

# The Bibliometric and Visualized Analysis of Research for Hospital Medication Management Based on the Web of Science Database

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**Objective:** Identify the collaborations between authors, countries, and institutions, respectively, and explore the hot issues and prospects for research on hospital medication management.

**Materials and Methods:** Publications on hospital medication management were retrieved from the Web of Science Core Collection. Bibliometric analyses were performed using CiteSpace 6.1.R3, HistCite 2.1, and VOSviewer 1.6.16. The network maps were created between authors, countries institutions, and keywords.

**Results:** A total of 18,723 articles related to hospital medication management studies were identified. Rapid growth in the number of publications since 2017. The high papers were published in AM J HEALTH-SYST PH, while JAMA-J AM MED ASSOC was the most co-cited journal. Manias E and WHO ranked first in the author and cited author. There were active collaborations among the top authors. Bates DW was the key author in this field. The authors have active collaborations in adverse drug events, acute coronary syndrome, in-hospital major bleeding, and so on. The US was the leading contributor in this field. The UK, Australia, and China are also very active. Active cooperation between countries and between institutions was observed. The main hot topics included matters related to outcome indicators, hospital pharmacy service behaviors, and medication use in pain management. More recent keywords focus on chronic disease medication management and clinical medication management.

**Conclusion:** Hospital medication management studies have significantly increased after 2017. There was active cooperation between authors, countries, and institutions. The application of hospital medication management in the emergency department and the relationship between medication management and medication adherence are current research hotspots. In addition, with the continuous progress of society, chronic diseases have become an important factor affecting people's health, and medication management is becoming more and more subdivided, so the direction of chronic disease medication management as well as precise medication may become the development direction of future research.

**Keywords:** bibliometric analysis, medication management, hospital, development trends, hot topics

## Introduction

Medication management is a multidisciplinary field that encompasses theoretical knowledge from epidemiology, education, economics, mass communication, psychology, sociology, and management science to address healthcare issues at the individual and population levels,<sup>1</sup> and Hospital medication management is part of medication management. In 2017, China issued the "Guidance on the Establishment of a Modern Hospital Management System", which emphasizes the important role of professional committees for medication management in the decision-making mechanism of hospitals.<sup>2</sup> The US Joint Commission International also has corresponding requirements for medication management in healthcare organizations, mainly including two core concepts, one is all to the patient medication safety as the first, every detail of the work should be fully embodied in the safe use of medication in order to patients; the second concept is to continue to

improve the management of pharmacy. In daily work, systems, processes or details that are not conducive to the safe use of medication by patients should be identified in a timely manner and improved and optimized.<sup>3</sup> In 2022, the European Health Management Association also published an article entitled DIGITAL MEDICATION MANAGEMENT IN HEALTHCARE SETTINGS: AN OPPORTUNITY FOR THE EUROPEAN UNION, highlighting the digital transformation of hospitals, and in particular investment in hospital medication management pathways, as a key opportunity for the EU, as medication management is a key core activity in hospitals across Europe.<sup>4</sup> In many countries, medication management plays an important role in the daily operation and administration of hospitals.<sup>5–7</sup> Comprehensive medication management contributes to the Quadruple Aim aspects of healthcare: better care, lower healthcare costs, improved patient experience and provider well-being.<sup>8</sup> Also, clinics with the Medication Therapy Management Program are more cost-effective than clinics without the Medication Therapy Management Program.<sup>9</sup> Implementing interventions related to medication use promotes medication coordination, education, communication, and care coordination, and medication management contributes to lower hospitalization rates.<sup>10</sup> As a cross-disciplinary field, the traditional literature review study is no longer sufficient for sorting out the systematic and comprehensive information among the existing research. Scientometrics is a subfield of informatics that quantifies and analyses models in the scientific literature to capture the burgeoning trends and intellectual structure of a field of study.<sup>11</sup> However, there has been no research on the bibliometric and visualized analysis in medication management in healthcare organizations. Therefore, it is essential to systematically summarize and sort out the literature in medication management in healthcare organizations by Scientometrics to show its future trends and knowledge structure.

Scientific mapping tools typically use scientific publications from the literature as inputs and derive reciprocal visual representations of complicated systems for statistical analysis and reciprocal visual discovery. Researchers and analysts are at the disposal of several scientific mapping tools, such as CiteSpace, VOSviewer, and HistCite. HistCite excels at generating chronological and other tables, as well as historical charts highlighting the most cited works inside and outside the bibliographic collection.<sup>12</sup> CiteSpace is one of the most popular software for bibliometric analysis and visualization. It aims to help researchers find important results in the field by building knowledge networks.<sup>13</sup> VOSviewer pays attention to the graphical representation of bibliometric maps and is particularly useful for displaying large bibliometric maps in an easily interpretable manner.<sup>14</sup> In contrast, VOSviewer's programming algorithms and computational logic are more reasonable and advanced, producing better results and visualization when dealing with large amounts of data.<sup>15</sup>

In this study, we conducted a bibliometric and visualized analysis to (1) describe the study status of hospital medication management in the matter of the year, journal, authors, country, co-cited journals, institution, keywords, and references; (2) determine the collaborations of which authors, countries, and institutions; (3) investigate the critical issues and developments.

## Method

### Data Collection

A full search was conducted online using the Web of Science (WoS) core database on July 29, 2022. The search was performed on a single day to avoid bias caused by the daily database updates. A comprehensive subject search for “hospital medication management” was performed, with no restrictions on language or data categories, and a combination of “and” for the terms pharmacy, pharmaceutical, medical, administrative, managerial and clinical, hospital, and institution, yielding a total of 18 results, which were summarized into a total of 21,149 records published between 1980 and 2022. The detailed search strategy is shown in [Appendix 1](#). After filtering out non-representative record types (eg, conference proceedings and notes), the dataset was reduced to 20,329 original research and review articles. After de-duplication by CiteSpace 6.1.R3, the dataset was reduced to 18,723 original research and review articles.

### Visualization and Analysis

HistCite pro 2.1 was applied to count languages and years of publication. VOSviewer 1.6.16 was applied to identify countries, institutions, journals, and co-cited journals and to create networks of productive governments and institutions,

which help to visualize countries and institutions with collaborative relationships.<sup>16</sup> The impact factor (IF) of journals is referenced in the Journal Citation Reports (JCR) for 2021.<sup>17</sup> The network and density maps for high-frequency keywords demonstrated a cluster analysis, which VOSviewer created. In the network map, different nodes represent different keywords, countries, or institutions. In turn, the node's size reflects the number or frequency of tags represented by that node.<sup>18</sup> The connecting lines between nodes represent co-occurrence, cooperation, or co-referencing relationships.<sup>19,20</sup> Different clusters or years can be identified by the colors of the nodes and lines.<sup>21</sup> CiteSpace is a scientific tool that exposes trends and movements in the documentation and identifies critical points in the development process of specific research areas.<sup>22,23</sup> CiteSpace can design dual-map overlays for journals, cooperation network maps for authors, and calculate citation bursts for concerns.

