

Current trends in pain management

A bibliometric analysis for the 1980-to-2023 period

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Abstract

There is currently no bibliometric analysis available regarding pain management (PM). The aim of this study was to monitor the advancement of the PM research field, demonstrate global productivity, identify the most highly cited studies, delineate collaborations between research areas and countries, and uncover new research topics and intriguing trends. A total of 16,216 articles on the subject of PM published between 1980 and 2023 were downloaded from the Web of Science database and analyzed using various bibliometric analysis methods. Trend keyword analysis, thematic evolution analysis, conceptual structure analysis, factor analysis, citation and co-citation analyses, and international collaboration analyses were conducted. The top 3 most active countries were the United States of America (n = 4021), the United Kingdom (n = 791), and Canada (n = 602). The most prolific author was Christine Miaskowski (n = 47). The most researched topics from the past to the present were chronic pain, opioids, analgesia/analgesics, cancer pain, postoperative pain, low back pain, opioid, cancer, acute pain, and self-management. Factor analysis identified key topics such as analgesia and various types of pain in the central factor, with additional subfactors including low back pain and physiotherapy, nursing, and postoperative anxiety and depression. In recent years, starting in 2020, trending research topics have shifted towards e-health, telemedicine, virtual reality, digital health, mental health, peripheral nerve blocks, erector spinae plane blocks, quadratus lumborum blocks, opioid use disorder, buprenorphine, musculoskeletal pain, COVID-19, cervicgia, and interprofessional collaboration. In addition to Western countries with major economies in the field of PM (USA, Canada, Australia, and European countries), we identified China, India, and Turkey as research leaders. Our bibliometric analysis of 10,566 articles on PM reveals a significant growth in research, with recent trends focusing on e-health, telemedicine, virtual reality, and peripheral nerve blocks. These emerging technologies and personalized treatment approaches are shaping the future of PM.

Abbreviations: AC = average citation, CC = co-citation, CI = confidence Interval, GDP = gross domestic product, NA = number of articles, NC = number of citations, NU = number of uses, PM = pain management, PY = publication year, TC = total citations, UK = United Kingdom, USA = United States of America, WoS = Web of Science.

Keywords: bibliometric analysis, global productivity, pain management, research trends, scientometric analysis

1. Introduction

Pain is a sensory and emotional experience that typically arises from causes such as tissue damage, illness, or stimulation of the nervous system. It is a highly complex phenomenon consisting of both sensory and emotional components. Pain can serve as a warning sign indicating potential harm or the presence of an issue within the body.^[1] Pain is a universal experience that affects human health and can be associated with various etiologies.

Therefore, the effective management of pain represents a significant area in clinical medicine.^[2]

Pain management (PM) represents an approach in which pain is addressed from a multidisciplinary perspective, and individualized treatment plans are developed.^[3] This approach encompasses a multidisciplinary approach involving the perception, assessment, treatment, and control of pain. Consequently, PM plays a crucial role among various healthcare disciplines, including physical therapy, neurology, anesthesiology, psychology, and

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others, working on different types and causes of pain. PM aims to reduce and control the severity of pain, manage its duration, improve the quality of life, and restore the functionality of patients. This approach encompasses a broad field of research, application, and learning to enhance patients' quality of life and minimize the adverse effects of pain.^[3,4]

PM addresses both acute and chronic pain conditions and encompasses pharmacological and non-pharmacological approaches. These approaches may include pharmacotherapy (drug treatment), non-pharmacological treatments (physical therapy, psychotherapy, acupuncture, massage, etc), rehabilitation, surgical interventions, and other interventions. Additionally, PM takes into account psychosocial factors that influence the patient's pain experience and considers the patient's specific needs.^[5,6] PM can be applied to different pain conditions, such as acute pain (e.g., post-surgical pain) and chronic pain (e.g., rheumatoid arthritis, cancer pain). Furthermore, PM aims to address the physical, emotional, and social dimensions through which the patient suffers due to pain.^[1,6]

Bibliometric analysis is a research field that examines the quantitative and qualitative characteristics of scientific literature and conducts these investigations using data analytics and statistical methods.^[7,8] This type of analysis is used for the examination and evaluation of text-based sources such as academic publications, journal articles, conference papers, theses, and other scientific documents.^[9] Bibliometric analysis is an important research method used to understand the development of scientific research fields, publication trends, citation relationships, and the structure of scientific communities.^[10] It provides valuable insights to researchers, scientific communities, and decision-makers, helping them guide and plan scientific knowledge more effectively.^[11] This type of analysis plays a significant role in the enhancement of scientific discoveries and research strategies.^[12]

The primary objectives of bibliometric analyses include Examining Publication Trends, Citation Analyses, Research Network Analyses, Data Mining and Discoveries. Publication Trends analysis evaluates academic trends by examining how publications are distributed and how they change over time within specific topics, disciplines, or research areas.^[7-13]

The aim of this study was to monitor the advancement of the PM research field, demonstrate global productivity, identify the most highly cited studies, delineate collaborations between research areas and countries, and uncover new research topics and intriguing trends.

2. Methods

2.1. Search strategy

To access scientific studies on the subject of PM, the Web of Science (WoS) database (Clarivate Analytics, Philadelphia) was used. Since publications prior to 1980 are not indexed in WoS, the starting year was set as 1980, and all studies indexed in WoS between 1980 and 2023 were accessed. Bibliometric analyses included only original articles, excluding other types of publications. Specifically, studies indexed in the research fields of Veterinary Sciences, Agriculture, and Zoology were excluded. The approach employed for conducting the search in this study was as follows: [(Title = (pain management) NOT (Veterinary Sciences AND Agriculture AND Zoology) AND [Document Type = (Article) AND Publication time: 1980 to 2023) (Access to articles was performed on August 1, 2023). This search method provided access to all articles containing the terms "pain management" (management of pain, management of cancer pain, management of chronic pain, management of acute pain, etc) in their titles.

2.2. Statistical and bibliometric analysis

Basic statistical analyses were performed using the SPSS software (Version: 22.0, SPSS Inc., Chicago, Licence: Hitit University). In

order to forecast the trajectory of articles in the field of PM for the next 5 years, we utilized the Smoothing Forecaster in Microsoft Office Excel. Seasonal adjustment was incorporated into the prediction model to anticipate the article trends. Exponential smoothing is a method used to forecast time series data. In this method, there is a greater emphasis on the recent observations. In other words, more importance is given to the data from closer time periods. The world map, displaying the intensity of colors to depict countries' contributions to the literature on PM, was generated utilizing the website www.paint-maps.com.^[14] Bibliometric analyses were performed using the biblioshiny interface in bibliometrix library (<http://www.bibliometrix.org/>), which is an R Studio-Tool for science mapping, and VOSviewer open access bibliometric software (Version 1.6.19, Leiden University).^[15,16] Bibliometrix and VOSviewer software packages are more commonly used in the literature to visualize and construct bibliometric networks, and they have some relative advantages and differences compared to each other. Therefore, in our study, both packages were used for bibliometric analyses and network visualizations.

2.3. Bibliometric concepts

Bibliometric networks can encompass countries, institutions, researchers, journals, keywords, and can be constructed based on citation, co-citation, or co-authorship relationships.^[12,13]

Co-occurrence analysis of keywords, also known as co-word analysis, is a bibliometric technique used to map research domains. In the field of bibliometrics, co-occurrence analysis is applied to explore potential associations between 2 terms that appear within the same publication. This analytical method investigates the simultaneous presence of pairs of items (keywords) within a document, aiming to uncover relationships among the terms found in textual content. Co-word analysis is closely related to co-citation analysis, with the former focusing on keywords within documents and the latter on citations. Co-citation analysis offers a means to chart the structural landscape of a research field by identifying documents that are jointly cited.^[7,9]

Reference Publication Year Spectroscopy (RPYS) is a bibliometric method that can be used to analyze the historical origins and development of research fields. This method maps the distribution of publication years of cited references. This analysis can be useful in understanding which years received the most attention in a field or subject and how this interest has changed over time (i.e., when the literature has concentrated in specific periods).^[15,17]

WordCloud analysis is used to create a visual representation of the frequency of a word or term within a text. The purpose of using WordCloud is to examine the most frequently used terms in articles published on a particular topic. In summary, Word Cloud is a system that reveals words in visual form by highlighting the frequency of occurrence of relevant words in articles.^[17]

Conceptual structure analysis is employed to understand the research landscape referred to as the "research front," and to identify the most important and current topics. This analysis helps determine the conceptual structure of publications related to a specific topic, revealing its main themes, subthemes, and relationships. Factor analysis, which is used as a subanalysis of conceptual structure analysis, examines the relationships and structures among numerous variables in a dataset, reducing these variables into smaller and meaningful groups or factors.^[15]

Thematic evolution analysis can be used to track developments and changes in a research domain. Researchers can observe the emergence of new topics and the evolution of existing ones over time by examining the conceptual structure of publications related to a specific topic. Themes in thematic evolution are interpreted according to the quarter in which they are placed in the thematic maps obtained for the

examined periods: top right quadrant: motor themes; bottom right quadrant: basic themes; bottom left quadrant: emerging or declining themes; and top left quadrant: highly specialized/ niche themes.^[15,17]

In factor analysis, the MCA method is used to visualize and analyze relationships between different categorical variables. It is particularly useful for understanding relationships among numerous categorical variables. MCA aims to represent multiple categorical variables with fewer components. Thus, MCA enables the reduction of the data set's dimensionality, resulting in a simpler and more comprehensible structure.^[15,17]

3. Results

As a result of the literature review, a total of 20,080 publications on the subject of PM were found in the WoS database between 1980 and 2023. Publications tagged under the research areas of Veterinary Sciences, Agriculture, and Zoology were excluded, and as a result, the remaining 19,734 publications were considered. The distribution of these publications was as follows: Articles (10,566, 53.5%), Review Articles (3096, 15.6%), Meeting Abstracts (2825, 14.3%), Letters (934, 4.7%), Proceedings Papers (618, 3.1%), and the remaining in other publication types (Editorial Materials, Book Chapters, Book Reviews, News Items, Notes, Books, Discussions, Software Reviews, Bibliographies, etc).

