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Retraction

Retracted: Knowledge Graph Analysis of Digital Emergency Management Research Based on CiteSpace Visualisation: Comparative Analysis of WOS and CNKI Databases

Discrete Dynamics in Nature and Society

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] R. Nan, W. Zhu, and Y. Xiao, "Knowledge Graph Analysis of Digital Emergency Management Research Based on CiteSpace Visualisation: Comparative Analysis of WOS and CNKI Databases," *Discrete Dynamics in Nature and Society*, vol. 2022, Article ID 4604223, 20 pages, 2022.

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Research Article

Knowledge Graph Analysis of Digital Emergency Management Research Based on CiteSpace Visualisation: Comparative Analysis of WOS and CNKI Databases

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Facing the dual background of risk society and the fourth scientific and technological revolution, digital emergency management (DEM) research has attracted wide attention worldwide. Based on the comparative analysis of data from Web of Science (WOS) and China National Knowledge Infrastructure (CNKI) databases, the research draws the knowledge map by CiteSpace, in order to analyse the spatiotemporal distribution, hotspots, and trends of DEM research. The following are the results: (1) DEM research shows a spiral growth, with a significant increase in the number of papers. Existing highly cited references are mainly carried out from the perspective of management or technology. (2) The complex countries' cooperation network has been formed from the USA, China, and other countries; the complexity of the institutions' cooperation network must be strengthened, and the density of the authors' cooperation network is low; DEM research has significant interdisciplinary attributes. (3) The hotspots of DEM research can be divided into three categories: means, processes, and objects, but the research emphases between international and China are different. (4) The evolution of DEM research can be divided into three stages between international and China: embryonic, development, and deepening stages, and research contents in each stage show some differences. (5) The trends of DEM research between international and China are different. The former are information technology, artificial intelligence, and machine learning, whereas the latter are emergency decision making, scenario analysis, and public health.

1. Introduction

The rapid development of digital technologies (DTs) represented by the Internet, big data, and blockchain has caused a huge impact on traditional concepts and models of public management. It has triggered a systematic reshaping of structures, relationships, and mechanisms of management. During the process of transforming to digital governance, countries all over the world have planned digital society construction and governance schemes to promote the transformation and development of governance mode. For example, in October 2020, the USA revealed that it would build a technology alliance to realise technology risk management. In March 2021, the European Union proposed to build a people-oriented and sustainable digital society. In March 2021, China issued a document on Outline of the 14th Five-year Plan (2021–2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China, which proposed to build a digital society and emphasised the change in the model of production and lifestyle driven by digital transformation. DTs are gradually becoming the basic elements of economic and social operations and important means of social governance. Digital governance is also gradually becoming the core index of governance capacity competition among countries around the world. At the same time, the world has entered the risk society where unknown and unpredictable consequences have become dominant forces. The sudden increase in unstable factors and the superposition of multiple risks during the process of modernisation have greatly increased the occurrence probability of emergencies. Frequent disasters have become the key features of risk society [1]. Under

the background of global risk society, emergency management for magnitude emergencies has become a new normal. The high complexity of magnitude emergencies puts forward high requirements for DTs. COVID-19 sweeping the world has brought a huge negative impact to the world. The experience in emergency management for magnitude emergencies (e.g., COVID-19) shows that DTs play an irreplaceable role, that is, innovating emergency management concepts with digital mindset and improving emergency management capabilities with DTs. In fact, building a relatively perfect DEM system has become important parts of the transformation and upgrading of an emergency management system around the world.

Under the dual background of digital governance and risk society, the traditional model of emergency management cannot quickly put forward the most suitable scheme for different practical situations. The efficient combination of emergency management and digitalisation also provides a new way for the future development of emergency management [2]. Gruntfest believed that the value of Internet resources in emergency management is growing and has introduced the Internet into the field [3]. DTs, represented by the Internet, are becoming one of the only remaining vectors for economic, educational, and social interactions [4], and are combined with the whole process of emergency management [5, 6], promoting the mode transformation of traditional emergency management to the DEM. However, existing research is too fragmented and lacks a systematic review of the field. As a common tool, CiteSpace is usually performed quantitatively on domain-specific research. It can use its visualisation function to grasp the hotspots and trends of DEM research and display the panorama [7]. It can also extract network relationships to analyse the node structure and characteristics. This is conducive to analysing the DEM research hotspots from an overall perspective, thereby summarising and exploring the research trends, which has important practical significance for accelerating the technological innovation and management optimisation. In order to achieve the purpose of comprehensive analysis, the database used for knowledge graph analysis should contain complete data [8]. In view of the differences in DEM research between international and China, this paper chooses WOS and CNKI databases as the data sources.

The structure of this paper is as follows: (1) Section 1 introduces data and methods. (2) Section 2 analyses the temporal distribution characteristics in terms of annual number and trends of papers and highly cited references and the spatial distribution characteristics in terms of countries, institutions, disciplines, and authors. (3) Section 3 analyses the hotspots and trends of DEM research by co-word and burst words. (4) Section 4 summarises the overall differences in DEM research between international and China and provides suggestions for scholars. This paper uses the knowledge map analysis method to address the following questions: (1) What is the temporal distribution of DEM research? (2) What is the spatial distribution of DEM research? (3) What are the hotspots of DEM research? (4) what are the trends of DEM research?

