Observational Study

Medicine

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Visual analysis of patient safety research hotspots and trends in the context of telemedicine based on Web of Science

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Abstract

To analyze the research status, hotspots, and trends of patient safety in the context of international telemedicine, and to provide reference for future research in various countries. The literature pertaining to patient safety within the realm of telemedicine was systematically retrieved from the Web of Science core collection database, encompassing the period from January 2010 to December 2023. Visual analysis of publication quantity, primary authorship, and keyword trends was conducted using CiteSpace (6.2R6) software. The geographical distribution of research focus was visualized through VOSviewer software and SCImago Graphica software, while research institutions were depicted using VOSviewer software and Highcharts software. Data organization was facilitated by Excel 2019 software. A total of 5356 related articles were included, and the number of published papers showed an overall upward trend, and the countries and institutions with the largest number of papers were the United States and Harvard University, respectively, and a stable core author research population had not yet been formed in this research field. Through keyword analysis, it can be seen that the research hotspots mainly focus on the research on the influencing factors of patient safety in the context of telemedicine, the research on the application value of telemedicine, and the research on coping strategies that affect patient safety. The research on patient safety in the context of telemedicine in foreign countries has a certain depth and breadth, which has important reference significance for improving the medical quality and patient safety of Internet hospitals in various countries.

Abbreviations: LLR = The log-likelihood ratio, SCIE = Science Citation Index Expanded, SSCI = Social Science Citation Index, TLS = Total link Strength, WHO = World Health Organization, WOS = Web of science.

Keywords: bibliometrics, patient safety, telemedicine, visual analytics, Web of science core database

1. Introduction

The emergence of telemedicine in the 1970s marked the advent of a new patient-centered medical service system, which utilizes electronic information and communication technology to expand access to medical treatment and information. This system integrates remote monitoring, treatment, education, and diagnosis with the aim of improving medical care and promoting patients' self-management of their conditions.[1] The increasing integration of Information and Communication Technology in healthcare has raised concerns about patient safety within Internet-based healthcare systems.[2,3] The inherent uncertainty, complexity, and virtual nature of the Internet may give rise to legal, ethical, and technical risks within telemedicine practices that could impact patient safety. According to World Health Organization(WHO) data, diagnostic errors in outpatient physical care account for approximately 5% of cases; however, the virtual nature of Internet hospitals may increase the risk of misdiagnosis.[4] Abramson's study[5] highlighted how vigilance fatigue, default dosing practices, as well as inaccurate or incomplete drug lists can elevate error rates. Odukoya's investigation[6] into e-prescribing errors at 5 community pharmacies in the United States revealed potential consequences associated with such errors. Drake[7] emphasized concerns regarding technical barriers limiting certain services provided by video telemedicine systems - particularly impacting lower-impact institutions, rural users,and elderly patients. Agha's analysis[8] suggested that telemedicine might have a negative impact on doctor-patient communication. Stanberry[9]

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All data generated or analyzed during this study are included in this published article (and its supplementary information files).

This study was completed independently by this group and is in no way plagiarized; citations of other results are noted. If this paper involves intellectual property disputes, the personnel of this research group will be fully responsible.

This study is based on the visual analysis of the public database WOS, and the data are all from the database, and do not involve human and animal experiments. Therefore, no ethical approval is required for this study.

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identified areas where telemedicine introduces new clinical risks and legal liabilities.

To sum up, patient safety in telemedicine is a complex issue involving people, organizations, machines, tasks, internal and external environments, etc. In addition to the impact of medical service providers,[10] patients themselves[11] and social aspects[12] in physical medical institutions on patient safety, There are also new problems brought about by telemedicine such as technical support, complex user interfaces, and special patient privacy rights. Therefore, patient safety in telemedicine is an urgent and serious public health issue.

