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Collaborative networks and thematic trends of research on the application of complementary and alternative medicine in cancer patients: A bibliometric analysis

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ABSTRACT

Background: and purpose: Complementary and Alternative Medicine(CAM) has been greatly used in cancer patients. This research aimed to explore the research priorities of CAM for cancer patient's treatment.
Methods: Web of Science(WoS), HistCite, BibExcel, GunnMap and VOSviewer were used to extract and visualize information.
Results: 2768 articles published in 789 journals were indexed in the WoS from 1989 to 2018. The USA(n = 1009) and Technion-Israel Institute Technology(n = 58) were the most prolific country and institution, respectively. Keywords co-occurrence analysis indicated that the research hotspots around the world formed five clusters, so did the author co-citation analysis. The research priorities of the top-five countries, the top-three prolific authors and the co-citation core authors were also discussed, which reveals the differences and similarities among them.
Conclusion: This study delineates a framework for better understanding the situational use of CAM in cancer patients, which could help health care workers to prioritize and organize future research.

1. Introduction

The World Health Organization (WHO) reports that cancer is the second leading cause of death globally and was estimated to account for 9.6 million deaths in 2018 [1]. Cancer incidence rates across five continents indicate that Asia, Europe and North America are the top three regions with the highest incidence of cancer and mortality, with the incidence of cancer in many countries being more than 106.5 per 100,000 in 2018 [2]. The top three cancer types are lung cancer, female breast cancer and colorectal cancer, respectively, which are ranked within the top five in terms of mortality. It is estimated that the global cancer burden of new cases has risen to 18.1 million in 2018, and the five-year prevalence, people who are alive within five years of a cancer diagnosis, is estimated to be 43.8 million [3]. On the basis of the current estimates in 2018, the cancer incidence worldwide is expected to be 29.5 million in 2040 [4]. The increase in cancer incidence brings a heavy burden to the society.

Cancer and cancer treatments can cause side effects such as anaemia, appetite loss and fatigue [5]. These side effects can negatively impact the quality of life and emotions of a cancer patient. To improve the situation, patients tend to integrate complementary and alternative medicine (CAM) with oncology treatment [6]. According to the National Centre for Complementary and Integrative Health (NCCIH, once named NCCAM from October 1998 to November 2014), a non-mainstream practice is considered ‘complementary’ when it is used with conventional medicine; nevertheless it is considered ‘alternative’ when used as a substitute for conventional medicine [7,8]. Previous research showed that cancer patients were more likely to use CAM than non-cancer patients [9]. According to data from the 2017 National Health Interview Survey (NHIS) released in November 2018, the number of American adults and children who used CAM, such as yoga, meditation and chiropractic treatments, had increased [10]. CAM therapies can be used to treat side effects caused by cancer or cancer treatment. For example, acupuncture is usually used to relieve symptoms, such as pain, nausea and vomiting, and improve the quality of life. Aromatherapy and yoga are used to lower stress and anxiety, and improve sleep in cancer patients [11]. Therefore, more and more cancer patients choose CAM as an adjuvant therapy to treat cancer, and studies have found that nearly 62.9% of cancer patients use CAM in non-Asian countries [12,13]. However, the use of CAM has some limitations that can

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potentially cause serious risks such as liver damage and influence the effects of chemotherapeutic drugs [14]. The effect of interactions between CAM and conventional methods, synergistic effects, drug antagonism and therapeutic incompatibility should be deeply understood.

Many researchers have explored the application of CAM in cancer patients. However, a comprehensive review and visualization perspective of prior literature is lacking. To present an overview of the scientific outputs of CAM in cancer patients and to analyse the topical hotspots, important articles and emerging trends, the bibliometric method can be applied. The bibliometric method uses quantitative analyses, based on statistics and mathematics, to track the knowledge structure, influence of publication and authors actively engaged in research, and collaborative networks and to compare the academic achievement among countries [15–17]. To our knowledge, no studies have specially explored the bibliometric profile of CAM in cancer patient research. The aim of this study was to use a bibliometric method to assess CAM and cancer patient research at a global level to attempt to bridge the research gap. The research results will help health care workers deepen their understanding of the application of CAM in cancer patients and decide what scientific topics to study.

2. Methods

2.1. Search strategy

Bibliometric data can be obtained through diverse search engines, such as Web of Science (WoS) database, Scopus database and PubMed database. The WoS database was used as the scientific research output in this bibliometric study, as it is one of the largest and comprehensive bibliographic databases covering multidisciplinary areas [18]. The 2018 Journal Citation Reports (JCR) covers 11,655 journals across 234 scientific disciplines spanning 80 countries [19].

In this study, information about scientific output was extracted from 6 databases in the Web of Science Core Collection (Science Citation Index EXPANDED (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Conference Proceedings Citation Index-Science (CPCI-S), Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH), Current Chemical Reactions (CCR-EXPANDED) and Index Chemicus (IC)) and the 2018 JCR, Science Edition. Literature search was performed for all published articles on CAM in cancer patients from the inception of these databases to 17 December 2018 with no language limitations. The purpose of this study is mainly to explore the research territory and trends of CAM in cancer patients; therefore, the search query (Table 1) can be divided into two parts: “complementary and alternative medicine” and “cancer”. To ensure data accuracy, several synonyms or related terms were included in the search strategy.

According to Table 1, the final search query was built as follows: TS (Topic) = ((‘complementary and alternative medicine’ OR ‘complementary and integrative medicine’ OR ‘complementary medicine’ OR ‘alternative medicine’ OR ‘integrative medicine’) AND (‘cancer’ OR ‘neoplas*’ OR ‘tumour’ OR ‘tumor’ OR ‘carcinoma*’ OR ‘leukemia’ OR ‘leukaemia’ OR ‘sarcoma’ OR ‘lymphoma’ OR ‘malign*’ OR ‘metastasis’ OR ‘adenocarcinoma’ OR ‘oncogene’)). Finally, 2768 articles were collected.

