Advances in Smart Healthcare Aging Research Based on Visual Econometric Analysis

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Abstract. Through literature research, we study the progress of smart healthcare for aging, and use visual econometric analysis methods to collate literature data for the medical health of the elderly group, which is proposed to solve the problem of digital divide in the process of medical treatment for elderly users and meet the demand of medical services for the elderly group. In this paper, the research literature included in Web of Science Core Collection Database and China Knowledge Network (CNKI) from 2013 to 2023 is used as the data source, and CiteSpace metrology software is used to draw knowledge maps in terms of the number of publications, research institutions, research hotspots, research frontiers, etc., to summarize the research lineage of smart healthcare for the elderly and analyze the development and development of smart healthcare for the elderly in China as an example. The study also analyzes the hot contents and development direction of smart medical aging research in China as an example. The study found that the research on smart aging in healthcare is on the rise from 2013 to 2021, and there is close cooperation between countries. In recent years, smart aging research has started to pay attention to the cognitive barriers and willingness to use of elderly users, and the research hotspot is smart aging based on the Internet and other information technologies, and the research is more inclined to the technical implementation. Experts in various fields should further study smart healthcare aging, enhance interdisciplinary research, and meet the diversified needs of elderly users.

Keywords: CiteSpace; visual econometric analysis; geriatrics; smart healthcare; knowledge graphs

1 Introduction

In the context of aging, the country's demographic structure has changed, and medical access has become a worldwide concern. At present, the development of intelligent medical care is in an upward trend, intelligent medical equipment, online medical consultation, pharmaceutical e-commerce services and other functions provide patients with medical convenience, breaking the time and geographical restrictions; remote consultation, remote diagnosis, optimizing the medical process, shortening the waiting time for patients to seek medical treatment, and improving the efficiency of patients' medical consultation. However, the digital healthcare system has increased the burden of medical treatment for the elderly, and has not enabled the elderly's demand for medical services to be fully met, and the elderly are still facing obstacles such as difficulty in making appointments, registering, and consulting. Scholars in various countries have conducted multidisciplinary and multidisciplinary research on aging in order to let the elderly enjoy the dividends of smart healthcare and integrate into the digital society. In

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this paper, through CiteSpace visual metrology software, we conduct literature clustering mapping analysis, and take China as a representative country to reveal the current status of smart healthcare research for elderly users, analyze the research hotspots, and predict the future research direction of age-appropriate smart healthcare products, which is of great significance for solving the problem of digital barriers to elderly people's access to healthcare.

Intelligent medical aging requires that it is based on user needs, enhance the immediacy, convenience, and social attributes of medical treatment, and expand the radius of medical services, so as realize intelligent medical services. Its research involves a wide range of professional fields, including medicine, computer science, sociology, psychology, etc., and relates to social service policy, hospital management system, application of intelligent equipment, improvement of medical system, and implementation of information technology. Therefore, intelligent medical aging to explore the digital divide of the elderly group is an important topic to be solved by multiple disciplines.

2 Data sources and methods

Bibliometrics is a commonly used analytical method for assessing or quantifying research literature and information [1], which takes scientific literature as the object of study, and is able to comprehensively and concretely reveal the relationship between related studies, and is an important tool for researchers to find research hotspots and research results [2]. CiteSpace is mainly based on the co-citation analysis and the path searching network algorithms to calculate the literature in a specific field, to explore the key evolutionary path and knowledge inflection points of a discipline [3], which can statistically analyze the literature data samples from the macro level, and help scholars analyze the current status and trends of research development in the field by generating the knowledge map of the authors, keywords, and institutions in the research field. In recent years, CiteSpace has been fully applied in many research fields such as psychology, medicine and management [4].

Literature research was conducted using Web of Science database and CNKI database as data sources, using advanced search method with the search formula: #1 OR #2 AND #3, i.e., #1 is TS=("Wise medical" OR "Wise Information Technology of med "OR "Internet+medical treatment "OR "Internet+medical care" OR "Digital medical treatment"); #2 is TS=("smart hospital" OR "e- Hospital"); #3 is TS=("Digital medical treatment" OR "elder*" OR" older" OR "aging*" OR "senile"). A total of 527 valid documents were retrieved through subjective screening by the three researchers, and after excluding irrelevant documents, the literature data were converted using CiteSpace-6.2.R1, and time slices were set from 2013 to 2023 to generate visual metric maps.

