A Visual Analysis of Chinese Internet Healthcare Research Based on Bibliometrics

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Abstract: This study aims to explore the current status, hotspots and trends of research in the field of Internet healthcare in China. We analyzed 1796 related literatures in CNKI database through COOC and Vosviewer visualization tools. The results show that the number of literature is growing and can be roughly divided into three phases: germination, development, and new venture development; the core researchers are generally scattered and national inter-institutional cooperation has not been formed yet; the research hotspots mainly focus on three themes of internet medical information construction, platform application construction and service model management. Further research might focus on digital hospital construction and exploring demand-oriented medical services

Keywords: Internet Healthcare, Visualization Research, COOC, Literature Metrics.

1 INTRODUCTION

Internet healthcare is a general term for a new medical and health service model formed by the deep integration of the Internet as a carrier and information technology with traditional medical services [1]. It plays an important role in improving the medical experience and solving the problems of patients' difficulties in accessing medical care, especially in the ongoing prevention and control of COVID-19, Internet healthcare has shown its unique advantages in maximizing the use of medical resources, reducing crowd gathering and avoiding cross-infection [2]. As Internet technology continues to be integrated with the medical field, more research has been conducted in the field of Internet healthcare, including the analysis of the construction path of Internet hospital informatization [3] and the exploration of Internet-based methods for chronic disease health management [4], but there are few macroscopic reviews of the development path of this field in China. In this paper, with the help of the COOC visualization tool, we will review the general situation of the Internet healthcare field in China from 2011 to 2021, discuss the hotspots and trends of research, to provide a reference for further research in this area.

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2 MATERIALS AND METHODS

The data studied in this paper come from CNKI Chinese database, searched with the theme of "Internet medical care", the time threshold is limited to 2011-2021, the literature source category is selected as all journals, by removing documents with missing information (authors, keywords, institutions, etc.) and those not related to the topic, we ended up with 1796 valid documents. Valid literature was exported in Refworks format to form a sample database in the field of Internet healthcare research. Synonym merging, frequency statistics, co-occurrence matrices, clustering plots and time zone plots were performed using COOC 12.6 [5] and Vosviewer software to draw visual plots for visual analysis.

3 RESULTS AND DISCUSSION

3.1 Annual Publication Volume

From Fig.1, it can be seen that the research in the domestic Internet medical field has an overall growth trend. The period from 2011 to 2014 was a budding phase with a low literature output. During the period from 2015 to 2019, the number of articles begins to grow, the Internet medical market gradually expanded and gradually received the attention of many scholars. Since 2020, the "Internet+ Health" has been accelerated due to the impact of COVID-19, more and more scholars have started to pay close attention to the field of Internet healthcare, and the number of publications has increased.

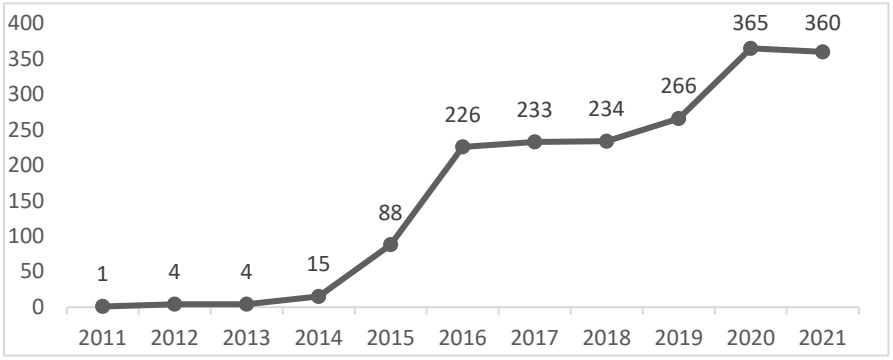

Figure 1. Internet Healthcare Publication -Year Distribution

3.2 Literature Source Journals

Table I shows, the nascent core publication position in the field of Internet healthcare in China has basically taken shape, with 1,796 Internet healthcare literature published in 629 journals including medical, health management and computer journals, "China Digital Medicine" contains the most relevant literature with a total of 75 articles, followed by 44 articles in "China Hospital".

