang: Conceptualization, data curation, software, formal analysis, investigation, methodology, writing – original draft, and writing – review & editing. **Zhi-qiang Li:** Data curation, formal analysis, investigation, and writing – original draft. **Heng Yin:** Investigation, visualization, and software. **Trine Stub:** Methodology and writing – review & editing. **Jian-ping Liu:** Conceptualization, methodology, funding acquisition, supervision, and writing – review & editing.

Declaration of Competing Interest

Prof. Jian-ping Liu and Prof. Trine Stub are the Editor-in-Chief and Editorial Board Member of *Evidence-Based Chinese Medicine and Technology Assessment*, respectively, but they are not involved in the peer review or decision of this article. The other contributing authors report no conflicts of interest in this work.

Electronic Supplementary Material

The online version contains supplementary material available at https://doi.org/10.26599/eCMTA.2025.9570001.

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