Excluding documents with too many authors using score counting method in VOSviewer (maximum authors per file: 25). CiteSpace uses the following parameters: time slice (1975–2022), year per slice (1), node type (one at a time), pruning (none), term source (all selection), selection criteria (g-index, k=25), and visualization (cluster view-static, show merged networks).

## Results

### Publication Language

In total, 18,723 articles published in twenty-one languages are included. Of the 18,723 papers, the top 9 published languages are English, Spanish, German, French, Portuguese, Japanese, Korean, Russian and Turkish. Detailed information is provided in Table 1. The others are published in Italian, Indonesian, Greek, Icelandic, Polish, Czech, Serbian, Slovenian, Afrikaans, Hungarian, Slovak, and Slovene, with less than 10 articles in each language.

### Journals and Co-Cited Journals

Co-cited journals are journals that are frequently co-cited by other authors. The 18,723 articles were published in 3103 journals. Table 2 presents the top ten journals and co-cited journals in the hospital medication management field. A total of 2388 (12.75%) articles were published in the top ten journals. AM J HEALTH-SYST PH (678, 3.62%) ranked first, followed by INT J CLIN PHARM-NET (263, 1.40%), BMJ OPEN (245, 1.31%), EUR J HOSP PHARM (236, 1.26%), and PLOS ONE (231, 1.23%). Of the top ten journals, five are from the US, two are from UK and Netherlands, and one is from Belgium. The impact factors of all journals were below 4.000. JAMA-J AM MED ASSOC (5439 co-citations, 2.76%), NEW ENGL J MED (5362 co-citations, 2.73%), LANCET (4176 co-citations, 2.12%), ARCH INTERN MED (3470 co-citations, 1.76%), ANN INTERN MED (2676 co-citations, 1.36%) were the top 5 co-cited journals. Of the top 10 co-cited journals, seven are from the US, nine have more than 2000 co-citations, six have impact factors of more than 10.000, and three have impact factors higher than 100.000.

Figure 1 shows a dual-map overlay of journals. The dual-map overlay method is a visual analysis method for analyzing and contrasting the features of a portfolio of publications.<sup>24</sup> The citation map is on the left, and the cited map is

**Table 1** Top 9 Published Languages of Medication Management

Rank	Languages	Quantities	Percentage
1	English	16,940	90.48%
2	Spanish	224	1.30%
3	German	182	0.97%
4	French	177	0.95%
5	Portuguese	70	0.27%
6	Japanese	30	0.16%
7	Korean	19	0.10%
8	Russian	19	0.10%
9	Turkish	13	0.07%

**Table 2** Top 10 Journals and Co-Cited Journals in Hospital Pharmacy Administration

Rank	Journal	N (%)	Country	IF (2022)	Co-Cited Journal	Co-Citation	Country	IF (2022)
1	AM J HEALTH-SYST PH	678(3.62%)	USA	2.980	JAMA-J AM MED ASSOC	5439(2.76%)	USA	157.335
2	INT J CLIN PHARM-NET	263(1.40%)	Netherlands	2.305	NEW ENGL J MED	5362(2.73%)	USA	176.079
3	BMJ OPEN	245(1.31%)	UK	3.006	LANCET	4176(2.12%)	UK	202.731
4	EUR J HOSP PHARM	236(1.26%)	Belgium	2.537	ARCH INTERN MED	3470(1.76%)	IRAN	3.138
5	PLOS ONE	231(1.23%)	USA	3.752	ANN INTERN MED	2676(1.36%)	USA	51.598
6	ANN PHARMACOTHER	187(1.00%)	USA	3.463	AM J HEALTH-SYST PH	2539(1.29%)	USA	2.980
7	BMC HEALTH SERV RES	186(0.99%)	UK	2.908	BMJ-BRIT MED J	2372(1.21%)	UK	93.333
8	AM J HOSP PHARM	137(0.73%)	USA	-	PLOS ONE	2187(1.11%)	USA	3.752
9	RSAP	114(0.61%)	Netherlands	3.348	CIRCULATION	2085(1.06%)	USA	39.918
10	J AM PHARM ASSOC	111(1.83%)	USA	2.118	ANN PHARMACOTHER	1894(0.96%)	USA	3.463

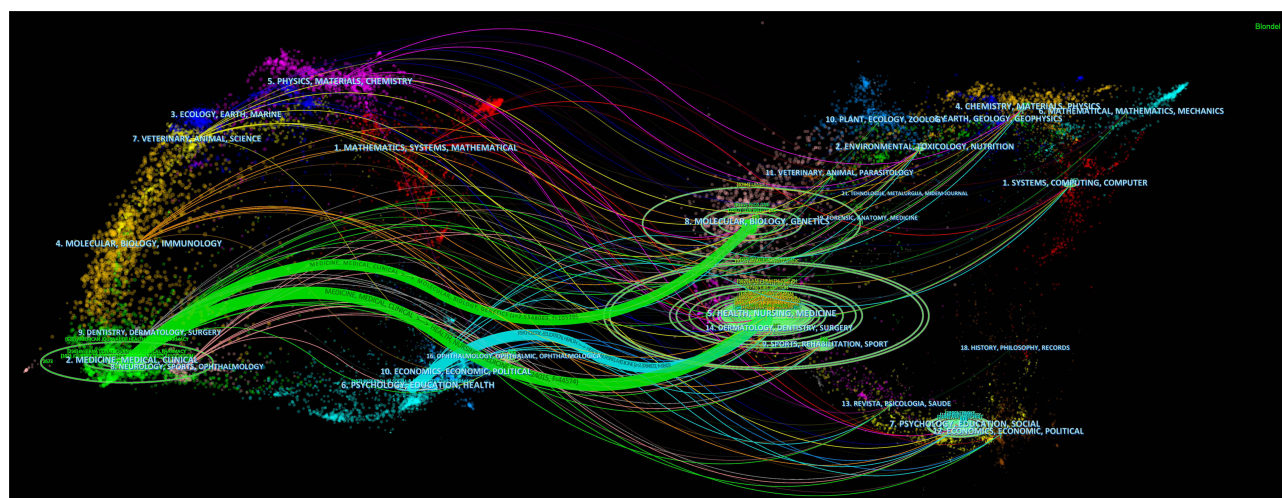
on the right. The colored curves represent the path of the references, starting from the citation map and pointing to the cited map.<sup>24</sup> There were three main citation paths on the current map: (1) medicine, medical, and clinical to health, nursing, and medicine, (2) medicine, medical and clinical to molecular, biology, and genetics, and (3) psychology, education, health to health, nursing, medicine.