2. Data and Methods

2.1. Data Collection and Processing. The data sources are the WOS Core Collection, CNKI's Core Journals of China, and Chinese Social Sciences Citation Index (CSSCI) source journals. Among them, WOS, as the world's largest comprehensive and influential academic information resource [9], covers peer-reviewed journals with high impact factors. As the largest full-text database of Chinese journals, CNKI is the largest data source in China, covering most Chinese journals. The retrieval programme is shown in Figure 1.

2.1.1. International Data. First, in order to search more comprehensively, the retrieval mode is set as follows: subject = "blockchain" or "big data" or "artistic intelligence" or "cloud computing" or "information technology" or "Internet" or "digital emergency management" and "emergency management." The language is English, and the time span is 1985–2022. The search was performed on April 25, 2022. Second, conference papers, data papers, online publications, book chapters, and recovered publications are eliminated. Data are also manually screened, excluding emergency medical and other indirectly related papers, and 3385 papers are obtained. Lastly, after the data cleaning by CiteSpace, 2885 valid papers are retained.

2.1.2. Chinese Data. First, referring to some previous studies [10], the retrieval mode is set as follows: subject = "digitisation" or "artificial intelligence" or "big data" or "blockchain" or "cloud computing" or "Internet" or "information technology" or "intelligence" or "intelligence" and subject = "emergency management." The search criteria = "precision," and the publish period is 1985–2022. The search was performed on April 22, 2022, and 462 papers are obtained. Second, manual screening and cleaning are carried out for the first retrieved papers, excluding book reviews, album prefaces, conference abstracts, and other indirectly related papers. Finally, 414 valid papers are retained.

2.2. Methods. CiteSpace is a commonly used tool for knowledge graph analysis, and the analysis results are visualised in the form of knowledge graphs. The valid papers from WOS and CNKI databases are exported in a plain text file and RefWorks format, respectively. In order to ensure language consistency, this paper translates the analysis results of the CNKI database into English. By statistical analysis, the temporal distribution of DEM research is mainly reflected in the annual number and trends of papers and highly cited references. By co-word analysis, the spatial distribution of DEM research is described from countries, institutions, disciplines, and authors. The hotspots and trends of DEM research are visually analysed through co-word clustering map, time zone map, and burst words. By comparative analysis, the differences in DEM research between international and China are analysed.

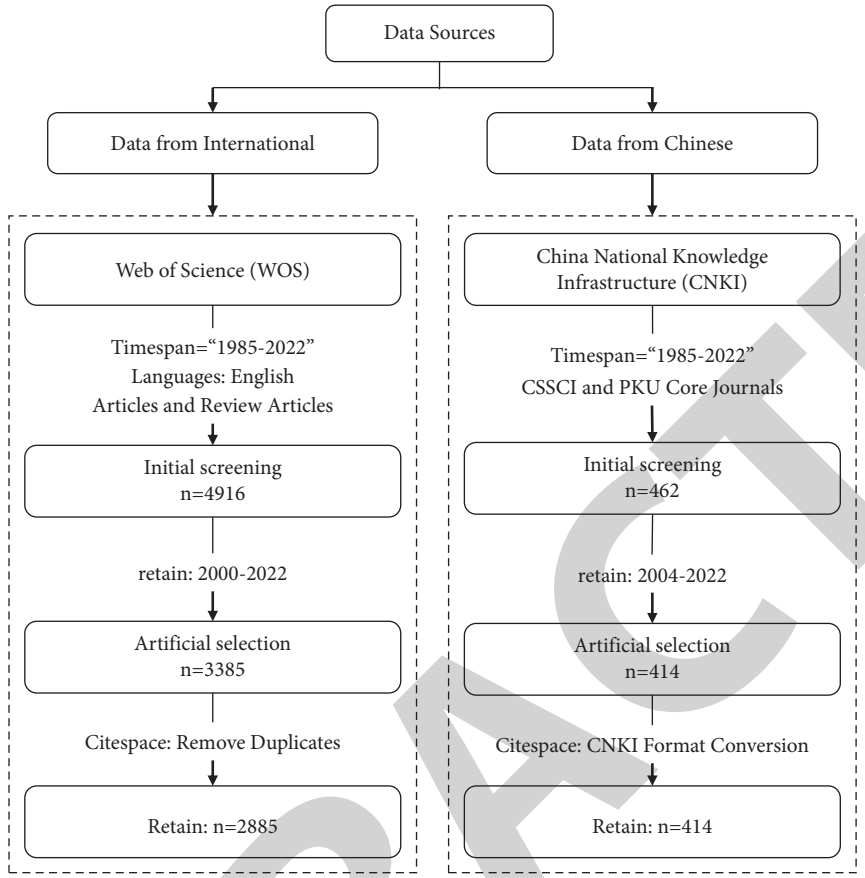

Figure 1: Paper retrieval procedure.

