

Bibliometric Analysis of Research Articles on Pain in the Elderly Published from 2000 to 2019

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Background: Given the rapid growth of the global aging population, pain has become an unneglectable concern amongst the elderly. The quantity of scientific research outputs on pain in the elderly has increased over time, but only a small number of studies have used bibliometric methods to analyze scientific research in this field. This paper aimed to analyze scientific research on pain in the elderly published from 2000 to 2019 in a systematic manner using bibliometric methods.

Methods: Articles on pain in the elderly published from 2000 to 2019 were retrieved from the Web of Science (WoS). Abstracts were coded on the basis of predetermined items (eg, type of article, topic, type of subjects, pain characteristics), and relevant information on the first author, citation scores, and article keywords were collected.

Results: A total of 2105 articles were included in this study. Statistical analysis revealed that the publication of articles on pain in the elderly increased in frequency over time ($P < 0.001$). Most of the publications were original articles. Amongst the countries identified, the United States published the largest number of papers on this topic. Pain characteristics (50.21%), pain intervention (35.68%), and pain assessment (9.69%) were the main topics of research on geriatric pain. Back pain (12.30%) appeared to be the most popular pain type described in the included papers.

Conclusion: This work provides researchers with an in-depth understanding of pain in the elderly by evaluating relevant publications in the past two decades. Researchers in this field are warranted to explore future directions on geriatric pain such as the transition from acute pain to chronic pain and the underlying mechanisms of pain in the elderly.

Keywords: elderly, pain, bibliometric analysis

Introduction

The elderly population is the fastest growing population in modern society. By 2050, one in six people in the world will be over 65 years old (16%), while this number was one in eleven (9%) in 2019.¹ Related to the physiological characteristics of age group, the incidence of many diseases has increased and led to various dysfunctions in the elderly.² Various conditions amongst the older persons are related to or accompanied by pain, such as musculoskeletal diseases,³ cancer⁴ and diabetes,⁵ all of which may increase the risk of pain in the elderly.

The prevalence of pain in the elderly, especially chronic pain, is fairly high (estimated at 25–85%),^{6,7} compared with that in younger group of adults (estimated at 7.3–68% in the age range of 40–66 years)⁸ and in children and adolescents (estimated at 11–38%).⁹ Thus, pain in the elderly is an issue worthy of concern. It is crucial for healthcare professionals to assess the pain of the elderly effectively and

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employ multidisciplinary intervention strategies to help address geriatric pain. Current studies on geriatric pain and its mechanisms could also improve the understanding of pain in the elderly and hence guide optimal treatment protocols.^{10–12} In short, research on pain in the elderly has attracted worldwide attention from scholars across the countries.

Bibliometrics, which refers to the application of mathematical and statistical methods to analyze scientific publications on a specific topic,¹³ serves to provide quantitative information on bibliographic properties, such as authors, journals, citation scores, and countries of distribution.¹⁴ Bibliometrics is an important tool to assess the impact or value in a specific field.¹⁵ Bibliometric analyses in the field of pain research usually involve a wide range of topics,^{16–21} such as specific disease-related pain.^{22,23} Only a limited number of bibliometric studies on the topic of pain among different age groups, especially in the elderly, have been conducted.

In view of the above-mentioned research gap, the purpose of the present study is to explore the scientific research trends in pain amongst the elderly as presented by related articles published between 2000 and 2019 in a systematic manner. This study used a bibliometric method similar to that employed by Mogil et al¹⁸ and Caes et al.²⁴ The Web of Science (WoS) Core Collection was selected as the database to search and screen articles related to pain in the older population. CiteSpace V (Drexel University, Philadelphia, USA),²⁵ which is frequently used for quantitative analysis, was adopted as an auxiliary tool. This visualization software is capable of producing node link maps and citation network maps, which allows an explicit manifestation of the development track, intellectual base, research hotspots, and other aspects of a discipline.²⁶ CiteSpace V can also help detect keywords and references in citation bursts. Citation bursts are characterized by intensity and duration. The burst of citations indicates that attention to related research has increased over a period of time, which is a key indicator for identifying emerging trends.^{27–29} This article mainly uses CiteSpace for references cluster analysis and citation bursts detection, and keywords citation bursts detection. Information on authors, journals, and country of distribution was also obtained.

Methods

Source and Search Strategy

WoS, particularly the core collection Science Citation Index (SCI) Expanded, was selected as the search database. The keywords for this study were referred from two previous meta-analyses^{30,31} and selected under the advice of a professor with extensive meta-analysis writing experience. We searched for all titles containing at least one word or phrase related to “elderly” and one word or phrase related to “pain”. The keywords employed are provided in [Supplement 1](#). We retained English articles only because of limitations in language mastery. Articles published in peer-reviewed journals from 2000 to 2019 were included for analysis in this study. We did not exclusively choose articles published in the journal PAIN because articles related to pain in the elderly may also be published in various medical-related journals. Besides original articles, we also considered reviews, theoretical articles and related guidelines. A total of 5096 articles were retrieved, and this step was completed on February 27, 2020.

Preliminary Screening

Two authors independently checked articles on the basis of their title to initially screen out duplicate papers and articles that met the exclusion criteria (eg, case studies, protocols, letters, books and articles that were unrelated to the topic of interest). Disagreements on inconsistent content were discussed and resolved. Articles that could not be judged as to whether they met the inclusion criteria based on their title were retained to the next step of screening. In this step, a total of 1691 (33.18%) articles were excluded because of several reasons, such as other non-pain-related elderly studies (N=147, 8.69%) or non-elderly studies (N=1046, 61.86%) due to the phrase being cut off or other reasons, articles identified in searches due to irrelevant words captured by truncated search terms or misspelled (N=374, 22.12%), case studies (N=96, 5.68%), duplicates (N=5 or 0.30%) and protocol articles (N=23, 1.36%). This screening step was completed on March 5, 2020.

Access to Information

The citation information of all articles was exported from WoS.

Coding Strategy

The coding system we used was developed by Mogil et al¹⁸ and modified it according to the version used in the research

of Caes et al²⁴ to meet the needs of the information acquired in this study. Information on the years the articles were published, content related to the authors (names and numbers), journals and citation scores were collected. We also collected information on the countries of the first authors. The information obtained from the titles and abstracts mainly included the following categories: (1) type of article (ie, research article, theoretical article, guidelines and reviews [ie, narrative reviews or systematic reviews]); (2) topic of the article (eg, characteristics, assessment, intervention, risk factors of pain); (3) subjects (eg, healthy cases, patients recruited from the community or clinical setting); and (4) pain characterisation (eg, experimental pain or clinical pain). Experimental pain includes pain induced by an electrical, mechanical, thermal, or other stimulus, while clinical pain includes pain caused by disease or surgery. Details of the coding system are provided in [Supplement 2](#). We did not categorise the articles according to age because we found during the precoding process that many studies on pain in the elderly included a relatively wide age range. Thus, we used inclusion and exclusion criteria to limit the age range of the articles reviewed ([Table 1](#)).

On the basis of the coding system developed by Mogil et al¹⁸, each article was assigned at least one code in

a category but allowed multiple codes because an article may match with multiple codes; For example, in terms of pain characteristics, chronic pain may be caused by a disease. Prior to formal coding, all of the authors involved in the coding process discussed and adjusted the relevant content of the coding system.

Coding

All abstracts obtained were equally distributed amongst four coders, who subsequently applied the coding system described above. In this step, a total of 1300 articles were excluded for the following reasons: (1) the article was not related to pain or did not specify pain as the main outcome (N=882, 67.85%), (2) the article involved a non-elderly population (N=299, 23%), (3) the article did not include an abstract (N=58, 4.46%) or (4) the article was a case study (N=57 or 4.38%). Finally, 2105 articles were included in the final step of analysis. The coding step was completed on March 31, 2020.