Through citation analysis, this study can reveal the internal connections between some important disciplines, predict the development direction of patient safety in the context of telemedicine, and provide a new research method for the research of bibliometrics and scientometrics. At present, the commonly used citation databases include Web of Science (WOS), Scopus, Google Scholar, and Pub Med. Pub Med mainly focuses on life science and biomedical disciplines, with a narrow scope and coverage. The number of literatures is small, and most of them are included in multidisciplinary citation databases such as WOS and Scopus.[13,14] The current coverage of Google Scholar is unclear, lacks citation analysis tools, and incorporates nonscientific content that is not peer-reviewed.[15,16] At the same time, Google Scholar lacks tools to perform advanced search and keyword optimization.[17] Halevi[18] and Bar-Ilan[19] also stated in their review that although the coverage of Google Scholar has significantly expanded; however, the quality of resources and overall policies for indexing are still unknown, so it should not be used as a tool for bibliometric analysis at present. WOS and Scopus are the 2 most widely used multidisciplinary citation databases.[20–22] In recent years, many studies have compared and analyzed the 2 databases, WOS and Scopus, in terms of literature coverage, literature content quality, citation analysis function, and data extraction tools. Scopus is the world's largest peer-reviewed journal abstract and citation database, covering >15,000 journals, books, and conference proceedings in the fields of natural sciences, life sciences, medicine and social sciences.[23] WOS is a large comprehensive, multidisciplinary, core journal citation index database. These include Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI), Arts and Humanities Citation Index, and 2 factual databases of chemical information and Conference Proceeding Citation Index-Science and Conference Proceeding Citation Index-Science and Humanities. In terms of collection time, WOS included all literature after 1900,[24] while Scopus only included literature after 1970.[25] In terms of literature quantity and quality, although AlRyalat[14] pointed out that Scopus retrieved more literature under the same retrieval conditions, Mika[26] found that WOS had higher literature quality and more accurate citation data than Scopus database. Duplicate publications are a serious problem for Scopus. Okagbue et al[27] made an analysis of the literature index gap between WOS and Scopus in 6 subject fields and found that the number of literature in WOS was higher than that in Scopus in the 4 fields of information science, medicine, demography, and environmental engineering. Lopez-Illescas et al[28] also found that WOS is a subset of Scopus in the medical field, but it tends to cover the best journals in terms of the citation impact of each paper. Zhang et al[29] pointed out that WOS and SCIE databases are the best databases for bibliometric data, including >12,000 high-impact, high-quality international scientific journals.

Therefore, based on the WOS core collection database, this study uses CiteSpace, VOSviewer, SCImago Graphica, and Highcharts software to conduct dynamic and visual analysis of its research. To explore the development trend and research hotspots of patient safety in the context of telemedicine at home and abroad, so as to provide reference for follow-up research in other countries.

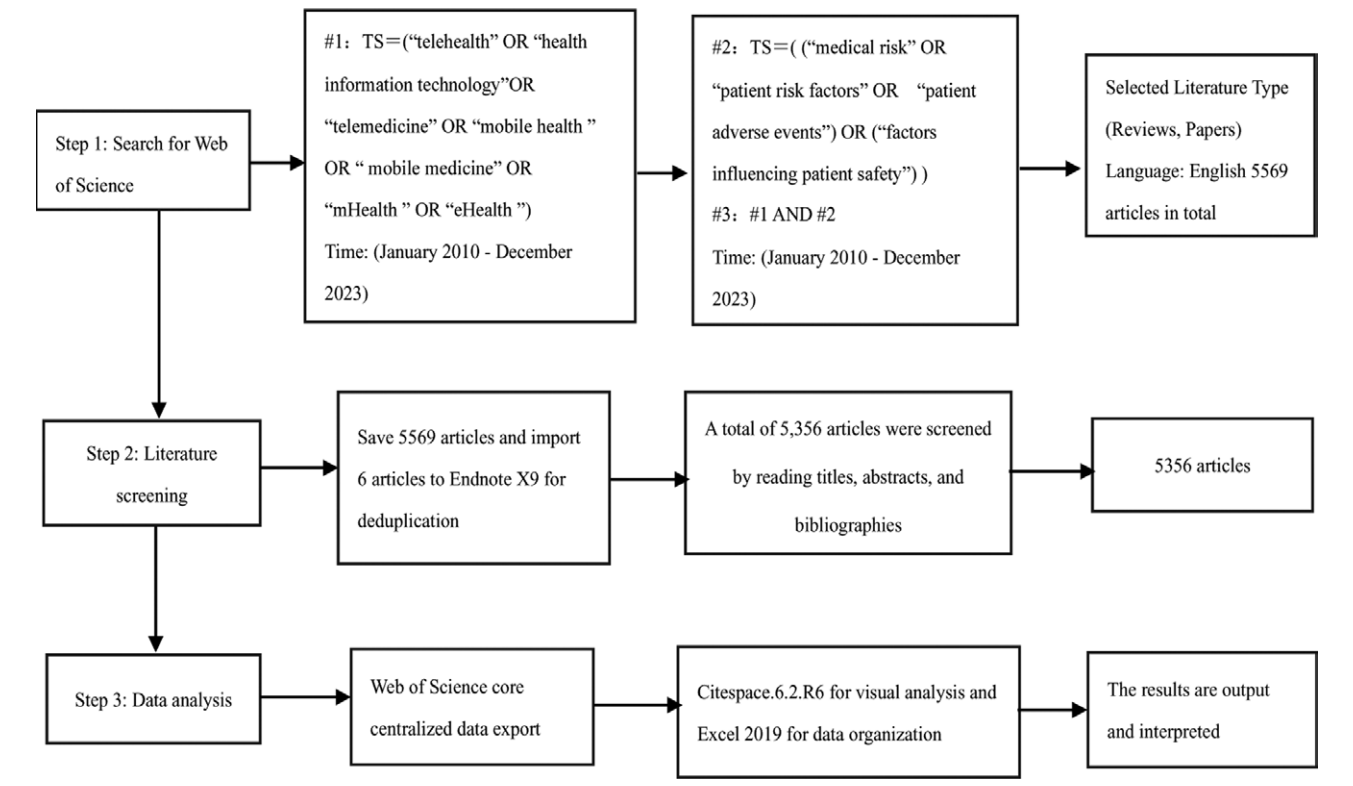
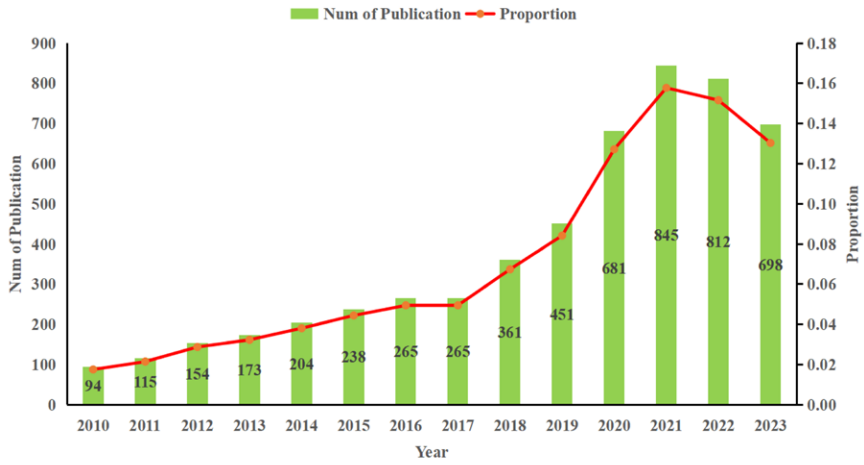