2.2. Data analysis

All bibliometric information was exported into text format from the WoS database. HistCite Pro2.1 and Microsoft Excel 2010 software were used for the statistical analyses and graphics. We used numerous markers to help identify the research trends worldwide, such as top prolific authors, language, countries, journals, institutions, hot fields and most cited papers. In addition, BibExcel and VOSviewer v.1.6.9 software was used to extract and build bibliometric diagrams to visualize, compute and analyse the co-occurrence network of terms extracted from the abstract of the articles, and to visualize the collaboration network between authors and countries. GunnMap 2 (http://lert.co.nz/map/) was used to generate the world map to show publication distribution.

3. Results

3.1. Descriptive analysis

Based on the selection criteria, 2768 publications about CAM in cancer patients were indexed in the WoS from 1989 to 2018 and were included in this study. Many of publications were research articles (2170, 78.4%), followed by review articles (598, 21.6%). English (95.3%) was the primary language of the published articles, while the remaining 4.7% of publications were written in German, French, Spanish, Korean, Polish, Portuguese, Hungarian, Turkish and Japanese.

3.1.1. Publication distribution across time and countries active in cancer research

Fig. 1 shows the annual publications from 1989 to 2018 (by 17 December 2018). It was clear that there were limited publications before 1998, and the articles began to increase steadily during the period from 1998 to 2016, reaching a peak (226) in 2016. This indicates that the research community has had increasing interest and output on CAM in cancer patients in recent years. There were 2521 (91.3%) papers indexed in the SCI-Expanded, 887 (25.3%) papers indexed in the SSCI, 106 (2.9%) papers indexed in the ESCI, 77 (2.1%) papers indexed in the CPCI-S, 20 (0.5%) papers indexed in the A&HCI and 11 (0.3%) papers indexed in the CPCI-SSH.

The data indicated that over 88 countries/regions have participated in research on CAM in cancer patients. Fig. 2 is a world map with productive countries based on the total number of papers on this theme. There were 41 countries that published only 1–5 articles and 47 countries that published at least 6 articles. The colour of each pattern represents the total number of articles published. The more reddish the colour of the pattern, the higher was the number of total articles. The USA, with 1009 publications, was the most prolific country in producing articles related to CAM in cancer patients, followed by Germany (312 publications), Canada (188 publications), United Kingdom (182 publications) and China (166 publications). The 25 most productive countries generated 3077 articles (111.2%), which indicated that there existed cooperation among nations. In order to find out the international collaboration networks among countries, country co-authorships network visualization was introduced. Fig. 3 shows the collaboration network of countries that had at least five articles. The nodes of the USA, UK, Germany, Israel, Turkey and Canada were the biggest, which means they had the closest collaboration with other countries. The USA

Table 1
Search strategy.

No.	Category	Search Query
1	complementary and alternative medicine	‘complementary and alternative medicine’ OR ‘complementary and integrative medicine’ OR ‘complementary medicine’ OR ‘alternative medicine’ OR ‘integrative medicine’
2	cancer	‘cancer’ OR ‘neoplas*’ OR ‘tumour’ OR ‘tumor’ OR ‘carcinoma*’ OR ‘leukaemia’ OR ‘leukaemia’ OR ‘sarcoma’ OR ‘lymphoma’ OR ‘malign*’ OR ‘metastasis’ OR ‘adenocarcinoma’ OR ‘oncogene’

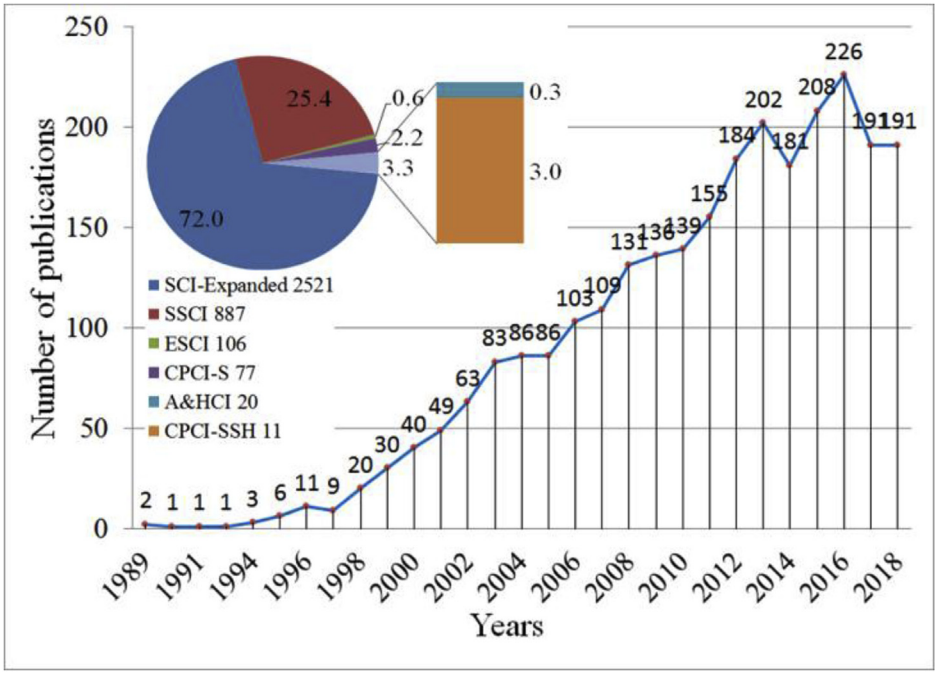

Fig. 1. Growth trend of the Web of Science (WoS) articles on "CAM in cancer patients" research over the last 30 years.

was the most networked country, collaborating with 36 countries, followed by the UK (n = 34), Germany (n = 26), Israel (n = 21), Turkey (n = 19) and Canada (n = 15). This shows that many countries attach great importance to the use of CAM in cancer patients and have formed close international cooperation networks, especially in developed countries, which may be related to their relatively advanced medical systems.

