

# Worldwide Productivity and Research Trend of Publications Concerning Cancer-Related Neuropathic Pain: A Bibliometric Study

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**Abstract:** Cancer-related neuropathic pain is a common adverse effect in the process of cancer development and treatment and has gradually attracted the attention of researchers. The purpose of this article is to systematically review the articles on cancer-related neuropathic pain published between 2012 and 2021 and visualize the data through CiteSpace and R software. The results show that in the past 10 years, a total of 5715 articles have been published, involving 118 categories, of which the most is Clinical Neurology, followed by Neurosciences, Pharmacology Pharmacy. The country with the most published articles is the United States, followed by China and Italy. A total of 22,228 authors were involved in the study of cancer-related neuropathic pain. These historical opinions about cancer-related neuropathic pain could be an important practical basis for further research into potential development trends.

**Keywords:** cancer, neuropathic pain, bibliometric, author, country, institution

## Introduction

According to the most recent data from the International Agency for Research on Cancer of the World Health Organization, there were 19.29 million new cancer cases and 9.96 million cancer deaths worldwide in 2021,<sup>1</sup> making it the second leading cause of death after cardiovascular diseases.<sup>2,3</sup> Moreover, cancer has caused immense troubles and difficulties to human beings,<sup>4,5</sup> significantly reducing the survival of cancer patients.<sup>6</sup> Therefore, prolonging the survival time of cancer patients has long been the focus of researchers. With the development of medicine and the progress of research, surgery,<sup>7</sup> chemotherapy,<sup>8</sup> radiotherapy,<sup>9</sup> targeted therapy,<sup>10</sup> and immunotherapy<sup>11</sup> can effectively treat cancer and improve the survival time of patients. However, some associated adverse effects of treatment affect the physical function or mood of patients during the occurrence and treatment of cancer. These include pain, anxiety, gastrointestinal reactions, depression, fatigue, etc.<sup>12-17</sup>

Cancer-related neuropathic pain is a very common symptom in cancer patients,<sup>18,19</sup> and it may be related to cancer or adverse effects caused by cancer drugs. For example, 90% of patients who receive cytotoxic drug chemotherapy develop peripheral neuropathy induced by chemotherapy. Most cancer patients are older adults, and also have some other underlying diseases.<sup>20</sup> Thus, neuropathic pain a type of pain experienced by patients. In clinics, opioids are commonly used in cancer-related neuropathic pain along with some anticonvulsant drugs and antidepressants.<sup>21</sup> Although the current treatment of cancer is becoming increasingly effective and the life expectancy of patients is improving, more attention should be paid to the adverse effects to enhance the quality of life of cancer patients.<sup>22</sup> In recent years, more studies focusing on cancer pain, especially in the field of cancer-related neuropathic pain are being conducted, and many articles are published every year.

Bibliometrics is a statistical analysis and quantitative tool for studying publications in all directions.<sup>23,24</sup> Emerging research trends and related hotspots can be determined through bibliometrics. At present, bibliometrics has been used in many fields. For example, some researchers have performed bibliometrics studies on cancer and pain comorbidities, whereas others have done conducted such studies on neuropathic pain related to depression. However, according to our previous research, bibliometric studies of cancer-related neuropathic pain have not yet been published. Therefore, this study aimed to systematically conduct a comprehensive scientific analysis of the research published in the past 10 years. To do this, we studied the publications related to cancer-related neuropathic pain in the WEB OF SCIENCE (WoS) database from 2012 to 2021, and drew countries, institutions, authors, keywords and subject categories, references, journals, co-citation networks, and citation burst analysis of keywords. Moreover, we explored the development trends and hot spots of cancer-related neuropathic pain to provide guidance and trend prediction for researchers in related fields.

## Materials and Methods

### Source of Data

We used WoS database as the basic retrieval tool. To ensure the papers are relevant to our topic and the quality of published articles, we chose the core database of WoS, through which we searched papers published from 2012 to 2021. We set the recording term as: (((((((TS=(Neuralgia)) OR TS=(Neurodynia)) OR TS=(Neuropathic pain)) OR TS=(Nerve pain)) OR TS=(Neuropathic Pains)) OR TS=(Pain, Neuropathic)) OR TS=(Pains, Neuropathic)) OR TS=(Nerve Pains)) OR TS=(Pain, Nerve)) OR TS=(Pains, Nerve) AND (((((((TS=(cancer)) OR TS=(tumor)) OR TS=(tumor)) OR TS=(neoplasia)) OR TS=(neoplasms)) OR TS=(tumors)) OR TS=(tumors)) OR TS=(cancers)).

### Inclusion Criteria

The papers screened included articles and reviews of cancer-related neuropathic pain in different academic journals. We excluded letters, conference summaries, published editorial materials, book reviews, meeting reports, news items, and corrections. The language of article was not restricted, and we did not specify the restrictions on species.

### Data Extraction

We extracted articles from the WoS core database through the software ENDNOTE. Meanwhile, we sorted out and summarized the details of these published articles, including the number of relevant papers published in each journal, the number of papers published by each author, frequency of citation of each paper, and organization and country of the author of each article. Thereafter, we summarized the top 10 subject categories included in the articles and reviews, with each paper marked with at least one category.