Bibliometric analyses were conducted using a subset of 10,566 articles from the total of 19,734 publications. Of these articles, 94.2% (n = 9948) were published in English, while the rest were published in other languages (German, French, Spanish, Korean, Turkish, Italian, Polish, Portuguese, etc). Furthermore, 76.3% (n = 8066) of the articles were indexed in SCI-Expanded, 24.8% (n = 2617) in the Social Sciences Citation Index (SSCI), and 17.2% (n = 1820) in the Emerging Sources Citation Index (ESCI) (note that a single article can be indexed in both SCI-Expanded and SSCI simultaneously).

3.1. Development of publications over the years and future publication trend

The line graph in Figure 1 illustrates the distribution of the number of articles published on the PM over the years. Since the year

2023 is not yet complete, it was not included in the forecasting model. In addition, the predicted values obtained by performing Exponential Smoothing with seasonal adjustment to determine the number of articles that could be published in a 5-year period from 2023 to 2027 are also presented in Figure 1. The model with the highest R^2 value (99%) was obtained with the exponential model. According to the exponential model findings, it is estimated that there will be 823 articles (confidence interval, CI: %: 762–884) published on PM in 2023 and 1031 articles (CI: %: 948–1113) in 2027 (Fig. 1).

3.2. Research areas

The research domains that featured a substantial volume of articles related to PM (240 or more articles) included: Anesthesiology (1697, 16.1%), Medicine General Internal (1631, 15.4%), Clinical Neurology (1493, 14.1%), Nursing (1177, 11.1%), Health Care Sciences Services (773, 7.3%), Surgery (685, 6.5%), Rehabilitation (622, 5.8%), Orthopedics (602, 5.6%), Pharmacology Pharmacy (515, 4.8%), Oncology (471, 4.4%), Pediatrics (456, 4.316), Neurosciences (399, 3.7%), Public Environmental Occupational Health (327, 3%), Emergency Medicine (308, 2.9%), Medicine Research Experimental (286, 2.7%), and Obstetrics Gynecology (245, 2.3%) (note that an article can be tagged in multiple research areas).

3.3. Keyword and conceptual structure analysis on PM: most frequent words, WordCloud, words frequency over time, trend topic analysis, and thematic evolution

In all 10,566 articles on the subject of PM, a total of 11,948 different keywords were used. Out of these keywords, 128 were co-occurrences used in more than 30 different articles, as presented in Table 1. Furthermore, the top 50 Author keywords used in articles over time, along with their co-occurrence counts, are depicted in Figure 2A (to optimize the figure, the top 3 most frequently used keywords, namely pain, PM, and chronic pain, were not included within the figure). The cumulative trend of the top 10 most frequently used keywords over time is shown in Figure 2B.

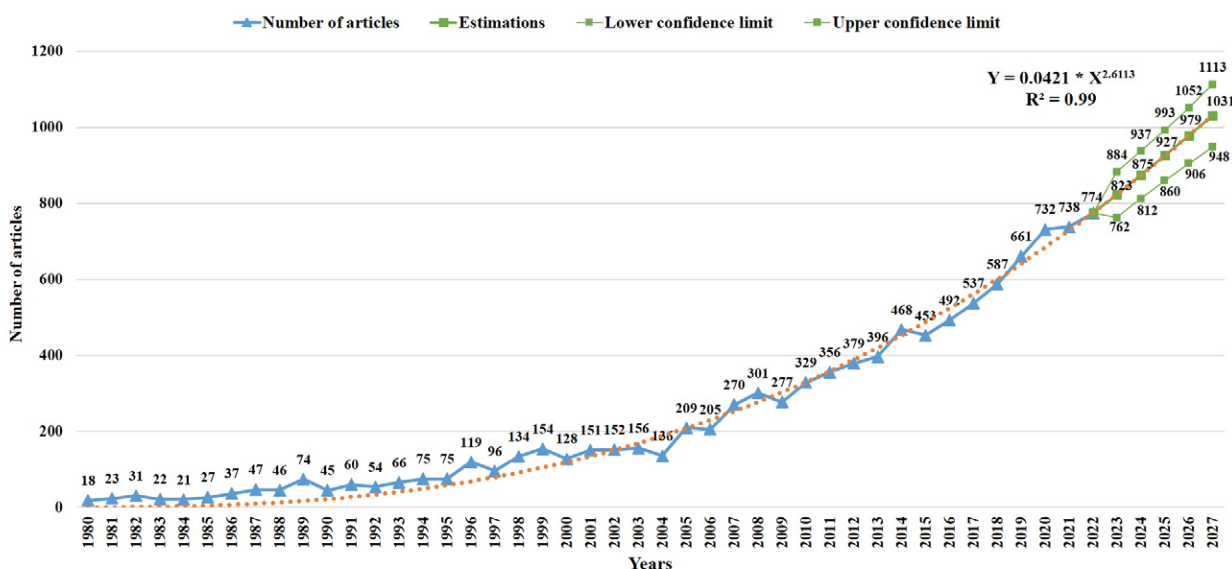
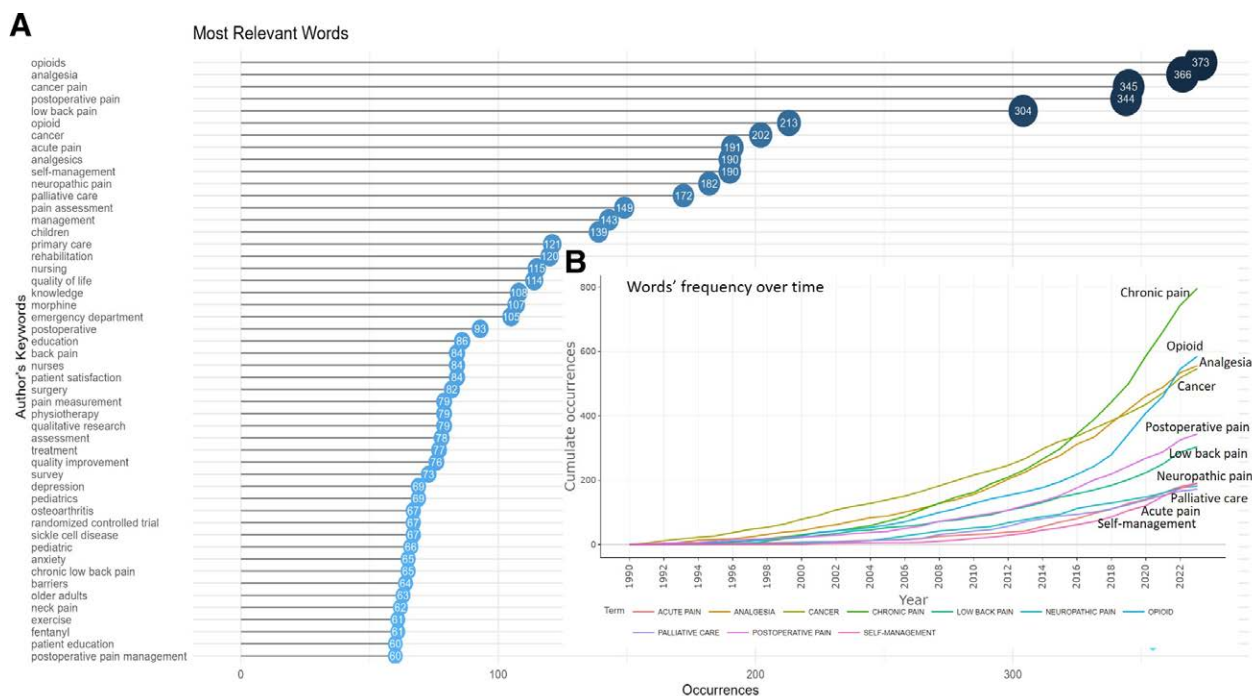


Figure 1. A line graph depicting the change in the number of articles published on pain management over the years and the estimated article trend for the years 2023 to 2027.