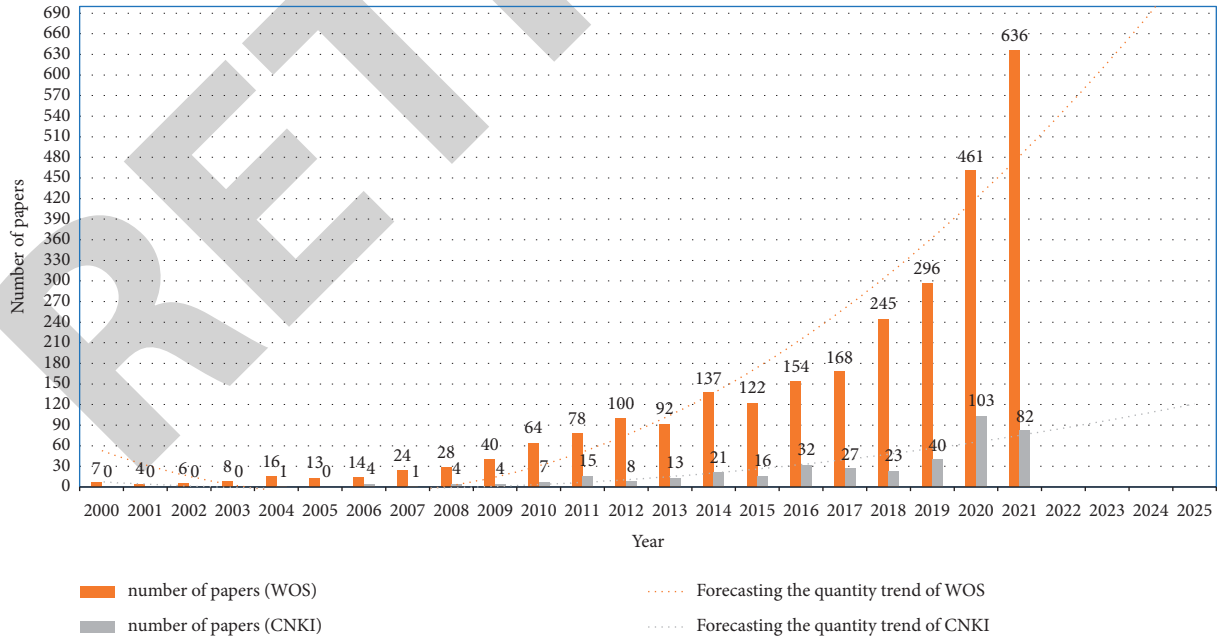

Figure 2: Annual number and trends of papers of DEM research.

3. Spatiotemporal Distribution

3.1. Temporal Distribution. The analysis of the temporal distribution of DEM research includes two aspects: first, the annual number of papers, which not only helps to visualise and show the development in different periods, but also helps to predict future development trends; and second, the highly cited references, which help to gain insight into the relationship between important research in different periods.

3.1.1. Annual Number and Trends of Papers. Based on WOS and CNKI data, the annual number and trends of papers are drawn (Figure 2).

In Figure 2, international DEM research began in 2000. From 2000 to 2021, related papers showed a spiral growth, with the annual number of papers peaking at 636 in 2021, accounting for 22% of the total. According to the annual number of papers, it can be roughly divided into three stages: in the first stage (2000–2008), the total number of papers is small, with an annual average of 13.3, which is in the initial stage; in the second stage (2009–2014), the number of papers has increased significantly, with an average annual rate of 85.2, which is significantly higher than the previous stage and is in the growth stage; and in the third stage (2015 to present), the number of papers continues to grow, with an average annual rate of more than 100. Specifically, in the period of 2020–2021, the number of papers increased dramatically, with respectively 461 and 636, which is in a period of rapid development. This is also a concrete manifestation of the positive response of the international DEM research to COVID-19. Under the influence of international DEM research, Chinese DEM research started in 2004 and showed a rapid growth trend. From 2004 to 2009, it was in the embryonic stage and the number of papers was small, with an annual average of 2.3. From 2010 to 2021, it exhibited a spiral growth, which is similar to the trend of international DEM research. It also indicates that DEM research is increasingly attracting the attention of Chinese scholars and has gradually emerged as a research hotspot.

According to Figure 2, polynomial prediction analysis is carried out on the data to predict the growth trend of the number of papers in the next four years.

The mathematical expression for predicting the number of papers of international DEM research is as follows:

$$y = 2.0596x^2 - 26.942x + 77.846\left(R^2 = 0.8932\right). \quad (1)$$

The mathematical expression for predicting the number of papers of Chinese DEM research is as follows:

$$y = 0.3298x^2 - 4.3619x + 11.506\left(R^2 = 0.8098\right), \quad (2)$$

where y is the number of papers, x is the year, and R^2 indicates the degree of fit of the trend line. R^2 values in the mathematical expressions are close to 0.9, indicating that the trend lines have a good fit. The trend lines imply that the number of papers will increase from 2022 to 2025. The number of international papers will increase significantly, while the rise in the number of Chinese papers will be relatively flat.