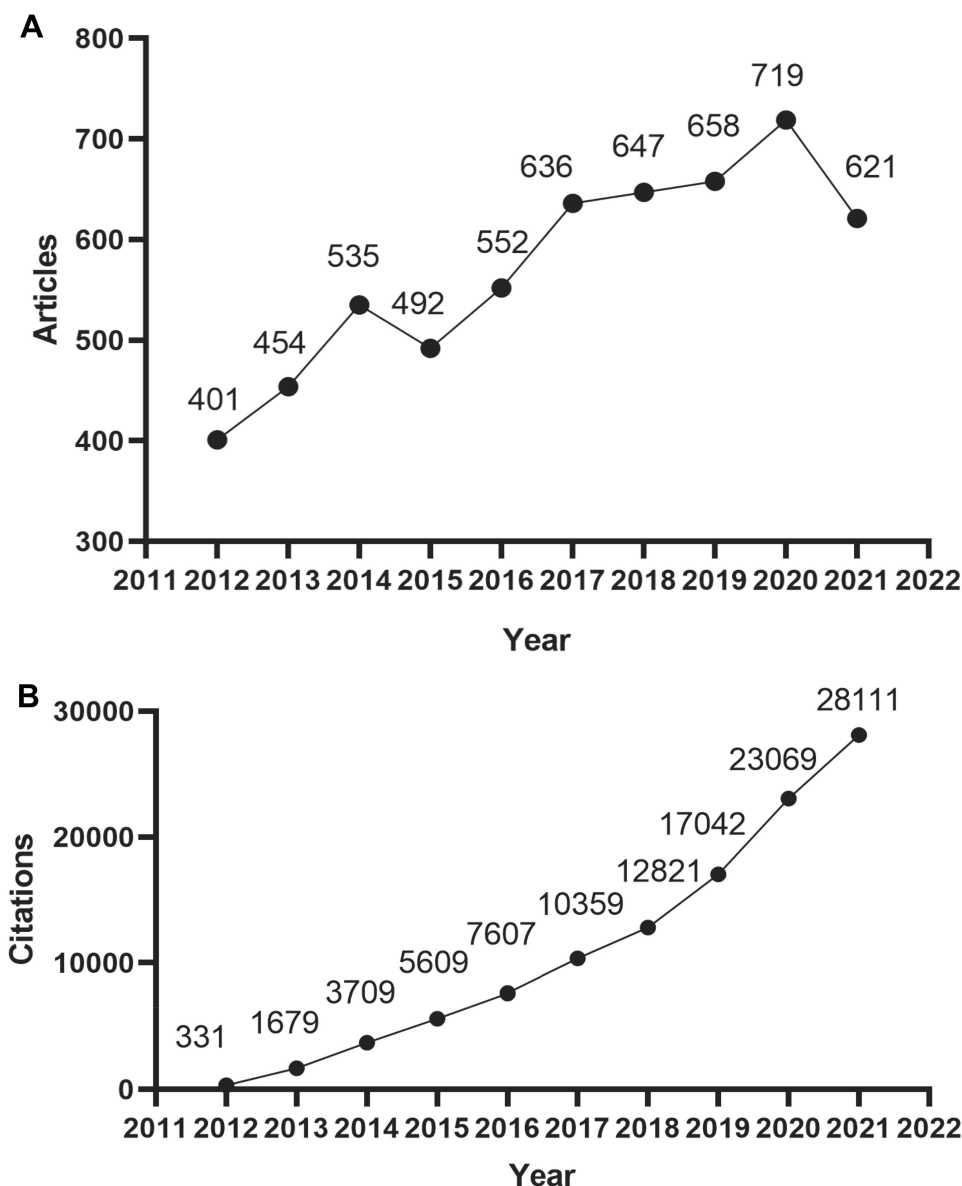
### Statistics Methods

The CiteSpaceV and R software were used to analyze articles about cancer-related neuropathic pain and information obtained from the WoS core database. CiteSpace visualized a publication network into a scientific map and also analyzed the keywords, evolution path, knowledge structure, and scientific development trends in this field. At the same time, we used the “biblioshiny” package of R software to analyze the data. In this study, we analyzed all publications in this field through CiteSpace and R software, and made the following statistics and analysis: (a) publication and citation trends; (b) distribution of journals and authors; (c) summarized discipline categories in WoS; (d) represented cooperation between countries or regions and institutions; (e) analyzed references and keywords. Linear regression was applied to evaluate whether the publications decreased or increased in a period of time.

## Results

### Paper Analysis

A total of 5715 papers met the inclusion criteria, and as shown in from Figure 1A, the overall trend of publication was set to increase from 401 in 2012, to 621 in 2021. Using linear regression analysis, the number of articles published increased gradually ( $p < 0.001$ ). Meanwhile, 5715 articles were cited 110,337 times (Figure 1B), with an average of 19.3 times per