TABLE I. DISTRIBUTION OF THE TOP 10 PUBLISHING JOURNALS

No.	Journal distribution	Amount	Kind	Scale（%）
1	China Digital Medicine	75	-	4.18
2	China Hospital	44	Core Journals	2.45
3	Chinese Health Information Management	43	-	2.39
4	Journal of Medical Informatics	38	-	2.12
5	Chinese Journal of Hospital Management	29	Core Journals	1.61
6	China Health	27	-	1.50
7	China Health Industry	26	-	1.45
8	China Health Quality Management	23	-	1.28
9	Hospital Management in China	22	Core Journals	1.22
10	Information and Computers	21	-	1.17
	Total	348		19.38

3.3 Author Network Analysis

A total of 4015 authors were included in the valid literature, and according to Price's theory, three or more publications are core authors in the field, with a total of 133 core authors for whom a co-occurrence diagram of researchers with collaborative relationships was constructed (Fig.2). The co-occurrence analysis shows that in the field of Internet healthcare, a research team has been formed with Yu Guangjun (19), Liu Lifei (3), Zhang Xinping (3), Lu Wei (6), Miao Wei (7) and Yu Junying (4) as the core, while there are also scholars with a large number of publications, such as Cui Wenbin (12), Zheng Xueqian (9), Liu Yang (8) and Chen Min (8).

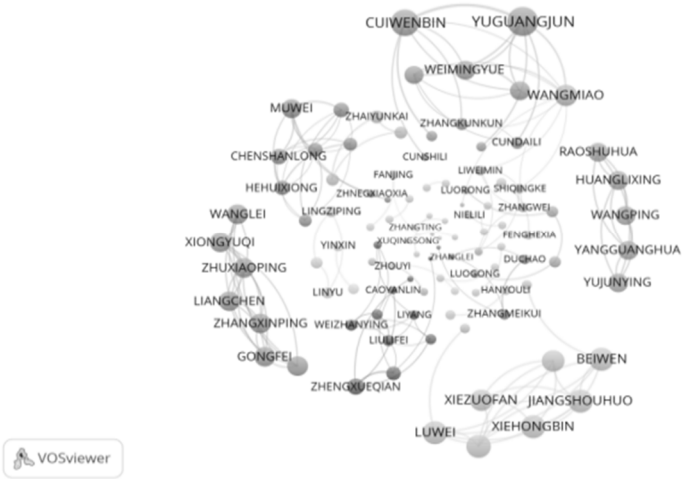

Figure 2. Author Co-occurrence Map

3.4 Institutional Network Analysis

Table II shows the top five organizations in terms of the number of articles published, all of which have more than ten articles, constituting the main position of research in the field of Internet healthcare. The 122 institutions with three or more publications were selected to build a collaborative network map (Fig.3), which revealed a team of research institutions with the School of Public Health of Shanghai Jiao Tong University, the First Hospital of Sun Yat-sen University and Sun Yat-sen Hospital of Sun Yat-sen University as the core.

TABLE II. TOP5 RESEARCH INSTITUTIONS

No.	Institution	Amount
1	School of Medicine and Health Management, Tongji Medical College, Huazhong University of Science and Technology	23
2	School of Health Management and Education, Capital University of Medical Sciences	12
3	School of Management, Shanghai University of Engineering and Technology	10
4	School of Public Health, Shanghai Jiao Tong University	10
5	Institute of Medical Information, Chinese Academy of Medical Sciences	10

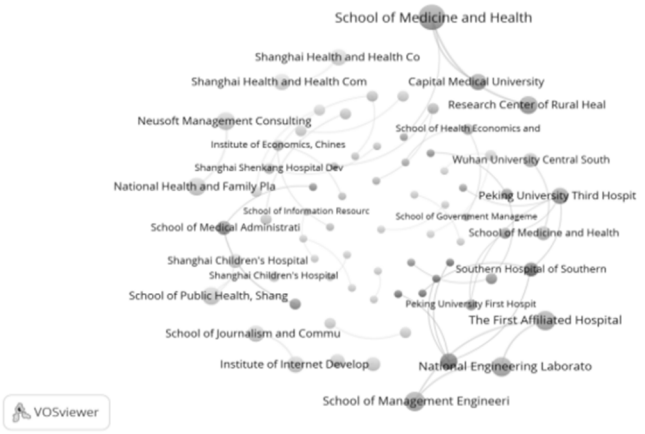

Figure 3. Institutional Cooperation Diagram

3.5 High-Cited Literature

Table III lists the top ten cited articles that have made significant contributions to Internet health research. The research content of the highly cited literature can be divided into three categories: The construction of application service model, Meng Qun [6-7] pointed out that platform construction in areas such as graded diagnosis and treatment and chronic disease management would promote medical development, Chen Huifang [8] took registration as an example to carry out innovative practice of service model, and He Xuesong [9] analyzed medical core business and auxiliary business applications. Industry development trend, Xu Zhirong [10] divided the Internet medical market pattern into four categories, Guo Wei [11] explained the

realistic positioning of Internet medical, Xie Wenzhao [12] pointed out four construction modes and application modes of Internet medical in China, and Yu Baorong [13] explored the operation form of Internet medical enterprises. The construction of the regulatory system, Wang Anqi [14] and Li Ying [15] made substantive suggestions on the supporting policies and related legislation in the field of Internet healthcare.