To ensure internal reliability, we randomly selected 10% of the articles assigned to each coder and asked the first author to code them. The range of the intraclass correlation coefficient obtained by statistics was 0.86–0.97.

Data Analysis

The publication dates of the included articles were divided into periods of 4 years (ie, 2000–2003, 2004–2007, 2008–2011, 2012–2015, 2016–2019), each quantitative data were presented as a percentage. The time period was then considered an independent variable, and the categorical data were considered dependent variables. Linear regression was used to calculate changes in the percentage of categorical data over time. Because multiple codes are allowed for each category, the sum of all percentages in a category may exceed 100%. Microsoft Excel 2016 and CiteSpace V were used for data collection and trend analysis, and IBM SPSS Statistics 22.0 software (SPSS Inc., Chicago, USA) was used for statistical analysis. P values less than 0.05 were considered to indicate statistically significant differences.

The complete data acquisition process is illustrated in [Figure 1](#).

Results

Time Trend of Publication Outputs

A total of 2105 articles were included for analysis. The number of publications increased from 25 articles in 2000 to 207 articles in 2019, and statistical analysis showed a significant correlation ($R^2=0.936$, $P<0.001$) between

Table 1 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
✓ Articles from peer-reviewed journals	✗ Dissertation
✓ Research articles	✗ Letters
✓ Reviews (ie, narrative review and systematic review)	✗ Conference abstracts
✓ Clinical guidelines	✗ Case studies
✓ Theoretical articles	✗ Protocols
✓ English articles	✗ Books
✓ Abstract available	✗ Non-elderly subjects
✓ Articles on pain in elderly persons aged ≥65 years old (at least half of the main subjects)	✗ Articles not related to pain or whose main outcomes were not pain
✓ Pain was the main outcome or topic of interest	✗ The symptoms of the disease may include pain, but the study did not focus on pain
✓ Articles about pain in the elderly reported by medical staff, caregivers, etc.	✗ Article was retrieved because of a misspelling or truncation

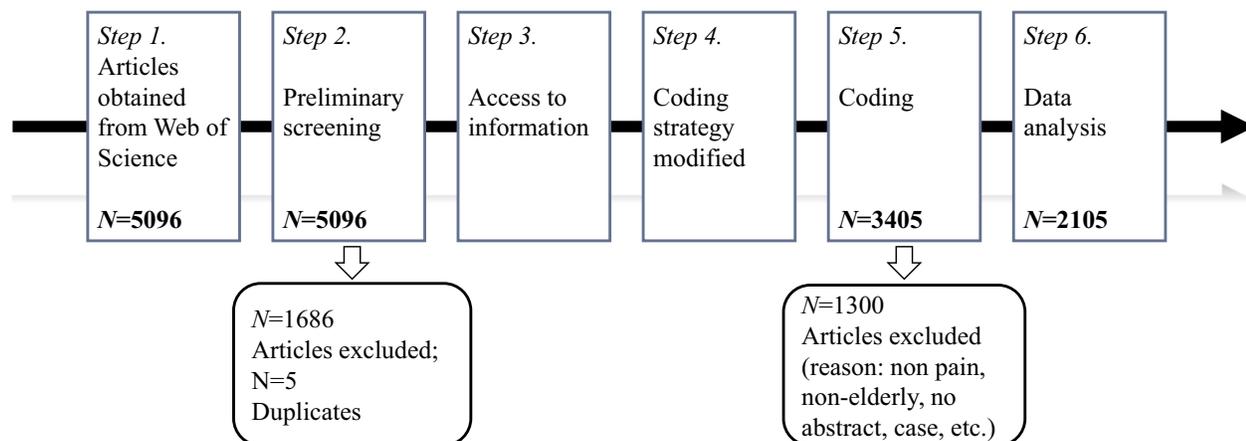


Figure 1 Flow chart for article selection.

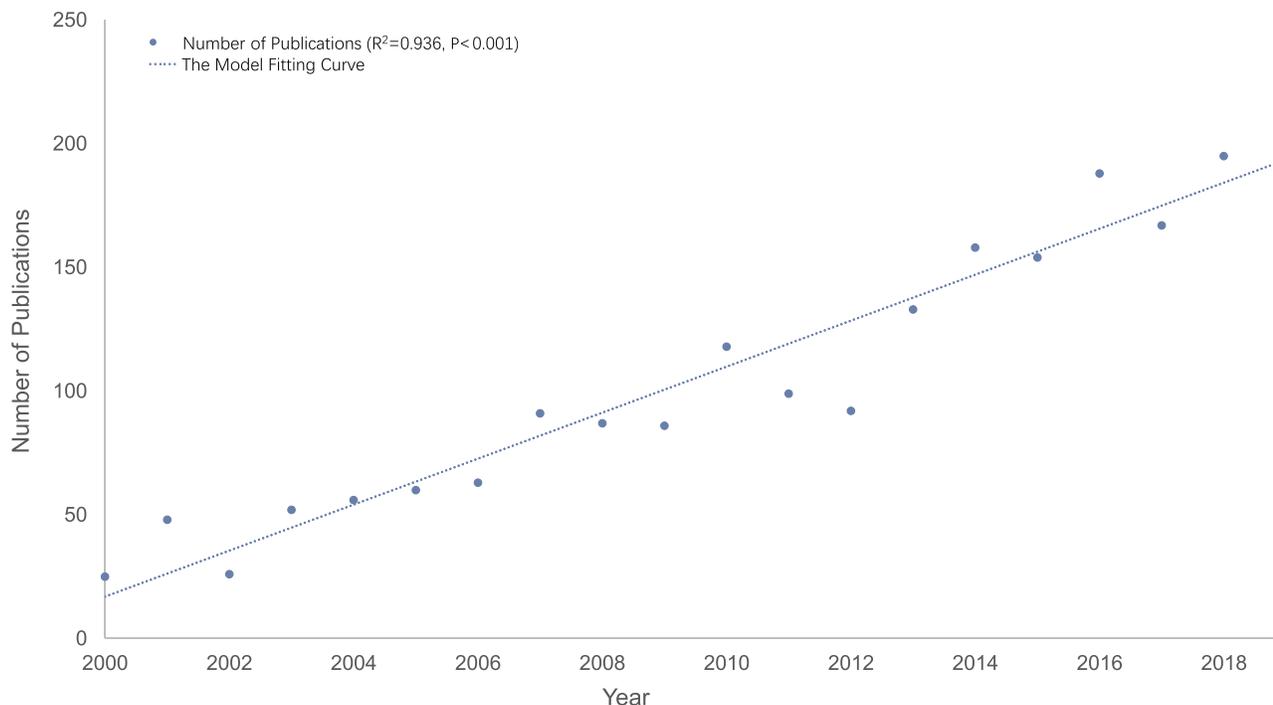


Figure 2 Number of articles published and the mode fitting curve from 2000 to 2019.

the year and number of publications. Details of the year distribution and time trends of the number of publications are shown in Figure 2.

Number of Citations

The top 20 articles with the highest total citation scores (ie, the total number of times cited) are shown in Table 2. The top 20 articles with the highest total citation scores focused on pain assessment (15%),

pain intervention (25%), pain characteristics (55%), and model development (10%). The relative citation score is calculated as the total citation score divided by number of years after publication. Table 3 lists the top 20 articles with relative citation scores. In terms of the relative citation scores, the top 20 articles shared the similar research themes (ie, pain assessment: 20%, pain intervention: 45%, pain characteristics: 35% and model development: 5%).