## Publication Outputs

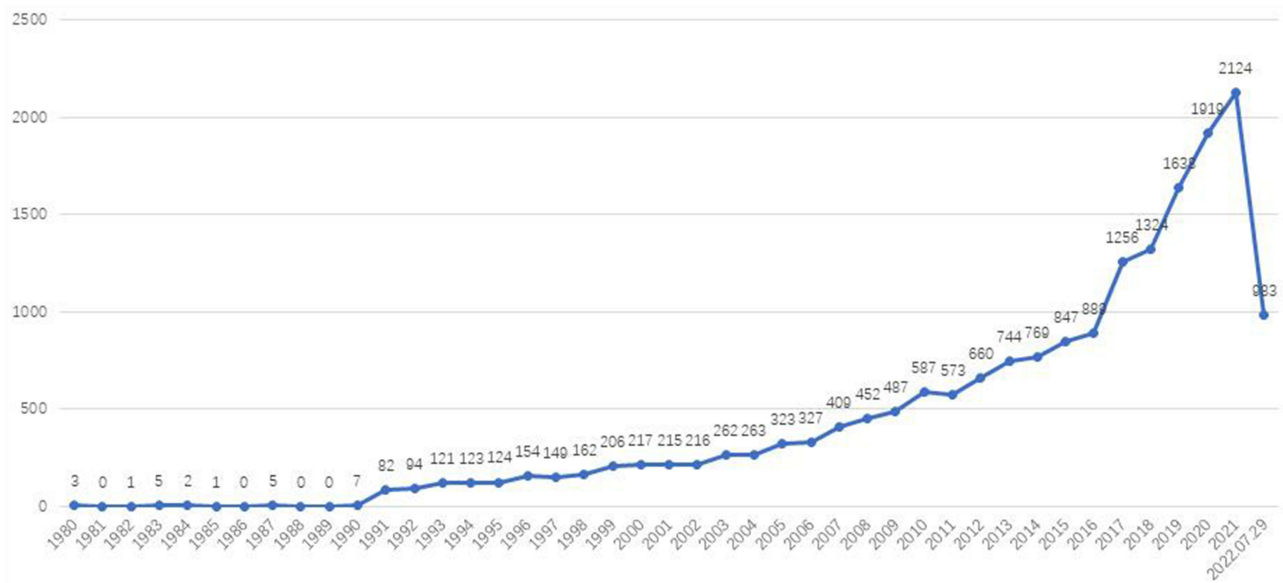
Our dataset contains 18,723 records published from 1980–2022 (Figure 2). These records collectively cited 339,003 references. The first study in the hospital medication management field was published in 1980, but less than 10 articles were published each year until 1990 (Figure 2). The number of publications increased slightly between 1991 and 1992, but there are still less than 100 scholarly publications per year. After 1993, yearly publications started growing, especially after 2017. Annual publications have gradually increased from 1256 in 2017, 1324 in 2018, 1638 in 2019, 1919 in 2020, and 2124 in 2021. From 2017 to 2021, 8261 hospital medication management papers were published, accounting for 44.12% of all included articles.

## Authors and Co-Cited Authors

Co-cited authors are those who are cited together, and the author and co-cited author maps reflect messages from influential research groups and potential collaborators.<sup>21</sup> Of the 18,723 articles published, a total of 82,497 authors were obtained. Table 3 presents the top ten authors and co-cited authors. The top ten authors published 400 (2.13%) papers. Manias E 60 (0.32%) was ranked first for the number of submissions published, followed by Peterson ED 47(0.54%),



**Figure 1** The dual-map overlay of journals related to hospital medication management.



**Figure 2** The distribution of the bibliographic records.

Bates DW 43(0.49%), Wang Y 42(0.48%), and Zhang Y 38(0.44%). WHO ranked first of the top 10 co-cited authors, with 1492 (3.95%) citations, followed by Bates DW (656 citations, 1.74%), Leape LL (569 citations, 1.51%), Kohn LT (346 citations, 0.92%), and Kaushal R (309 citations, 0.82%) while the rest of authors had accumulated less than 300 citations. CiteSpace 6.1.R3 was used to map an author network with the selection criteria of g-index (k=25). The network map contains 1396 nodes and 1426 links (Figure 3). To make the focus of the mapping clearer, we clustered the authors by keywords and left the top 10 clusters in the mapping. In addition, there is an active collaboration among the authors with results. Among others, Bates DW and Franklin BD have worked closely together in the field of adverse drug events, Fonarow GC and Peterson ED have worked closely together in the field of acute coronary syndrome, and so on.