3.1.2. Distribution of Highly Cited References. Based on WOS data, the top 10 cited references of international DEM research are shown in Table 1. Among them, the research contents of highly cited references are mainly studied from the perspective of management or technology. First, from the perspective of management, the research focus is social media, and how to embed social media into the whole process of emergency management is discussed. For example, Yates and Paquette pointed out that social media, as a major knowledge-sharing tool and mechanism, have different impacts on knowledge sharing and emergency decision making [6]. At the same time, social media can work together with other information sources [11]. Subsequently, Kavanaugh et al. pointed out that social media can help improve emergency response, but the huge data flow generated by social media can create data noise and affect decision-making accuracy [12]. The research also found that social media can be used to track contents and pay attention to the changes in public sentiments to decipher the meanings and consequences of emergencies for helping the government form an effective connection from daily management to emergency management using social media. Most existing research focuses on the positive effects of social media on emergencies, but emergencies also magnify the risks of using social media, which may infringe on privacy and other issues. Therefore, the government should pay attention to moral warnings and ensure that social media will not be abused or misused [13]. Second, from the perspective of technology, the optimisation of technology is discussed to enhance the efficiency of emergency management. For example, Li et al. pointed out that networked microgrid can enhance the elasticity of power system, thus improving the flexibility of smart city to deal with extreme events [14]. Goodchild and Glennon emphasised that geographic data and tools are essential in the whole cycle of emergency management. Yet, the information quality of voluntary geographic information provided by amateurs is worrying [5]. In case of emergency, the risks associated with the information are often offset by the benefits of its use [15]. Fotovatikhah et al. revealed that artificial intelligence and computational intelligence technologies can be used to improve flood management systems and improve flood debris prediction accuracy [16].

3.2. Spatial Distribution

3.2.1. Countries' Distribution. Based on WOS data, the functional area is set as "country" to generate the knowledge map of countries' cooperation network (Figure 3) and extract the top 20 countries in the number of papers (Table 2).

In Figure 3, DEM research has formed a countries' cooperation network from China, the USA, England, Australia, Canada, Italy, South Korea, Spain, and India. The interconnection among countries is complex and diverse, indicating a high degree of cooperation. In Table 2, the top

Table 1: Top 10 highly cited references of international DEM research.

Rank	Citations	Year	Title	Author
1	520	2010	Crowdsourcing geographic information for disaster response: a research frontier	Goodchild M. F. and Glennon J. A.
2	500	2011	Emergency knowledge management and social media technologies: a case study of the 2010 Haitian earthquake	Yates D. and Paquette S.
3	270	2012	Social media use by government: from the routine to the critical	Kavanaugh A. L. et al.
4	265	2017	Networked microgrids for enhancing the power system resilience	Li Z. Y. et al.
5	246	2014	Social media in disaster risk reduction and crisis management	Alexander D. E.
6	245	2020	COVID-19 and digital inequalities: reciprocal impacts and mitigation strategies	Beaunoyer E. et al.
7	220	2018	Survey of computational intelligence as basis to big flood management: challenges, research directions and future work	Fotovatikhah F. et al.
8	202	2011	Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples	Boulos M. N. K et al.
9	198	2015	A geographic approach for combining social media and authoritative data towards identifying useful information for disaster management	de Albuquerque J. P. et al.
10	188	2010	Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: propositions from field exercises	Bharosa N. et al.

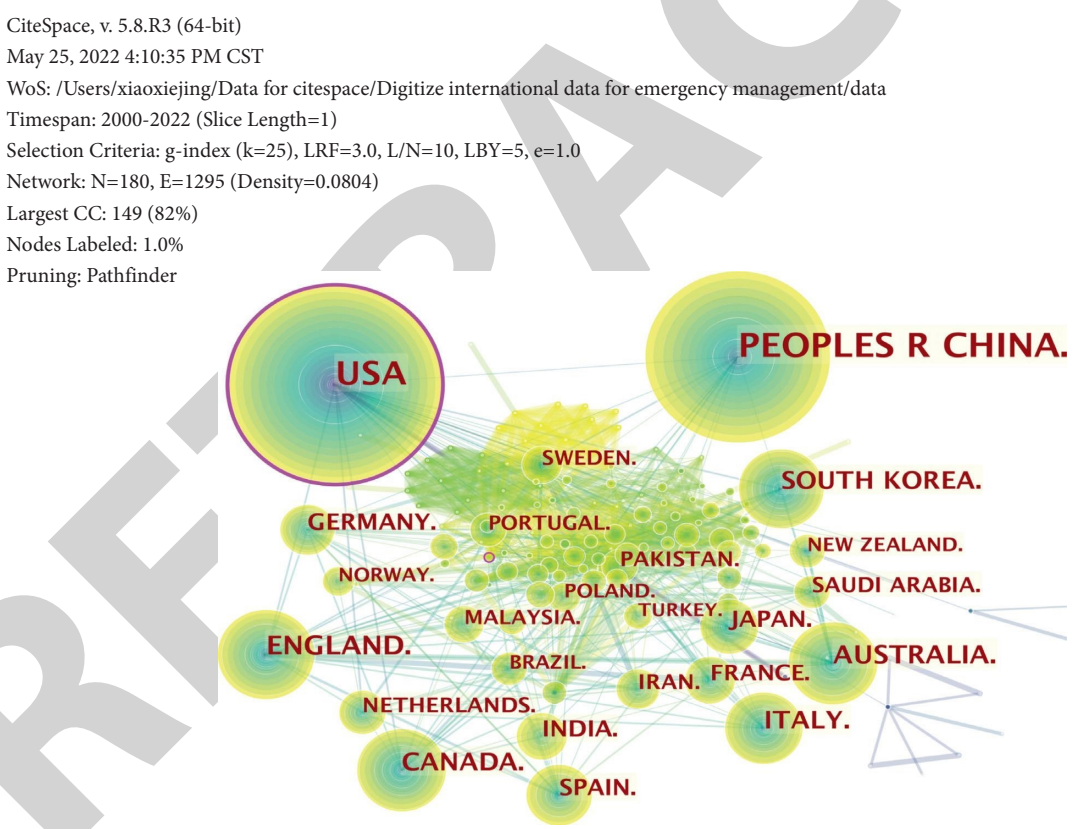

Figure 3: Countries' cooperation network of DEM research.