3.1.2. Publication analysis based on journals

Source journals that published the selected articles on CAM in cancer patients were identified, visualized and evaluated in this study. All the retrieved articles were published in 789 different journals. The top 20 active journals with five major measurements are shown in Table 2, including the Journal Impact Factor (JIF), number of publications, total citations received, average citation per publication and journal country. The most prolific journal in this field was the Journal of Alternative and Complementary Medicine (125, 4.5%), followed by Integrative Cancer Therapies(124, 4.5%), Supportive Care in Cancer (107, 3.9%) and BMC Complementary and Alternative Medicine (99, 3.6%). The total number of articles published in the top 20 journals was 1020, accounting for 36.8% of the total retrieved articles. The Global Citation Score per Article (GCSA) and Journal Impact Factor represent the research significance of the journal. Although some journals published fewer articles, they were important due to the huge number of GCSA, such as the Journal of Clinical Oncology (94.0), European Journal of Cancer (38.4) and Psycho-Oncology (35.6). Furthermore, most of the top 20 productive journals had an official JIF of more than 1.5, and the majority of the publishers were from the USA or UK.

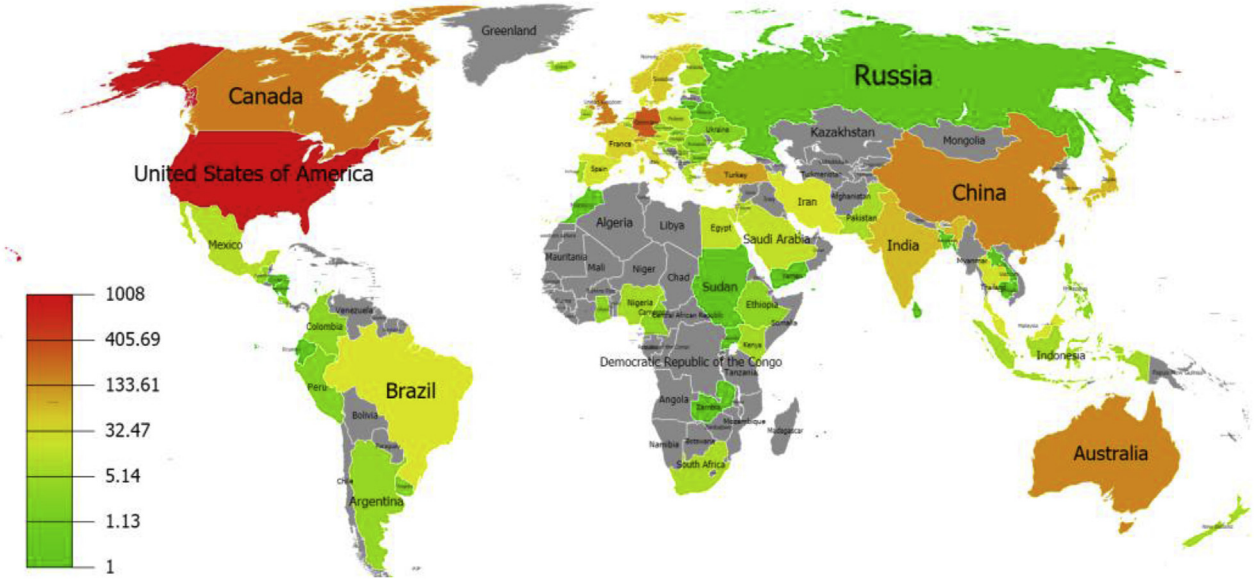

Fig. 2. Global geographic distribution of the total number of articles by country/region.