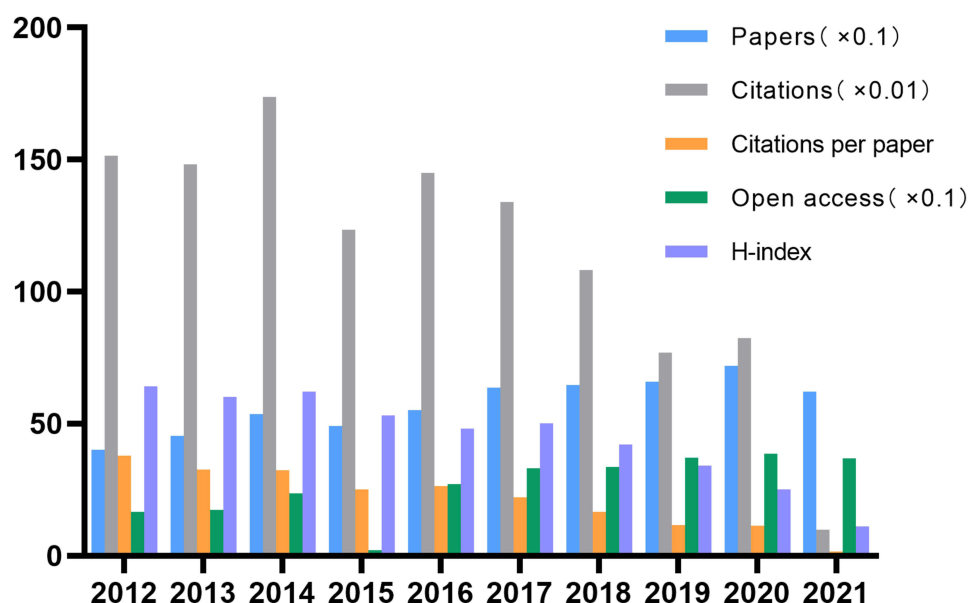


**Figure 1** (A) The number of annual publications on cancer-related neuropathic pain research from 2012–2021; (B) the number of annual citations on cancer-related neuropathic pain research from 2012–2021.

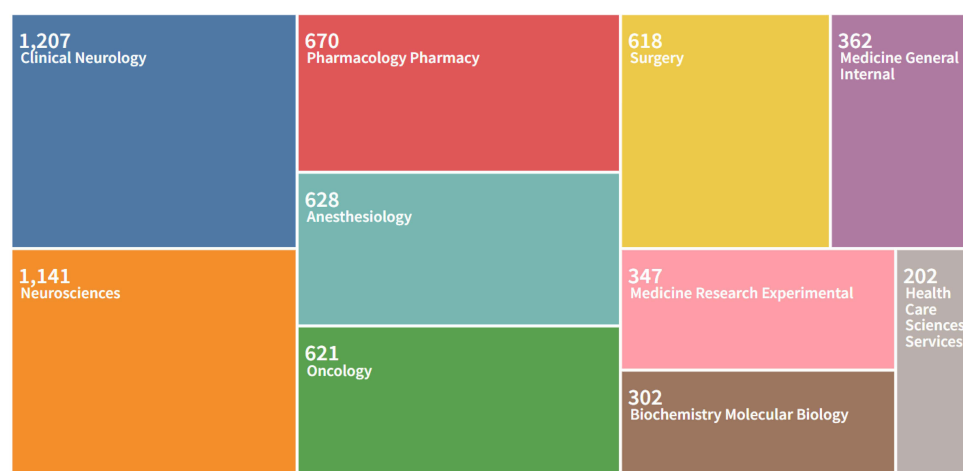
article. Overall, the increase of the total amount of papers in this field confirmed the annual growth trend of related citations from 331 times in 2012 to 28,111 times in 2021. Then, we compiled the statistics of the articles and related data published each year (Figure 2), and observed that the articles published in 2014 were the most frequently cited, up to 17,383 times, whereas the average year in which articles were cited is 2012, with an average of 37.77 times per article. This revealed that 2012 was the year with the highest H-index index at 64. The largest number of papers was published in 2020, with 719 published papers on tumor-related neuropathic pain.

## Subject Categories of the WoS Database

Each review or article was marked with at least one subject category in the WoS database (5715 articles belong to 118 topics). Figure 3 shows that the top ten subjects are Clinical Neurology, Neurosciences, Pharmacology Pharmacy, Anesthesiology, Oncology, Surgery, Medicine General Internal, Medicine Research Experimental, Biochemistry Molecular Biology, and Health Care Sciences Services. We analyzed the number of publications, citations, open access



**Figure 2** Number of papers, citations, citations per paper, open access paper and H-index for each year time period.



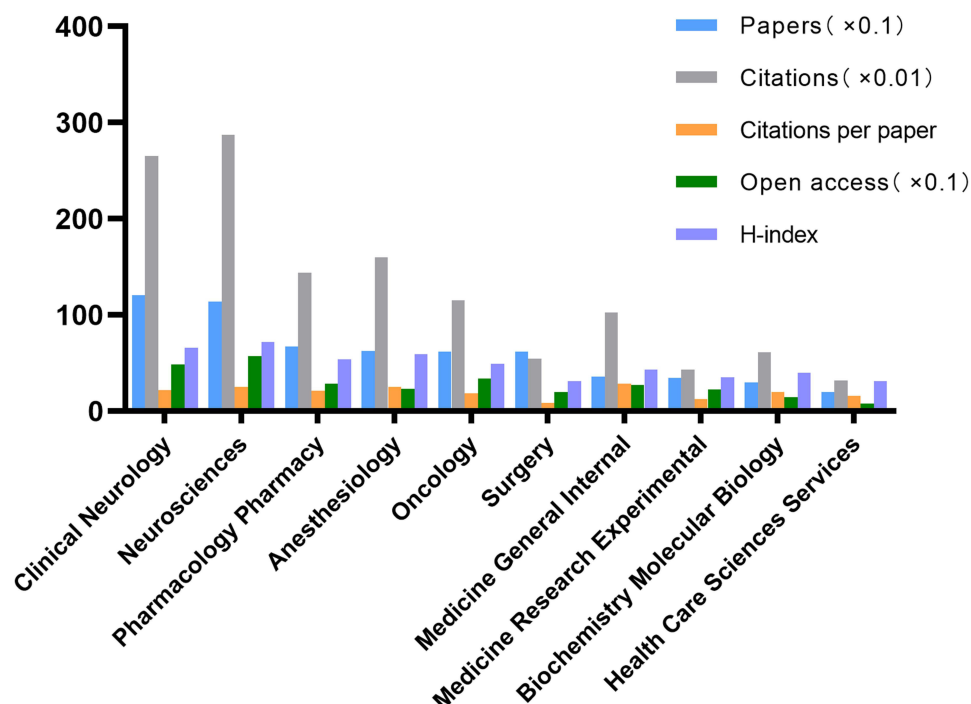
**Figure 3** Top 10 categories in WoS database.

articles, and h-index on these 10 subjects (Figure 4). The findings revealed that highest number of published articles was in the field of Clinical Neurology—a total of 1207 related papers were published in this field, and the subject with the largest total citation was Neurosciences (28,748 times). Medicine General Internal had the highest number of citations per paper (28.39). Moreover, the highest category of H-index was Neurosciences (72). These ten topics cover most of the papers in the field of tumor-related neuropathic pain, and hold certain reference value.