Figure 1. Flow chart of literature screening and data extraction and analysis.



Legend list		
Picture number	**Legend**	**paraphrase**
Figure 2		Number of publications (articles)
		proportion

Figure 2. Annual distribution of patient safety-related literature in the context of telemedicine from 2010 to 2023.

2. Materials and methods

2.1. Sources and search strategies

Search WOS databases for terms TS=("telehealth" OR "health information technology" OR "telemedicine" OR "mobile health" OR "mobile health" OR "mobile medicine" OR "mHealth" OR "eHealth") AND TS=("medical risk" OR " patient risk factors" OR "patient adverse events" OR "factors influencing patient safety") with article type and language of "English." The search period was limited to January 2010 to December 2023.

2.2. Literature selection criteria

Inclusion criteria included the following: (1) the study subjects were patients and the study content was related to patient safety in the context of telemedicine; (2) published literature; exclusion criteria: (1) conference papers, abstracts, letters, notices, reviews, news reports and other literature; (2) republished or retracted literature; (3) literature with missing contents. A total of 5569 related literature was retrieved, and 5356 English literature was finally included by using Endnote X9 software to deduplicate, and read abstracts and bibliographies, and when there was disagreement after double verification, a third party would view the full text. The specific process is shown in Figure 1

2.3. Data analysis

The full records and cited references of 5356 English literature data screened in the WOS database were exported in "RefWorks" format, the exported literature data was named "download_txt," and the information visualization analysis software Citespace developed based on Java language was used to draw the visualization map. The year of the first article in English literature is 2010, so the time span of parameter setting is January 2010 to December 2023, the time slice is selected as "1," the authors and keyword thresholds were selected as TopN: 50, and the clipping method is Pathfinder + Pruning the merged network. The synonyms of the keywords were combined, and the log-likelihood ratio method was selected as the clustering method. The rest of the parameters are the default settings. VOSviewer software and SCImago Graphica software were used to visualize the number of national publications and total link strength (TLS). VOSviewer software and Highchaarts software were used to display the top ten institutions, Total link strength (TLS), and total citations. Utilize Excel software for data collation.

Table 1

The top 10 authors and papers published in the literature on patient safety in the context of telemedicine from 2010 to 2023.

Rank	Author	Number of papers published (number of papers)
1	Hardeep Singh	18
1	Gregory Y.H. Lip	18
1	David W. Bates	18
4	Julie Redfern	16
5	Dean F. Sittig	15
6	Aziz Sheikh	14
7	Lis Neubeck	12
8	Hayden B. Bosworth	11
9	Anushka Patel	10
10	Philippe Courtet	9