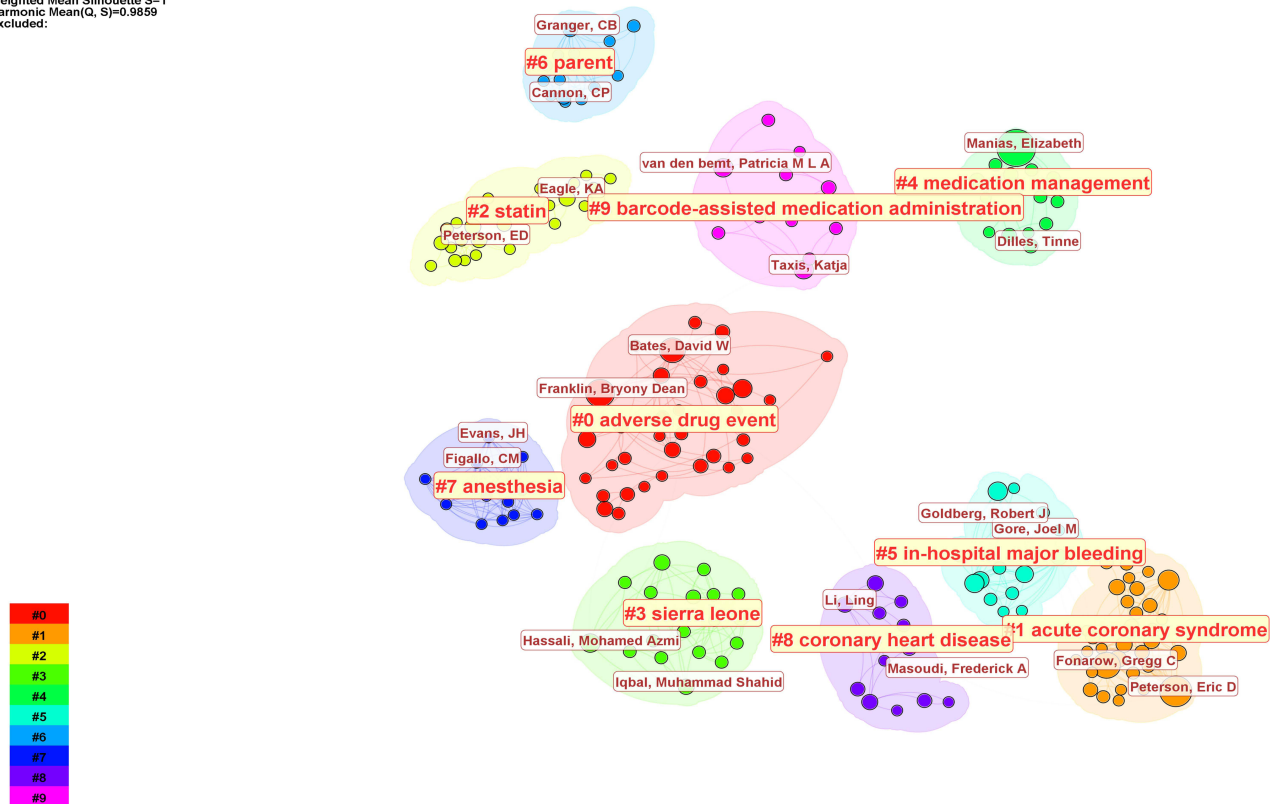
### Countries and Institutions

Documents from Hong Kong, Taiwan, and Macau are included in China, while records from England, Scotland, Wales, and Northern Ireland are included in the UK. Publications in the field of hospital medication management research have been published in 86 countries. The top four countries are the US (6551, 34.98%), the UK (1537, 8.21%), Australia (1231, 6.57%), and China (1158, 6.18%), the other countries published less than 1000 articles (Table 4). A country network map was created, restricted to countries with frequencies greater than ten. As illustrated in Figure 4, the map has

**Table 3** The Top 10 Authors and Co-Cited Authors of Hospital Pharmacy Administration

Rank	Author	N (%)	Co-Cited Author	Citations
1	Manias E	60 (0.32%)	WHO	1492(3.95%)
2	Peterson ED	47(0.25%)	BATES DW	656 (1.74%)
3	Bates DW	43(0.23%)	LEAPE LL	569 (1.51%)
4	Wang Y	42(0.22%)	KOHN LT	346 (0.92%)
5	Zhang Y	38(0.20%)	KAUSHAL R	309 (0.82%)
6	Bond CA	35(0.19%)	BOND CA	273 (0.72%)
7	Franklin BD	35(0.19%)	CHARLSON ME	243 (0.64%)
8	Fonarow GC	34(0.18%)	MORISKY DE	233 (0.62%)
9	Li L	34(0.18%)	YUSUF S	228 (0.60%)
10	Lee JH	32(0.17%)	BARKER KN	226 (0.60%)

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 WoS: D:\a\工作\论文\相关\sci\医院药事管理\data  
 Timespan: 1980-2022 (Slice Length=1)  
 Selection Criteria: g-index (k=5), LRF=3.0, L/N=10, LBY=5, e=1.0  
 Network: N=1398, E=1426 (Density=0.0015)  
 Largest 5 CCs: 189 (13%)  
 Nodes Labeled: 1.0%  
 Pruning: None  
 Modularity Q=0.9722  
 Weighted Mean Silhouette S=1  
 Harmonic Mean(Q, S)=0.9859  
 Excluded:



**Figure 3** The network map of authors for hospital medication management.

84 nodes and 1298 links. These 84 countries comprise 6 clusters, and there is active cooperation between countries and clusters.

17,648 institutions published 18,723 papers. The top 10 institutions published a total of 2183 (11.66%) articles, including six institutions from the US, three from Australia, and one from Canada (Table 4). Among the top ten institutions, Harvard Univ (410, 2.24%) has the highest number of outputs, followed by Univ Toronto (211, 1.13%), Monash Univ (206, 1.10%), Brigham & Women's Hosp (204, 1.09%), and Univ Calif San Francisco (203, 1.08%). The institutions' network map with frequencies higher than 50 has 108 nodes and 1928 links (Figure 5). These 108 institutions were divided into 4 clusters, and there was active cooperation between institutions, particularly between the institutions in the same cluster.

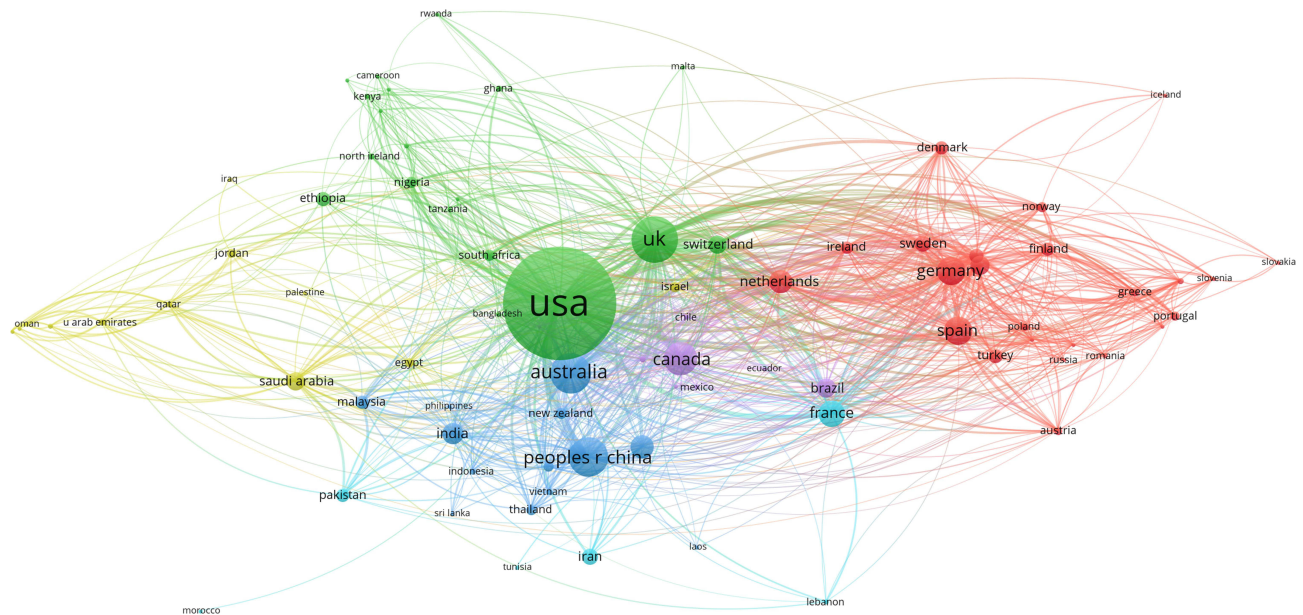
## Co-Cited References and References with Citation Bursts

Co-cited references are those references that are co-cited in a group of publications. Table 5 lists the top ten co-cited references in the hospital medication management. All ten references were co-cited more than 30 times. One reference<sup>25</sup> was co-cited more than 60 times, six<sup>26-31</sup> were co-cited between 40 and 50 times, and three<sup>32-34</sup> were co-cited in the range of 30 and 40 times. References with citation bursts are documents that have been cited frequently over a while. References with citation bursts are documents that have been cited frequently over a while. Set the minimum duration of citation burst to 5 years in CiteSpace with the g-index (k=25) as the selection criterion, and 56 references with strong citation bursts were found