## Journal Distribution

[Supplementary 1](#) shows a total of 1498 journals published articles on neuropathic pain of tumors, and the top 10 journals contributed 790 articles (13.8%). Among them (Table 1), the journal with the largest number of articles was *Pain*, which published a total of 142 articles in 10 years. Its impact factor was also the highest among the top ten journals (IF = 6.961), and its various categories were in the Q1 division (the top 25% of the distribution of impact factors), followed by 2–10, contributing more articles. Moreover, the magazine with the highest H-index was *PLoS One* (H-index=332), indicating that the journal had great academic influence, and its articles can provide reference for many researchers.



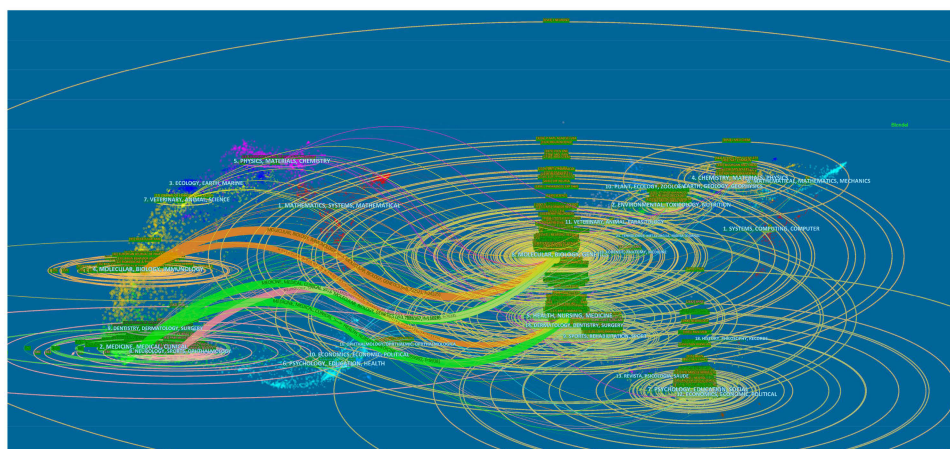


**Figure 4** Number of papers, citations, citations per paper, open access paper and H-index for each category.

As shown in Figure 5, dual-map overlay of the journal is obtained using CiteSpace (5.5, R2). In a dual-map, the left side of map indicates citing journals, whereas the right side of the map includes cited journals. The label of the double atlas represents the discipline of the journal, and the lines are regarded as the connection of the citation, that is, from cited journals to the citing journals. Consequently, most papers that are published in molecular, biology, immunology, medicine, medical, clinical, neurology, sports, and ophthalmology journals, mainly cite from molecular, biology, genetics, health, nursing, and medicine fields.

**Table 1** The Top 10 Journals of Origin of Papers in the Cancer-Related Neuropathic Pain

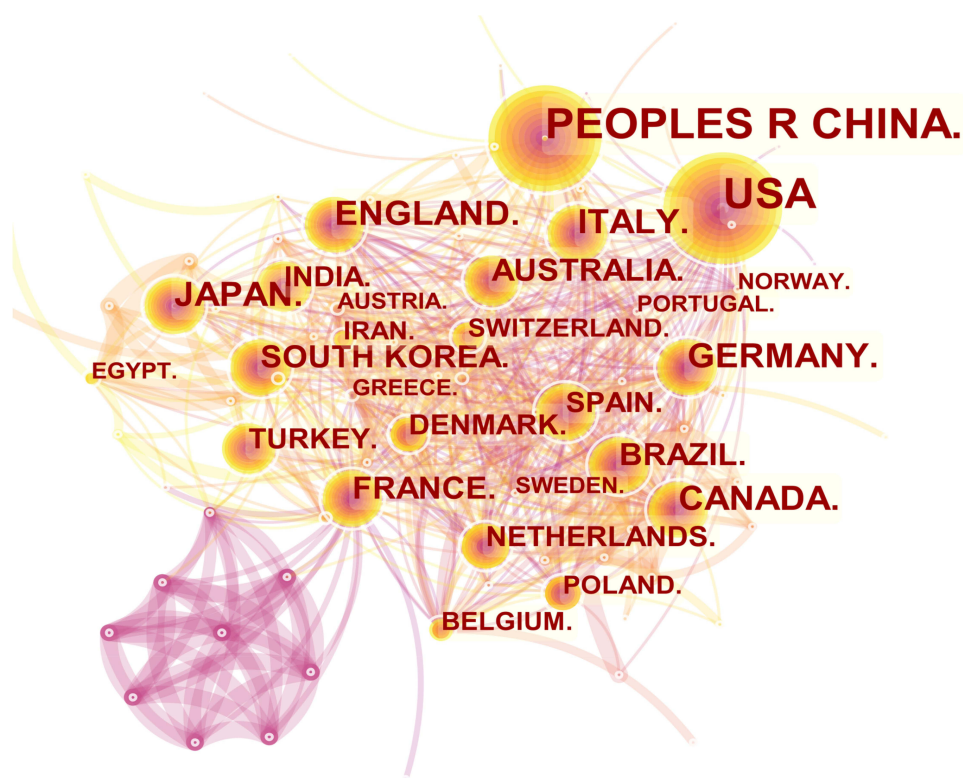
Sources	Articles	Category	Quartile	IF (2020)	H-Index
Pain	142	Neurosciences; Clinical Neurology; Anesthesiology	Q1; Q1; Q1	6.961	258
World Neurosurgery	97	Neurosciences	Q3	2.104	95
Molecular Pain	93	Neurosciences	Q3	3.395	83
PLoS One	83	Multidisciplinary Sciences	Q2	3.24	332
Journal of Pain Research	77	Clinical Neurology	Q3	3.133	49
Pain Physician	72	Anesthesiology; Clinical Neurology	Q2; Q2	4.97	99
Medicine	59	Medicine, General & Internal	Q2	1.889	148
Supportive Care in Cancer	59	Oncology; Health Care Sciences & Services; Rehabilitation	Q2; Q2; Q1	3.603	112
Journal of Pain	56	Clinical Neurology; Neurosciences	Q1; Q1	5.828	127
Scientific Reports	52	Multidisciplinary Sciences	Q1	4.38	213