3. Results

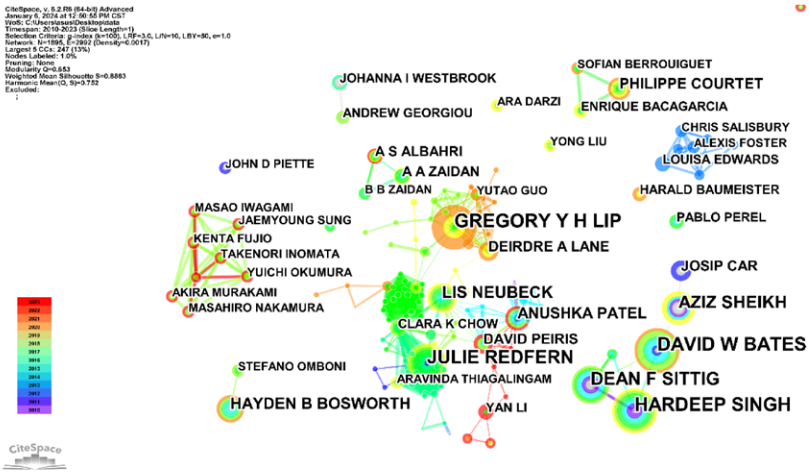
3.1. Analysis of the number of literature and its change trend

To a certain extent, the number of papers published annually can reflect the research status in related fields and the research hotspots and priorities in a certain period of time.[30] According to the search strategy and literature selection criteria, a total of 5356

records were exported, and the annual number of published papers showed an overall upward trend. The first stage (2010–2021) is a continuous growth stage, of which the slow growth period is before 2017, and the high-level growth period is after 2017, with the largest number of papers in 2021, as high as 845 articles. In the second stage (2021–2023), the number of related publications showed a slow downward trend. See Figure 2 for details.

3.2. Analysis of the number of authors published and their partnerships

Statistical analysis of the core authors of a research field can reveal the main representative scholars and research teams in that research field so that a quick insight into the research field can be obtained. The total number of authors of 5356 articles was 1887, and the number of published articles per person ranged from 1 to 18, among which Hardeep Singh, Gregory Y.H. Lip and David W. Bates contributed the most and published the most articles with 18 articles. The top 10 authors and the number of papers published are shown in Table 1. The co-occurrence map of author collaboration reflects the relationship and intensity of cooperation between authors.[31] The results show (Fig. 3) that the number of nodes N = 1895, the number of connections E = 2992, and the density D = 0.0017 indicate that there is a cooperative relationship between the authors, but the centrality is 0, indicating that the cooperative relationship is not close.



Legend list		
Picture number	**Legend**	**paraphrase**
Figure 3		2023 year
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		2010 year

Figure 3. The author co-produced the picture.

3.3. Analysis of the number of papers published in relevant national literature

A country's overall research capacity, level, and influence can be reflected by the number of published papers and the frequency of citations. The results showed (Fig. 4) that the relevant literature involved researchers from 143 countries, among which the top 5 countries in terms of publication volume were the United States, the United Kingdom, China, Australia, and Germany, especially the United States with 2813 articles. Centrality and total link strength (TLS) are important indicators of the research status of a node. The higher the centrality of a node is, the more intensive the cooperation with other nodes is. When the centrality is >0.1, the country has an important position in the research of patient safety in the context of telemedicine. The higher TLS, the greater the weight used to draw links in the visual analysis, to some extent also reflects the cooperative communication relationship between countries, as shown in Table 2.

3.4. Analysis of the number of papers published in institution-related literature

This study shows that a total of 1668 research institutions participated in the study, of which 109 were published by the

Legend list		
Picture number	**Legend**	**paraphrase**
Figure 4		The number of national publications was 21-329
		The number of national publications was 330-608
		The number of national publications was 609-917
		The number of national publications was 918-1227
		The number of national publications was 1228-1563
		The number of national publications was 1567-1843
		The number of national publications was 1844-2183
		Total link Strength (TLS)

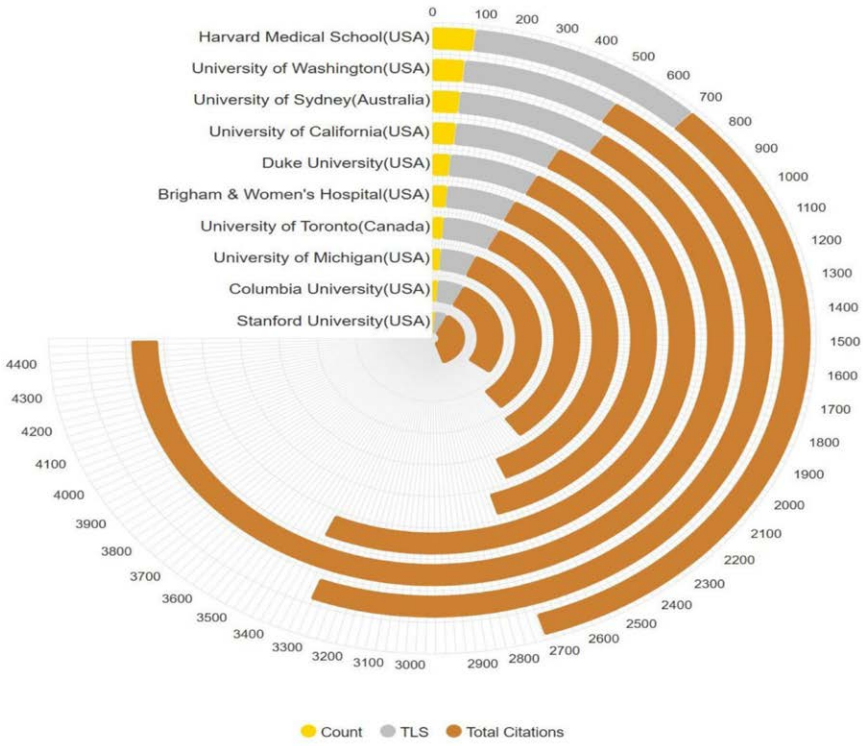
Figure 4. Number of publications and total link strength (TLS) geographic map of patient safety-related countries in the context of telemedicine, 2010 to 2023.