10 countries are China, the USA, England, Australia, Canada, Italy, South Korea, Spain, India, Japan, and Germany. Research should respond to practical needs, and the relatively large number of papers in these countries is due to the following reasons: first, the USA, Canada, Australia, and India have large areas and experience frequent natural disasters. Second, England, Italy, South Korea, Spain, Japan, and Germany have good economic development and developed science and technology. In conclusion, DEM research comes from the urgent needs of emergency management or the support of strong science and technology. In terms of time, the USA is the first (since 2000), followed by China, England, and Australia (since 2007).

3.2.2. Institutions' Distribution. Based on WOS and CNKI data, the functional area is set to "institution," and the knowledge map of institutions' cooperation network can be

Table 2: Top 20 countries in the number of papers.

Rank	Countries	Count
1	China	1011
2	USA	860
3	England	205
4	Australia	180
5	Canada	163
6	Italy	152
7	South Korea	138
8	Spain	107
9	India	100
10	Japan	97
11	Germany	93
12	France	78
13	Netherland	73
14	Saudi Arabia	63
15	Pakistan	61
16	Iran	61
17	Malaysia	59
18	Sweden	59
19	Portugal	50
20	Brazil	48

generated (Figures 4 and 5), and the top 20 institutions in the number of papers of international and Chinese DEM research can be extracted, respectively, as shown in Tables 3 and 4. Nodes represent institutions. Node sizes indicate the number of papers by institutions, and the number of links between nodes refers to the strength of cooperation between institutions.

In Figure 4, the density of institutions' cooperation network is 0.0084, and the network presents small-group characteristics. The network structure is relatively compact, and the breadth and depth of node interactions are high. Therefore, there is a high degree of institutions' cooperation and frequent information sharing of international DEM research, which is conducive to integration, deepening, and innovation of knowledge. In Table 3, the top 5 institutions are Chinese Academy of Sciences, Beijing Normal University, Tsinghua University, Beihang University, and University of Washington. For the institutional attributes, these institutions all belong to the university, suggesting that universities are still the main research institutions. In terms of the countries where the institutions are located, 40% of the institutions are from China and 20% are from the USA, both accounting for 60% of the total, indicating that DEM research is still concentrated in China and the USA. Among them, since the Wenchuan earthquake in 2008, the research perspectives of Chinese scholars have gradually diversified, from single computer technology research to multiple-perspective cross-domain technology integration.

In Figure 5, the density of institutions' cooperation network in China is 0.0036. The structure of institutions' cooperation network is relatively loose, mainly manifested as a single-line cooperation network. Sichuan University and Chinese Academy of Social Sciences have published large numbers of papers, and both work independently rather than in cooperation with other institutions. In Table 4, institutions that have published 10 or more papers are Sichuan University, Civil Aviation University of China, Harbin Institute of Technology (Shenzhen), Nanjing University of Science and Technology, Nantong University and Tsinghua University, and Anhui University.

Comparing the institutions' distribution, most are found to have advanced technical advantages or deep management foundation, so they can promote DEM research from the perspective of technology or management. However, due to the strong professional characteristics of technologies, carrying out in-depth cooperation is difficult for institutions with different technical directions, resulting in the inability of institutions to form a close cooperation network.

3.2.3. Disciplines' Distribution. Based on WOS data, with "category" as the network node, the time slice is set to one year, and the knowledge map of disciplines of international DEM research can be derived by CiteSpace (Figure 6). The larger the circle, the more the papers published; the thicker the line, the closer the correlation. The complex linkages established by multiple nodes indicate that DEM research is significantly interdisciplinary.

In Figure 7, the top 6 disciplines of international DEM research in 2000–2022 can be obtained. The closest of the disciplines are engineering, computer science, and healthcare science and services. Before 2017, research in all disciplines was still in the exploratory stage, and the number of papers was basically at the same level. Since then, with the maturity and wide application of DTs, such as blockchain, the number of papers has begun to show a geometric growth trend, and DTs have shifted from simple technical research to complex application research, such as government and governance [17]. At the same time, the world is facing the dual background of risk society and the fourth generation of scientific and technological revolution. The change in the social background provides complex and diverse practical