Table 2 Top 20 Articles with the Highest Total Citation Scores

Rank	Year	Authors	Title	Journal	Citation Score
1	2001	Peat et al ⁴⁰	Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care	Annals of the Rheumatic Diseases	725.00
2	2004	Messier et al ⁴¹	Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis - The arthritis, diet, and activity promotion trial	Arthritis and Rheumatism	611.00
3	2010	Blagojevic et al ⁴²	Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis	Osteoarthritis and Cartilage	528.00
4	2003	Lin et al ⁴³	Effect of improving depression care on pain and functional outcomes among older adults with arthritis - A randomized controlled trial	JAMA	375.00
5	2007	Hadjistavropoulos et al ⁴⁴	An interdisciplinary expert consensus statement on assessment of pain in older persons	Clinical Journal of Pain	331.00
6	2004	Thomas et al ⁴⁵	The prevalence of pain and pain interference in a general population of older adults: cross-sectional findings from the North Staffordshire Osteoarthritis Project (NorStOP)	PAIN	314.00
7	2013	Abdulla et al ⁴⁵	Guidance on the management of pain in older people	Age and Ageing	300.00
8	2004	Herr et al ⁴⁶	Pain intensity assessment in older adults - Use of experimental pain to compare psychometric properties and usability of selected pain scales with younger adults	Clinical Journal of Pain	267.00
9	2001	Helme and Gibson. ⁴⁷	The epidemiology of pain in elderly people	Clinics in Geriatric Medicine	255.00
10	2006	Herr et al ⁴⁸	Tools for assessment of pain in nonverbal older adults with dementia: A state-of-the-science review	Journal of Pain and Symptom Management	254.00
11	2008	Morone et al ⁴⁹	Mindfulness meditation for the treatment of chronic low back pain in older adults: A randomized controlled pilot study	PAIN	249.00
12	2001	Jones et al ⁵⁰	The effect of age on pain, function, and quality of life after total hip and knee arthroplasty	Archives of Internal Medicine	236.00
13	2010	Solomon et al ⁵¹	The comparative safety of analgesics in older adults with arthritis	Archives of Internal Medicine	236.00
14	2001	Gibson and Helme ⁵²	Age-related differences in pain perception and report	Clinics in Geriatric Medicine	235.00
15	2009	Leveille et al ⁵³	Chronic musculoskeletal pain and the occurrence of falls in an older population	JAMA	228.00
16	2005	Gagliese et al ⁵⁴	The measurement of postoperative pain: A comparison of intensity scales in younger and older surgical patients	PAIN	226.00
17	2004	Gibson and Farrell ⁵⁵	A review of age differences in the neurophysiology of nociception and the perceptual experience of pain	Clinical Journal of Pain	212.00
18	2005	Lautenbacher et al ⁵⁶	Age effects on pain thresholds, temporal summation and spatial summation of heat and pressure pain	PAIN	211.00

(Continued)

Table 2 (Continued).

Rank	Year	Authors	Title	Journal	Citation Score
19	2015	Silverwood et al ⁵⁷	Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis	Osteoarthritis and Cartilage	211.00
20	2003	Edwards et al ⁵⁸	Age-related differences in endogenous pain modulation: a comparison of diffuse noxious inhibitory controls in healthy older and younger adults	PAIN	209.00

Table 3 Top 20 Articles with the Highest Relative Citation Scores

Rank	Year	Author	Title	Journal	Relative Citation Scores
1	2010	Blagojevic et al ⁴²	Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis	Osteoarthritis and Cartilage	52.80
2	2013	Abdulla et al ⁶	Guidance on the management of pain in older people	Age and Ageing	42.86
3	2015	Silverwood et al ⁵⁷	Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis	Osteoarthritis and Cartilage	42.20
4	2004	Messier et al ⁴¹	Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis - The arthritis, diet, and activity promotion trial	Arthritis and Rheumatism	38.19
5	2001	Peat et al ⁴⁰	Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care	Annals of the Rheumatic Diseases	38.16
6	2013	Patel et al ⁵⁸	Prevalence and impact of pain among older adults in the United States: Findings from the 2011 National Health and Aging Trends Study	PAIN	29.57
7	2007	Hadjistavropoulos et al ⁴⁴	An interdisciplinary expert consensus statement on assessment of pain in older persons	Clinical Journal of Pain	25.46
8	2010	Solomon et al ⁵¹	The comparative safety of analgesics in older adults with arthritis	Archives of Internal Medicine	23.60
9	2017	Avidan et al ⁵⁹	Intraoperative ketamine for prevention of postoperative delirium or pain after major surgery in older adults: an international, multicentre, double-blind, randomised clinical trial	Lancet	23.33
10	2003	Lin et al ⁴³	Effect of improving depression care on pain and functional outcomes among older adults with arthritis - A randomized controlled trial	JAMA	22.06
11	2008	Morone et al ⁴⁹	Mindfulness meditation for the treatment of chronic low back pain in older adults: A randomized controlled pilot study	PAIN	20.75
12	2009	Leveille et al ⁵³	Chronic musculoskeletal pain and the occurrence of falls in an older population	JAMA	20.73
13	2004	Thomas et al ⁴⁵	The prevalence of pain and pain interference in a general population of older adults: cross-sectional findings from the North Staffordshire Osteoarthritis Project (NorStOP)	PAIN	19.63

(Continued)

Table 3 (Continued).

Rank	Year	Author	Title	Journal	Relative Citation Scores
14	2006	Herr et al ⁴⁸	Tools for assessment of pain in nonverbal older adults with dementia: A state-of-the-science review	Journal of Pain and Symptom Management	18.14
15	2004	Herr et al ⁴⁶	Pain intensity assessment in older adults - Use of experimental pain to compare psychometric properties and usability of selected pain scales with younger adults	Clinical Journal of Pain	16.69
16	2013	Langan et al ⁶¹	Herpes zoster vaccine effectiveness against incident herpes zoster and post-herpetic neuralgia in an older US population: A cohort study	PLoS Medicine	16.43
17	2016	Morone et al ⁶²	A mind-body program for older adults with chronic low back pain a randomized clinical trial	JAMA Internal Medicine	16.25
18	2009	Vitiello et al ⁶³	Cognitive behavioral therapy for insomnia improves sleep and decreases pain in older adults with co-morbid insomnia and osteoarthritis	Journal of Clinical Sleep Medicine	16.09
19	2014	Hadjistavropoulos et al ³²	Pain assessment in elderly adults with dementia	Lancet Neurology	15.83
20	2014	Makris et al ³³	Management of persistent pain in the older patient a clinical review	JAMA	15.67

Journals

All included articles were published in 535 journals, and 261 journals published two or more of these articles. The top three journals with the greatest number of publications related to pain in the elderly were Pain Medicine, PAIN, and Journal of the American Geriatrics Society. Details of the top 20 journals with the highest number of pain-related articles published are shown in Table 4. The average impact factor (IF) of all journals was 3.053 (median, 2.930; range, 1.595–5.483, 2019), and the total number of citations of PAIN reached 4337 (publications, 78; IF, 2019 =5.483; citations per paper, 55.60), which was the journal with the largest total number of citations and the journal with the most citations per article. In addition, over half of the top 20 journals that published articles on pain were from the United States.

Authors

The percentage of articles in which two or more authors collaborate gradually increased over time. Author collaborations increased from 91.39% in 2000–2003 to 97.90% in 2016–2019 ($R^2=0.886$, $P<0.05$). Conversely, the proportion of articles published by a single author declined over this same period ($R^2=0.882$, $P<0.05$). Details of our

analysis on authors are provided in Figure 3. No articles in which the authors were anonymous or not listed were obtained.

The articles included in this analysis were published in 48 countries (Supplement 3), but most came from the United States ($N=741$, 35.20%), Australia ($N=175$, 8.31%) and the United Kingdom ($N=167$, 7.93%). The distribution of articles published per country is shown in Figure 4.