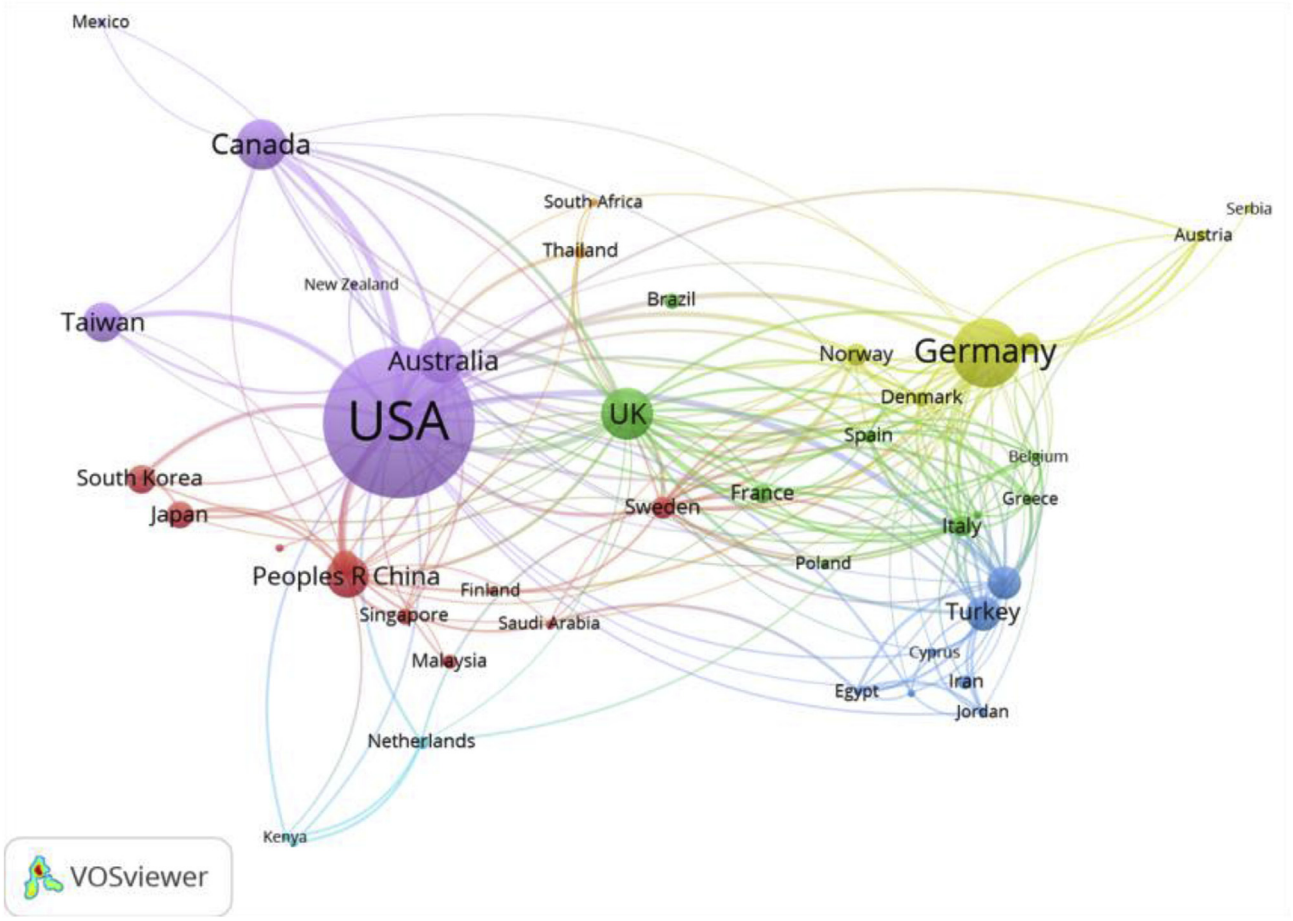

Fig. 3. Network visualization map of country co-authorships. Of the 88 countries, 47 had at least six publications that met the threshold. (Thicker lines indicate stronger collaborations. Countries represented with larger circle size or font size had relatively more publications).

3.1.3. Publication analysis based on institutions

Table 3 illustrates the top 20 prolific institutions based on the number of articles related to CAM in cancer patients. It is worth noting that the Technion - Israel Institute Technology in Israel ranked first in terms of the total articles (n = 58), followed by Columbia University in Turkey (50 articles) and University of Toronto in Canada (49 articles). Of the 3195 institutions, 109 had published at least 10 articles. Among the top 20 most active institutions, 11 were in North America, six were in Asia, two were in Europe and one was in Oceania. A total of 53 organizations have been cited at least 500 times. Columbia University

Table 2
Quantitative measurements of journals publishing CAM in cancer patient research.

No.	Source Title	JIF (R)	TA (%)	TGCS	GCSA	JC
1	Journal of Alternative and Complementary Medicine	1.498	125(4.5)	2684	21.5	USA
2	Integrative Cancer Therapies	2.657	124(4.5)	1293	10.4	USA
3	Supportive Care in Cancer	2.676	107(3.9)	1946	18.2	USA
4	BMC Complementary and Alternative Medicine	2.109	99(3.6)	1141	11.6	England
5	Evidence-Based Complementary and Alternative Medicine	2.064	90(3.3)	663	7.4	England
6	Complementary Therapies in Medicine	2.084	74(2.7)	1198	16.2	Scotland
7	European Journal of Cancer Care	2.409	37(1.3)	720	19.5	USA
8	European Journal of Integrative Medicine	0.698	36(1.3)	137	3.8	USA
9	Cancer Nursing	1.844	34(1.3)	702	20.6	USA
10	Plos One	2.766	34(1.2)	464	13.6	USA
11	Cancer	6.537	33(1.2)	1120	33.9	USA
12	Journal of Clinical Oncology	26.36	30(1.1)	2821	94.0	USA
13	Journal of Ethnopharmacology	3.115	29(1.0)	431	14.9	Ireland
14	Onkologe	0.193	28(1.0)	27	1.0	Germany
15	Psycho-Oncology	3.455	28(1.0)	998	35.6	USA
16	Patient Education and Counselling	2.785	25(0.9)	356	14.2	Ireland
17	European Journal of Cancer	7.191	23(0.8)	883	38.4	England
18	Oncology Nursing Forum	1.785	22(0.8)	389	17.7	USA
19	Alternative Therapies in Health and Medicine	1.011	22(0.8)	367	16.7	USA
20	Explore the Journal of Science and Healing	0.991	21(0.8)	247	11.8	USA

Note: JIF: Journal Impact Factor; TA: Total Articles; TGCS: Total Global Citations Score, which is the number of citations by the papers of Web of Science; GCSA: Global Citation Score per Article, which is the TGCS divided by the TA; and JC: Country of Journal's Origin.

Table 3
Quantitative measurements of journals publishing CAM in cancer patient research.