**Figure 5** The dual-map overlay of journals of cancer-related neuropathic pain research.

## Analysis of Countries and Institution Distribution

Through CiteSpace, researchers from 121 countries ([Supplementary 2](#)) have published relevant articles. Considering the number of papers, we list the top 10 countries, of which the most published is the United States (1623), accounting for 28.4% of all articles, followed by China, Italy, Japan, Germany, England, Canada, France, South Korea, and Australia. We drew the article-world-map according to the number of posts in each country and the cooperative relationship of the authors in each country ([Figure 6](#)). For cancer patients, most often, the diagnosis and treatment of neuropathic pain is not the first goal in the treatment, and is easily ignored. We checked the GDP rankings of the top 10 countries through the World Bank, and found that the GDP of these top 10 countries concerned about cancer pain, is among the top 15 in the



**Figure 6** Network map of countries/territories engaged in cancer-related neuropathic pain research.

**Table 2** The Top 10 Countries with the Largest Numbers of Articles and Their GDP Ranks

Country	Articles	GDP Rank
U. S. A	1623	1
China	1285	2
Italy	380	8
Japan	359	3
Germany	349	4
England	283	5
Canada	249	9
France	237	7
South Korea	207	10
Australia	166	13

world (Table 2). Only the richer countries and regions have more economy and energy to pay attention to the treatment of tumor neuropathic pain.<sup>25</sup> In contrast, tumor treatment itself may be the primary goal for poorer areas.<sup>26</sup> A total of 5774 institutions have published articles on tumor neuropathic pain, and we listed the ten institutions that published the most articles (as shown in the figure). Sun Yat-sen University is the institution with the highest number of articles, with a total of 233 articles in 10 years (Figure 7A). Further, we analyzed the number of papers by each institution and the cooperative relationship through these institutions (Figure 7B). Figure 8B shows that institutions that published more articles are from economically developed countries. Further, most institutional cooperation also comes from these countries. This result also confirms the correlation between economic development and research in the field of cancer-related neuropathic pain.

## Distribution by Authors

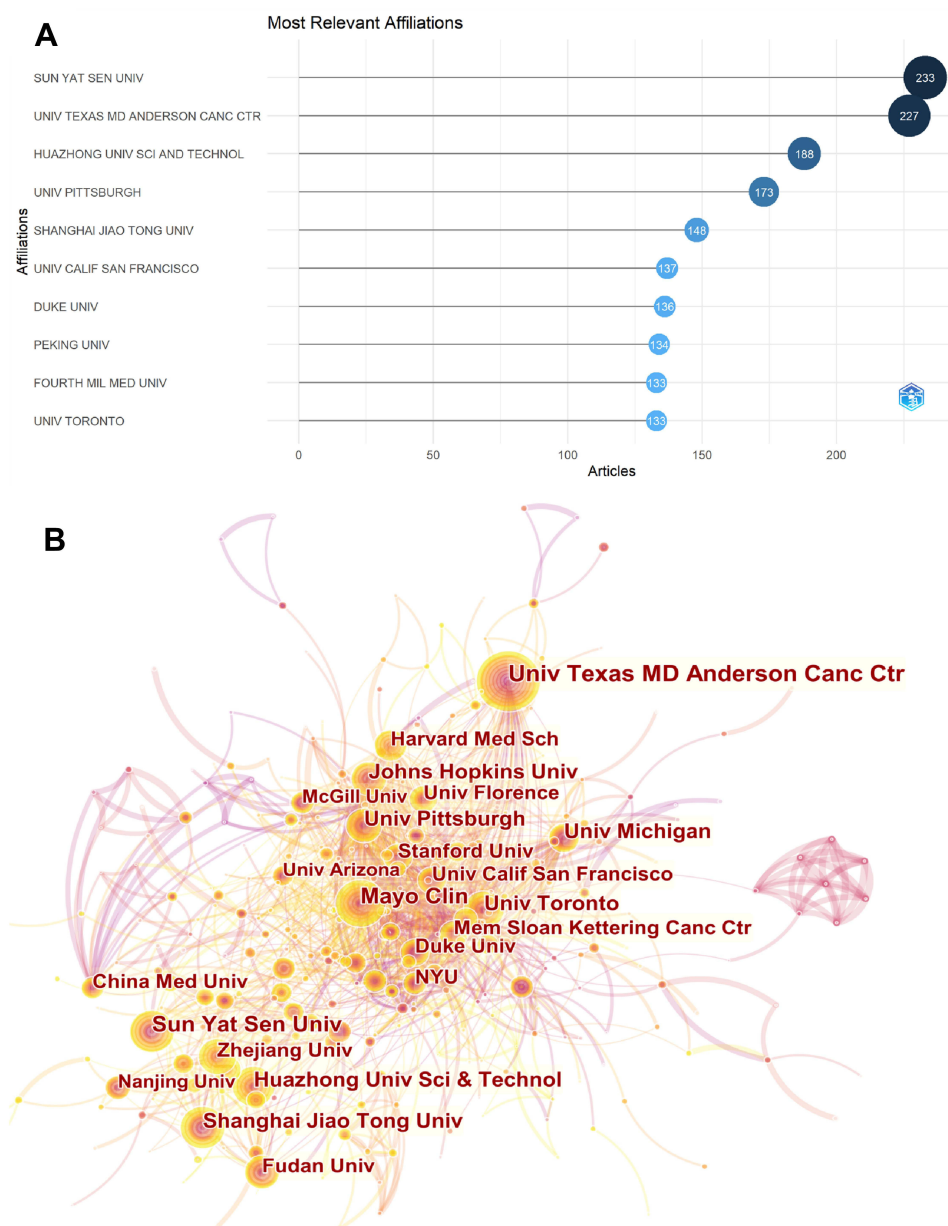
A total of 22,228 authors were involved in the study of cancer-related neuropathic pain (Supplementary 3). We listed the top ten authors who contributed most to this field (Figure 8A). The author with the largest number of publications was Li Y; he published a total of 81 articles, and these articles have been cited 5458 times in this decade. Li Y is also the author with the largest number of citations. Analyzing the cooperative relationship between authors revealed that most authors cooperate with other researchers in their own countries, and that cooperation between different regions is rare.