3 Visual measurement analysis

3.1 Analysis of the volume of publications

The number of publications can intuitively respond to the hot situation of the research field in a specific time period [5], such as Figure 1 shows the chart of the number of publications of smart healthcare aging-friendly research. Overall, the research process of aging-friendly smart

medical research shows an increasing trend from 2013 to 2021, and the number of publications reaches a peak in 2021, and the relevant research starts to decrease significantly and with a larger decline in 2021-2023, showing a decreasing trend year by year. Early 21st century Europe first began to explore the use of intelligent means to solve the health problems of the elderly [6], and proposed telemedicine, healthy smart home (HSH) and other smart medical service concepts. In some developing countries, such as China, due to the gradual maturity of the development of smart medical technology, the popularity of smart medical systems has increased dramatically, and they have begun to pay attention to the problem of digital barriers to health care for the elderly, but the research on smart health care services for the elderly started late compared to the research on smart health care services for the elderly in the developed countries.

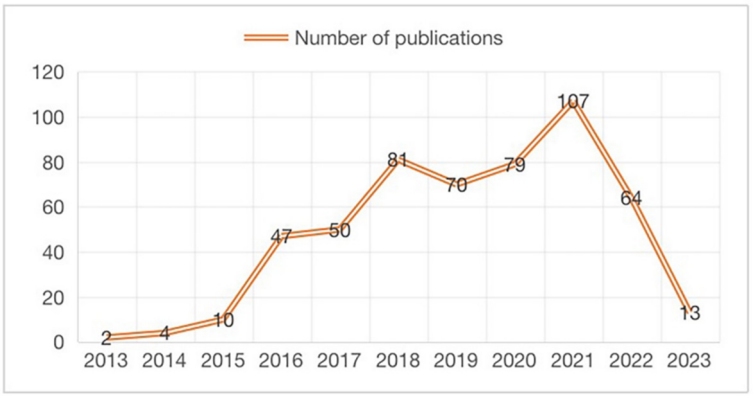

Fig. 1. Smart healthcare aging-friendly research publications, 2013-2023

After 2021, the number of articles published on aging-related research will begin to decline, but the problem of the digital divide in aging healthcare is still unresolved, and barriers to access to healthcare for the elderly are still a serious problem, indicating that there is still more room for the development of research in this field, and that there is an urgent need to find breakthroughs in innovation.

3.2 Geographical distribution and institutional analysis

Using CiteSpace-6.2 to calculate the "country" node type on the Web of Science literature data, we obtained a map of the geographical distribution of smart healthcare aging research (Figure 2), involving 92 countries. The larger nodes in the country map represent more research and stronger influence, and it can be seen that China, the United States, and South Korea have a relatively large number of publications in this field and strong influence, followed by India, the United Kingdom, Canada, and Saudi Arabia, as shown in Table 1.

The depth of the graph color indicates the time of research, the darker the color represents earlier research, so in 2013-2023 the research on age-friendly smart healthcare started earlier in the United States, South Korea, Bangladesh, New Zealand, while China's research in this field is explored later. Meanwhile, the connecting lines between nodes indicate the degree of national cooperation [7], in general, countries cooperate more closely in the field of smart healthcare.

Fig. 2. Geographic Distribution of Smart Healthcare Aging Research

Table 1. TABLE I. Number of articles issued by country (TOP 10)

serial number	nation	Year of first occurrence	volume of publications
1	CHINA	2016	30
2	USA	2013	24
3	SOUTH KOREA	2014	23
4	INDIA	2016	13
5	ENGLAND	2017	10
6	TAIWAN	2015	10
7	CANADA	2014	9
8	SAUDI ARABIA	2020	8
9	SPAIN	2017	7
10	ITALY	2017	7

Literature institutional mapping network nodes, node connectivity, network density of 200, 257, 0.0129 (Figure 3). Among them, Hwang, Hee is the author with the most number of publications in foreign smart healthcare aging research, which focuses on the development of healthcare information technology, seeks to update the user information platform, and advocates for improving healthcare services [8]. The institution with the most publications is Harvard University, with a total of 8 publications, which are more authoritative.