Table 1**The 128 most frequently used keywords in published articles on pain management.**

Keywords	NU	Keywords	NU	Keywords	NU	Keywords	NU
Pain	1579	Physiotherapy	79	Attitudes	52	Abdominal pain	36
Pain management	1535	Qualitative research	79	Guidelines	52	Qualitative	36
Chronic pain	796	Assessment	78	Bupivacaine	50	Telemedicine	36
Opioids	373	Treatment	77	Postoperative analgesia	50	Virtual reality	36
Analgesia	366	Quality improvement	76	Tramadol	50	Emergency	35
Cancer pain	345	Survey	73	Acupuncture	49	Knee	35
Postoperative pain	344	Depression	69	Opioid analgesics	49	Neuromodulation	35
Low back pain	304	Pediatrics	69	Pelvic pain	49	Pain postoperative	35
Opioid	213	Osteoarthritis	67	Cancer pain management	48	Safety	34
Cancer	202	Randomized controlled trial	67	Trauma	47	Sedation	34
Acute pain	191	Sickle cell disease	67	Disability	46	Epidural	33
Analgesics	190	Pediatric	66	Epidural analgesia	46	Paracetamol	33
Self-management	190	Anxiety	65	Anesthesia	45	postoperative pain	33
Neuropathic pain	182	Chronic low back pain	65	Attitude	45	Buprenorphine	32
Palliative care	172	Barriers	64	Musculoskeletal pain	45	e-Health	32
Pain assessment	149	Older adults	63	Total knee arthroplasty	45	Methadone	32
Management	143	Neck pain	62	Analgesic	44	Nurse	32
Children	139	Exercise	61	Diagnosis	44	Oxycodone	32
Primary care	121	Fentanyl	61	Regional anesthesia	44	Pain relief	32
Rehabilitation	120	Patient education	60	Dementia	43	Chronic pelvic pain	31
Nursing	115	Postoperative pain management	60	Evidence-based practice	42	Fibromyalgia	31
Quality of life	114	Child	59	Gabapentin	42	Ibuprofen	31
Knowledge	108	Ketamine	59	Complex regional pain syndrome	41	Infant	31
Morphine	107	Multimodal analgesia	59	Outcomes	41	m-Health	31
Emergency department	105	Physical therapy	59	Self-efficacy	41	Nursing care	31
Postoperative	93	Acetaminophen	58	Addiction	40	Pregabalin	31
Education	86	Patient-controlled analgesia	58	Endometriosis	39	Procedural pain	31
Back pain	84	Chiropractic	57	Spinal cord stimulation	39	Evaluation	30
Nurses	84	Elderly	56	Ultrasound	39	Intervention	30
Patient satisfaction	84	Nerve block	55	Laparoscopy	38	Lidocaine	30
Surgery	82	Pain control	55	Primary health care	38	Opioid use disorder	30
Pain measurement	79	Chest pain	54	Satisfaction	38	Parents	30

NU = Number of uses (co-occurrences).

**Figure 2.** (A) A graphic showing the top 50 keywords most commonly used in articles from the past to the present. (B) A line graph illustrating the cumulative frequency of usage over time for the top 10 most frequently used keywords in articles.

Trend keyword analysis using the Biblioshiny application was conducted in 3 different time periods. The findings of trend keyword analysis from 1980 to 2004 are presented in Figure 3A,

from 2005 to 2013 in Figure 3B, and from 2014 to 2023 in Figure 4. The usage frequencies and yearly distribution of 5 trend keywords for each year are visualized in the figures.

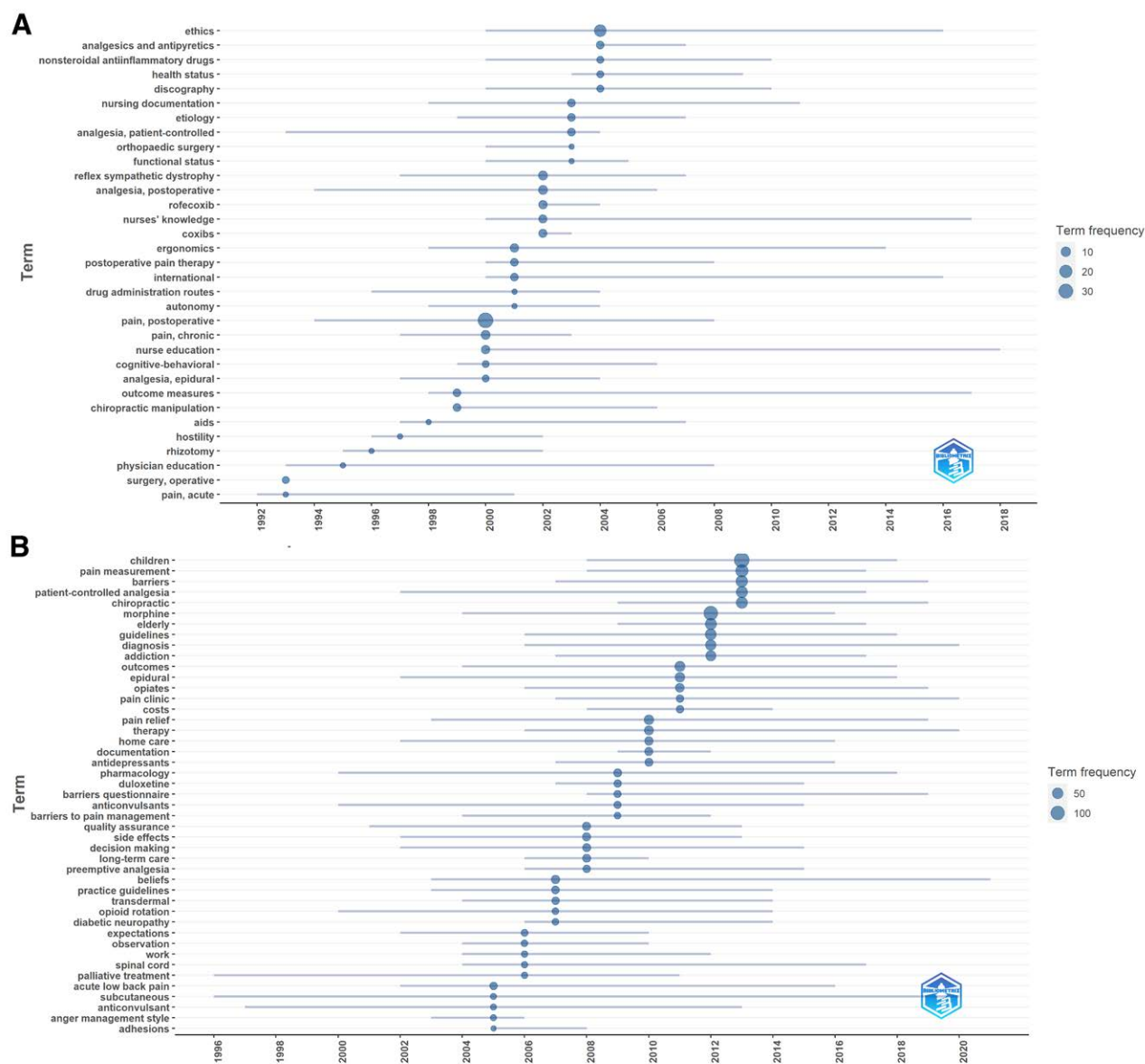


Figure 3. (A) A graphic depicting the findings of trend keyword analysis from 1980 to 2004. (B) A graphic depicting the findings of trend keyword analysis from 2005 to 2013. Footnote: Lines represent the usage trend of keywords over the years, and circle sizes indicate the frequency of usage.

The network visualization map generated through cluster analysis using the VOSviewer package is presented in Figure 5A. Based on the Cluster analysis findings for 128 keywords used in at least 30 different articles (co-occurrences = 30), 8 distinct clusters were identified. Additionally, a trend network visualization map for the period 1980 to 2023, aiming to determine historical and current research trends, is provided in Figure 5B. The Keyword Heatmap generated using the VOSviewer package is displayed in Figure 5C, and the WordCloud visualization obtained using the Biblioshiny package with Keyword Plus is shown in Figure 5D.

A factor analysis was conducted using author keywords to determine the conceptual structure of the PM subject. The findings of the factor analysis, performed using Multiple Correspondence Analysis, are presented in Figure 6.

To determine the conceptual structure of the PM subject using author keywords, thematic evolution analysis was conducted. Thematic evolution for the defined periods of 1980 to 2004, 2005 to 2013, and 2014 to 2023 based on publication trends is presented in Figure 7A, and thematic maps for each period are shown in Figure 7B.

3.4. Active countries and International Collaboration Networks

The top 20 most productive countries contributing to the literature on PM in descending order are the United States of America (Number of articles: 4021), United Kingdom (791), Canada (602), Australia (456), China (394), Germany (388), France (295), Italy (273), India (269), Turkey (229), Spain (184), Korea (159), Iran (156), Sweden (126), Japan (117), Netherlands (116), Switzerland (93), Norway (91), Brazil (82), and Denmark (80). A color density map illustrating the distribution of article counts by country is presented in Figure 8A. The top 20 countries with the highest total citation counts are as follows: USA (total citations: 95,018, Average citation: 23.6), United Kingdom (18,339, 23.2), Canada (14,728, 24.5), Australia (9596, 21), Germany (5966, 15.4), Italy (4603, 16.9), China (3973, 10.1), France (3648, 12.4), Netherlands (3183, 27.4), Sweden (2703, 21.5), Turkey (2522, 11), Spain (1900, 10.3), India (1865, 6.9), Ireland (1739, 22), Norway (1571, 17.3), Denmark (1379, 17.2), Korea (1332, 8.4), Switzerland (1323, 14.2), Iran (1242, 8), and Finland (1227, 20.4).