## Analysis of References

The concept of co-cited references was adopted to evaluate the relationship between publications, and is regarded as an important indicator in Bibliometrics research. The results in Figure 9 show a timeline view of the reference co-citation analysis. The first 5 clusters named by index words in the cited literature are also provided. Q value indicates the importance of community structure, that is,  $q > 0.3$  corresponds to significant community structure. The Q value of this work was 0.7671. “paclitaxel” is the first category (#0), followed by “microglia” (#1), “mastectomy” (#2), “bone cancer pain” (#3), and “therapeutic use” (#4). Most articles on cancer-related neuropathic pain published in the past decade cited the publications in these five clusters.

## Analysis of Keywords

We used CiteSpace to extract all the keywords of cancer-related neuropathic pain articles published in recent ten years (Figure 10),<sup>27</sup> and screened out the strongest citation bursts keywords. The keywords in 2012 include “necrosis factor

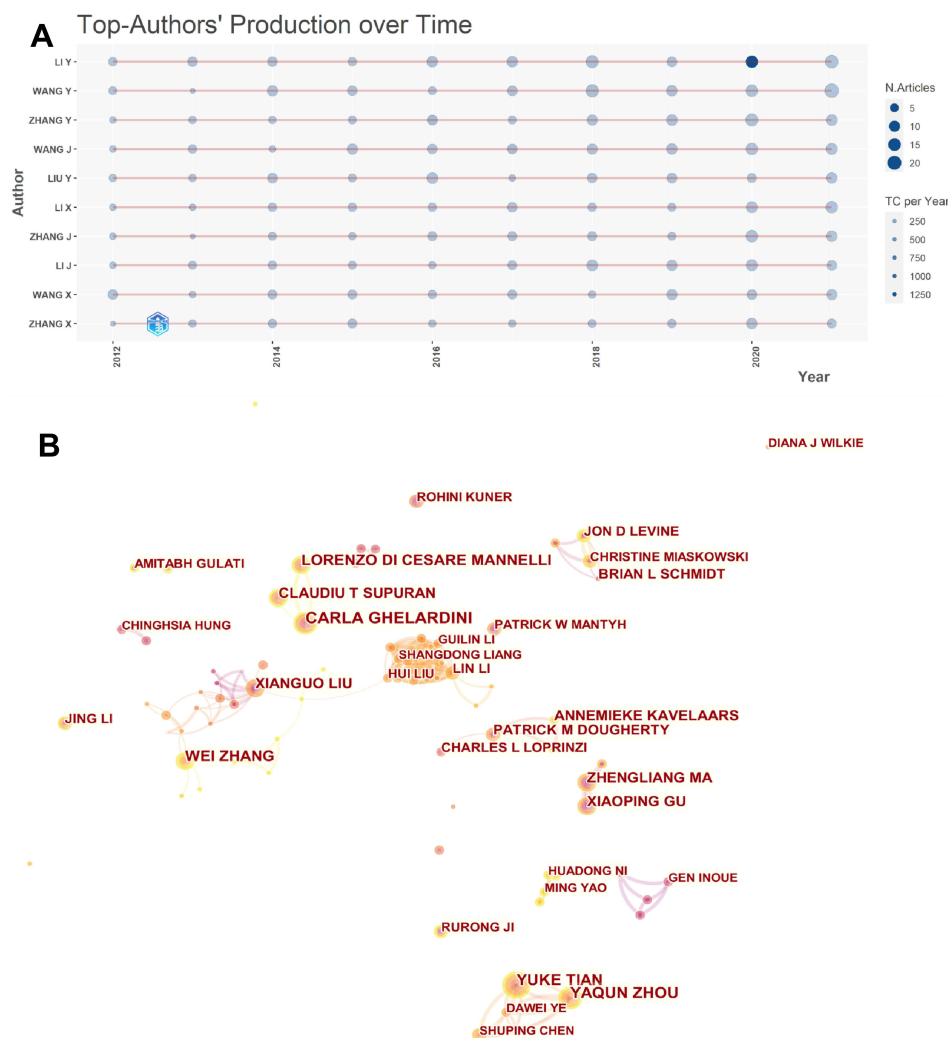


**Figure 7 (A)** The top 10 institutions that have published articles on cancer-related neuropathic pain; **(B)** Network map of institutions engaged in cancer-related neuropathic pain research.