Keywords

CiteSpace was used to detect burst keywords which were identified as indicators of emerging trends. The burstiness of a keyword was obtained by calculating the weighted sum of its frequency in one- or multiple-time windows. If the probability of these occurrences is higher than a data-dependent global threshold, that keyword is considered to have a burst. All keywords of the included papers were obtained by CiteSpace V. The top 68 keywords with the strongest citation bursts are shown in Table 5. The burst keywords in the beginning of 2000 were “migraine”, “osteoarthritis”, “rheumatoid”, “gender”, “nursing home” and “physical disability”. By comparison, the most recent burst keywords included “balance” (2014–2019), “burden”

Table 4 Top 20 Journals with the Highest Number of Published Articles

Rank	Journal	Country	IF (2019)	Count	Citation Scores	Citations per Paper
1	Pain Medicine	USA	2.513	105	2477	23.59
2	PAIN	USA	5.483	78	4337	55.60
3	Journal of the American Geriatrics Society	USA	4.180	70	3099	44.27
4	Pain Management Nursing	USA	1.595	50	670	13.40
5	Drugs & Aging	New Zealand	2.824	48	1016	21.17
6	European Journal of Pain	England	3.492	39	729	18.69
7	Journal of Pain	USA	4.621	38	1531	40.29
8	Clinical Journal of Pain	USA	2.893	38	1803	44.45
9	Clinics in Geriatric Medicine	USA	2.966	32	1064	33.25
10	Bmc Geriatrics	England	3.077	31	232	7.48
11	Bmc Musculoskeletal Disorders	England	1.879	30	648	21.60
12	Archives of Gerontology and Geriatrics	Ireland	2.128	30	314	10.47
13	Journals of Gerontology Series a-Biological Sciences and Medical Sciences	USA	5.236	27	700	25.93
14	Journal of Pain and Symptom Management	USA	3.077	26	969	37.27
15	SPINE	USA	2.646	24	716	29.83
16	Aging Clinical and Experimental Research	Italy	2.697	24	154	6.42
17	Journal of Clinical Nursing	England	1.972	23	345	15.00
18	Clinical Interventions in Aging	New Zealand	3.023	22	268	12.18
19	PLoS One	USA	2.740	20	160	8.00
20	Geriatrics & Gerontology International	Japan	2.022	20	103	5.15

(2015–2019), “cognitive impairment” (2015–2019), ‘meta-analysis’ (2015–2019), “impact” (2016–2019), “mortality” (2016–2019), “predictor” (2017–2019) and “persistent pain” (2017–2019).

Subject Category in Web of Science

All articles included in the analysis were divided into 52 categories in WoS. Most of the published articles described topics related to *Geriatrics & Gerontology* (N=508), followed by *Neurosciences & Neurology* (N=464) and *Clinical Neurology* (N=406). The top 10 subject categories with the strongest citation bursts in the last 20 years are shown in Table 6. Whilst the subject category with the strongest citation bursts at the beginning of 2000 was Neurosciences (2000–2005),

the top 10 subject categories with the strongest citation bursts by the end of 2019 included Multidisciplinary Sciences (2015–2019) and Science & Technology–Other Topics (2015–2019).

References

Reference analysis is an essential aspect of bibliometric research in a specific field. CiteSpace V was used to obtain citation data from the included articles, and the top 19 clusters are displayed in a timeline view in Figure 5; the scientific relevance of the included articles is also shown in the map. “Hip fracture” formed the largest cluster #0, “elderly patient” formed the second largest cluster #1, and “community-based” (#2) and “functional self-efficacy” (#3) respectively formed the third and fourth largest clusters.

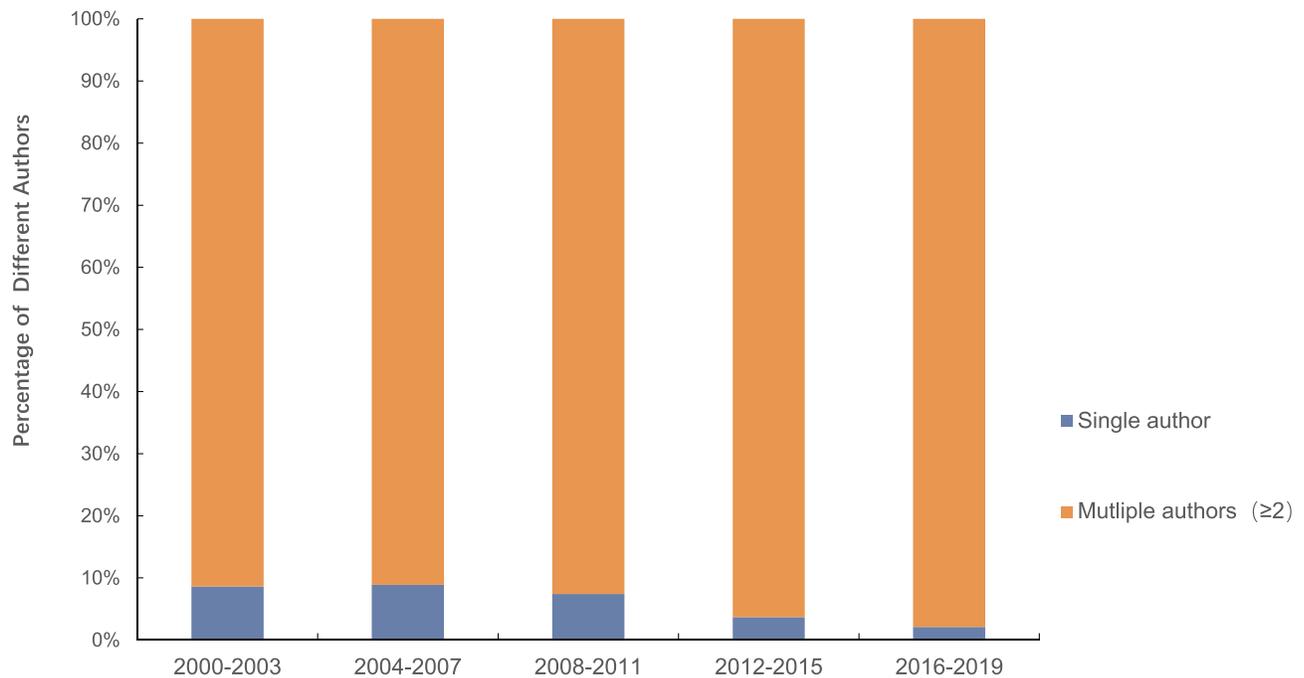


Figure 3 Percentage of papers published by single and multiple authors.

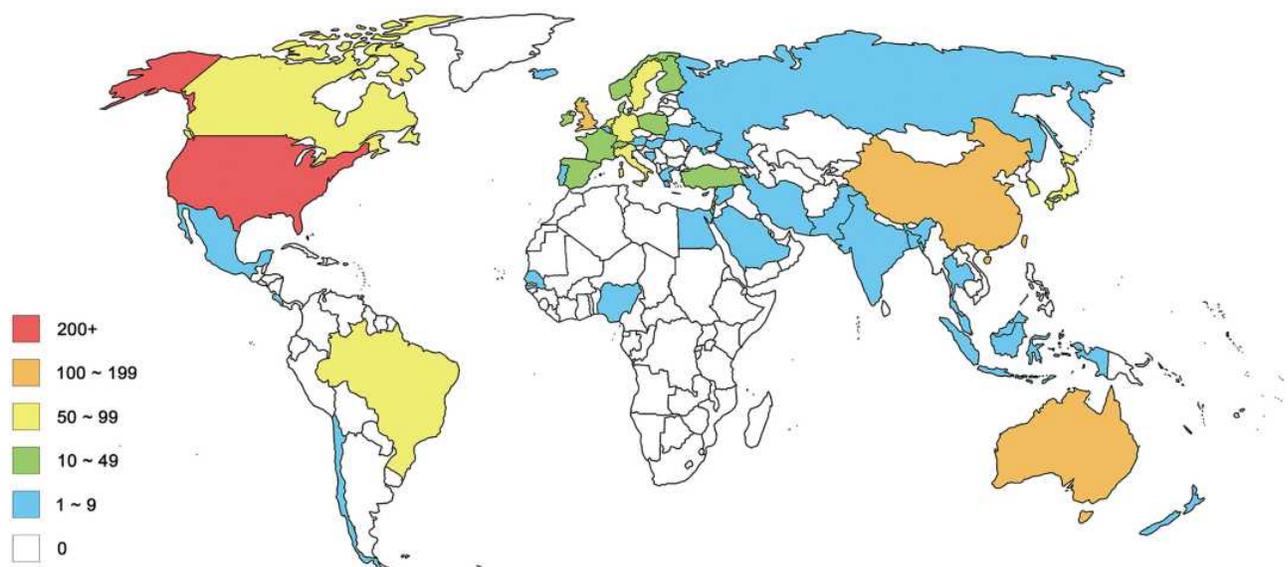


Figure 4 World map of total country outputs.