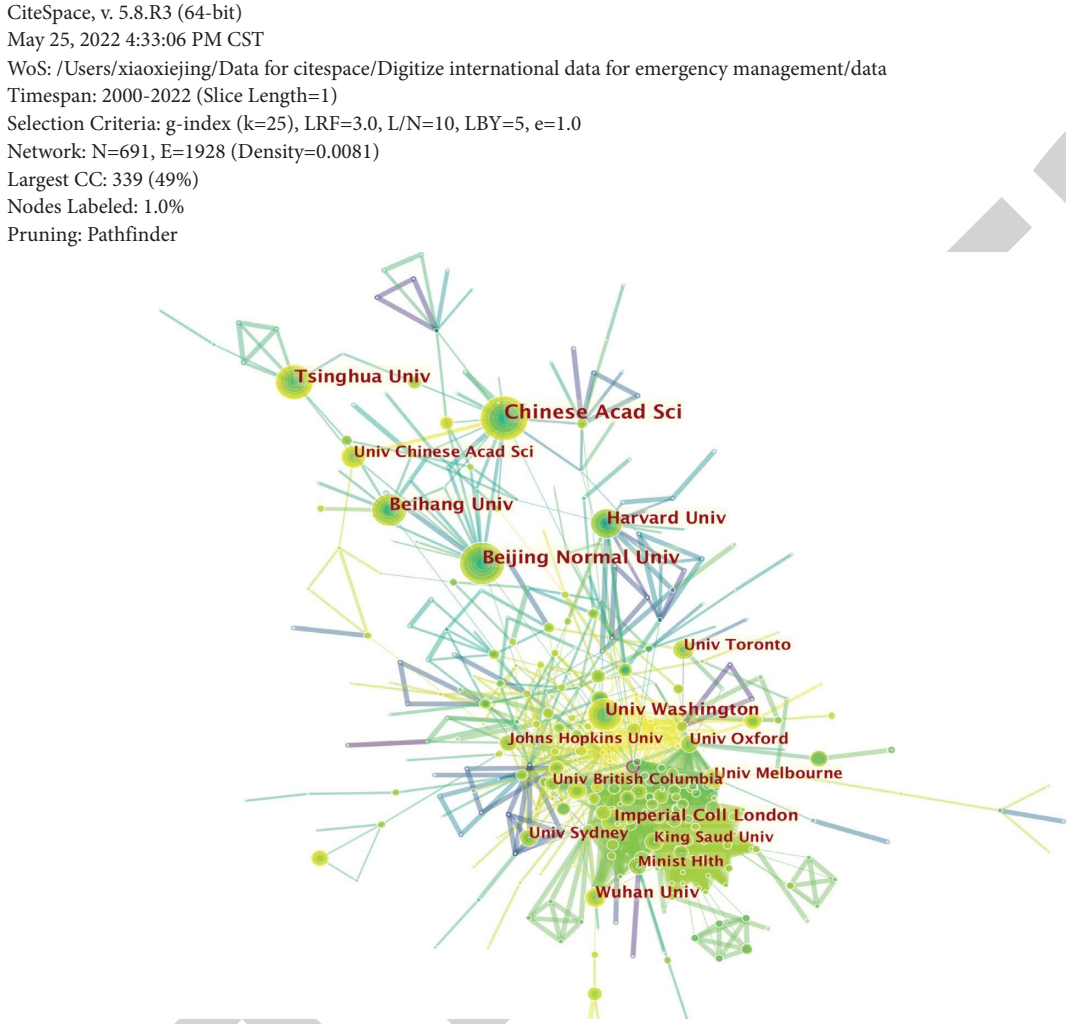

Figure 4: Institutions' cooperation network of international DEM research.

problems for DEM, and the rapid iteration of DTs provides reliable technical support for DEM. Therefore, the number of papers will continue to grow rapidly.

3.2.4. Authors' Distribution. Based on WOS and CNKI data, the functional area is set to "author," and the knowledge map of authors' cooperation network can be exported (Figures 8 and 9). Nodes represent authors. Node sizes indicate the number of papers by authors, and the number of links between nodes refers to the strength of cooperation between authors. The larger the nodes, the denser the connections, indicating that authors play an important role in the network.

In Figure 8, the density of authors' cooperation network of international DEM research is 0.0039, with low network density and loose overall structure, indicating that knowledge dissemination and information penetration in the current research are weak, and the breadth and depth of network node interaction must be further strengthened. In terms of citation, the top 3 authors are Abdallah Samy, Ali Mokdad, and Adnan Kisa.

In Figure 9, the authors' cooperation network of Chinese DEM research shows an obvious small-group characteristic, forming a close-knit small-group network with Yi Liu, Gangyan Xu, Cejun Cao, and Ting Wang as core members. Among them, Liu's research team, whose members are all from Tsinghua University, has been cited the most, and the research results of the team are authoritative in this field.

Comparing the authors' distribution, authors are found to have formed two normal cooperation modes, which are dominated by a certain institution or core member. However, Chinese and international cooperation research is not close enough, and future research should strengthen the broad learning and exchange between Chinese and international authors.

4. Hotspot and Trend Analysis

4.1. Hotspot Analysis. Research hotspots are analysed in CiteSpace by the following two types of maps. The first is the co-word clustering map, which shows the hotspots that scholars pay more attention to. The second is the time zone