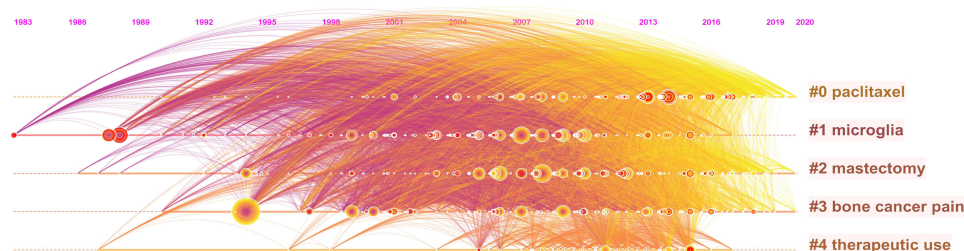
alpha”, “cancer”, “dorsal horn neuron”, “nitric oxide”, and “scale”. By 2021, keywords include “neuropathic pain”, “neuroinflammation”, “medical marijuana”, and “stimulation”.

## Features of the Top 10 Most Cited Publications

We listed the top 10 articles cited in this field (Table 3). The citations of these 10 articles (3684) accounted for 13.1% of the citations of all articles. Among them, the article “Neurological Pain” was published in *Nature Reviews Disease Primers* in 2017,<sup>28</sup> with the most citations (797). Among these ten publications, six articles with  $IF \geq 10$  were published in *Nature Reviews Disease Primers*, *Bone Research*; *BMJ-British Medical Journal*, *Cancer Treatment Reviews*, *Journal of Clinical Oncology*, and *Annals of Oncology*.<sup>28–33</sup> Two were published in journals with  $5 \leq IF < 10$  (*Pain*; *Expert Opinion on Drug Discovery*)<sup>34,35</sup> and two were published in journals with  $3 \leq IF < 5$  (*Pharmacotherapy*; *Neuroscience Letters*).<sup>36,37</sup>



**Figure 8 (A)** The top 10 authors that have published articles on cancer-related neuropathic pain; **(B)** Network map of authors engaged in cancer-related neuropathic pain research.



**Figure 9** The analysis of references. Co-citation map (timeline view) of references from publications on cancer-related neuropathic pain research.

## Discussion

We performed a systematic and visual review of literature dosimetric statistical analysis of publications on cancer-related neuropathic pain from 2012 to 2021. In the past decade, 5715 articles have been published, with 110,337 citations in total. The number of publications in this field has been increasing steadily each year, along with the citations of



## Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2012 - 2021
necrosis factor alpha	2012	9.33	2012	2015	
cancer	2012	4.1	2012	2015	
dorsal horn neuron	2012	3.94	2012	2015	
nitric oxide	2012	3.93	2012	2015	
scale	2012	3.85	2012	2016	
release	2012	3.62	2012	2015	
capsaicin receptor	2012	2.71	2012	2015	
relief	2012	6.43	2013	2016	
intervertebral disc	2012	4.4	2013	2016	
induced hyperalgesia	2012	3.04	2013	2016	
neurinoma	2012	3.04	2013	2016	
placebo controlled trial	2012	5.1	2014	2017	
sensitization	2012	4.38	2014	2018	
protein kinase	2012	4.38	2014	2018	
combination	2012	3.85	2014	2017	
benign	2012	3.17	2014	2017	
acetyl l carnitine	2012	2.81	2014	2017	
multicenter	2012	4.22	2015	2019	
opioid analgesics	2012	3.33	2015	2018	
bone cancer	2012	3.06	2015	2018	
electroacupuncture	2012	2.61	2015	2018	
neuropathic pain	2012	4.1	2016	2021	
neuroinflammation	2012	5.62	2017	2021	
medical marijuana	2012	5.01	2017	2021	
stimulation	2012	3.41	2017	2021	

**Figure 10** The keywords with the strongest citation bursts of publications on cancer-related neuropathic pain research.

publications, indicating that cancer-related neuropathic pain has started to gradually receive attention from researchers. The number of papers published in 2020 was the highest (719), accounting for 12.6% of all papers published in the past decade, whereas the number of articles published was the highest in 2014 (17,383). The United States published the most papers (1623), accounting for more than a quarter (28.4%) of all papers, followed by China, Italy, Japan, Germany, the United Kingdom, Canada, France, South Korea and Australia. Moreover, we conducted statistics on the top 10 institutions with the most publications, and found that all of them are located either in China or the United States. We compared the GDP from the World Bank with the above data, and found that the countries with a large number of publications were all countries with a high GDP ranking. The number of publications is directly related to the economy. This is a reasonable finding because prolongation of survival is the most important goal for cancer patients, and management of neuropathic pain will only continue to be considered if it is financially feasible. Meanwhile, we found that many institutions work only with institutions in their own countries, indicating low institutional cooperation with other countries. We hope that in the near future, various structures can be established to elicit more cooperation between