Type of Article

Original research articles were the dominant article type published and consistently made up 80.37–88.38% of the total number of articles published in each time period. By comparison, review articles made up 11.26–16.67% of the published articles. The percentage of theoretical articles and guidelines was relatively small (Figure 6A). Narrative reviews (N=197, 74.06%) accounted for the largest

proportion of all review articles. Whilst the proportion of systematic reviews was initially low, this article type showed an upward trend over time ($R^2=0.729$, $P=0.065$).

Topic of Article

Figure 6B shows the distribution of all included articles by topic (refer to Supplement 4 for detailed coding rules of topics). Articles on pain characteristics

Table 5 Top 68 Keywords with the Strongest Citation Bursts in Publications on Pain in the Elderly

Keywords	Year	Strength	Begin	End	2000–2019
Migraine	2000	4.2682	2000	2008	
Osteo arthritis	2000	7.9365	2000	2001	
Rheumatoid arthritis	2000	14.2934	2000	2011	
Gender	2000	3.8488	2000	2005	
Nursing home	2000	10.8974	2000	2005	
Physical disability	2000	4.2917	2000	2003	
Severity	2000	4.0377	2002	2005	
Pain assessment	2000	4.3778	2002	2006	
Mini mental state	2000	4.5985	2002	2008	
Mobility	2000	5.3971	2003	2011	
Geriatrics	2000	4.2576	2003	2006	
Validity	2000	3.8645	2003	2007	
Questionnaire	2000	7.0498	2003	2005	
Headache	2000	3.4825	2003	2004	
Health status	2000	5.2123	2003	2008	
Depressive symptom	2000	6.7369	2003	2007	
Elderly people	2000	6.1618	2003	2008	
Surgery	2000	3.5827	2003	2010	
Attitude	2000	3.5439	2003	2005	
Postoperative pain	2000	5.1525	2003	2009	
Communication	2000	3.7038	2004	2009	
Disease	2000	3.5381	2004	2008	
Arthroplasty	2000	4.1529	2004	2006	
Assessment	2000	4.1674	2004	2009	
Experience	2000	3.2414	2005	2011	
Minimum data set	2000	3.1373	2005	2006	
Nursing home resident	2000	5.7317	2006	2008	
Intensity	2000	5.7697	2006	2008	
Follow up	2000	3.7993	2007	2011	
Validation	2000	7.6445	2007	2012	
Morphine	2000	5.7343	2008	2010	
Patient	2000	3.3089	2008	2013	
Disorder	2000	6.8295	2008	2011	

(Continued)

Table 5 (Continued).

Keywords	Year	Strength	Begin	End	2000–2019
Knee pain	2000	3.1164	2008	2009	
General population	2000	3.2829	2008	2009	
Nurse	2000	3.6281	2009	2011	
Cancer	2000	5.4605	2009	2013	
Barrier	2000	3.6625	2009	2013	
Alzheimer's disease	2000	5.5734	2010	2012	
Guideline	2000	5.5734	2010	2012	
Knee	2000	4.4126	2010	2013	
Fibromyalgia	2000	5.0512	2010	2011	
Diagnosis	2000	3.1101	2011	2013	
Nonsteroidal anti-inflammatory drug	2000	3.1223	2011	2014	
Pain management	2000	4.176	2012	2013	
Efficacy	2000	5.8437	2012	2015	
Analgesia	2000	3.6708	2012	2013	
Cancer pain	2000	3.3727	2012	2013	
Program	2000	3.8164	2012	2014	
Safety	2000	4.0307	2012	2015	
Outcome	2000	9.3702	2013	2016	
Anxiety	2000	4.8392	2013	2016	
Elderly patient	2000	5.3176	2013	2014	
Double blind	2000	3.3266	2013	2015	
Neuropathic pain	2000	3.6078	2014	2015	
Perception	2000	3.389	2014	2015	
Balance	2000	3.5721	2014	2019	
Performance	2000	3.167	2014	2015	
Burden	2000	6.4995	2015	2019	
Cognitive impairment	2000	3.3577	2015	2019	
Cohort	2000	5.8722	2015	2017	
Clinical trial	2000	3.4816	2015	2017	
Meta-analysis	2000	12.6695	2015	2019	
Impact	2000	3.5607	2016	2019	
Physical function	2000	4.5148	2016	2017	
Mortality	2000	7.3694	2016	2019	

(Continued)

Table 5 (Continued).

Keywords	Year	Strength	Begin	End	2000–2019
Predictor	2000	5.339	2017	2019	
Persistent pain	2000	7.4243	2017	2019	

Table 6 Top 10 Subject Categories of Articles on Pain in the Elderly with the Strongest Citation Bursts in Web of Science

Subject Categories	Year	Strength	Begin	End	2000–2019
Neurosciences	2000	5.0467	2000	2005	
Gerontology	2000	3.285	2004	2005	
Rheumatology	2000	3.2323	2004	2007	
Anesthesiology	2000	3.1168	2007	2008	
Oncology	2000	6.4401	2008	2010	
Pharmacology & Pharmacy	2000	4.058	2012	2014	
Health Policy & Services	2000	3.646	2013	2014	
Obstetrics & Gynecology	2000	3.6245	2014	2016	
Multidisciplinary Sciences	2000	3.9403	2015	2019	
Science & Technology - Other Topics	2000	3.9403	2015	2019	

(42.56–53.90%), pain intervention (30.74–39.23%) and pain assessment (7.53–13.85%) accounted for the largest proportion of all articles published from 2000 to 2019. All topic categories showed a relatively stable distribution percentage over time (all $R^2 < 0.638$, n.s.).

Subject Type

Approximately 49% of all articles did not mention the source of their subjects. Other articles recruited subjects from the clinical (23.82%) and community (18.95%) settings. Healthy subjects (3.17%), nursing home residents (3.07%), health professionals (2.22%), and animals accounted for a small proportion of the subjects described in the articles (Figure 7). All studies subjects did not reveal significant changes over time. We found that, besides traditional clinical samples, a large proportion of the subjects came from the community. Studies in which subjects were recruited from the community were published in 31 countries. Figure 8 shows the proportion of published research involving community-based subjects relative to the total number of studies

published in each country. Nigeria, Bosnia–Herzegovina and Bangladesh published only one article each including community-based subjects. The countries with the highest percentages of published studies involving community-based subjects were Finland (50%), Thailand (44.44%) and Japan (34.02%).