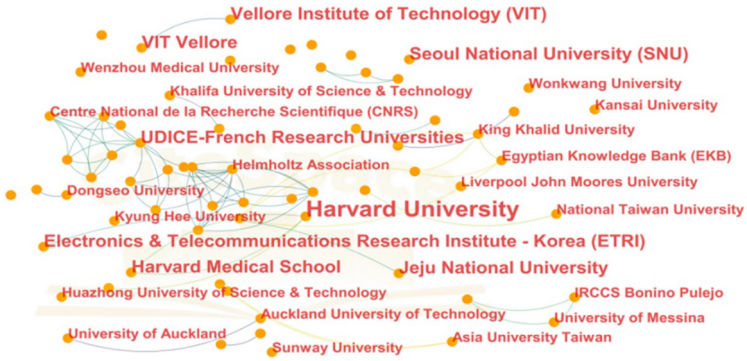

Fig. 3. Mapping of organizations that publish research on aging in smart healthcare

3.3 Analysis of keywords and research hotspots

Keywords reflect the core points of the literature, and the keyword clustering map and k-clustering co-occurrence map can reflect the popular research topics in a specific period of time, and show the type of research and emerging trends in this knowledge area. Using "keyword" as the node, the Web of Science literature data was analyzed by clustering (Figure 4). The keyword clustering of smart healthcare aging is concentrated in the computer field, "internet", "care", "big data", "system", "smart healthcare", "health", "cloud", and "artificial intelligence" are the keywords that appear more frequently. Smart healthcare for aging in various countries focuses more on the development of intelligent technology, and most research focuses on the daily life of the elderly through information technology to identify, assess and intervene in the status of their signs and symptoms, to solve the problem of social aging.

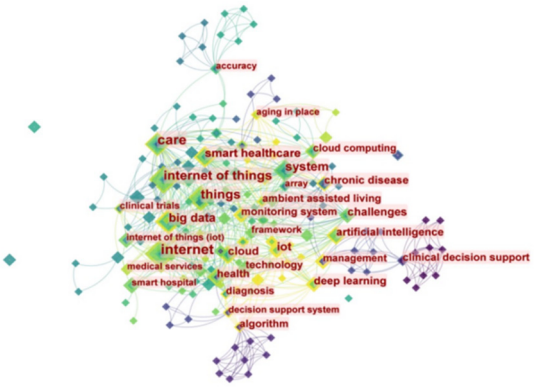

Fig. 4. Keyword clustering map

The keyword co-occurrence mapping was obtained by path Finder to simplify the network and highlight the features in order to understand the structural characteristics of smart healthcare aging research, as shown in Figure 5, where the curves between the nodes represent the links between the keywords [9]. Its S-value is 0.8479>0.7 and Q-value is 0.6633>0.3, which indicates that the clustering structure is effective and significant [10].

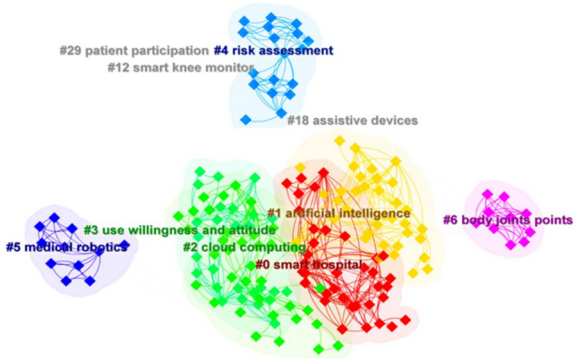

Fig. 5. Keyword co-occurrence clustering map

The most clustered tag "smart hospital" contains 97 articles. A smart hospital is an innovative digital hospital that has emerged in the context of Internet users, increasing demand for healthcare resources, and an aging global population. Hu H et al. (2022) stated that in modern healthcare delivery systems, patient electronic health records (EHRs) have replaced medical paper documents, and that smart hospitals typically use communication technology (ICT) environments and the Internet of Things (IoT) for automated processes to provide assessment, counselling, treatment, services and integrated care [11]. Zhang H et al. (2018), Rizwan P et al. (2018) developed wearable devices using IoT by innovating smart hospital technologies and designed a patient remote monitoring system to continuously monitor the health status of elderly patients with chronic illnesses, which will play an important role [12-13]. In the face of the problems and challenges of improving healthcare services for the elderly, most scholars in Europe believe that the accelerated development of the digital society creates unpredictable opportunities, but at the same time potentially amplifies the challenges of how different groups can access information and use science and technology, and it chooses to sound healthcare service measures for the elderly by researching intelligent information technology and adopting intelligent healthcare tools.

Taking China as an example, which has a significant aging problem among developing countries, CNKI is chosen as the data source, and the keyword clustering map is obtained by repeating the clustering method, as shown in Figure 6. The keywords identified in the literature based on the theme of smart healthcare for the elderly appear in descending an order of frequency as "Internet+", "smart aging", "combination of healthcare and nursing", "elderly", "elderly service". Among all the keywords, the high-frequency keywords can best reflect the research hotspots and research trends in specific fields [14].