Table 2

The top 10 countries in terms of number of publications TLS and centrality in the literature on patient safety in the context of telemedicine from 2010 to 2023.

Rank	Number of publications	(TLS)	Country	Rank	Intermediary centrality	Country
1	2183	1111	USA	1	0.21	USA
2	677	1123	UK	2	0.11	UK
3	494	331	China	3	0.11	France
4	412	460	Australia	4	0.09	Scotland
5	320	556	Germany	5	0.08	India
6	299	340	Canada	6	0.07	South Africa
7	297	474	Italy	7	0.07	Malaysia
8	220	365	Netherlands	8	0.05	Australia
9	215	390	Spain	9	0.05	Belgium
10	197	352	France	10	0.05	Japan

TLS = total link strength.



Legend list		
Picture number	**Legend**	**paraphrase**
Figure 5		Count
		Total link Strength (TLS)
		Total Citations

Figure 5. Polar bar chart of patient safety-related institutions in the context of telemedicine from 2010 to 2023.

universities with the largest number of papers, followed by 91 and 88 papers, and the top 10 except for the University of Sydney belonged to the United States. Using VOSviewer and Highcharts software, a polar bar chart was made to show the top 10 organizations in the number of publications, total link strength (TLS), and total number of citations (Fig. 5). The top 10 institutions in the world in terms of the number of published papers are all university-affiliated research institutions, indicating that the scientific research level of patient safety in the context of university telemedicine is higher than that of others, which may be related to the presentation of research results on such topics within the organization and personnel training. See Table 3 for details.

3.5. Keyword analysis

3.5.1. Co-occurrence of keywords. Keywords reflect the main research content of the literature, and their intermediary

Table 3

The top 10 institutions in the global telemedicine context by the number of papers published in the global telemedicine context, 2010–2023.

Rank	Research Institutes	Country	Number of publications	TLS	Total citations
1	Harvard Medical School	USA	109	610	1979
2	University of Washington	USA	91	450	2792
3	University of Sydney	Australia	88	488	3891
4	University of California	USA	86	392	2909
5	Duke University	USA	77	385	2245
6	Brigham and Women's Hospital	USA	77	360	2163
7	University of Toronto	Canada	74	371	1939
8	University of Michigan	USA	74	314	1955
9	Columbia University	USA	72	359	1669
10	Stanford University	USA	72	374	2237

TLS = total link strength.

centrality and frequency are important indicators to reflect the research hotspots in this field, and nodes with centrality >0.1 indicate the future research direction of the discipline.[32] The co-occurrence analysis of keywords showed (Fig. 6) that there were 391 nodes and 1067 connections in the graph, and the network density was 0.014. The results showed that "telemedicine" had the highest frequency and "patient safety" had the highest centrality. After merging the synonyms of the keywords, the top 10 keywords are sorted, as shown in Table 4.

3.5.2. Keyword cluster analysis. The log-likelihood ratio (LLR) algorithm was used to simplify the keywords into a small number of clusters, and the results of the clustering analysis showed that the clustering module value was Modularity Q = 0.4334 > 0.3, and the average contour value of clustering was Silhouette = 0.7314 > 0.7, indicating that the clustering was convincing.[33] The keyword timeline map not only reflects the results of the clustering map, but also reflects the evolution of the time zone map, so the Timeline View function of CiteSpace software is used to output the keyword clustering evolution map, as shown in Figure 7.