Pain Characteristics

Studies on disease-related pain in the elderly were highly popular at all period studied and showed an increasing trend over time ($R^2 = 0.973$, $P < 0.01$). These studies made up 47.02% of all studies published in 2000–2003 and 57.46% of all studies published in 2016–2019. The types of pain with the largest number of publications were back pain (N=259, 12.30%), arthritis (N=241, 11.45%) and postsurgical pain (N=98, 4.66%). Moreover, in all periods studied, the proportion of studies related to chronic pain was higher than the proportion of studies related to acute pain (Figure 9A). Studies on elderly surgery-related pain showed fair stability over time and varied between 4.47%

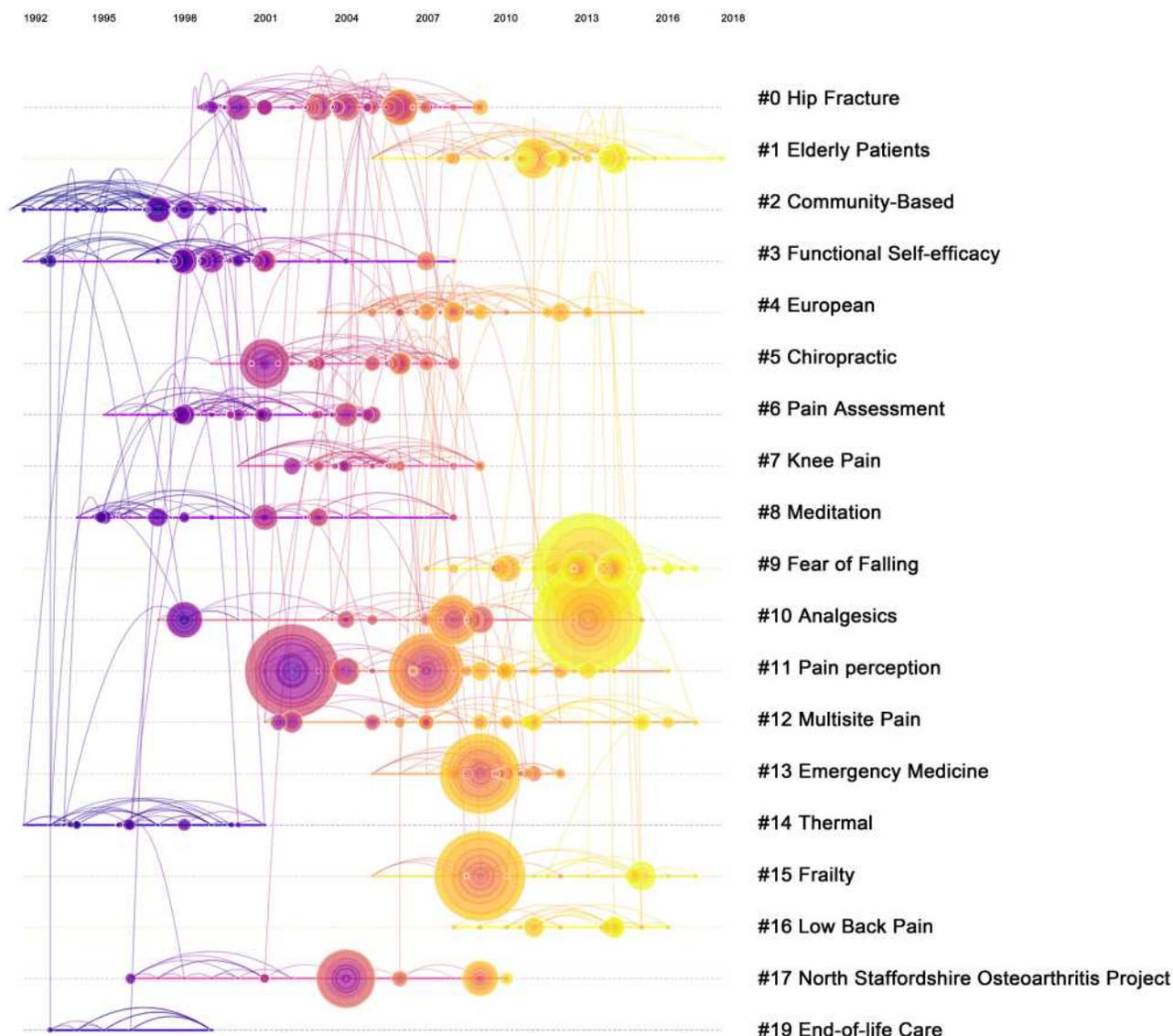


Figure 5 Co-citation map (timeline view) of references from publications on pain in the elderly. The size of the nodes reflects the number of publications or frequency; the larger the node, the higher the number of publications or frequency. The different colors within the nodes represent different times, the connection lines between the nodes reflect the relationship between the co-operation or co-citation, and the color of the line reflects the years when the co-operation or co-citation first appeared. Nodes with a larger centrality are more likely to become the key nodes in the network and are represented by purple on the node ring in the knowledge network map.

and 5.55% from 2000 to 2019 (Details of the coding rules for pain characteristics can be found in [Supplement 4](#)).

Experiments on humans or animals have been applied to pain-related studies on the elderly (N=110, 5.23%). Whereas thermal (41.53%) and mechanical (37.76%) stimuli were the most frequently used types of pain stimuli, injury pain stimuli were used the least (1.43%; [Figure 9B](#)).

Discussion

This review presents a bibliometric analysis of published articles on pain in the elderly over the last 20 years. A total of 2105 related articles were included, and the article types

that made up the largest proportion of these publications are research articles (84.89%, N=1787) and review articles (12.64%, N=266). The overall number of articles published over time revealed an unstable upward trend, especially after 2012. This growth trend is consistent with previous growth trends observed in the fields of general pain,^{18,19} pediatric pain field,²⁴ and overall biomedical publications.³⁴

Bradford's law can be used to identify the "core" journals in a field. [Table 7](#) shows the Bradford zones of scattering for articles on elderly pain. All journals were sorted by number of articles into three zones, each with approximately 33% of the total number of articles, and the number of journals in

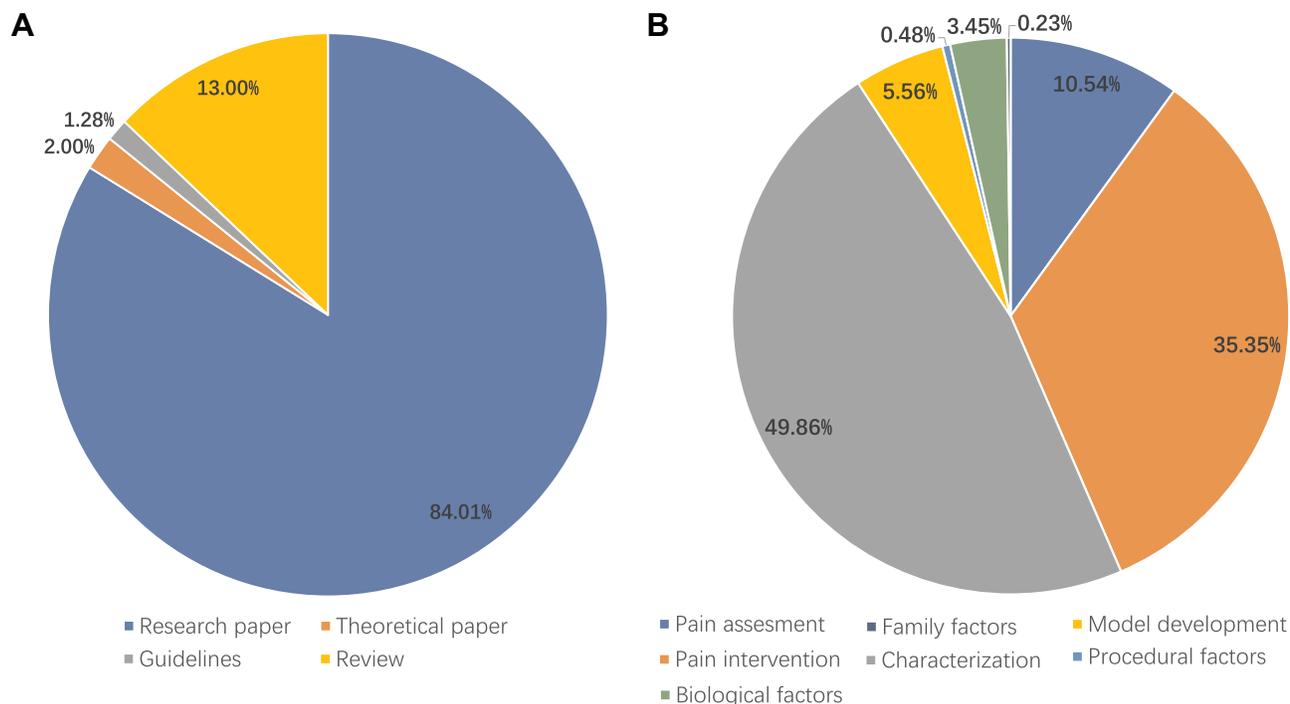


Figure 6 (A) Average percentage of each article type published from 2000 to 2019; (B) average percentage of topics discussed in articles published from 2000 to 2019.