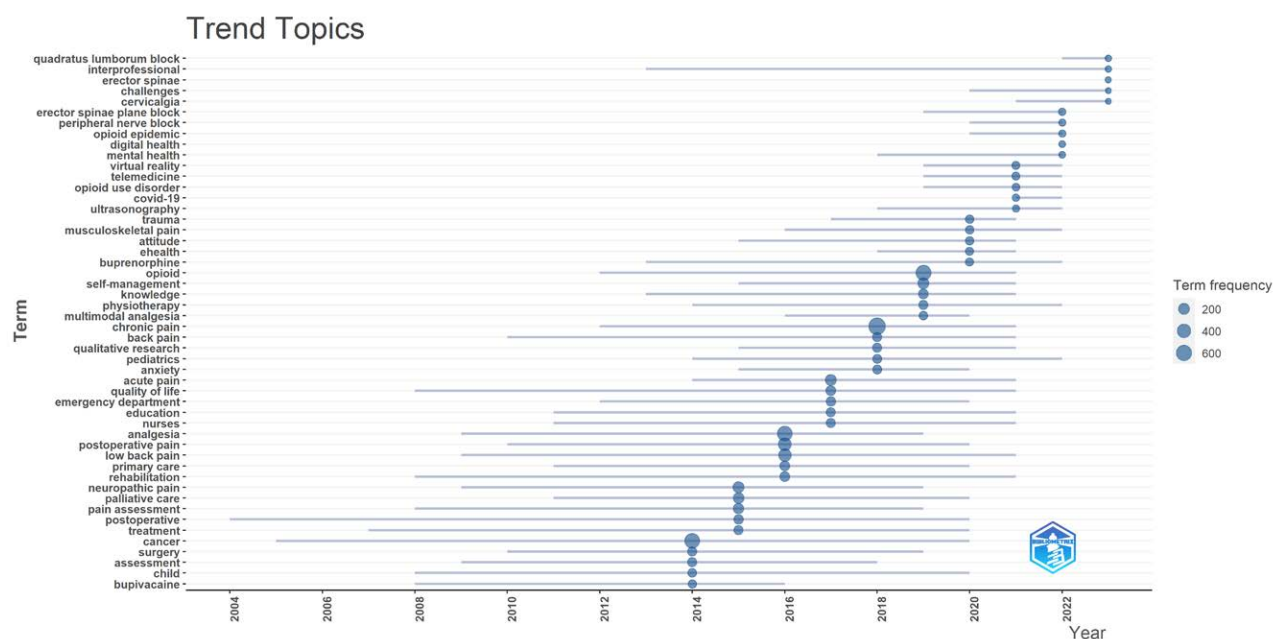


Figure 4. A graphic depicting the findings of trend keyword analysis from 2014 to 2023. Footnote: Lines represent the usage trend of keywords over the years, and circle sizes indicate the frequency of usage.

International collaboration analysis among countries was conducted using Biblioshiny, and, the Biblioshiny corresponding author's countries for the top 20 most prolific countries, taking into account the corresponding author numbers, are shown in Figure 8B. The top 15 countries with the highest Multiple Countries Publication (MCP) scores are as follows: USA = 256, Canada = 145, United Kingdom = 135, Australia = 86, Germany = 71, China = 57, Italy = 43, Netherlands = 40, Norway = 37, Switzerland = 34, France = 29, Denmark = 29, Ireland = 29, Spain = 26, and Sweden = 25. Additionally, the biblioshiny Country collaboration map is presented in Figure 8C.

According to VOSviewer scores for international collaboration, the top 15 countries with the highest scores are as follows: USA = 1038, England in UK = 843, Germany = 536, Canada = 489, Australia = 443, Italy = 428, Netherlands = 355, Belgium = 339, Spain = 316, France = 309, Switzerland = 307, Sweden = 245, Denmark = 237, Austria = 206, and China = 190.

3.5. Active and impactful journals

A total of 10,566 articles related to PM were published across 2457 different scientific journals. Notably, the journals that had the most substantial impact on the literature, each with more than 50 articles, included Pain Management Nursing (n = 215), Pain Medicine (n = 200), Journal of Pain and Symptom Management (n = 196), Clinical Journal of Pain (n = 122), Pain (n = 117), Journal of Pain Research (n = 108), Anesthesia and Analgesia (n = 89), European Journal of Pain (n = 78), Schmerz (n = 69), Pain Physician (n = 67), Pain Research & Management (n = 65), Journal of Pain (n = 64), BMJ Open (n = 60), Spine (n = 56), Journal of Clinical Nursing (n = 54), Pain Practice (n = 54), British Journal of Pain (n = 53), Journal of Advanced Nursing (n = 53), and Supportive Care in Cancer (n = 53). The top 50 scientific journals in PM, based on their h-index, along with their g, and m-index values, total citation counts, article counts, average citation counts per article, and publication start years, are presented in Table 2.

3.6. Active authors

The most active authors in PM (with 20 or more articles published) were, in order, Miaskowski C. (Number of articles: 47,

h-index: 25, total citations: 2759), Meissner W. (NA: 44, h: 14, TC: 884), Kerns RD. (NA: 32, h: 15, TC: 1028), Bruera E. (NA: 26, h: 13, TC: 776), Bhatnagar S. (NA: 22, h: 5, TC: 124), Kaye AD. (NA: 21, h: 11, TC: 722), Bair MJ. (NA: 20, h: 14, TC: 944), and Bennett MI (NA: 20, h: 8, TC: 296).

3.7. Citation analysis in PM

Among the 10,566 articles published in PM, the top 30 articles with the highest total citation counts, along with their titles, authors, journal names, publication years, total citation counts, and average citation counts per year, are shared in Table 3.

3.8. Co-citation analysis in PM

Among the 10,566 articles published in PM, a total of 213,495 publications were cited in the reference sections. Among these studies, the 7 most impactful studies with more than 180 co-citations each were, in order, Cleeland (1994, Co-Citation: CC = 235), Melzack (1965, CC = 216), Cleeland (1994, CC = 208), Breivik (2006, CC = 200), Chou (2016, CC = 194), and Apfelbaum (2003, CC = 193).^[4,18–23] Additionally, reference spectroscopy obtained using all the cited publications in the articles is presented in Figure 9.

4. Discussion

An examination of the article distribution in the field of PM from 1980 to 2022 reveals 3 distinct publication trends: 1980 to 2004, 2005 to 2013, and 2014 to 2022. Between 1980 and 2004, an average of 78 articles (min–max: 18–156) were published. The year 2005 marked the onset of an increasing trend in the number of articles, with an average of 302 articles (min–max: 205–396) being published during 2005 to 2013. Subsequently, in 2014, another surge in article publications began, resulting in an average of 605 articles (min–max: 453–774) during the period from 2014 to 2022. Evaluating the 5-year forecast for 2023 and beyond, it becomes evident that the productivity of PM articles is expected to continue its exponential growth.