Rank	Institution	Country	TA (%)	TGCS	GCSA
1	Technion - Israel Institute Technology	Israel	58(2.1)	455	7.8
2	Columbia University	Turkey	50(1.8)	1861	37.2
3	University of Toronto	Canada	49(1.8)	1270	25.9
4	Goethe University Frankfurt	Germany	49(1.8)	146	9.4
5	University of Texas MD Anderson Cancer Center	China	49(1.8)	564	11.5
6	Mem Sloan Kettering Cancer Center	USA	43(1.6)	960	22.3
7	University of Washington	USA	43(1.6)	1388	32.3
8	Clalit Health Services	Israel	42(1.5)	306	7.3
9	University of California, San Francisco	USA	42(1.5)	1181	28.1
10	Harvard University	USA	40(1.4)	1840	46.0
11	National Yang-Ming University	Taiwan	40(1.4)	410	10.3
12	University of Calgary	Canada	39(1.4)	736	18.9
13	University of Pennsylvania	USA	35(1.3)	688	19.7
14	University of Sydney	Australia	34(1.2)	700	21.9
15	University of California, Los Angeles	USA	34(1.2)	1251	36.8
16	National Cancer Institute	USA	32(1.2)	115	34.8
17	Witten/Herdecke University	Germany	32(1.2)	304	9.5
18	Fred Hutchinson Cancer Research Center	USA	31(1.1)	991	32.0
19	Mayo Clinic	USA	31(1.1)	545	17.6
20	University of Haifa	Israel	31(1.1)	888	28.6

Note: TA: Total Articles; TGCS: Total Global Citations Score, which is the number of citations by the papers of Web of Science; GCSA: Global Citation Score per Article, which is the TGCS divided by the TA.

obtained the highest citation number (1861 citations), followed by Harvard University (1840 citations), University of Washington (1388 citations) and University of Toronto (1270 citations).

3.2. Research focused analysis by co-occurrence of keywords and research category

Keywords represent the main contents of existing studies and depict the topics that have been focused on within a given domain. Therefore, the keyword co-word analysis can be used to detect research focus, as well as monitor the research frontier transitions of research themes [20,21]. First, the process of standardization was taken to deal with different words which stood for the same meaning; in the meantime, the upper lower case conversion was also used. The minimum occurrence of a keyword was set at six. Initially, 231 out of 4186 keywords met the threshold, from which some general items were removed, e.g., 'complementary and alternative medicine', 'complementary medicine', 'alternative medicine', 'CAM' and 'complementary', along with 'cancer', 'neoplasm', 'carcinoma' and 'cancer patients'. Finally, a total of 64 keywords were selected and the density visualization network graph is shown in Fig. 4. Studies indicated that there were five clusters. The first cluster (blue cluster) focused on the cancer populations (breast cancer, prostate cancer, ovarian cancer) and the research contents mainly concentrated on quality of life, chemotherapy, apoptosis and so on. The second cluster (red cluster) was about the application of herbal medicine and dietary supplements on cancer patients. The third cluster (green cluster) centred on cancer-related symptoms (depression, anxiety, pain, etc.) management and related therapies (meditation, yoga, massage, etc.). The fourth cluster (purple cluster) focused on Traditional Chinese Medicine and homeopathy, where acupuncture was the most used in Traditional Chinese Medicine. The fifth cluster (yellow cluster) was mainly on the knowledge and attitude of nurses. There were many cross-links between terms from different clusters, which indicated that the five clusters had a very close relationship with each other.

Table 4 presents the top 20 research categories ranked by count. Among all the research categories, Oncology (910, 32.9%) was found to be the common topic in the most publications, followed by Integrative Complementary Medicine (782, 28.3%), Health Care Sciences Services (267, 9.6%) and General Internal Medicine (224, 8.1%). Nursing was ranked fifth in the research categories.

3.3. Top 10 cited articles analysis

Top 10 cited articles are listed in Table 5. The highest citation number was 590 for the article entitled 'Complementary/alternative medicine use in a comprehensive cancer center and the implications for oncology', which was published in the Journal of Clinical Oncology in 2000 [22]. The second-highest-cited article by Molassiotis et al. focused on the 'Use of complementary and alternative medicine in cancer patients in Europe' [23]. The latest article in the top 10 published in 2013, by Bailey et al., investigated 'Why US Adults Use Dietary Supplements' and has been cited 225 times [24]. In terms of the average normalized citation, the article of 'Dissemination and publication of research findings: an updated review of related biases' [25] received the highest yearly-based attention in the academic community, illustrating factors that may make the research about CAM biased. Among the top 10 highly cited articles, the first author of five articles were all from the USA, followed by England (two papers).

3.4. Author analysis

The leading researchers could be identified through the analysis of author information. Furthermore, the major citation networks and research focuses could be identified through co-citation analysis. Because the name of the same author may have different forms of abbreviations, the two names were combined before they were analyzed further.

3.4.1. Influential authors

To a certain extent, the devoted efforts of a researcher can be reflected by the number and citations of publications, and the ratio of citations/publications. Totally, 149 out of 10,399 authors published more than six articles in this field. Professor Huebner J, who came from Goethe University Frankfurt (Germany), was active in the recent nine years and published the most articles (57 articles) among all of the authors. He was followed by Ben-Arye E (55 articles), Micke O (42 articles) and Schiff E (35 articles). Details of the top 20 most prolific authors are presented in Table 6. The study identified that some authors (such as Ernst E, Cassileth BR and Standish LJ) had a comparatively small number of articles, high cited frequency, and large centrality, which indicated that the studies on CAM in cancer patients of these authors were comparatively hot, with relatively great influence and high levels of attention.

3.4.2. Collaboration network analysis

By drawing out the co-citation relations among authors of the academic literature, author co-citation network could be obtained and used to guide scientific research. A total of 5310 authors were cited at least 10 times, accounting for 51.1% of the total 10,399 authors, 1322 authors were cited at least 50 times (12.7%), and 487 authors were cited at least 100 times (4.7%). Fig. 5 is the co-citation analysis results of the authors who are divided into five clusters in terms of cluster size, quality and representative authors, as well as the main research front, which represented the research network of five groups of scholars in CAM in cancer patients, for example, the Ernst E. group, the Eisenberg D. group, the Cassileth B. group, the Molassiotis A. group and the Mao J. group.