3.5.3. Keyword burst analysis. Emergent keywords refer to keywords that are frequently used in a short period of time, which can predict the development trend and frontier of research in this field. In Citespace, Burstnes calculated the emergent information of patient safety keywords in the context of telemedicine, and finally obtained 25 emergent words, among which "electronic health records" and "medication errors" were the 2 emergent words with the longest duration and the strongest research frontier. In recent years, the words that have emerged are "pandemic," "medical services," "coronary heart disease," "virtual care," and "sensor," as shown in Figure 8

4. Discussion

4.1. Analysis of the publication status and research strength

From 2010 to 2023, the number of patient safety-related research publications in the context of telemedicine has generally shown an upward trend, indicating that the global attention to it is increasing. Especially since 2019, the number of related publications has been >400, maintaining a high level of output and research popularity. This trend is highly related to the global environment and the relevant policies issued at the same time. In late 2019, the novel coronavirus spread around the world, and although telemedicine consultations could not provide complete medical services, they were widely accepted by patients during special times such as the global coronavirus pandemic.[34] In the face of the pandemic, telemedicine can both maintain continuity of care and ensure the safety of patients and physicians by reducing the risk of infection by avoiding direct contact between patients and healthcare professionals.[35] At the same time, relevant policies have been introduced around the world to support the development of telemedicine. In 2020, China issued the Notice on Doing a Good Job in Internet Diagnosis and Treatment Consulting Services in Epidemic Prevention and Control, which provides policy support and practical needs for China's telemedicine to promote patient safety research. In the analysis of research strength, the formula for calculating the core authors in Price's law is $M0.749 * Nmax^{\frac{1}{2}}$, where M refers to the number of papers, and Nmax refers to the number of papers published by the authors with the largest number of papers in the corresponding years when the number of published papers is more than M and the papers written by the core authors reach 50% of all papers in the field, it means that the core author group has been formed.[36] According to Price's law formula, the number of core authors published is at least 3.18, and there are 106 core authors who meet the conditions, accounting for 10.02% (537/5356), which is lower than the proportion of 50% of the number of core authors published in this law, indicating that a stable core author research population has not yet been formed in this research field. Through further analysis of the co-authorship and co-occurrence diagram of the authors, it can be found that the research on patient safety in the context of telemedicine is still in a state of "partial concentration and overall decentralization," and the cross-citation relationship between various research teams is weak. In today's digital globalization, it is foreseeable that the research topic on telemedicine will continue to deepen in the coming period.

4.2. Analysis of the issuing country and institution

The analysis of high-yield research countries and institutions around the world can help Chinese researchers keep abreast of the latest progress in related research fields, so as to seek foreign core research teams for exchanges and cooperation and promote the development of related research in China. This study shows that most of the top 5 countries are developed countries in the West, among which the United States has the largest number of papers with a node centrality of 0.21, and 9 of the top 10 institutions are from the United States, which shows that the United States has a high influence in this research field. Although China ranks third in the world in terms of the number of publications, its centrality is 0.01, and it is necessary to strengthen cooperation and exchanges with other countries in the future.

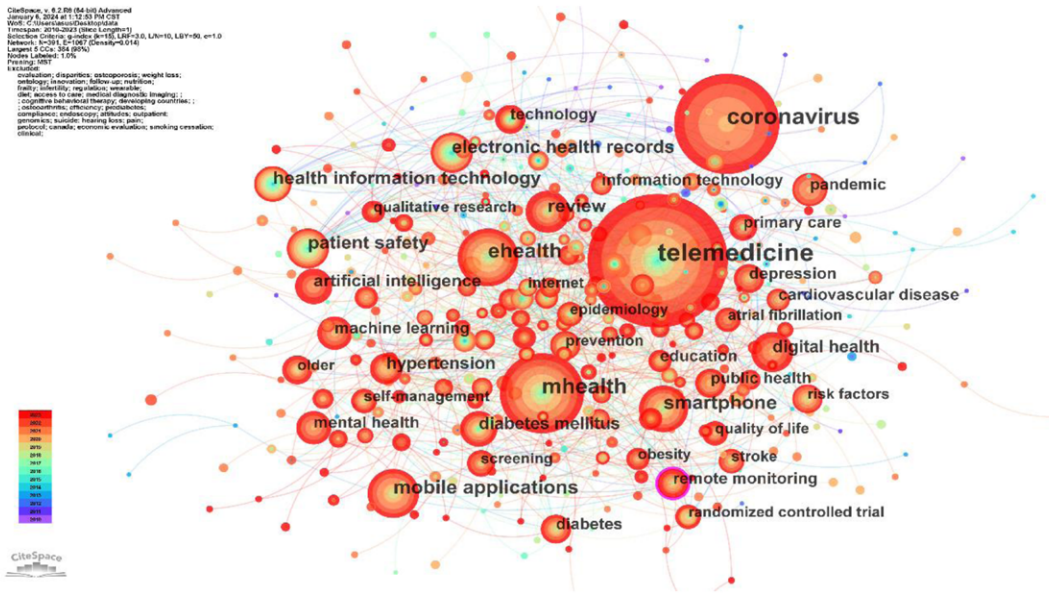


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Figure 6. Keyword co-occurrence analysis.