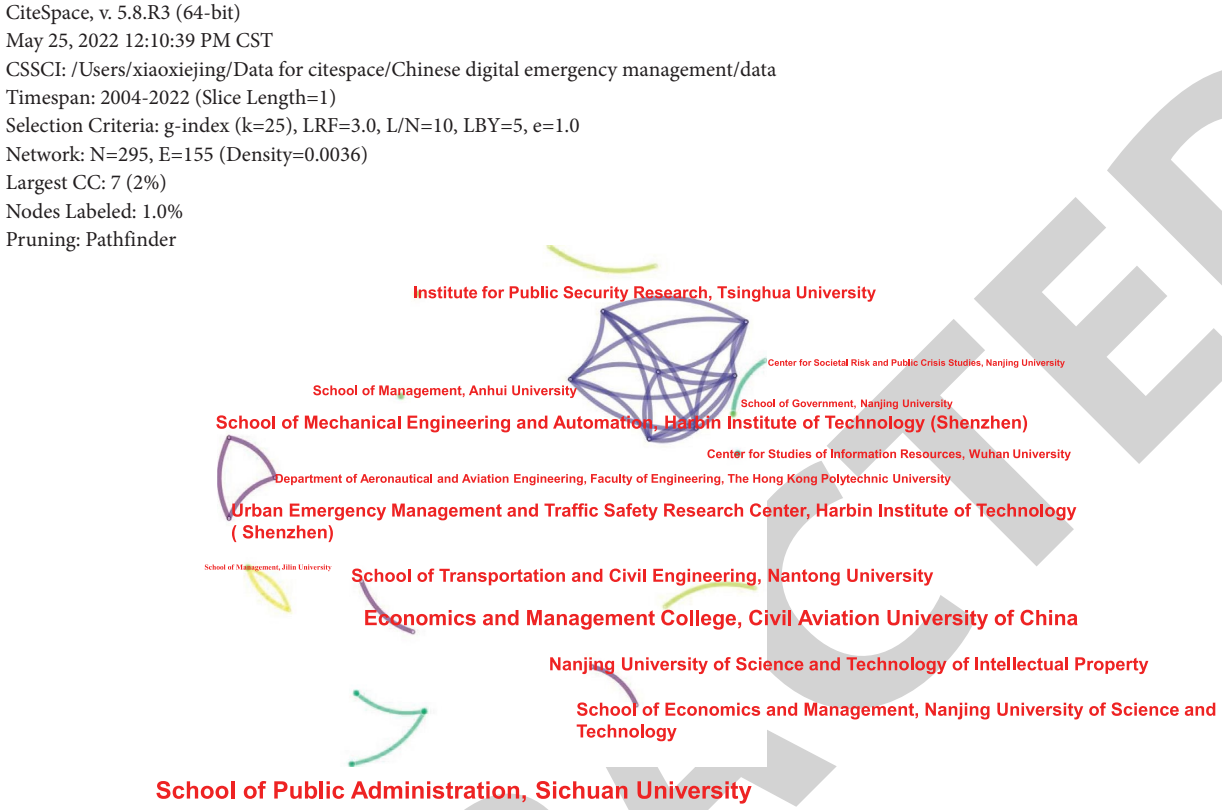

Figure 5: Institutions' cooperation network of Chinese DEM research.

Table 3: Top 20 institutions in the number of papers of international DEM research.

Rank	Institutions	Count
1	Chinese Academy of Sciences	84
2	Beijing Normal University	68
3	Tsinghua University	57
4	Beihang University	53
5	University of Washington	49
6	Harvard University	44
7	Imperial College London	35
8	Wuhan University	34
9	University of Chinese Academy of Sciences	32
10	University of Toronto	31
11	University of Melbourne	31
12	University of Sydney	31
13	University of Oxford	28
14	Johns Hopkins University	27
15	Ministry of Health	26
16	University of British Columbia	26
17	King Saud University	25
18	Huazhong University of Science and Technology	24
19	China University of Mining and Technology	24
20	University of Queensland	24

map of keywords, which shows the distribution and changes of the most popular hotspots in different periods.

4.1.1. Cluster Analysis of Co-Word. Based on WOS and CNKI data, co-word clustering analysis was performed, and co-word clustering maps of international and Chinese DEM research could be obtained, respectively (Figures 10 and 11). In Figures 10 and 11, DEM research is divided into three categories: means, processes, and objects.

(1) DEM Means. The co-word of international DEM research mainly includes #0 Internet of things, #1 mobile phones, #4 simulation, and #11 predictive models. The efficiency improvement of emergency management requires to strengthen the accuracy of information collection and the timeliness of information transmission, and DTs represented by the Internet of things and mobile phones have reshaped the information transmission mechanism. The Internet of things organically combines people and things, enabling "people" to perceive comprehensive information of "things" and even obtain the multidimensional information of "people" through the "things" perception, enhancing the depth, breadth, and fluidity of information [18]. Mobile phones, as important mobile terminals, combine mobile communication with the Internet to realise timely information transmission. The global popularity of mobile phones provides possible solutions for emergency management and establishes perfect systems and mechanisms to deal with disasters [19]. The prediction model and simulation software based on big data conduct scientific analysis

Table 4: Top 20 institutions in the number of papers of Chinese DEM research.

Rank	Institutions	Count
1	School of Public Administration, Sichuan University	21
2	Economics and Management College, Civil Aviation University of China	18
3	Urban Emergency Management and Traffic Safety Research Center, Harbin Institute of Technology (Shenzhen)	16
4	School of Mechanical Engineering and Automation, Harbin Institute of Technology (Shenzhen)	16
5	School of Economics and Management, Nanjing University of Science and Technology	16
6	Nanjing University of Science and Technology of Intellectual Property	16
7	School of Transportation and Civil Engineering, Nantong University	16
8	Institute for Public Security Research, Tsinghua University	12
9	School of Management, Anhui University	11
10	Department of Aeronautical and Aviation Engineering, Faculty of Engineering, The Hong Kong Polytechnic University	8
11	Center for Studies of Information Resources, Wuhan University	8
12	School of Information Management, Nanjing University	7
13	Institutes of Science and Development, Chinese Academy of Sciences	6
14	School of Government, Nanjing University	6
15	School of Management, Lanzhou University	5
16	Center for Societal Risk and Public Crisis Studies, Nanjing University	5
17	College of Computer Science and Technology, Beihua University	4
18	School of Management, Harbin Institute of Technology	4
19	School of Resources and Safety Engineering, Central South University	4
20	School of Management, Jilin University	4