4. Discussion

Because of the importance of CAM in cancer treatment and the fast-growing attention of academia, more efforts should be taken to advance

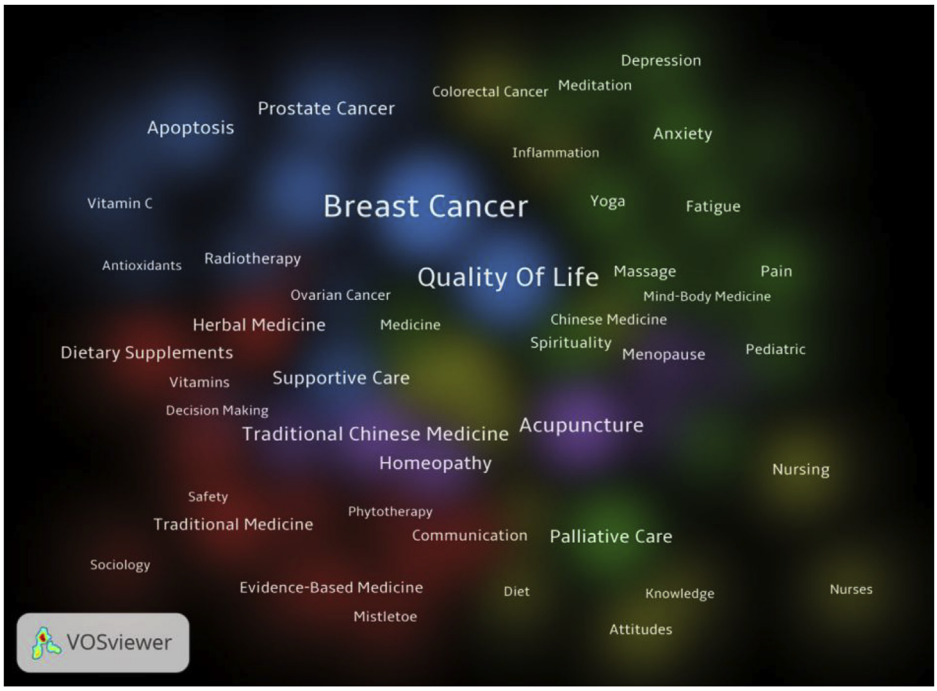

Fig. 4. Density map of the most frequently encountered terms extracted from the abstracts of retrieved articles. The larger circle size or font size indicates a higher occurrence.

research in this field. In this study, a coherent comprehensive bibliometric evaluation framework was used to explore the research territory and global trends of CAM within cancer patients.

The number of published articles has significantly increased since 1998, which is consistent with the analysis performed by Hubner [32]. The subsequent country publications comparative analysis indicated that the five largest contributors were the USA, Germany, Canada, United Kingdom and China. The USA (n = 36), UK (n = 34), Germany (n = 26), Israel (n = 21) and Turkey (n = 19) were the top five countries with most cooperation networks. Compared with other countries, the USA has focused more on the research of CAM in cancer patients. According to a systematic review of surveys on CAM used in cancer patients in Australia/New Zealand, North America and Europe, the US cancer patients had the highest CAM use rate and its CAM usage has been continuing to grow over the past 30 years [33,34], which may be related to paying high attention on CAM in cancer patients in the United States.

Keywords co-occurrence analysis indicated that the research hotspots around the world formed five clusters. To further compare the research emphases of different countries, the research hotspots of the top five countries—USA, Germany, Canada, UK and China—were extracted from the literature (Table S1). There were some differences and similarities in research priorities among the five countries. The results showed the most concerned type of cancer is breast cancer by all countries, however the second and third types varied from country to country, prostate and ovarian cancer in the USA, prostate and renal cell cancer in Germany, lung and prostate cancer in Canada, prostate and head-neck cancer in UK and hepatocellular and pancreatic cancer in China. The cancer populations concerned in different countries had a certain relationship with the CAM prevalence in cancer patients. A European survey found that CAM usage among cancer patients differed markedly based on the cancer type [23]. The prevalence is likely to grow as cancer incidence and survival increase [35]. In addition, all countries focused highly on the quality of life of cancer patients, which has some relevance to the importance of improving quality of life in cancer patients. Research shows that cancer survivors have a two-times higher probability of suffering from a poor quality of life compared with non-cancer populations [36]. Furthermore, there were also some differences. The United States focused more on symptom management, especially the function of acupuncture to improve cancer related symptoms [37,38]. Germany and the UK both attached great importance to the management of website information [39,40]. In addition, the Germans highly valued the establishment of evidence-based CAM information support [41]. Canada highly valued the treatment

Table 4
The top 20 research categories ranked by count.

Rank	Research Category	TA (%)	Rank	Research Category	TA (%)
1	Oncology	910(32.9)	11	Research Experimental Medicine	71(2.6)
2	Integrative Complementary Medicine	782(28.3)	12	Pediatrics	68(2.5)
3	Health Care Sciences Services	267(9.6)	13	Psychology	63(2.3)
4	General Internal Medicine	224(8.1)	14	Biochemistry Molecular Biology	58(2.1)
5	Nursing	210(7.6)	15	Neurosciences Neurology	54(2.0)
6	Public Environmental Occupational Health	170(6.1)	16	Nutrition Dietetics	53(1.9)
7	Pharmacology Pharmacy	160(5.8)	17	Urology Nephrology	51(1.8)
8	Rehabilitation	152(5.5)	18	Science Technology Other Topics	50(1.8)
9	Obstetrics Gynecology	92(3.3)	19	Plant Sciences	46(1.7)
10	Biomedical Social Sciences	78(2.8)	20	Social Sciences Other Topics	45(1.6)

Note: TA: Total Articles.