TABLE III. TOP 10 HIGH-CITED LITERATURE ON INTERNET HEALTHCARE

No.	Topic	Author	Year	Journal	Citat-io ns
1	Analysis of innovation and opportunities for traditional industries in the era of "Internet+"	Xu Jian rong	2015	Internet World	244
2	Current situation and thoughts on the development of Internet healthcare in China	Meng Qun et al.	2016	Chinese Journal of Health Information Management	123
3	The current situation of Internet healthcare operation in China - a survey and analysis based on 3 hospitals	Wang Anqi et al.	2016	China Health Policy Study	113
4	Innovative development of "Internet + Medical"	Li Ying et al.	2016	Macroecono-mic management	98
5	Realistic positioning and future development of Internet healthcare	Guo Wei et al.	2016	Explore	68
6	Research and Practice of Internet + Chronic Disease Management	Meng Qun et al.	2016	Chinese Journal of Health Information Management	66
7	The development status of Internet healthcare in China and the challenges it faces	Xie Wen zhao et al.	2016	Chinese Journal of Medical Library Information	64
8	The development history, business model and macro-influencing factors of Internet medical care in China	Yu Bao rong et al.	2019	Journal of Shandong University (Medical Edition)	50
9	Research on Internet healthcare service models from the perspective of value co-creation	Chen Hui fang et al.	2016	Modern management science	48
10	Current status and trends in the application of Internet healthcare	He Xue song et al.	2018	China Health Policy Study	45

3.6 Keyword Analysis

Fig.4 shows the top 20 keywords by frequency, the high-frequency keywords inclued Internet+, Internet medical, Internet hospital, mobile medical, smart medical, medical service, etc. These keywords are important hot content in the field of Internet medical research. A keyword co-occurrence map with a frequency of 5 times and above was constructed (Fig.5), and there were 170 nodes and 1,186 connections in the map. Cluster analysis provides a fuller understanding of the thematic links between individual research hotspots, table IV shows the five keyword clusters.