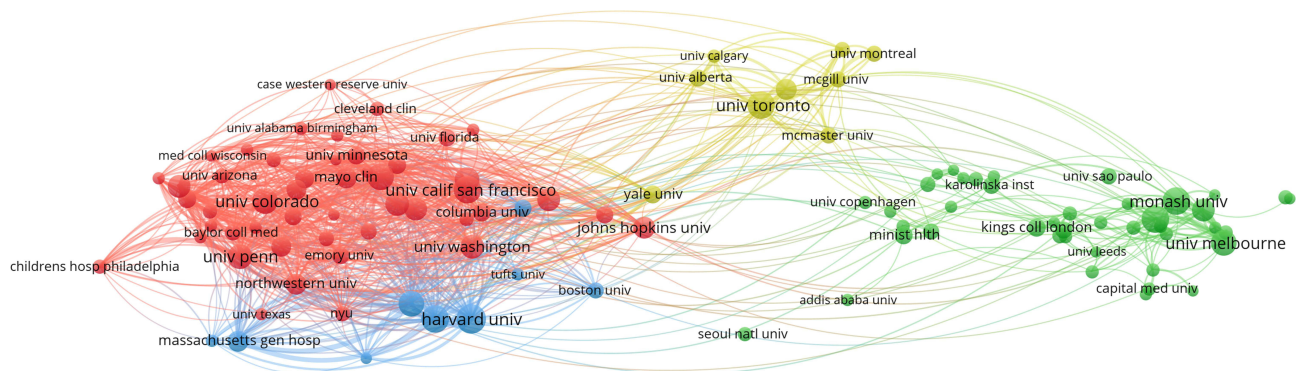
**Table 4** The Top 10 Countries and Institutions Contributed to Publications of Hospital Pharmacy Administration [n (%)]

Rank	Country	N (%)	Institution	N (%)
1	USA	6551 (34.98%)	Harvard Univ (USA)	410(2.24%)
2	UK	1537(8.21%)	Univ Toronto (Canada)	211(1.13%)
3	Australia	1231(6.57%)	Monash Univ (Australia)	206(1.10%)
4	China	1158(6.18%)	Brigham & Women's Hosp (USA)	204(1.09%)
5	Canada	899 (4.80%)	Univ Calif San Francisco (USA)	203(1.08%)
6	Spain	661 (3.53%)	Univ Sydney (Australia)	200(1.07%)
7	Germany	651 (3.48%)	Duke Univ (USA)	199(1.06%)
8	France	583 (3.11%)	Univ Melbourne (Australia)	187(1.00%)
9	Japan	480 (2.56%)	Univ Colorado (USA)	185(0.99%)
10	Netherlands	475 (2.54%)	Univ Penn (USA)	178(0.95%)

(Figure 6). In Figure 6, the blue line denotes the timeline. The red line indicates the period when the literature bursts in, and the ends of the line indicate the first and last years of duration.<sup>35</sup> Citation bursts in the hospital medication management field emerged in 1990, and the strongest burst in 2017 resulted from a paper in 2016.<sup>25</sup> Approximately 80% of the references were cited in the post-2000 burst. The last time the citation burst occurred was in 2017.



**Figure 4** The network map of countries for hospital medication management.



**Figure 5** The network map of institutions for hospital medication management.

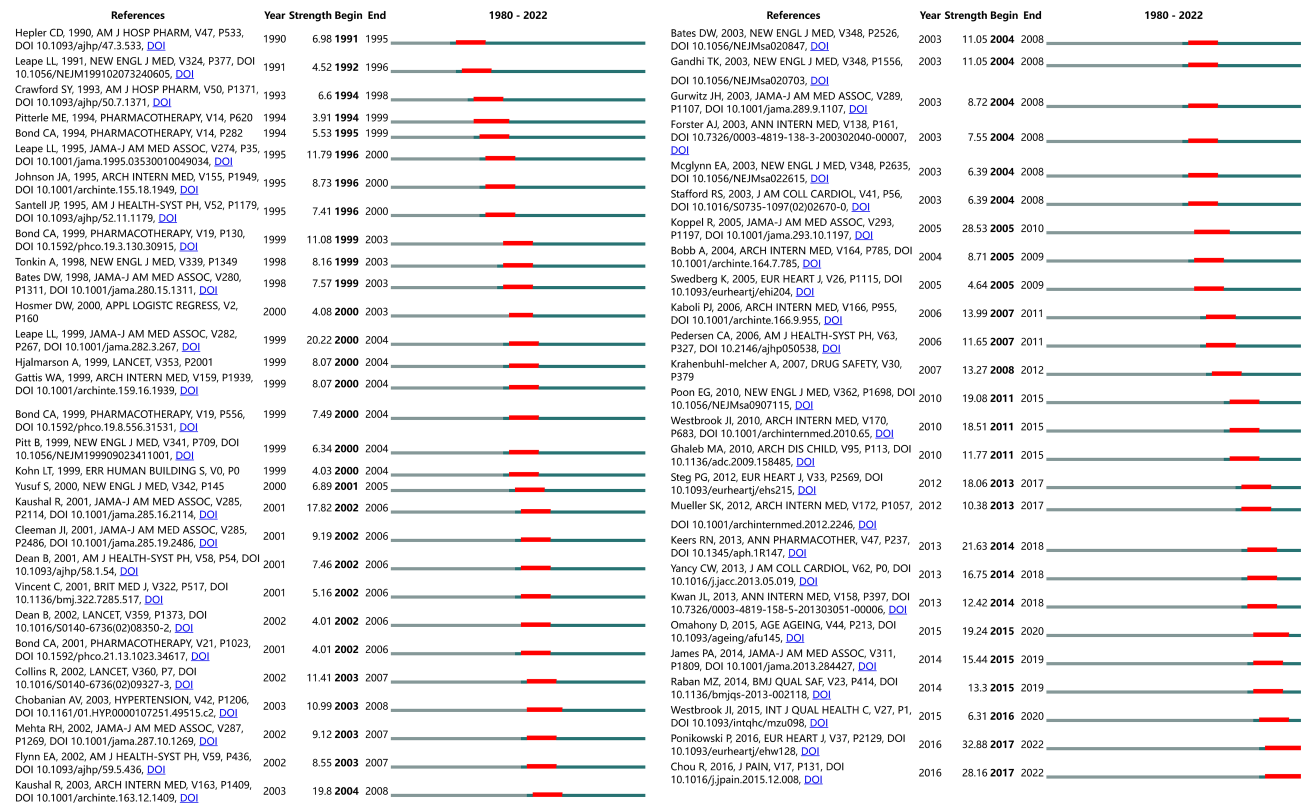
**Table 5** Top 10 Co-Cited References Related to Hospital Pharmacy Administration Field