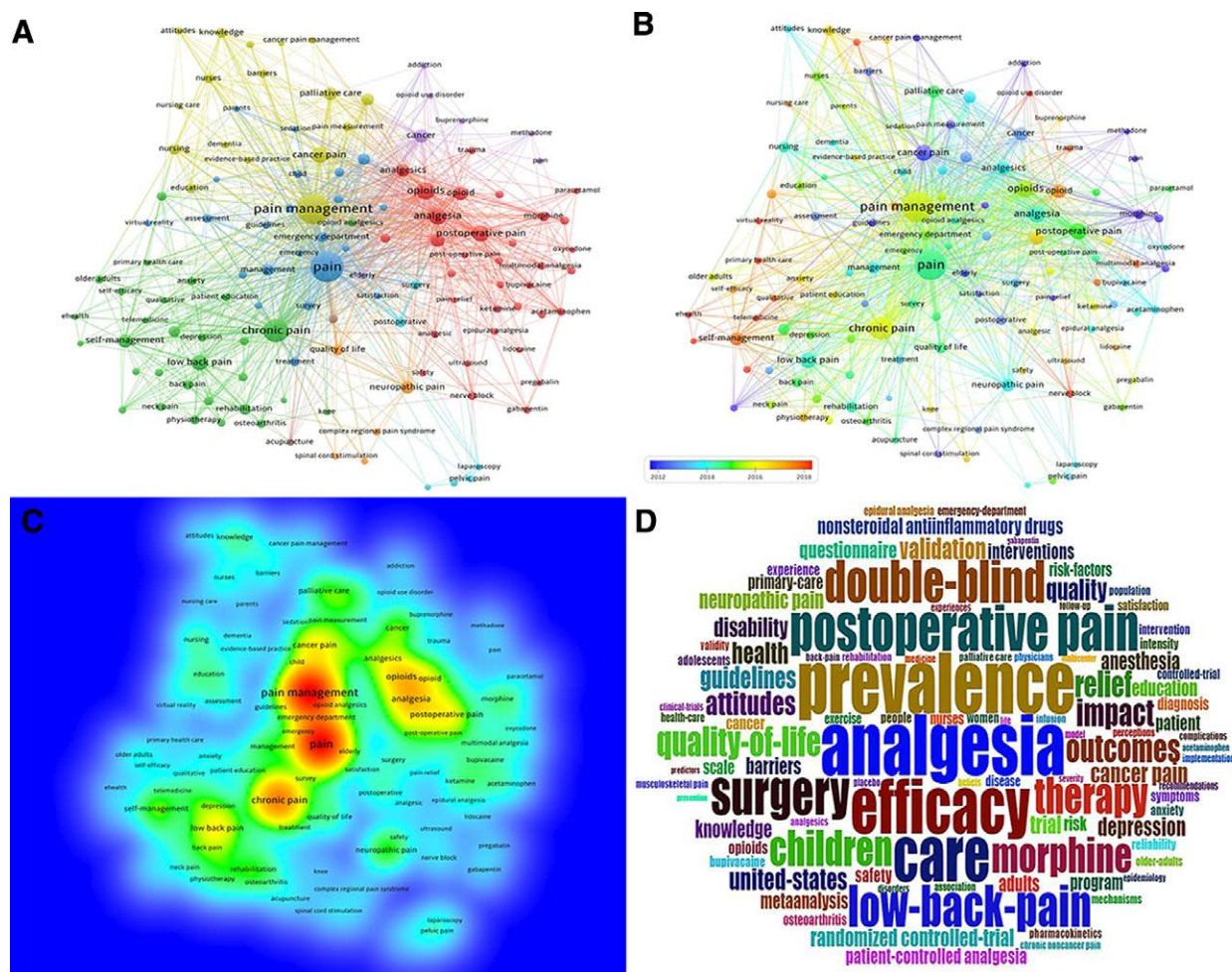


Figure 5. (A) A network visualization map illustrating the results of cluster analysis. Footnote: Keywords with the same colors belong to the same clusters. As the number of keywords used in articles increases, the size of the circle also increases. In general, the closer 2 terms are to each other, the stronger their relationship. (B) A network visualization map showing past and current trends on pain management. Footnote: In the legend at the bottom right corner of the figure, as the relevance of topics increases, the colors transition from blue to red (blue–green–yellow–red). The blue color indicates that a term was published in previous years, while the red color indicates that a term was published in later years. (C) The Keyword Heatmap. Footnote: The transition from blue to red indicates an increase in the importance of keywords. (D) WordCloud visualization obtained with Keyword Plus.

When evaluating the findings of the keyword analysis conducted in the field of PM, it can be observed that the most studied topics from the past to the present, aside from the main headings of pain and PM, are chronic pain, opioids, analgesia/analgesics, cancer pain, postoperative pain, low back pain, opioid, cancer, acute pain, and self-management. Other frequently used keywords can be seen in the tables and figures. When examining the cumulative totals of these topics from the past to the present, it was determined that the prevalent topics in PM are chronic pain, opioids, analgesia/analgesics, cancer pain, postoperative pain, and low back pain.

When evaluating the findings of keyword analysis conducted in 3 different time periods to determine trending topics, the following observations were made: Up until the early 2000s, common topics in PM included acute pain, physician education, rhizotomy, hostility, AIDS, chiropractic manipulation, and outcome measures. Starting in the year 2000, topics such as postoperative pain, chronic pain, nurse education, epidural analgesia, and cognitive-behavioral approaches gained prominence. From 2000 to 2005, areas of research interest included ergonomics, nurses' knowledge, postoperative analgesia, reflex sympathetic dystrophy, nursing documentation, nonsteroidal anti-inflammatory drugs, and ethics, which were frequently studied over extended periods. Between 2005 and 2013, topics such as anticonvulsants, subcutaneous treatments, acute low

back pain, palliative treatment, spinal cord interventions, opioid rotation, beliefs, decision making, pharmacology, home care, pain relief, opiates, epidural methods, morphine, and pediatric PM were the focus of extensive research. From 2014 to 2019, notable research areas included bupivacaine, cancer pain, pain assessment, neuropathic pain, rehabilitation, low back pain, postoperative pain, analgesia, nurses' education, quality of life, pediatrics, chronic pain, and physiotherapy. In recent years, starting in 2020, trending research topics have shifted towards e-health, telemedicine, virtual reality, digital health, mental health, peripheral nerve blocks, erector spinae plane blocks, quadratus lumborum blocks, opioid use disorder, buprenorphine, musculoskeletal pain, COVID-19, cervicalgia, and inter-professional collaboration.

When conducting trend keyword analysis without segmenting by time periods (with a threshold of a minimum of 30 occurrences of a keyword), it was observed that in the earlier years, topics like morphine, fentanyl, cancer pain, and chiropractic were frequently researched, while in recent years, topics such as telemedicine, e-health, m-health, virtual reality, primary health care, musculoskeletal pain, nerve blocks, opioid use disorder, multimodal analgesia, and total knee arthroplasty have gained more significant research attention.

In the analysis of cluster findings, we identified 7 clusters of keywords representing significant areas of interest

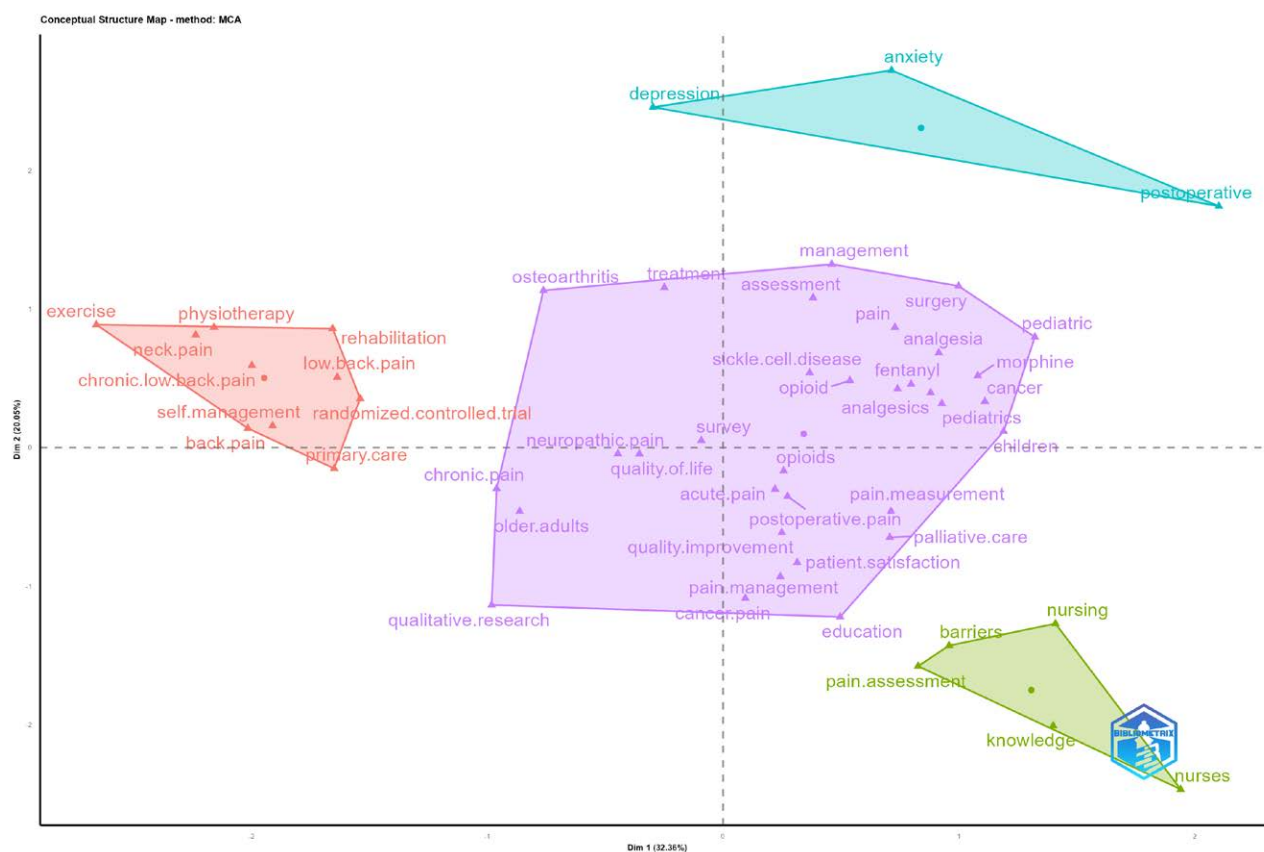


Figure 6. A conceptual structure map displaying the findings of factor analysis conducted using Multiple Correspondence Analysis. Footnote: The origin of the map represents the average position of all column profiles and therefore represents the center of the research area (indicating common and widely shared topics).