Table 5
Top 10 cited articles on CAM in cancer patients from inception of the searched databases to 2018.

Article	Author(s)	Journal	Country	TC	TC/Y	Year
Complementary/alternative medicine use in a comprehensive cancer center and the implications for oncology	Richardson, MA; Sanders, T; Palmer, JL; et al. [22]	Journal of Clinical Oncology	USA	590	31.05	2000
Use of complementary and alternative medicine in cancer patients: a European survey	Molassiotis, A; Fernandez, OP; Pud, D; et al. [23]	Annals of Oncology	England	522	37.29	2005
Use of alternative medicine by women with early-stage breast cancer	Burstein, HJ; Gelber, S; Guadagnoli, E; et al. [26]	New England Journal of Medicine	USA	407	20.35	1999
Efficacy, safety, quality control, marketing and regulatory guidelines for herbal medicines (phytotherapeutic agents)	Calixto, JB [27]	Brazilian Journal of Medical and Biological Research	Brazil	369	19.42	2000
Dissemination and publication of research findings: an updated review of related biases	Song, F.; Parekh, S.; Hooper, L.; et al. [25]	Health Technology Assessment	England	364	40.44	2010
Complementary and alternative medicine for menopausal symptoms: A review of randomized, controlled trials	Kronenberg, F; Fugh-Berman, A [28]	Annals of Internal Medicine	USA	335	19.71	2002
Use of complementary/alternative medicine by breast cancer survivors in Ontario: Prevalence and perceptions	Boon, H; Stewart, M; Kennard, MA; et al. [29]	Journal of Clinical Oncology	Canada	282	14.84	2000
Psychological Status in Childhood Cancer Survivors: A Report From the Childhood Cancer Survivor Study	Zeltzer, LK.; Recklitis, C; Buchbinder, D; et al. [30]	Journal of Clinical Oncology	USA	264	26.4	2007
Why US Adults Use Dietary Supplements	Bailey, RL.; Gahche, JJ.; Miller, PE.; et al. [24]	Jama Internal Medicine	USA	225	37.5	2013
Disclosure of CAM use to medical practitioners: a review of qualitative and quantitative studies	Robinson, A; McGrail, MR [31]	Complementary Therapies in Medicine	Australia	219	14.6	2004

Note: TC: Total Citation; TC/Y: Average Citations per Year, which is the TC divided by the Year.

decision making in cancer patients. For example, Lynda et al. explored patients CAM information needs to make informed decisions [42]. China attached more attention to the research of Traditional Chinese Medicine [43], which has some relevance to the long history of Traditional Chinese Medicine culture in China.

To deeply understand this research topic, the research contents of the top three prolific authors were summarised. They all paid attention to CAM cognition, information needs of cancer patients and health care workers, and the potential interaction between CAM and anticancer drugs [44–50]. Both Ben-Arye E and Micke O investigated the use of CAM in cancer patients (such as the prevalence, the reasons for CAM use and the main types of CAM used) [51,52]. Huebner J and Micke O both valued evidence-based research on CAM and attached importance to the quality assessment of CAM-related information in order to provide evidence-based information consultation for patients [53,54]. In addition, Huebner conducted extensive research on CAM-related EHealth literacy in patients with cancer [39]. Ben-Arye E paid attention to the application of CAM in symptom management, such as the role of CAM in relieving gastrointestinal concerns in cancer patients [55]. In general, the research contents had a very close relationship with each other.

To obtain insights into each cluster of author co-citation network, a content analysis was conducted to identify the research themes of the co-citation core authors. Ernst E, coming from the Universities of Exeter and Plymouth, led a research team which focused on evaluating the quality of information and evidence-based study of CAM in cancer patients and made a series of great contributions in this research area. For example, one of his studies focused on accessing websites on CAM for cancer [40]. Eisenberg D. was interested in the research of the factors related to visits to CAM providers and correlated the utilization of different types of CAM by cancer patient. For instance, one of the studies concentrated on the effect of insurance coverage on the frequency of use of CAM providers [56]. Cassileth B.'s group focused on the application of CAM in symptom management. Molassiotis A.'s group mainly paid attention to the application status analysis of CAM in European cancer patients. Mao J.'s group focused on the application of CAM in breast cancer and compared the different uses of CAM between cancer and non-cancer patients. Multiple cross-links between terms from different clusters indicated that there were many similarities in the research content. In addition, Ernst E and Cassileth B, together with Standish LJ who focused on the effects of CAM treatment on patients decision-making, treatment, etc. [57,58], were the first three highly-cited authors.

This study reviewed the research on CAM in cancer patients in general, but there are limitations to the study. First, this study was based on the WoS database only and did not involve journals not covered by WoS, so the analysis was relatively limited. In the future, researchers should include more databases for centralised analysis. Second, this study was limited to its literature sample, as only articles were included. Third, original research and review research were not distinguished, the citation ratio of literature review is often higher than the original research. In the future, researchers should make further improvements to the methodology.

5. Conclusion

CAM is playing a significant role in cancer treatment research which has attracted the fast-growing attention of academia. The current study can help scientists to locate the prolific country, journal, institutions, author, global research hotspots, emerging trends and collaboration network of CAM in cancer patients by offering comprehensive analyses and structured information on this topic. Following the scientometric analysis, the research hotspots in the top five countries were discussed. The research contents of the top three prolific authors and highly cited authors and co-citation core authors were also summarised. Additionally, the results of this study delineate a framework for better

Table 6
Top 20 contributing authors in terms of publications.