Rank	Co-Cited Reference	Co-citation
1	Ponikowski P, 2016, EUR HEART J, V37, P2129	63
2	Chou R, 2016, J PAIN, V17, P131	54
3	Koppel R, 2005, JAMA-J AM MED ASSOC, V293, P1197	51
4	Masnoon N, 2017, BMC GERIATR, V17, P0	43
5	Radcliff S, 2015, J AM GERIATR SOC, V63, P2227	42
6	Zhou F, 2020, LANCET, V395, P1054	40
7	Keers RN, 2013, ANN PHARMACOTHER, V47, P237	40
8	O'mahony D, 2015, AGE AGEING, V44, P213	39
9	Fick DM, 2019, J AM GERIATR SOC, V67, P674	38
10	Ravn-Nielsen LV, 2018, JAMA INTERN MED, V178, P375	37

### Co-Occurrence Keywords and Cluster Analysis

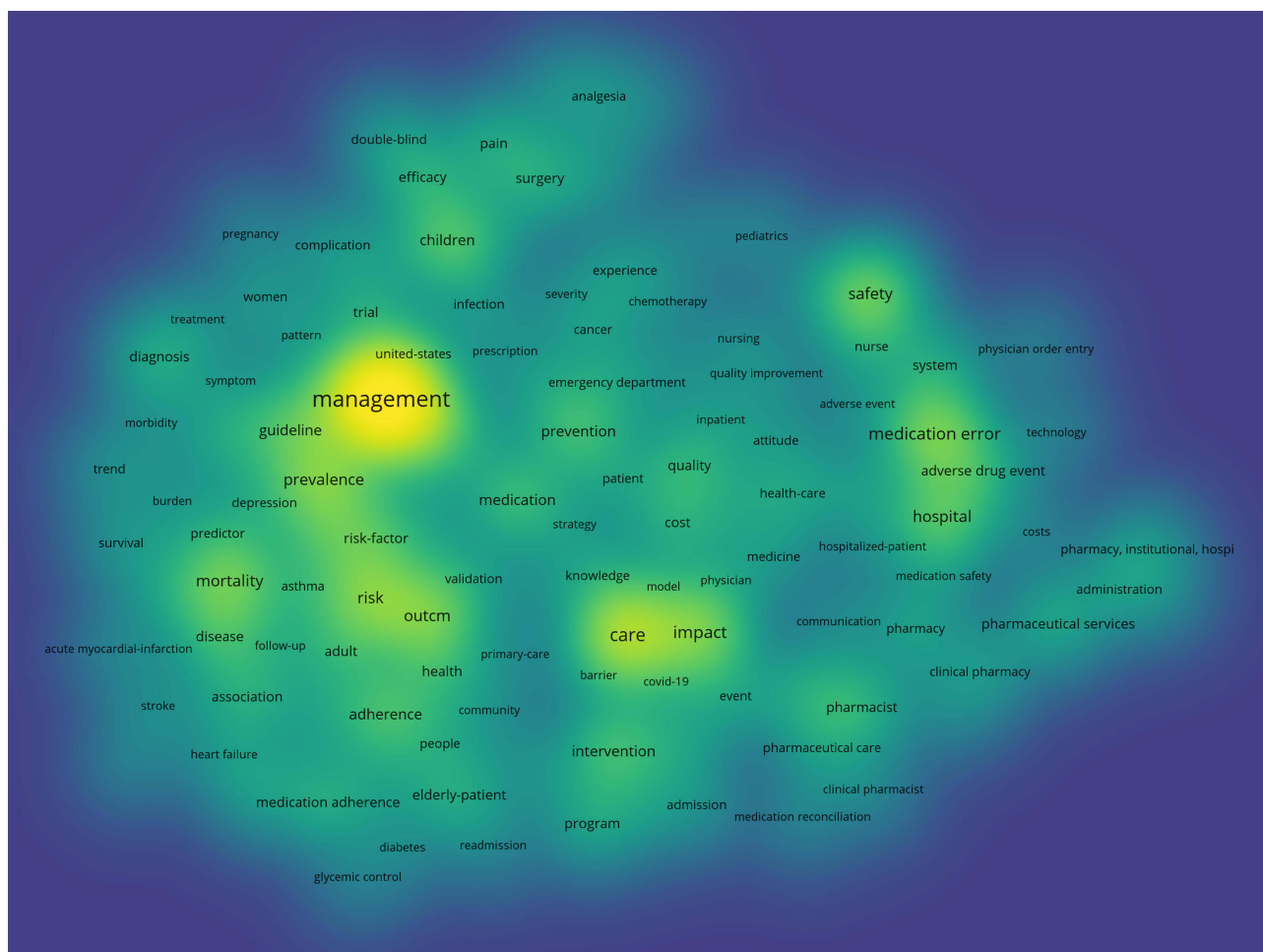
35,370 keywords were retrieved from 18,723 papers. After careful examination, the keywords were filtered and cleaned. The terms “quality of life, quality-of-life”, “older-adult, elderly, elderly-patient”, “patient safety, safety”, “error, medication errors, medication error”, “pharmacists, pharmacist”, “hospitals, hospital”, “pharmacy service, pharmaceutical services”, “emergency-department, emergency department” merged, the principle of merging is to make the keywords that appear less frequently integrate into the keywords that occur more often. A density map was created with the keywords that co-occurrence more than 150 times, for a total of 131 keywords (Figure 7). As Figure 7 and Table 6 show, Management was the most important keyword, with 4193 (11.85%) co-occurrences, followed by Care (1846, 5.22%),