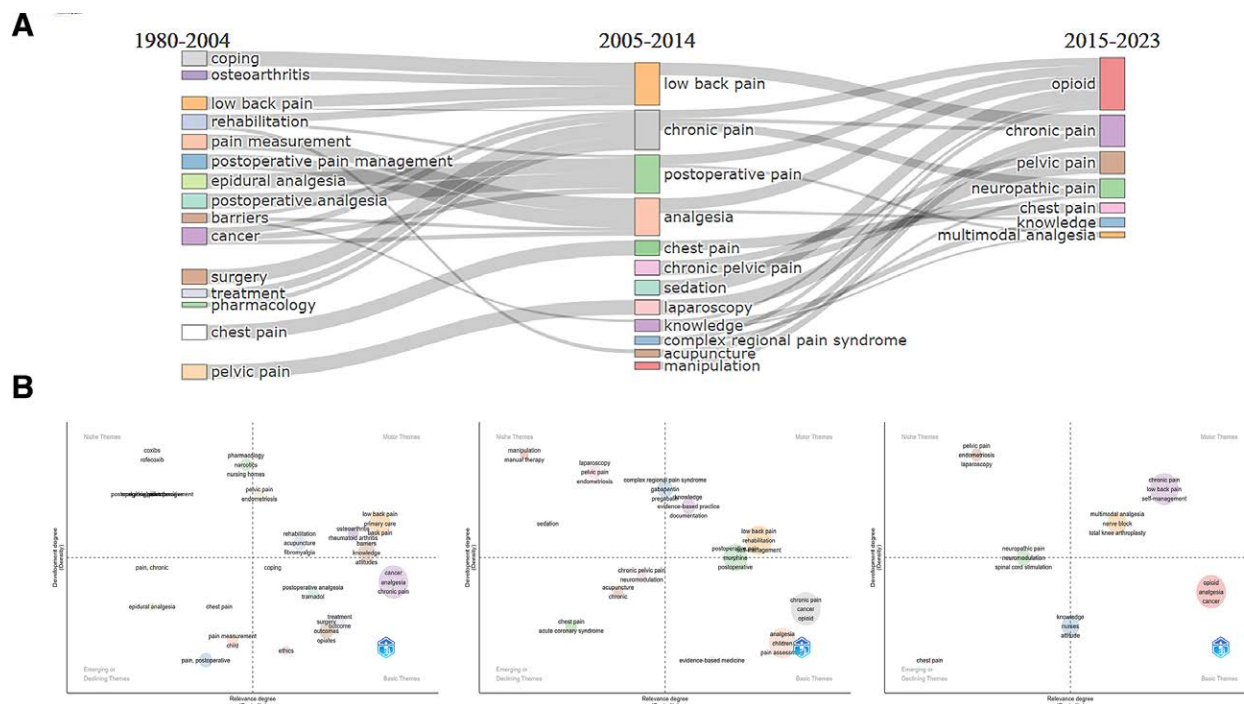


Figure 7. (A) Thematic Evolution Maps for the Periods 1980 to 2004, 2005 to 2013, and 2014 to 2023. (B) Thematic Maps for the Periods 1980 to 2004, 2005 to 2013, and 2014 to 2023. Footnote: Thematic maps obtained for the examined periods: (1) top right quadrant: motor themes; (2) bottom right quadrant: basic themes; (3) bottom left quadrant: emerging or declining themes; (4) top left quadrant: highly specialized/niche themes.

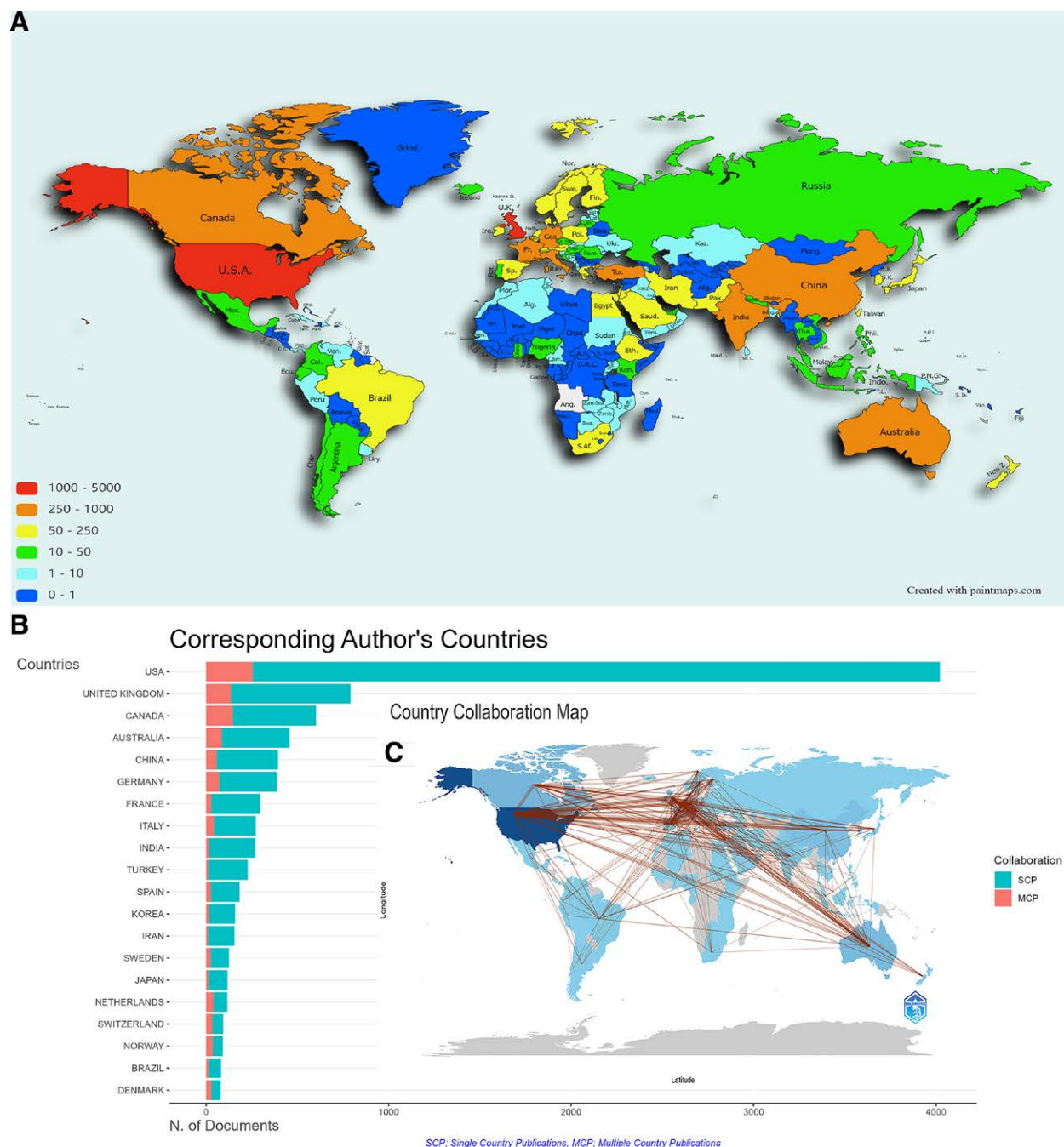


Figure 8. (A) A world map depicting the distribution of article numbers by countries. (B) A graph showing the proportion of corresponding authors' countries for the top 20 most productive countries compared to the total. Footnote: SCP: Single Country Publication, MCP: Multiple Countries Publication; MCP specifies the number of documents with at least 1 coauthor from a different country for each country. MCP measures the level of international collaboration for a given country. (C) Country collaboration map.

in PM according to the network map. These focal points, in order of cluster sizes, were as follows: the red cluster encompassed topics related to analgesia, opioids, postoperative, and acute pain; the green cluster focused on chronic pain, low back pain, self-management, exercise, rehabilitation, physiotherapy, telemedicine, and e-health; the blue cluster was associated with topics concerning the emergency department, children, chest pain, and abdominal pain; the yellow cluster revolved around cancer pain, palliative care, pain assessment, pain measurement, and nurses' education and knowledge; the purple cluster addressed opioid use disorder (specifically buprenorphine and methadone); the

turquoise cluster delved into pelvic pain, endometriosis, and laparoscopy; and the orange cluster centered on neuropathic pain, neuromodulation, spinal cord stimulation, and quality of life, while the brown cluster related to acupuncture and sickle cell disease.

Additionally, through keyword co-occurrence analysis, the evolution of research hotspots was determined. In the field of PM, we can identify primary hotspots as chronic pain, opioids, analgesia, and postoperative pain, while secondary hotspots include low back pain, cancer pain, acute pain, the emergency department, abdominal pain, self-management, neuropathic pain, palliative care, and pain assessment.