Rank	Scholar	Affiliation	TA	TGCS	GCSA
1	Huebner J	Goethe University Frankfurt, Germany	57	398	7.0
2	Ben-Arye E	Clalit Health Services, Israel	55	417	7.6
3	Micke O	Franziskus Hospital, Germany	42	419	10.0
4	Schiff E	Bnai Zion Med Center, Israel	35	249	7.1
5	Samuels N	Sheba Med Center, Israel	30	132	4.4
6	Mao JJ	Mem Sloan Kettering Cancer Center, USA	28	374	13.4
7	Munstedt K	Goethe University Frankfurt, Germany	28	225	8.0
8	Cohen L	University of Texas MD Anderson Cancer Center, USA	26	274	10.5
9	Muenstedt K	Ortenau Clinic, Germany	22	288	13.1
10	Broom A	University of New South Wales, Australia	21	421	20.0
11	Ernst E	University of Exeter, England	21	806	38.4
12	Adams J	University of Technology Sydney, Australia	20	235	11.8
13	Frenkel M	University of Texas Medical Branch, USA	20	363	18.2
14	Muecke R	Ruhr University Bochum, Germany	19	249	13.1
15	Sibbritt D	University of Technology Sydney, Australia	18	195	10.8
16	Standish LJ	Bastyr University, USA	18	563	31.3
17	Cassileth BR	Mem Sloan Kettering Cancer Center, USA	17	556	32.7
18	Greenlee H	Columbia University, USA	16	380	23.8
19	Verhoef MJ	University of Calgary, Canada	16	305	19.1
20	Prott Fj	RNS Praxisgemeinschaft, Germany	15	246	16.4

Note: TA: Total Articles; TGCS: Total Global Citations Score, which is the number of citations by the papers of Web of Science; GCSA: Global Citation Score per Article, which is the TGCS divided by the TA.

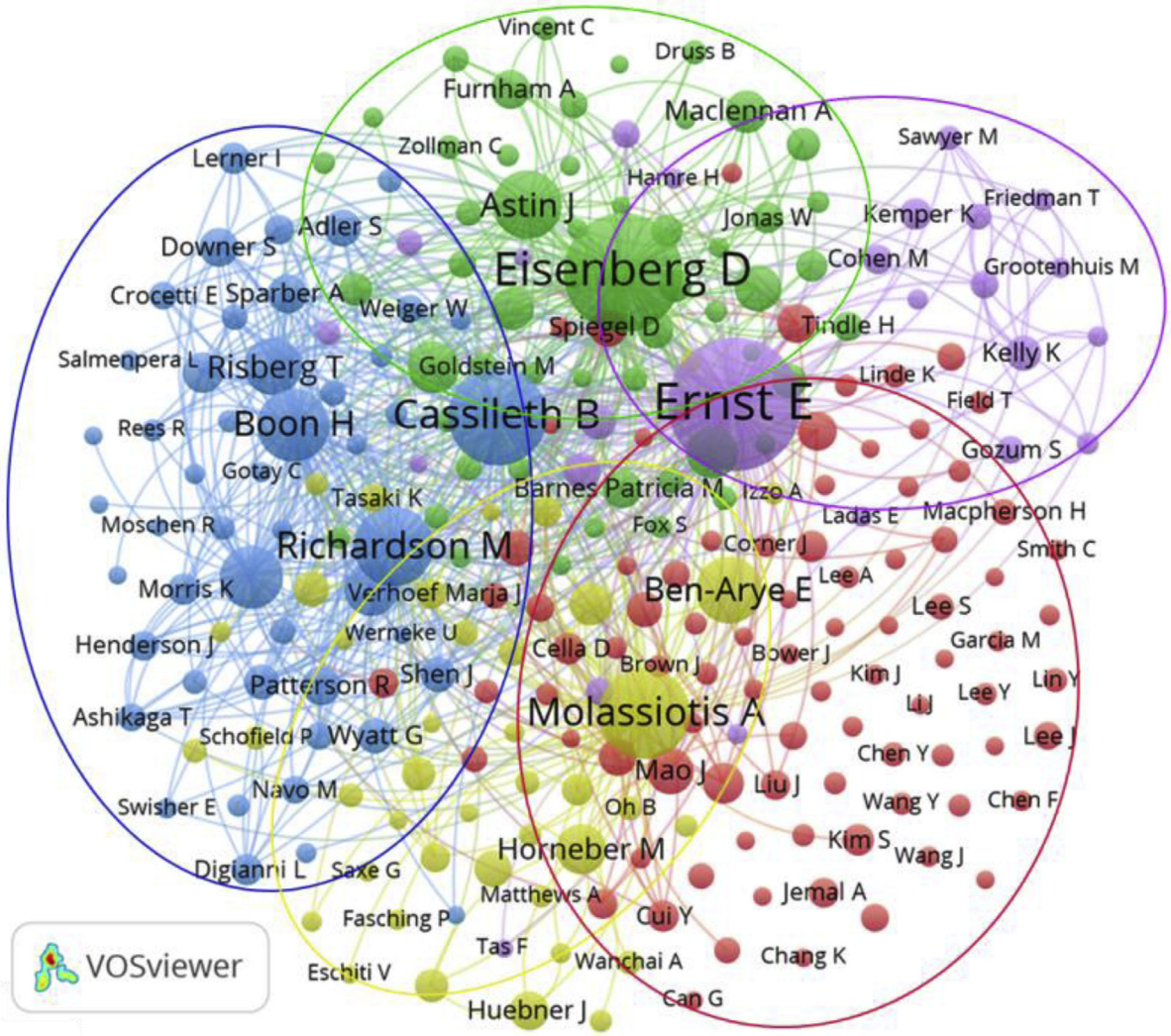

Fig. 5. Author co-citation network analysis in the field of application on CAM in cancer patients.

understanding the situational use of CAM in cancer patients, which could help health care workers to prioritize and organize future research.

Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ctcp.2019.08.008.

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