**Top 56 References with the Strongest Citation Bursts**



**Figure 6** Top 100 references with strong citation bursts.



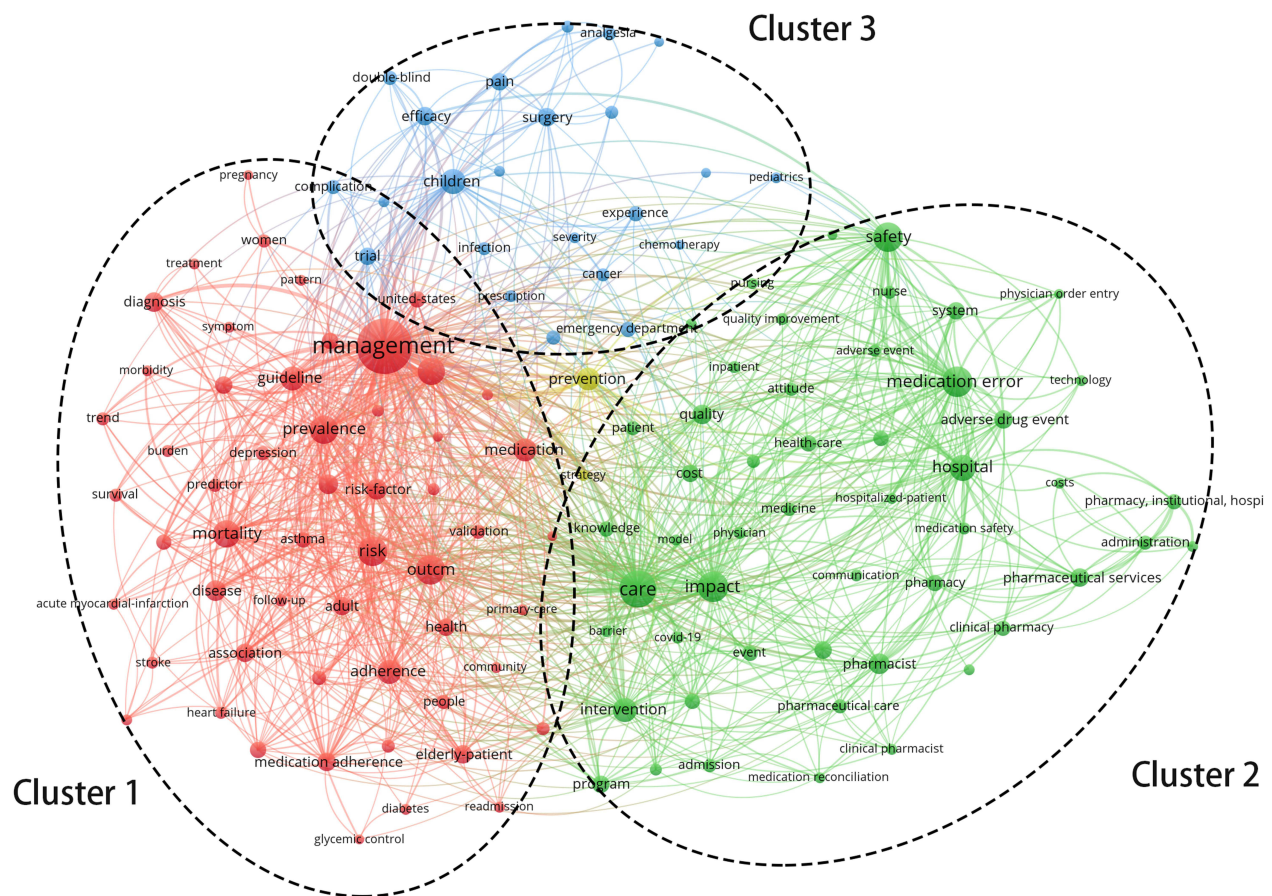


**Figure 7** The density map of keywords for hospital medication management.

Medication Error (1274, 3.60%), Impact (1249, 3.53%), Safety (1182, 3.34%), Risk (1148, 3.25%), Prevalence (1067, 3.02%), Mortality (1053, 2.98%), and Therapy (1034, 2.92%). In the top 20 keywords, some are related to medication behaviors in treating diseases, such as medication error, therapy, guideline, intervention, medication, prevention, disease, and pharmacist. Others are told of the effect of differences in the use of pharmaceutical management methods on patient outcome indicators such as management, impact, safety, risk, prevalence, mortality, and risk factor.

**Table 6** The Top 20 Keywords in Terms of Frequency for Hospital Pharmacy Administration

Rank	Keyword	N (%)	Rank	Keyword	N (%)
1	Management	4193(11.85%)	11	Hospital	933 (2.64%)
2	Care	1846(5.22%)	12	Children	891(2.52%)
3	Medication Error	1274(3.60%)	13	Guideline	795(2.25%)
4	Impact	1249(3.53%)	14	Adherence	786(2.22%)
5	Safety	1182(3.34%)	15	Intervention	770(2.18%)
6	Risk	1148(3.25%)	16	Medication	734(2.08%)
7	Outcm	1141(3.23%)	17	Prevention	706(2.00%)
8	Prevalence	1067(3.02%)	18	Risk-factor	606(1.71%)
9	Mortality	1053(2.98%)	19	Disease	593(1.68%)
10	Therapy	1034(2.92%)	20	Pharmacist	570(1.61%)



**Figure 8** The network map of keywords for hospital medication management.

Cluster analysis of co-occurring keywords was conducted, and VOSviewer mapped the network map. After computing, a keywords' network map with more than 150 occurrences was mapped. There were 131 nodes and 7359 links on the network map. These 131 high-frequency keywords were grouped into 4 clusters, and we showed the three biggest clusters in Figure 8. Cluster 1 is the red node which is the largest cluster that includes 55 keywords, mainly related to management, prevalence, mortality, medication adherence, quality-of-life, elderly-patient, hypertension, epidemiology, and polypharmacy. Cluster 2 is the green nodes which contained 51 keywords, including medication error, adverse drug event, pharmaceutical services, clinical pharmacy, pharmaceutical care, hospital pharmacy, medication safety, and medication reconciliation. Cluster 3 is the blue node with 23 keywords, mainly related to cancer, pain management, analgesia, postoperative pain, prescription, anesthesia, chemotherapy, and pharmacokinetics. Cluster 4 contained less than three keywords, so we will not list them here.

## Discussion

A comprehensive document search was performed in the WoS for this study. 18,723 articles published in 3103 journals in twenty-one languages were searched. The average number of articles per journal was 6.03. Only 13.86% of journals published more than 10 papers. Correspondingly, 15.86% of the journals published two works, while 40.75% of journals only contributed one paper. This suggests that most journals published a few hospital medication management studies. American Journal of Health-system Pharmacy was the most prolific journal, it published 678 articles. Five of the top ten journals are from the US, while seven of the top 10 co-cited journals are from the US, suggesting that American journals published the most studies and attracted the most co-citations. Three of the top 10 co-cited journals are also in the top 10 journals, and of these 10 co-cited journals, six's impact factors are higher than 10.000. Three of them had impact factors higher than 100.000, indicating that the high-impact journals are more frequently co-cited and have greater influence in

the field. The reason is that the US has richer social and medical resources and more relevant talents, and at the same time, the economic strength of the US is second to none, so the US performs better in all aspects of this field and plays a leading role.

Changes in the number of scientific publications reflect changes in specific areas based on bibliometrics.<sup>36</sup> The first hospital medication management study was published in 1980. However, until 1990, the number of publications was fewer than or equal to 10 per year, indicating a slow development in the field. The number of publications increased after 1991, but until 2006 there were still less than 100 scholarly outputs per year. After 1993, the number of articles per year began to grow. From 2017 onwards, in particular, the number of publications increased from 1256 (6.71%) in 2017 to 2124 (11.34%) in 2021. The main factor contributing to this development is that in 2016, the CDC published guidelines for the use of opioids in the treatment of chronic pain,<sup>37</sup> which triggered a series of articles discussing the rationale for the clinical use of opioids,<sup>38,39</sup> followed by a greater focus by scholars after 2017 on the role pharmacists<sup>40</sup> and hospital pharmacies<sup>41</sup> in patient care and hospital management. In 2015, Barack Hussein Obama proposed THE PRECISION MEDICINE INITIATIVE and allocated \$215 million for the precision medicine program in the 2016 budget,<sup>42</sup> which raised the importance of hospital pharmacy management, and the research content of hospital pharmacy management is more subdivided and in-depth. Finally, the 2019 epidemic caused by the novel coronavirus has been responsible for the rise in the relevant literature.<sup>43–45</sup> As the focus on hospital pharmacy and pharmacists grows, the number of hospital medication management-related articles continues to rise.