The top 10 institutions in the world in terms of the number of published papers are all university-affiliated research institutions, and the knowledge graph of the institutional cooperation network shows that the number of nodes is N = 1363, the number of connections is E = 9692, and the density is D = 0.0104. In terms of the main connection points, Harvard University, the University of Washington, the University of Sydney, and the University of California show strong intermediary centrality. It reflects the diffusion of academic influence and academic connections in the field of patient safety-related research in the context of global telemedicine, mainly in the way of cultivating students.

Table 4

The top 10 keywords in the literature frequency of patient safety in the context of telemedicine from 2010 to 2023.

Rank	Keyword	Frequency	Intermediary centrality
1	Telemedicine	1096	0.11
2	Coronavirus	549	0.02
3	Mhealth	414	0.08
4	Ehealth	275	0.17
5	Smartphone	182	0.02
6	Patient safety	170	0.33
7	Review	156	0.05
8	Electronic health records	143	0.17
9	Health information technology	136	0.05
10	Hypertension	107	0.12

4.3. Research hotspots and cutting-edge analysis of patient safety in the context of telemedicine

Combined with the analysis of keyword co-occurrence, clustering, and emergent word distribution map, it can be found that the research objects, research methods, and research contents of patient safety in the context of telemedicine are diverse, and the current and future research hotspots can be summarized into the following 3 aspects: (1) Research on the influencing factors of patient safety in the context of telemedicine. The hotspot includes the keyword "patient safety" and the emergent words "medication errors" and "adverse events." It mainly involves patient privacy and safety issues, related legal and ethical issues, limitations at the level of telehealth technology, and the potential risks posed to patients by some popular mobile applications. Research has shown that telemedicine faces ethical and legal challenges, with issues such as informed consent, patient data protection, medical malpractice, and telemedicine regulations that need to be considered.[37] Among them, ethical and legal issues are more complex and diverse.[38] In recent years, mHealth programs have been developed in large numbers, and despite some initiatives, there are still no specific regulatory procedures, certification systems, or uniform standards to aid in the development of applications and to ensure the quality of applications.[39] This situation can raise issues related to information quality, data security, data privacy, data availability, and validity.[40] Even some wearable devices require patients to disclose sensitive information, such as health information and personal information (location, email, name, etc.).[41] GPs have also stated that the development of these mobile tools has the potential to increase the risk of patient self-diagnosis and self-medication and that wearable devices may contribute to self-monitoring logic, thereby compromising patient autonomy and overall health.[42] However, at present, domestic scholars' research on patient safety in Internet hospitals mainly focuses on the qualitative analysis of the understanding of patient safety in Internet hospitals and the protection of patient privacy, and there is a lack of systematic quantitative research on the identification and evaluation of the influencing factors of patient safety in Internet hospitals. Therefore, in the future, Chinese researchers can use this as a research point to explore quantitative research on the impact of patient safety in the context of telemedicine and improve the level of patient safety. (2) Research on the application value of telemedicine. The hotspots include the keywords "Coronavirus" and "Hypertension" and the emergent words "emergency medicine" and "chronic disease." The novel coronavirus pneumonia epidemic has greatly promoted the use of telemedicine in healthcare visits.[43] In healthcare, the benefits of digitalization outweigh the risks, and the widespread use of telemedicine has become an inevitable trend. At present, it has been widely used in primary care,[44] psychotherapy,[45] transitional care,[46] treatment and management of chronic diseases,[47] and implementation and supervision of rehabilitation training.[48] China has also kept up with the pace of the times and vigorously developed Internet hospitals, which have an important influence in the application of telemedicine. However, there is an imbalance in technological development between regions in China, the development of mobile applications is scarce, and the overall development of telemedicine in the field of neonatal medicine is still in the initial exploration stage, and there are many problems that need to be solved urgently.[49,50] In the future, We should pay attention to technology development, strengthen multi-field and multidisciplinary cooperation, learn from foreign research experience, explore the development of mobile health applications suitable for your country's cultural background, and pay attention to the development of telemedicine in the field of neonatology. (3) Research on coping strategies to promote patient safety under telemedicine. The hot spot includes the keyword "health information technology" and the emerging words "clinical decision support systems," "risk management," "sensor," etc. Telemedicine is a product of the times, and the emergence of new organisms is bound to bring many problems, and we should pay more attention to dealing with them than suppressing them. Foreign countries focus on the development and verification of safety electronic health record assessment tools, the development of mobile application assessment scales, and the improvement of relevant laws and regulations. In recent years, more attention has been paid to randomized controlled studies of various review software,[51] new concepts such as blockchain technology and federated learning to protect the security and privacy of Internet patients,[52] the introduction of human factors in the software design process to reduce patient safety risks while improving the usability and productivity of end users,[53] and the establishment of a cybersecurity risk management framework for telemedicine.[54] Therefore, the enlightenment for the establishment of Internet hospitals is that it is necessary to further formulate and improve the relevant quality control standards and policies of Internet hospitals, strengthen the construction of laws and regulations, promote the innovation of relevant technologies, and strengthen personal information protection measures to ensure the safety of patients.