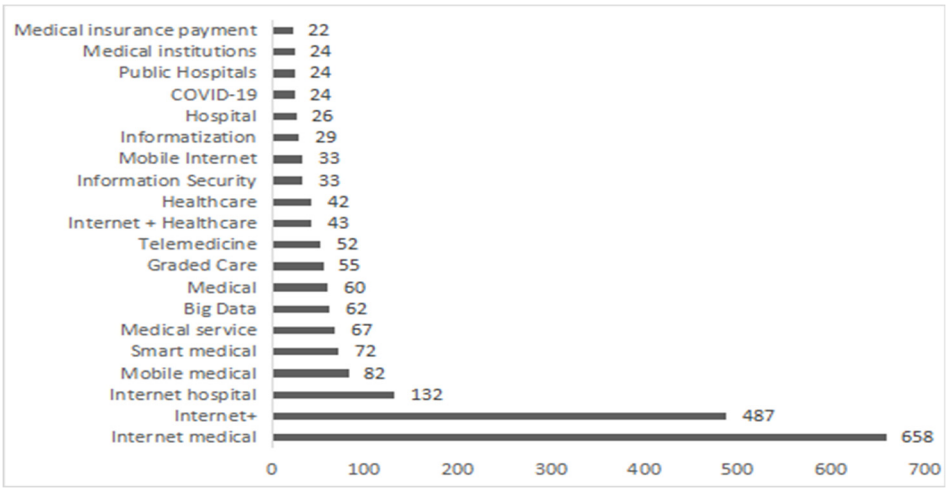

Figure 4. Statistics of the top 20 keywords in terms of word frequency

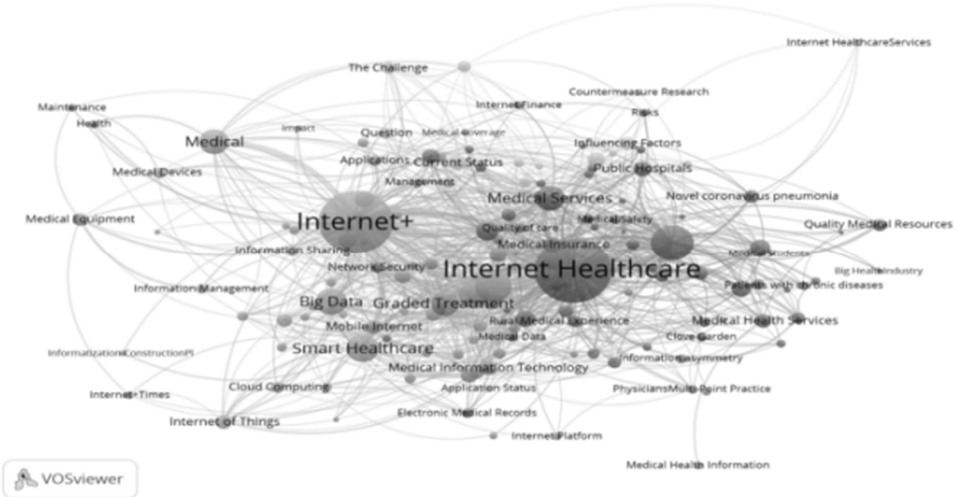

Figure 5. Keyword co-occurrence map

TABLE IV. KEYWORD CO-OCCURRENCE NETWORK CLUSTERING TABLE

Cluster	Cluster size	Part of frequent keywords
0	53	Graded treatment, medical platform, doctor-patient relationship, hospital information system, medical information security, chronic disease management, medical service system
1	45	Health care, cloud platform, regional medicine, precision medicine, community medicine, rehabilitation medicine, network medicine
2	33	Internet hospitals, medical and health services, artificial intelligence, palm hospitals, dingxiang garden, epidemic prevention and control
3	30	Mobile Health, telemedicine, healthcare information, outpatient services
4	9	Medical information, data security

Through the combing of relevant literature and clustering keywords, it is concluded that the current domestic Internet medical research mainly revolves around the following three themes:

Internet medical information technology construction: the common present symbols are "hospital information system", "medical information security", "medical data", "medical health information", etc. Insufficient total medical resources and unbalanced structural layout have always been the pain and difficulty of China's health care reform [16], in recent years, hospitals at all levels in China are exploring information technology and intelligent medicine, especially during the prevention and control of COVID-19, the research of medical information technology construction has developed rapidly, and the construction of medical information technology effectively expands the diagnosis and treatment information outwardly and connects inwardly, which is an important link in the development of Internet medical and health care. However, the research on the security regulation of medical information data still needs to be improved, a specialized legal regulatory system has not yet been formed, and the legal rank is low.

Internet medical platform construction: the common symbolic words are "medical platform", "palm hospital", "cloud platform", "Dingxiangyuan", etc.There are two types of Internet hospital platforms, namely hospital-based and enterprise-based. In recent years, various forms of medical platforms have emerged to truly move the "hospital" to the mobile terminal and fully realize the non-geographical medical environment, such as Tang Ming [17] designed a wisdom rehabilitation medical service platform for the elderly and Qiu Xiaolu [18] established an Artificial Intelligence platform for autistic children, the application effects are effective and provide data and theoretical basis for the platform establishment. However, the construction of application platform standards has not yet been unified, and the construction of a complete platform system is still the focus of research.

Internet medical service model: The common symbols are "medical service system", "health consultation", "precision medicine", "outpatient service", etc. Medical service itself is a demand service, and the construction of the system has more research results in the fields of graded treatment, chronic disease management, and medical care integration. Personalized precision medicine services are designed to address the need for continuous medical and health services at the individual level, and the precision medicine strategy is part of China's 13th Five-Year

Plan, and the state plans to provide 60 billion yuan of financial support for precision medicine development by 2030 [19], strengthening the construction of precision medicine hardware and software in China and providing truly human-centered services are the keys to promoting the steady development of health care.