82,497 authors contributed to the 18,723 articles, but 82.56% of the authors published only one piece. The top ten authors only contributed 2.13% of the papers, and none of the authors had more than 100 articles. This indicates a high number of participants but few authors with productive results. Bates DW appeared in the top ten and the top ten co-cited authors, indicating that he is the key researcher in this field. The network map of productive authors reveals active collaboration between lead authors, particularly between authors in developed countries. This result may provide hints for future research in the field of medication management using expert rating methods such as the Delphi expert method as a research method.

17,641 institutions published a total of 18,723 articles from 171 countries. The US, UK, and Australia were the top three countries. Of the developing countries, only China is among the top ten countries, indicating the weak research capacity of developing countries in this area. Developing countries should, therefore, develop strategies and actively learn from developed countries to promote research development in this area. As for the institutional side, the top ten institutions come from four countries, reflecting the relatively homogeneous geographical location of research institutions in this field. None of the institutions come from a developing country. Cluster analysis shows that countries with high output are grouped into 6 clusters, the highly productive institutions were grouped into three clusters, and it has collaborated actively between both countries and institutions.

The developments in a field can be partly described by the articles with citation bursts.<sup>46</sup> The first and most massive burst in 1991 was the result of a paper published in 1990, and the burst was sustained for five years.<sup>47</sup> This article examined the opportunities and responsibilities in pharmaceutical care. It demonstrated that pharmacy, a profession with strong social commitment, can reduce preventable drug-related morbidity and mortality.<sup>47</sup> The most refreshing burst from 1999 relates to a paper published in 1999 by Leape et al.<sup>48</sup> This study authoritatively indicated that in the medical intensive care unit, the rate of adverse drug events caused by prescribing errors is greatly reduced when a pharmacist is present in the room as a full member of the patient's care team. Of the citation burst that happened in 2005, the most substantial one was due to a publication by Koppel R et al in 2005.<sup>27</sup> In this article, the risk of medication errors that may result from the Hospital's computerized physician order entry system was noted for the first time. The most recent and most vigorous burst occurred in 2017 due to a publication by Dowell D et al in 2016,<sup>37</sup> and the bursts continue. This article, issued by CDC members, authoritatively developed guidelines for treating chronic pain with opioids to improve the safety and efficacy of pain management and reduce the risks associated with long-term opioid therapy, which many scientists subsequently used as a reference.

35,370 keywords were extracted from studies on the hospital medication management field between 1980 and 2022. However, over 67.27% of the keywords occurred only once. 6.02% of the keywords appeared more than 10 times, indicating that only a minority of keywords were used more frequently. In bibliometrics, a network map of keyword co-

occurrences could be a reflection of hot topics.<sup>21</sup> Cluster analysis of co-occurrence keywords shows four clusters in this field. Cluster 1 is the largest, containing 55 keywords. There are descriptions of outcome indicators, such as mortality, prevalence, risk-factor, medication adherence, morbidity, and survival. The above indicators are closely related to the clinical use of drugs.<sup>49–52</sup> Therefore, many articles use the indicators mentioned above to evaluate the rationality of the clinical use of drugs. Cluster 2 consists of 51 keywords, focusing on the hospital pharmacy service behaviors, such as medication error, adverse drug event, pharmaceutical services, clinical pharmacy, pharmaceutical care, hospital pharmacy, medication safety, and medication reconciliation. These behaviors are closely related to hospital medication management, and the quality of hospital medication management determines the occurrence or non-occurrence of these behaviors.<sup>53–57</sup> Therefore, hospital-drug-use behavior has also become a popular research topic. Cluster 3 includes 23 keywords, mainly related to medication use in pain management, such as cancer, pain management, analgesia, postoperative pain, prescription, anesthesia, chemotherapy, and pharmacokinetics. It is well known that drugs need to be used with great care during pain management to avoid side effects such as addiction and provide as much pain relief as possible and improve the patient's quality of life.<sup>58–62</sup> Therefore, medication management in the pain management process has also become a hot research topic for scholars. In addition, more recent keywords focus on chronic disease medication management as well as clinical medication management, such as diabetes, glycemic control, clinical pharmacist, and medication reconciliation. This indicates that with the continuous progress of society, chronic diseases have become an important factor affecting people's health, and medication management is becoming more and more segmented.

To summarise the above analysis, trending topics in hospital medication management are outcome indicators, hospital pharmacy service behaviors, and medication use in pain management. The government and researchers in this field should pay more attention to the development of policies about chronic diseases and the development of precision medicine.

## Strengths and Limitations

To our knowledge, this is the first study to conduct a bibliometric analysis of hospital medication management. Three visualization tools were used to explore research hotspots in the field and communication and collaboration between authors, countries, and institutions to get a comprehensive picture of the current status and trends in hospital medication management. However, this study has a degree of limitations. First, the data were from one single source, retrieved only from WoS. However, the amount of data we included was sufficient to analyze the current state of hospital medication management. Second, the languages included in the study were mostly English, and relevant articles in other languages may not have been included in their entirety.<sup>63</sup> Hence, it may be that our results do not apply to studies that are published in other languages.<sup>64</sup> Last, as some keywords have different formulations, we have standardized them as far as possible, but bias may still be present.

## Conclusions

The quantity of hospital medication management-related publications has been growing rapidly since 2017. AM J HEALTH-SYST PH, INT J CLIN PHARM-NET, and BMJ OPEN are the three most prolific journals. JAMA-J AM MED ASSOC, NEW ENGL J MED, and LANCET are the three most prolific co-cited journals. Manias E is the most productive author, and WHO ranks first among co-cited authors; Bates DW is the most decisive and influential authors in the field. There is active collaboration between principal authors, particularly between authors from the developed world. The US leads this research area, contributing 34.98% of all the publications. Six of the top ten institutions in terms of the number of publications are from the US, which highly contributes to the development of research in hospital medication management. The higher-output countries are grouped into 6 clusters, and the higher-output institutions are grouped into 4 groups, with active collaboration between both countries and institutions. Outcome indicators, hospital pharmacy service behaviors, and medication use in pain management are the main hot topics. With the continuous progress of society, chronic diseases have become an important factor affecting people's health, and medication management is becoming more and more segmented. The government and researchers in this field should pay more attention to the development of policies about chronic diseases and the development of precision medicine.

## Acknowledgment

We would like to thank the Evidence-Based Medicine Center of Lanzhou University for its guidance.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Funding

This work was supported by the 2021 Lanzhou University Party Building Research Project (LZUDJ-202117) and the 2021 Lanzhou University First Hospital Intramural Fund Project (ZX-62000002-2021-25).

## Disclosure

All authors declare that they have no conflicts of interest.

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