Table 2**The 50 most influential scientific journals according to the h-index on pain management.**

Journal	h-Index	g-Index	m-Index	TC	NA	AC	PY start
Pain	54	91	1.227	8519	117	72.8	1980
Journal of Pain and Symptom Management	49	70	1.485	7024	196	35.8	1991
Clinical Journal of Pain	40	56	1.111	3825	122	31.4	1988
Anesthesia and Analgesia	36	61	0.857	4085	89	45.9	1982
Pain Medicine	35	58	1.522	4784	200	23.9	2001
Spine	32	56	0.8	3911	56	69.8	1984
Journal of Pain	30	64	1.25	4119	64	64.4	2000
Pain Management Nursing	29	43	1.45	3009	215	14.0	2004
Anesthesiology	29	42	0.744	4650	42	110.7	1985
European Journal of Pain	27	45	1.174	2173	78	27.9	2001
Pain Physician	23	42	1.438	1856	67	27.7	2008
British Journal of Anaesthesia	23	36	0.535	1561	36	43.4	1981
Journal of Advanced Nursing	22	33	0.564	1229	53	23.2	1985
Journal of Pain Research	19	29	1.727	1222	108	11.3	2013
Journal of Clinical Nursing	19	31	0.731	1126	54	20.9	1998
Journal of Arthroplasty	19	31	0.704	1139	31	36.7	1997
BMC Musculoskeletal Disorders	18	26	0.947	775	48	16.1	2005
Regional Anesthesia and Pain Medicine	18	33	0.692	1111	44	25.3	1998
Physical Therapy	18	42	0.409	2023	42	48.2	1980
Cancer Nursing	18	29	0.5	891	35	25.5	1988
Cancer	18	25	0.462	1526	25	61.0	1985
Pain Research & Management	17	41	1	1737	65	26.7	2007
Pain Practice	17	30	1.133	1017	54	18.8	2009
Archives of Physical Medicine and Rehabilitation	17	29	0.395	849	37	22.9	1981
Pediatric Anesthesia	17	26	0.85	707	34	20.8	2004
Current Opinion in Anesthesiology	17	23	0.895	646	23	28.1	2005
Journal of General Internal Medicine	17	21	0.607	1200	21	57.1	1996
PLoS One	16	27	1.333	765	46	16.6	2012
Journal of Orthopaedic & Sports Physical Therapy	16	28	0.571	1042	28	37.2	1996
Journal of Clinical Anesthesia	16	25	0.5	633	26	24.3	1992
Pediatrics	16	24	0.471	2087	24	87.0	1990
Supportive Care in Cancer	15	20	0.577	550	53	10.4	1998
Current Medical Research and Opinion	15	27	0.366	766	33	23.2	1983
Medical Clinics of North America	15	23	0.405	609	23	26.5	1987
Journal of the American Geriatrics Society	15	22	0.556	1272	22	57.8	1997
Journal of Clinical Oncology	15	15	0.517	1939	15	129.3	1995
BMJ Open	14	22	1.167	583	60	9.7	2012
American Journal of Emergency Medicine	14	23	0.368	574	37	15.5	1986
Neuromodulation	14	23	0.538	559	30	18.6	1998
American Family Physician	14	26	0.341	716	29	24.7	1983
International Journal of Nursing Studies	14	21	0.35	545	21	26.0	1984
Journal of Cardiothoracic and Vascular Anesthesia	14	20	0.483	473	20	23.7	1995
Pediatric Clinics of North America	14	18	0.35	497	18	27.6	1984
Acta Anaesthesiologica Scandinavica	13	22	0.31	514	33	15.6	1982
European Journal of Anaesthesiology	13	21	0.481	605	21	28.8	1997
Drugs	13	20	0.333	867	20	43.4	1985
Canadian Journal of Anaesthesia-Journal Canadien D Anesthesie	13	18	0.361	500	18	27.8	1988
Clinical Orthopaedics and Related Research	13	17	0.433	852	17	50.1	1994
Anaesthesia	12	24	0.324	596	24	24.8	1987
Academic Emergency Medicine	12	16	0.522	448	16	28.0	2001

AC = average citation per document, NA = number of articles, PY = publication year, TC = total citations.

Furthermore, when evaluating the Word Cloud analysis visualization conducted using keyword plus terms, which are added to publications to express broader topics or related fields and provide a broader context for the content of the publication instead of author keywords, it was observed that the main topics in PM research encompass analgesia, postoperative pain, prevalence, low back pain, care, double-blind, efficacy, surgery, children, quality of life, morphine, therapy, and outcomes.

When evaluating the findings of factor analysis, it was determined that in the central factor, which occupies a central position, the key topics included analgesia, opioids, postoperative pain, acute pain, cancer pain, and chronic pain. Apart from these central topics, the 3 subfactors were identified as follows: low back pain, neck pain, exercise, rehabilitation, and physiotherapy (red factor); nurses, nursing (green factor); and postoperative, depression, anxiety (turquoise factor).

When evaluating the thematic evolution visualization conducted during 3 separate publication trend periods, it can be noted that there have been no significant changes in the topics, but in recent years, the concepts of “opioid” and “neuropathic pain” have become more prominent. Additionally, the visuals generated through thematic evolution analysis are crucial in displaying basic, emerging or declining, niche, and motor themes for each of the 3 periods. Researchers can gain detailed insights into the rising and falling topics for each period from these visuals. In the current period (2015–2023), when evaluating the themes, it will be observed that the fundamental themes are opioid, analgesia, and cancer, while emerging or declining themes include chest pain, motor themes encompass chronic pain, low back pain, self-management, multimodal analgesia, nerve block, and total knee arthroplasty, and niche themes represent pelvic pain, endometriosis, and laparoscopy. It should be noted that motor themes

Table 3
The first 30 high-impact articles based on the total number of citations on pain management.

No	Article	Author	Journal	PY	TC	AC
1	Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit	Barr J. et al.	Critical Care Medicine	2013	2217	201.5
2	Neuropathic pain: etiology, symptoms, mechanisms, and management	Woolf C.J. and Mannion R.J.	Lancet	1999	1561	62.4
3	Management of postoperative pain: a clinical practice guideline from the american pain society, the american society of regional anesthesia and pain medicine, and the american society of anesthesiologists' committee on regional anesthesia, executive committee, and administrative council	Chou R. et al.	Journal of Pain	2016	1540	192.5
4	Recommendations for the pharmacological management of neuropathic pain: an overview and literature update	Dworkin R.H. et al.	Mayo Clinic Proceedings	2010	880	62.8
5	Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomized controlled trial	Hill J.C. et al.	Lancet	2011	878	67.5
6	Practice guidelines for acute pain management in the perioperative setting an updated report by the American Society of Anesthesiologists task force on acute pain management	Ashburn M.A. et al.	Anesthesiology	2012	832	69.3
7	Executive summary: clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU	Devlin J.W. et al.	Critical Care Medicine	2018	817	136.1
8	Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU	Devlin J.W. et al.	Critical Care Medicine	2018	795	132.5
9	Management of pain in elderly patients with cancer	Bernabei R. et al.	JAMA – Journal of the American Medical Association	1998	764	29.3
10	Spinal cord stimulation vs conventional medical management for neuropathic pain: a multicentre randomized controlled trial in patients with failed back surgery syndrome	Kumar K. et al.	Pain	2007	705	41.4
11	The assessment and management of acute pain in infants, children, and adolescents	Hagan J.F. et al.	Pediatrics	2001	646	28.1
12	Pain management: a fundamental human right	Brennan F. et al.	Anesthesia and Analgesia	2007	599	35.2
13	Physician attitudes and practice in cancer pain management – a survey from the eastern-cooperative-oncology-group	VONROENN J.H. et al.	Annals of Internal Medicine	1993	544	17.5
14	Patient-related barriers to management of cancer pain	WARD S.E. et al.	Pain	1993	512	16.5
15	Guidance on the management of pain in older people	Abdulla A. et al.	Age and Ageing	2013	502	45.6
16	Clinical guidelines for the management of low back pain in primary care – an international comparison	Koes B.W. et al.	Spine	2001	481	20.9
17	Anticonvulsant drugs for management of pain - a systematic review	MCQUAY H. et al.	British Medical Journal	1995	472	16.2
18	Management of cancer pain	Portenoy R.K. et al.	Lancet	1999	456	18.2
19	Interdisciplinary chronic pain management past, present, and future	Gatchel R.J. et al.	American Psychologist	2014	415	41.5
20	Pharmacological management of chronic neuropathic pain – consensus statement and guidelines from the canadian pain society	Moulin D.E. et al.	Pain Research & Management	2007	389	22.8
21	Randomized clinical trial of an implantable drug delivery system compared with comprehensive medical management for refractory cancer pain: impact on pain, drug-related toxicity, and survival	Smith T.J. et al.	Journal of Clinical Oncology	2002	389	17.6
22	A double-blind, randomized multicenter trial comparing duloxetine with placebo in the management of diabetic peripheral neuropathic pain	Raskin J. et al.	Pain Medicine	2005	376	19.7
23	Early identification and management of psychological risk factors (yellow flags) in patients with low back pain: a reappraisal	Nicholas M.K. et al.	Physical Therapy	2011	375	28.8
24	Opioids in the management of chronic non-cancer pain: an update of american society of the interventional pain physicians' (ASIPP) guidelines	Trescot A.M. et al.	Pain Physician	2008	357	22.3
25	Management of cancer pain in adult patients: ESMO clinical practice guidelines	Fallon M. et al.	Annals of Oncology	2018	347	57.8
26	Management of chronic pain in survivors of adult cancers: american society of clinical oncology clinical practice guideline	Paice J.A. et al.	Journal of Clinical Oncology	2016	330	41.2
27	Practice guidelines for acute pain management in the perioperative setting	Ashburn M.A. et al.	Anesthesiology	2004	328	16.4
28	Postoperative pain management and opioids 1 transition from acute to chronic pain after surgery	Glare P. et al.	Lancet	2019	322	64.4
29	A population-based, randomized clinical trial on back pain management	Loisel P. et al.	Spine	1997	313	11.5
30	Optimized antidepressant therapy and pain self-management in primary care patients with depression and musculoskeletal pain a randomized controlled trial	Kroenke K. et al.	JAMA – Journal of the American Medical Association	2009	312	20.8

AC = average citations per year, PY = publication year, TC = total citations.

represent the main and predominant research topics in a field, often found in numerous studies, while niche themes denote narrower or more specific subjects, typically centered around a particular subtopic or specialized area of interest, and are generally newer and emerging research topics compared to motor themes.