**Table 3** The Top 10 Papers with the Largest Citation Frequency in the Cancer-Related Neuropathic Pain

Title	Corresponding Author	Journal	Year	IF (2020)	WoS Categories	Citations (WoS)
Neuropathic pain <sup>28</sup>	Colloca, Luana	Nature Reviews Disease Primers	2017	52.329	Medicine, General & Internal	797
Chronic pain as a symptom or a disease: the IASP Classification of Chronic Pain for the International Classification of Diseases (ICD-11) <sup>35</sup>	Treede, Rolf-Detlef	Pain	2019	6.961	Anesthesiology; Clinical Neurology; Neurosciences	567
Osteoarthritis: toward a comprehensive understanding of pathological mechanism <sup>29</sup>	Chen, Di	Bone Research	2017	13.567	Cell & Tissue Engineering	435
Rates and risk factors for prolonged opioid use after major surgery: population based cohort study <sup>30</sup>	Clarke, Hance	BMJ-British Medical Journal	2014	39.89	Medicine, General & Internal	319
The Pharmacologic and Clinical Effects of Medical Cannabis <sup>36</sup>	Borgelt, Laura M.	Pharmacotherapy	2013	4.705	Pharmacology & Pharmacy	288
Advances in structure-based drug discovery of carbonic anhydrase inhibitors <sup>34</sup>	Supuran, Claudiu T.	Expert Opinion on Drug Discovery	2018	6.098	Pharmacology & Pharmacy	285
Chemotherapy-induced neuropathy: A comprehensive survey <sup>32</sup>	Miltenburg, N. C.	Cancer Treatment Reviews	2014	12.111	Oncology	255
International Myeloma Working Group Consensus Statement for the Management, Treatment, and Supportive Care of Patients With Myeloma Not Eligible for Standard Autologous Stem-Cell Transplantation <sup>33</sup>	Palumbo, Antonio	Journal of Clinical Oncology	2013	44.544	Oncology	248
Management of cancer pain in adult patients: ESMO Clinical Practice Guidelines <sup>31</sup>	Fallon, M.	Annals of Oncology	2018	32.976	Oncology	247
Chemotherapy-induced peripheral neuropathy: What do we know about mechanisms? <sup>37</sup>	Carozzi, V. A.	Neuroscience Letters	2015	3.046	Neurosciences	243

the countries, especially in economically developed areas and poorer regions to obtain different perspectives for the scientific research data. These efforts can also help in garnering relief to cancer patients in poor areas. More than 20,000 authors participated in the research in related fields, among which Li Y from China published the most. He published 81 papers in ten years, and is also the author with the most citations. He has studied many cancer-related pain, especially neuropathic pain. His articles can provide a lot of help to other researchers. Thus, he has made a great contribution to the research in this field. In addition, Wang Y, Zhang y, Wang J, Li x, Liu y, Zhang J, Li J, Wang X have all published more than 50 articles.

Regarding research categories at WoS over the past decade, articles on cancer-related neuropathic pain have covered 118 topics, mainly focusing on clinical neurology (1207), followed by neuroscience, pharmacological pharmacy, anesthesiology, and oncology. We conducted statistical analysis of all cited literatures. Co-cited literature is an important indicator of bibliometrics. We divided this literature into 5 clusters, among which “paclitaxel (#1)” is most frequently co-cited followed by “microglia (#1)”, “mastectomy (#2)”, “bone cancer pain (#3)”, and “therapeutic use (#4)”. A total of



1498 journals published articles on cancer-related neuropathic pain. We listed the top ten journals, accounting for 13.8% (790) of all journals. The leading journal is *Pain*, which has published 142 articles in the past decade, followed by *World Neurosurgery*, *Molecular Pain*, *PLoS One*, and *Journal of Pain Research*.

Keywords can be an important component of an article, and can reflect the core content of an article; thus, we took a count of keywords in all publications, and citation burstness indicated the most commonly used keywords of the year. In 2012, the key words were “necrosis factor alpha”, “cancer”, “dorsal horn neuron”, “nitric oxide”, “scale”, “release”, whereas in 2021, the keyword were “neuropathic pain”, “neuroinflammation”, “medical marijuana”, and “stimulation”. Based on this result, we believe that researchers may have focused on the mechanism of cancer-related neuropathic pain in the first few years. In recent years, doctors have paid more attention to the clinical response and treatment of the pain. With the progress of medical technology, the survival time of many patients has been prolonged. Thus, improving the quality of life of cancer patients has become the current research focus of researchers. In all publications, “Neurological Pain” was cited the most (797); it was published in 2017 on the *Nature Reviews Disease Primers*, and the IF of this journal was 52.329 in 2020. It has a great influence in the field of cancer-related neuropathic pain and provides references for many subsequent articles.

The main strength of this bibliometric study is the systematic review of all articles on cancer-related neuropathic pain from 2012 to 2021, and the analysis of global trends. All data are from the WoS core database, with a very high level of confidence. This article summarizes the pilot projects in the past ten years, which provides a good analysis for doctors, patients, policy makers and governments, and has certain reference value. However, there are some limitations of this study. We only analyzed one database, and did not carry out too much analysis in other databases, so there may be some research bias. We will continue to improve the scope of this work in the future.

## Conclusion

This article focuses on the area of cancer-related neuropathic pain, and analyzed and collated the publications from 2012 to 2021. The results of this study may provide some value for the treatment of patients with cancer-related neuropathic pain. Although there are some limitations, this study can still reflect relevant trends in the field. Both the number of articles published and the number of citations is constantly increasing, which reflects that this is an emerging topic of interest. We hope that this article can provide useful information for many researchers; these efforts will draw more attention to this field and offer better treatment alternatives for cancer patients.

## Acknowledgments

We would like to thank Editage ([www.editage.cn](http://www.editage.cn)) for English language editing.

## Funding

This work was funded by Beijing Municipal Science and Technology Project (Z211100002521011) and National Science and Technology Major Project (2017ZX09304026).

## Disclosure

The authors report no conflicts of interest in this work.

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