Fig. 6. Keyword clustering map of Chinese literature

Note: There are 244 network nodes, 594 node connections (E-594), Density=0.02. The nodes in the graph represent keywords and the size of the nodes depends on the number of keywords.

The larger the node, the higher the frequency of keyword occurrence, and the more connections between nodes indicate the higher frequency of co-occurrence between different keywords.

The sprouting of smart senior care services in China since 2014, researchers have begun to pay attention to the effective combination of medical and healthcare and senior care services in the context of aging. The popularity of the Internet and intelligent products, information

technology is widely used in the field of health care, how to organically integrate the Internet with the medical and health care combination of the elderly model, to promote the rapid development of elderly care and health care services, and to build an age-friendly society, has become a key issue of concern for researchers in China at present [15]. Under the new model of smart hospital, Liu H, Zou L (2018), Guo X et al. (2021) pointed out that hospitals should establish a hospital information system with "electronic medical records as the core", develop a humanized data platform, integrate online and offline services, strictly require medical care [16], provide remote services and emergency warnings for the elderly, and use the Internet to integrate hospitals with medical care [17]. And emergency warnings for the elderly population, using the Internet to closely link hospitals and the elderly population [18]. According to research predicts that China's aging population will exceed 400 million in 2050, of which 220 million will suffer from chronic diseases [19]. In the face of the phenomenon of chronic diseases in the elderly, Shen Q and Xu Y (2020) explored the factors influencing the willingness of the elderly to participate in the "Internet + chronic disease management", and proposed that the environment of health disease management should be improved from various aspects [20]. Liu X et al. (2023) pointed out that a healthcare consortium should be established to carry out continuity of service for discharged elderly patients with chronic diseases, and construct a continuity of care model for elderly patients with chronic diseases based on "Internet + healthcare consortium", to improve the needs and satisfaction of patients and reduce the burden of caregivers [21]. Xiao Y (2018) and Li X (2018) believe that the construction of an Internet information platform can enable the efficient integration of resources in the home care industry and promote its diversified development [22-23].

3.4 Co-citation analysis

When multiple documents are cited by the same document, the interrelationship between these documents is said to be a co-citation relationship. The co-citation map can reflect the related knowledge and cross-disciplines of a scientific field, and the larger its nodes are, the higher the centrality among the nodes. And the nodes with higher centrality can be regarded as the key nodes that promote the development of the research field [24].

As shown in Figure 7, Qadri Y A has the most co-cited document in the journal IEEE Communications Surveys & Tutorials published in 2020. This scholar believes that the impact of Internet of Things (IoT) on the development of the healthcare industry is huge, and the emergence of Medicine 4.0 has led to an increase in the number of hardware and software development platforms, identifying the future direction of improving the quality of healthcare services by using new technologies such as Artificial Intelligence and Internet of Things [25]. Foreign research in this field has received a lot of attention due to the ability of IoT technologies to alleviate the pressure on the healthcare system caused by the aging population and the increase in chronic diseases. Baker S B (2017) presented the challenges faced by IoT in healthcare, including security, privacy, arability, and low-power operation, and evaluated their strengths, weaknesses, and overall applicability to wearable IoT healthcare systems [26], whose implications for the research in the field of smart healthcare aging is highly influential.

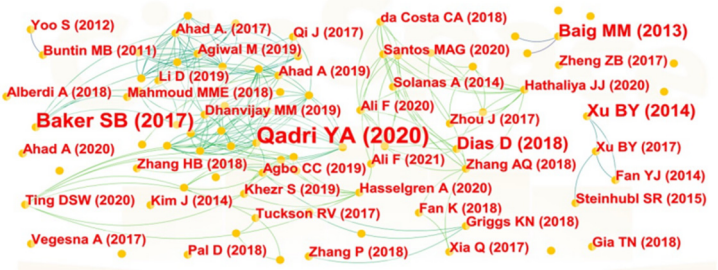

Fig. 7. Co-citation mapping

3.5 Analysis of research frontiers

Figure 8 shows the timeline map of the literature, from which it can be seen that the current research in the "smart hospital" in various countries have more exploration, which attaches importance to the research and development of intelligent care systems in the aging society, the use of Internet of Things technology to improve medical and health services and technology acceptance model to explore the acceptance of elderly patients [27]. In contrast, researchers have emphasized the "use willingness" of older people, arguing that the perceptual characteristics of older people are a crucial factor.