5. Conclusions

In summary, this paper uses CiteSpace software to conduct quantitative analysis of the relevant literature in this study, objectively shows the research status, rules, content, and hotspots of patient safety in the context of telemedicine, helps researchers quickly grasp the historical context of research in this field, predicts the future development trend, and provides a reference for Chinese scholars to research in this field, but there are certain limitations in research methods. In this study, only the WOS core collection database was analyzed, which may have the problem of incomplete literature collection. In the future, a variety of research methods can be combined to analyze the Chinese and English databases, so as to have a more comprehensive understanding of their research hotspots and development trends.

Author contributions

Conceptualization: Caijin Wen, Jing Zhang.
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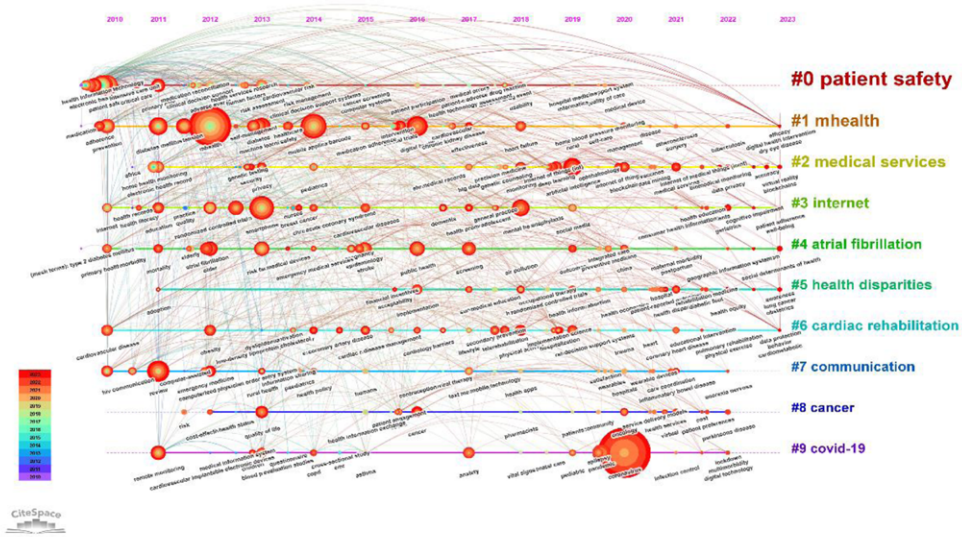
Visualization: Caijin Wen.
Writing—original draft: Caijin Wen, Wenxia Luo, Yan Liu.
Writing—review and editing: Wenxia Luo, Yan Liu, Jing Zhang.
Supervision: Xi Luo, Jing Zhang.
Validation: Jie Li.



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		2010 year

Figure 7. Keyword clustering evolution map of patient safety-related literature in the context of telemedicine from 2010 to 2023.

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2010 - 2023
electronic health records	2010	19.74	**2010**	2018	
medication errors	2010	8.03	**2010**	2018	
decision making	2010	3.01	**2010**	2017	
communication	2011	5.81	**2011**	2016	
home health monitoring	2011	3.99	**2011**	2017	
adverse events	2012	6.3	**2012**	2017	
clinical decision support	2012	3.19	**2012**	2019	
emergency medicine	2012	2.18	**2012**	2014	
risk assessment	2013	4.21	**2013**	2018	
clinical decision support systems	2014	5.69	**2014**	2018	
safety	2014	3.45	**2014**	2017	
chronic disease	2014	3.37	**2014**	2016	
prevention	2010	3.23	**2014**	2015	
risk management	2014	2.71	**2014**	2015	
health information exchange	2015	4.95	**2015**	2019	
medication adherence	2015	3.57	**2015**	2018	
patient participation	2016	3.63	**2016**	2020	
patient safety	2010	8.91	**2017**	2018	
precision medicine	2018	2.85	**2018**	2020	
health apps	2018	2.45	**2018**	2020	
pandemic	2020	7.93	**2020**	2023	
medical services	2021	4.13	**2021**	2023	
coronary heart disease	2021	3.56	**2021**	2023	
virtual care	2021	3.24	**2021**	2023	
sensor	2019	3.1	**2021**	2023	

Legend list		
Picture number	**Legend**	**paraphrase**
Figure 8		There is no emergent stage yet
		The emergence phase begins
		Emergence stage

Figure 8. Prominent word distribution of patient safety-related research in the context of telemedicine from 2010 to 2023. TLS = total link strength.

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