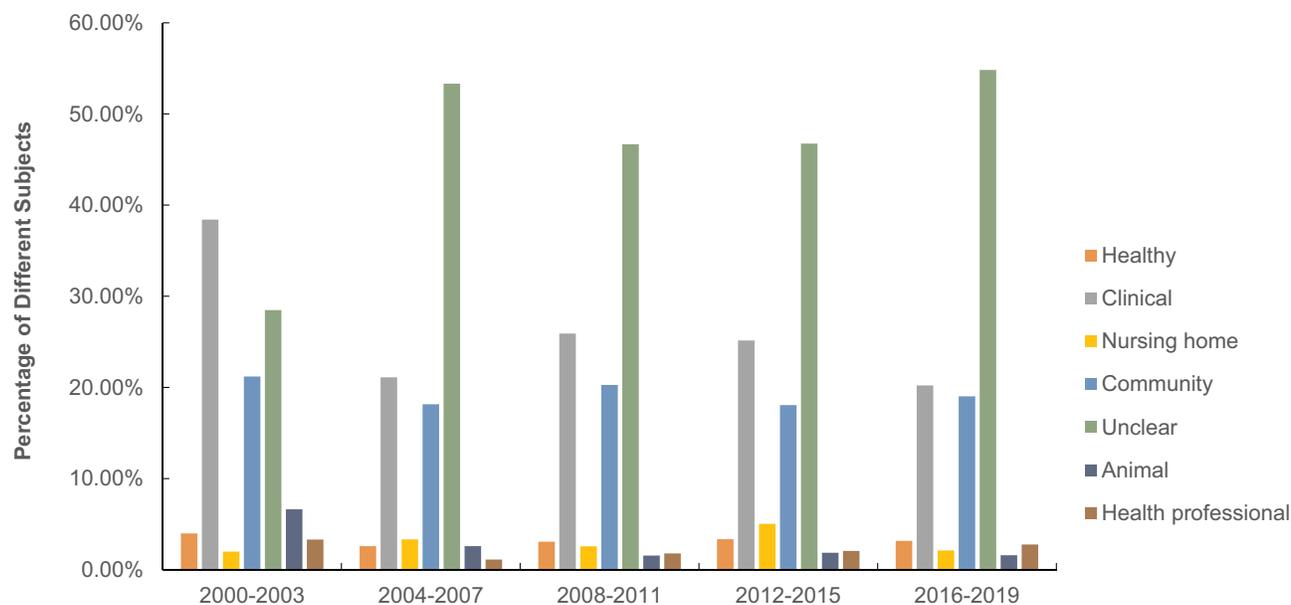


Figure 7 Trends of the percentage of subject type.

each zone was proportional to $1: n: n^2$. The top 20 journals accounted for 36.72% of the total number of publications in this field (773 publications), and the distribution of these articles is in accordance with Bradford’s law. The IFs of all

top 20 journals were below 10. Journals with $3 \leq IF < 5$ contributed 20% of these articles, and journals with $5 \leq IF < 10$ contributed 10% of these articles. Pain Medicine published the greatest number of studies in the field of elderly pain,

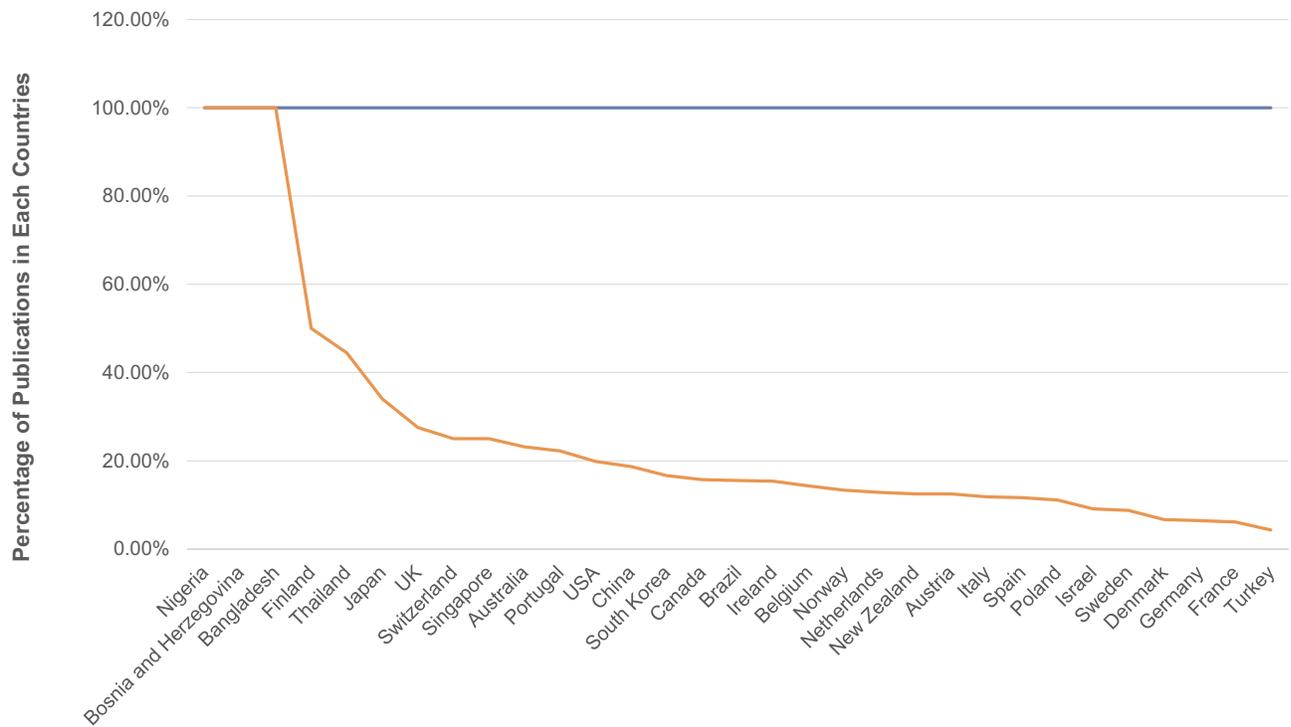


Figure 8 Percentage of community sample-based research studies amongst all research articles in each country (ie, in each country, the proportion of research studies in which subjects come from the community to the total number of studies in the country).