3.7 Evolutionary Path of Internet Healthcare Theme Hotspots

The time zone view can show the evolution trend of knowledge in Internet medical field in time dimension. 15 keywords with the highest frequency each year are used to draw the knowledge map in time zone view (Fig.6), and each circle in the cumulative time zone map represents a keyword, and the larger the circle is, larger circles indicate higher keyword frequency. China has been exploring in the field of Internet medical care, during 2011-2014, domestic Internet medical research was in the initial stage, and the keywords that appeared more frequently were mainly Internet+, mobile medical, medical equipment, etc., and the research direction was relatively macro; during 2015-2019, domestic Internet medical research studies increased rapidly and became more specific, mainly focusing on Internet hospitals, graded diagnosis and treatment, telemedicine, medical information security, medical platforms and medical health, and the application of Internet information technology in the medical field continued to deepen and the market scale gradually expanded; since 2020, the new risk development stage has seen the emergence of keywords such as online consultation and online medical care. Under the influence of the new pneumonia epidemic, people have started to have new demands for medical services, and the advantages of Internet medical care during the new pneumonia prevention period are highlighted by its convenient process and spatial freedom, and the contactless "Internet + medical health" service model has become a new trend.

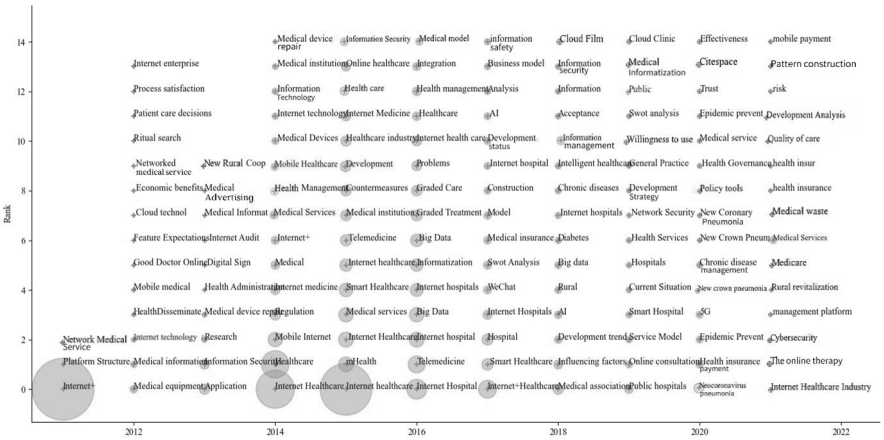

Figure 6. Keyword Cumulative Time Zone Evolution Diagram

4 CONCLUSIONS

The article is based on the literature in China's Internet medical field as the research object, by using COOC12.6 and Vosviewer visualization tools to analyze important journals, major research institutions, core author groups and research hotspots in the research field, and draws the following conclusions:

First, the annual publication volume in China's Internet medical field in the past 10 years is generally on the rise, with a large number and wide range of published journals, but fewer high-quality core papers, and the research level and research depth need to be improved; the cooperation of core researchers is generally scattered, and the regional cooperation of research institutions is low; the content of high-frequency cited literature is focused on the application service model, industry development trend and the construction of the regulatory system.

Second, through keyword co-occurrence network mapping and cluster analysis, it can be seen that the hot keywords are Internet+, Internet hospital, mobile medical, medical services, etc., which are in the center of the co-occurrence network mapping and closely related to other keywords; a total of five keyword clusters are obtained, and the main research directions of their formation can be classified into the following three aspects: Internet medical information construction, Internet medical platform application and the construction of Internet medical service model, and the hot research themes have a certain stage continuity, on the one hand, attributed to the development of the information age, on the other hand, due to the impact of the new crown epidemic, all deepen the process of China's Internet medical career research in different degrees.

Third, from the evolution of subject terms, the research path in the field of Internet healthcare in China is divided into three stages:Active exploration phase (2010-2014) The research content focuses on the application of Internet technology in the medical field, exploring and applying mobile medical devices, and laying the foundation for the subsequent technological innovation of Internet medicine; Vigorous development stage (2015-2019) Research content tends to explore the construction of Internet hospital informatization and personalized medical services (such as chronic disease management, graded diagnosis and treatment, medical and health care integration, etc.). The continuous integration of health big data and artificial intelligence technology, exploring more accurate diagnosis and treatment services has become a hot topic in this period; New Risk Development Phase (2020-now) Under the influence of the new crown epidemic, the research content gradually shifts to the construction of a service system that focuses on the needs of the audience, online medical care and online consultation become hot keywords, sharing medical resources without geography and providing real-time medical service model are the frontier and direction of future Internet medical development.

In summary, the further construction of information technology for Internet hospitals and demand-driven medical services are likely to be the main directions of development in the field of Internet healthcare in the future. There are also shortcomings in the present study. The data sources are mainly Chinese literature published in journals, which has limited coverage and different parameter settings may lead to different results. In future studies, the author will continue to expand the sample database and continue to focus on the development of the Internet healthcare field.

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