When examining the productivity of countries in the field of PM, it was observed that out of the top 20 countries contributing the

most to the literature, 16 were developed countries, while only 4 (China, India, Turkey, Iran) were developing countries. These developing countries, however, had substantial economies. In the literature, various bibliometric studies in different fields have identified a significant correlation between a country's economic size and its research productivity. When exploring the collaborative authorship network among countries, it was generally found that global

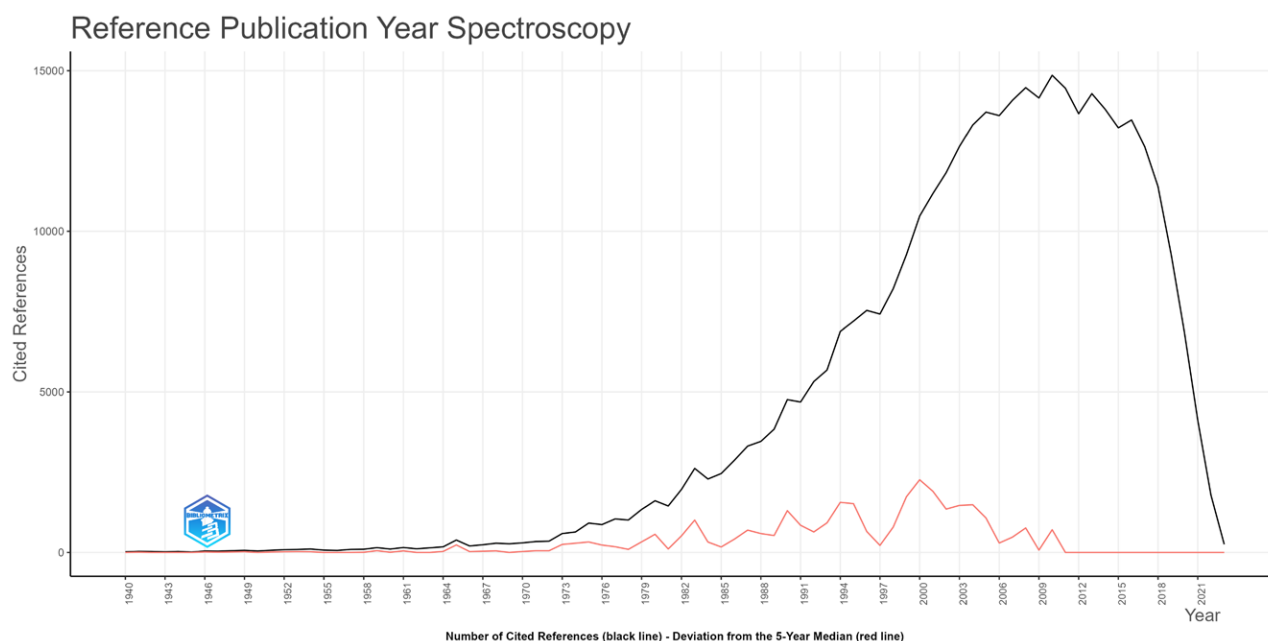


Figure 9. A line graph illustrating the findings of Reference Publication Year Spectroscopy (RPYS).

collaborations were widespread. Upon evaluating the findings of inter-country collaboration analysis, the top 5 countries contributing the most to international collaboration in PM were determined to be the USA, Canada, United Kingdom, Australia, and Germany, followed by European countries and China.

In the results section presenting the ranking of active journals contributing the most to PM literature and the most effective journals according to their h-index, these findings have been provided. We recommend these journals to researchers preparing publications in this field. Additionally, when assessing the average citations per document for journals after publication, the most effective journals were found to be the *Journal of Clinical Oncology* (Average citation per document, AC: 129.3), *Anesthesiology* (110.7), *Pediatrics* (87), *Pain* (72.8), *Spine* (69.8), *Journal of Pain* (64.4), *Cancer* (61), *Journal of the American Geriatrics Society* (57.8), *Journal of General Internal Medicine* (57.1), and *Clinical Orthopaedics and Related Research* (50.1). For researchers who prioritize greater impact for their articles after publication, we recommend considering these journals.

When analyzed based on the total number of citations received, the most cited study was identified as Barr et al.'s (2013) work titled "Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit," published in *Critical Care Medicine*.^[24] The second most influential study was Woolf and Mannion (1999) article titled "Neuropathic pain: etiology, symptoms, mechanisms, and management," published in *The Lancet*.^[25] The third most influential study was Chou et al.'s (2016) guideline on the management of postoperative pain published in the *Journal of Pain*.^[4] When evaluated based on the average citations per year, the most influential study was also Barr et al.'s (2013) article.^[24] The second most influential study was Chou et al.'s (2016) article.^[4] The third most influential study was Devlin et al.'s (2018) clinical practice guidelines in the field of PM.^[26] The importance of average citations per year lies in its ability to adjust for the advantage that older documents have more time to accumulate citations compared to newer documents.

Regarding the co-citation numbers, which represent the citations shared by all analyzed articles, the most influential works were Cleeland (1994), Melzack (1965), Cleeland (1994), Breivik (2006), Chou (2016), and Apfelbaum (2003).^[4,18–23] We recommend these studies as essential readings for researchers

interested in this field. According to the historical development analysis conducted using RPYS analysis, it can be stated that interest in the field of PM began to increase after 1981, with a more significant growth observed after 1991. The interest continued to rise with a steeper slope, and the highest surge in interest was seen from 1997 to 2010, reaching its peak in 2010.

As a result of our literature review, we did not come across a comprehensive bibliometric study on the general field of PM. Damar et al. (2018) conducted a bibliometric analysis specifically on research related to PM in nursing.^[27] Chen et al. (2021) focused solely on the bibliometric analysis of research on PM in osteoarthritis.^[28] Mei et al. (2023) performed a bibliometric analysis exclusively on research related to musculoskeletal PM.^[29] Chen et al. (2023) and Zhai et al. (2023) conducted bibliometric analyses only on research related to post-cesarean section PM.^[30,31] Liao et al. (2023) exclusively conducted a bibliometric analysis of research on neonatal PM.^[32] In our study, we analyzed 10,566 articles, and we can claim that it is superior to other studies in terms of both scope and a broader time period as well as the scope of bibliometric analyses. As a limitation of this research, it could be argued that we only preferred the WoS database for our literature search. However, it has been emphasized in many studies that PubMed database is not preferred for bibliometric analyses as it does not allow citation and co-citation analyses.^[7–9] Additionally, it is noted that Scopus database indexes some lower impact journals.^[10,11] The WoS database indexes articles published in higher impact journals (mostly SCI-expanded) compared to other databases.^[12,13]

5. Conclusion

In this study, we presented a bibliometric analysis of 10,566 articles on the topic of PM, which has shown an exponential growth trend in recent years. This article provides an important bibliometric analysis that will help us understand the current approaches to PM and future research directions. In recent years, starting in 2020, trending research topics have shifted towards e-health, telemedicine, virtual reality, digital health, mental health, peripheral nerve blocks, erector spinae plane blocks, quadratus lumborum blocks, opioid use disorder, buprenorphine, musculoskeletal pain, COVID-19, cervicalgia, and interprofessional collaboration. In recent years, telehealth, e-health, mobile health, and virtual

reality applications have started to play a more significant role in PM. These technologies can facilitate communication between patients and experts and assist patients in monitoring and managing their pain. Since every patient's experience of pain is different, the importance of personalized treatment plans has also increased in recent years. Furthermore, peripheral nerve blocks have become 1 of the most frequently researched topics in recent years. Peripheral nerve blocks involve the direct application of local anesthetic drugs to nerves, resulting in minimal systemic effects (e.g., some complications associated with general anesthesia). Advances in imaging technologies have recently contributed to the more precise and safer administration of peripheral nerve blocks. This approach encourages collaboration among health-care professionals from various specialties, including anesthesiologists, surgeons, rheumatologists, and pain specialists.

We have identified research leadership not only in Western countries with major economies (USA, Canada, Australia, and European countries) but also in China, India, and Turkey in the field of PM. While there are significant international collaborations globally, we believe that increasing international collaborations in developing countries is essential.

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