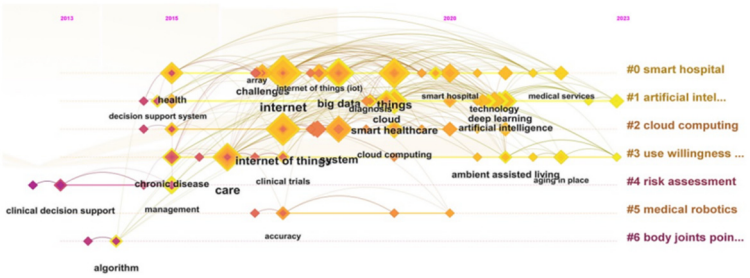

Fig. 8. Timeline mapping

Keyword emergence refers to the frequent citation of a keyword during a certain period of time. The emergent words in recent years can be regarded as cutting-edge topics in the research field, which can help predict the future research trends in the field [28]. From the perspective of the emergent word mapping, smart medical aging research has paid more attention to the application of intelligent information technology in the field of healthcare in recent years, focusing on the construction of aging-friendly intelligent systems and algorithms as well as the processing of cloud computing and big data.

The keywords that are still highly emergent in the study from 2019 to the present are "things", "Internet", "artificial intelligent", and "Internet of things", as shown in Figure 9. The emergence of information technology such as artificial intelligence and IoT has enhanced the feasibility of smart health care detection. T Vaiyapuri (2021) pointed out that the possibility of accidents such as falls in daily life of elderly people is very challenging for their health and remote monitoring, and he designed an IoT-based fall detection model for elderly people for smart home care [29]. E Park (2018) used information technology to derive key aspects of a

smart healthcare environment and integrated electronic medical records and patient guardian information into a pre-diagnostic healthcare delivery system based on the Internet of Things [30]. Overall, the smart healthcare aging research field is currently mostly explored in the direction of key smart technologies.

Fig. 9. Keyword emergence mapping

4 Conclusions

In the face of the increasingly serious aging problem of the society and the application of artificial intelligence, the Internet and other emerging information technologies, how to provide effective intelligent aging and health services for the elderly has become a common concern of the healthcare service industry and academia in various countries. This paper applies CiteSpace metrology software, draws clustering maps, and conducts visual analysis of research hotspots, research frontiers, etc., on the literature related to smart medical aging in the past decade, and analyzes it with China as an example, thinking about the current status of research in this field and the future development trend, and comes up with the following aspects.

(1)There has been some progress in smart healthcare aging research and closer cooperation between countries, but there is still a lack of disciplinary crossovers.

(2)Smart aging and medical care integration based on the Internet and other information technologies are research hot spots in various countries. Smart medical aging research in the Internet, Internet of Things, artificial intelligence, cloud computing medical services research is more in-depth, and it attaches importance to the development of intelligent information technology, and seeks to create an age-friendly smart medical service environment.

(3)Focusing on the cognitive barriers and willingness to use of elderly users, building service-oriented smart hospitals is at the forefront of smart medical aging research. Scholars in various countries pay attention to user experience to improve the medical information model and sound geriatric medical service measures by studying the smart information technology involved in smart hospitals, optimizing electronic medical records, intelligent nursing services, Internet guided diagnosis, remote guardianship systems, and Internet of Things (IoT) wearable devices.

(4)Multidisciplinary and cross-disciplinary intelligent elderly service is the trend of smart medical aging research. Multidisciplinary and interdisciplinary research is an important means

to deepen the research on smart aging. In the future, smart medical aging research should improve the smart medical system and medical service facilities, and build a new type of smart hospital; based on the cognitive characteristics of the elderly group, pay attention to the willingness of the elderly users to use, and establish a smart medical and nursing service model that is closely integrated with online monitoring and offline services, to satisfy the needs of the elderly users' applicability to medical treatment; develop the Internet, Internet of Things, cloud computing, big data and other smart medical-related information technology to optimize the structure of medical services, realize medical information sharing, and create an all-round environment for the elderly; strengthen the close integration of practical research, theoretical research and hospital services, and popularize aging-appropriate medical service facilities.

In summary, smart medical aging research is still in the development stage, and the obstacles to the integration of the elderly into digital medical care have not been effectively solved. The research is insufficiently innovative and specific; still lacks multidisciplinary and interdisciplinary cross-research; and lacks practical validation and scientific analysis, so experts and scholars in various fields need to conduct further research in the field of smart medical care for the elderly in an order to meet the diversified service needs of elderly users.

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