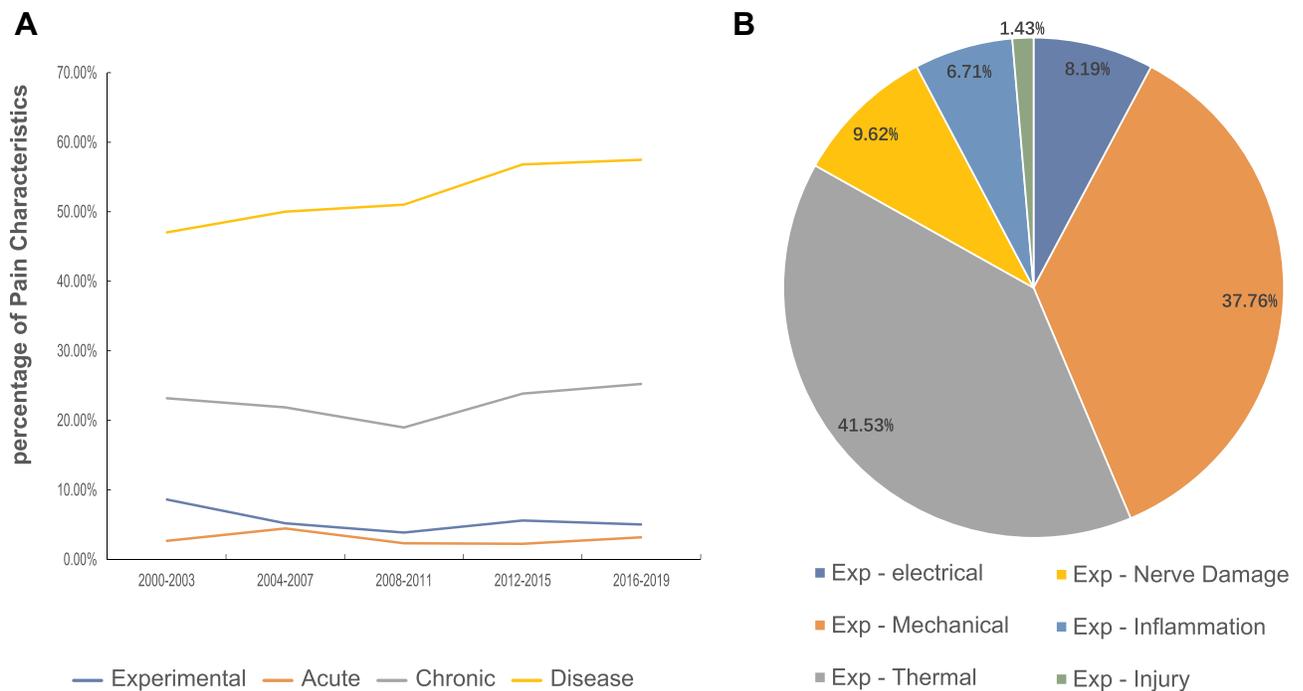


Figure 9 (A) Trends in the percentage of pain characteristics reported every 4 years; **(B)** average percentage of experimental designs reported every 4 years.

followed by PAIN, Journal of the American Geriatrics Society, Pain Management Nursing and Drugs & Aging. Interestingly, these findings differ from the results of

previous general pain studies.^{18,19} This ranking shows that researchers in the field of pain in the elderly are highly inclined to focus on elderly audiences in addition to the

Table 7 Bradford's Law of Scattering for Journals That Published Articles on Elderly Pain Research from 2000 to 2019

	n	n/N(%)
Zone1	17	3.18
Zone2	77	14.39
Zone3	441	82.43

Notes: Each zone represents about 33% of the total articles (2105); n, the number of journals in each zone; N, the number of all journals (535).

broader pain field. Amongst the top 100 journals that published articles on pain, 26 were related to old age or aging and 14 focused on pain. This result is also consistent with previous findings. In terms of the disciplinary classification of journals, journals related to nursing (N=11) and rehabilitation (N=7) appeared to publish more articles on pain than other types of journals. Such a finding is consistent with the age characteristics of the elderly and a previous study.³⁵

The United States appeared to be the primary source country of articles in this field with the most publications. In addition, 8 of the 20 articles with the highest citation scores and 11 of the top 20 journals in the number of published papers were from the United States. Although the choice of database may affect this specific result, this finding is similar to that of a previous general pain study.¹⁹ The top 10 countries with the largest number of published articles included were from three American countries, three Pacific countries and four European countries.

Our research found that researchers of pain in the elderly often focus on disease-related pain and chronic pain. These results are consistent with the general trend of adult pain literature, which mainly discusses chronic and disease-related pain.^{16,18} Previous studies reported that the most common types of pain in the elderly are low back or neck pain (65%), musculoskeletal pain (40%) and peripheral neuropathic pain (40%).^{36–38} Similarly, the present study found that the types of pain receiving the greatest research attention are back pain (12.30%), arthritis (11.45%) and postsurgical pain (4.66%). This observation may be related to the characteristics of this age group (such as the acceleration of aging and more susceptibility). Research on pain in the elderly has increased over time and may reflect the upward trends life expectancy, quality of life and social and economic development.

It is found that the most popular pain research topics include pain characteristics, intervention and assessment,

which was supported by the fact that over half of the top 20 articles cited were related to pain characteristics. This result indicates that descriptions of pain in the elderly are a popular research topic in this field. These studies formed the basis for further basic or mechanistic studies and clinical intervention studies, and also indicated that evidence from animal and laboratory studies were not sufficient. Future preclinical research should be recommended to explore the related risk factors in the elderly and to establish animal models for mechanistic research. Experimental human research has been conducted, but these studies are relatively infrequent on account of reasons such as ethical challenges and experimental costs. In addition, we noticed that among the top 20 original articles in terms of total citation score or relative citation score, articles related to pain caused by arthritis received more attention ([Supplement 5](#) and [Supplement 6](#)), but the citation score was relatively lower than the reviews of the same topic. This may imply that more innovative and breakthrough original research is needed. For musculoskeletal pain with a high prevalence in the elderly, such as low back pain, the citation score is significantly lower than that of original studies on this topic in the general population.³⁹ Hence, the field of elderly pain deserves more appeal from future studies. According to our analysis of the keywords with strongest citation bursts and the subject categories in WoS, the strongest citation bursts changed from Neurosciences to the recent Multidisciplinary Sciences and Science & Technology–Other Topics, as can be seen, the development of elderly pain research has gradually transitioned from phenomenon to mechanism and evolved from a single discipline to multiple disciplines.

There exist several strengths of value presented in this bibliometric analysis. First, the source of the literature was not limited to one journal, such as PAIN. Specifically, we collected articles from 535 journals to enrich the data. Second, we performed a detailed analysis of the general information, including author, year and journal, and abstracts of all included articles. Data indicators were not restricted to the properties such as the number of publications and citation scores. Therefore, the results of our analyses provide a rather precise description of publication trends. Furthermore, this study used two bibliometric analytical methods (ie, literature coding and CiteSpace V software) to produce more comprehensive analyses.

This review also possessed some limitations that may affect the interpretation of the results. Firstly, we merely used the SCI Expanded core collection of WoS to retrieve

articles, and only those articles containing abstracts were included in this work. Moreover, non-English articles were excluded from the analysis. The adoption of a single database with English language restriction may probably lead to selection bias. We also excluded a number of conference abstracts that may describe novel content in the field. These omissions might lead to incomplete information acquisition. In addition, subjects were not grouped by age because the age range involved in the retrieved studies was fairly wide. Some articles did not mention details of their source of subjects in their abstracts.

Conclusions

Our study showed a significant increase in the number of elderly pain-related articles published in the past decades. This review, to a large extent, is a representative reflection of research trends on pain in the elderly. The research topics of articles included in this work generally focused on pain characteristics, pain intervention and assessment, chronic pain in the elderly, and the main types of pain included back pain, arthritis and postsurgical pain. Little is known about the transition from acute to chronic pain and the mechanisms of pain in the elderly population remain not clear. Therefore, future studies concerning chronic pain evolution and the underlying pain mechanisms are warranted.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Disclosure

The authors have no conflicts of interest to declare.

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