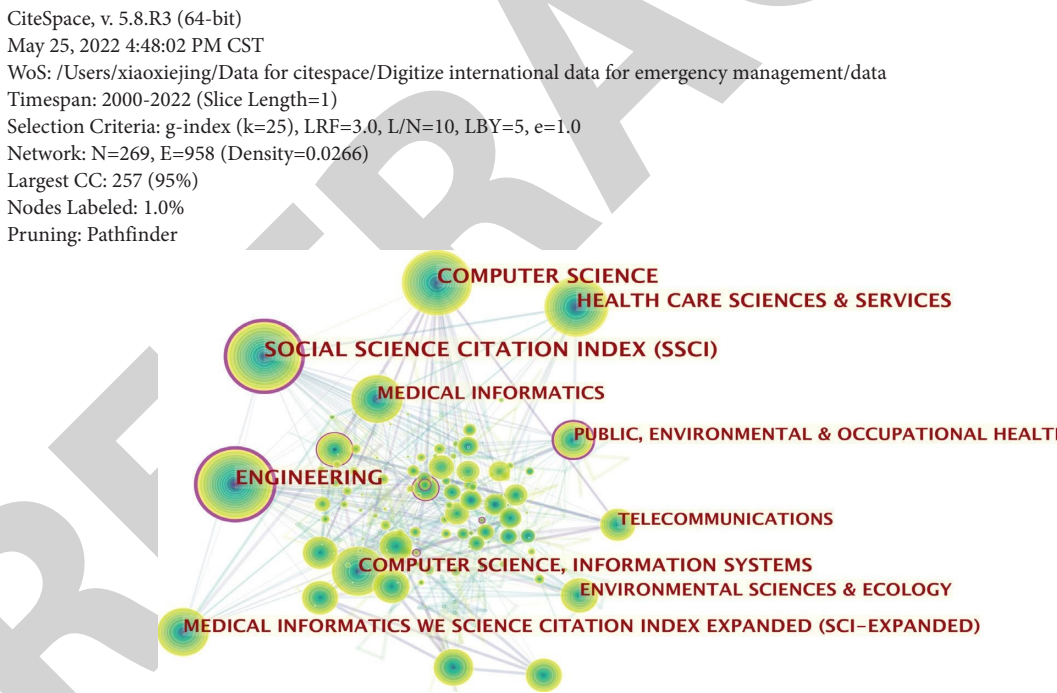

Figure 6: Disciplines' distribution map of international DEM research.

on massive information by integrating digital and intelligent technology to make relatively accurate judgment on reality and prediction, reconstruct the emergency decision making mode, and improve the accuracy and timeliness of emergency decision making. The co-word of Chinese DEM research mainly includes #4 big data, #7 intelligent contract, and #8 cloud computer. Chinese DEM research emphasises DTs as a new growth pole for modernising the emergency management system and capacities. DTs are necessary to achieve the transition from the traditional government-led to a collaborative governance model of emergency management with multiple actors. In fact, DT-driven emergency management has become an important part of the Chinese emergency management system.

(2) DEM Process. International DEM research emphasises the use of DTs throughout the emergency management process, and its co-word includes #3 health information exchange, #7 crisis management, and #9 trends. The creation of digital governments and digital nations is driving the

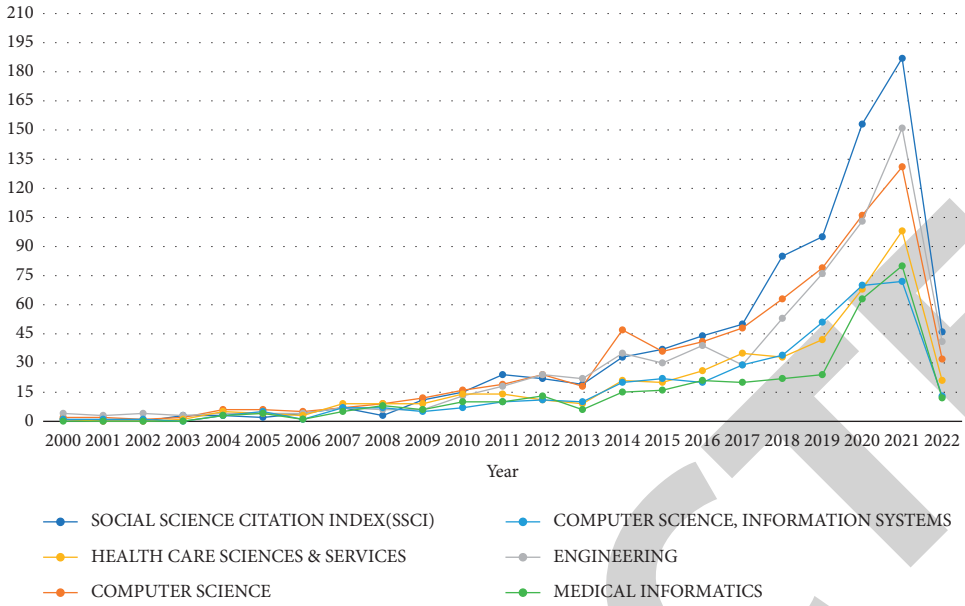

Figure 7: Top 6 disciplines of international DEM research in 2000–2022.

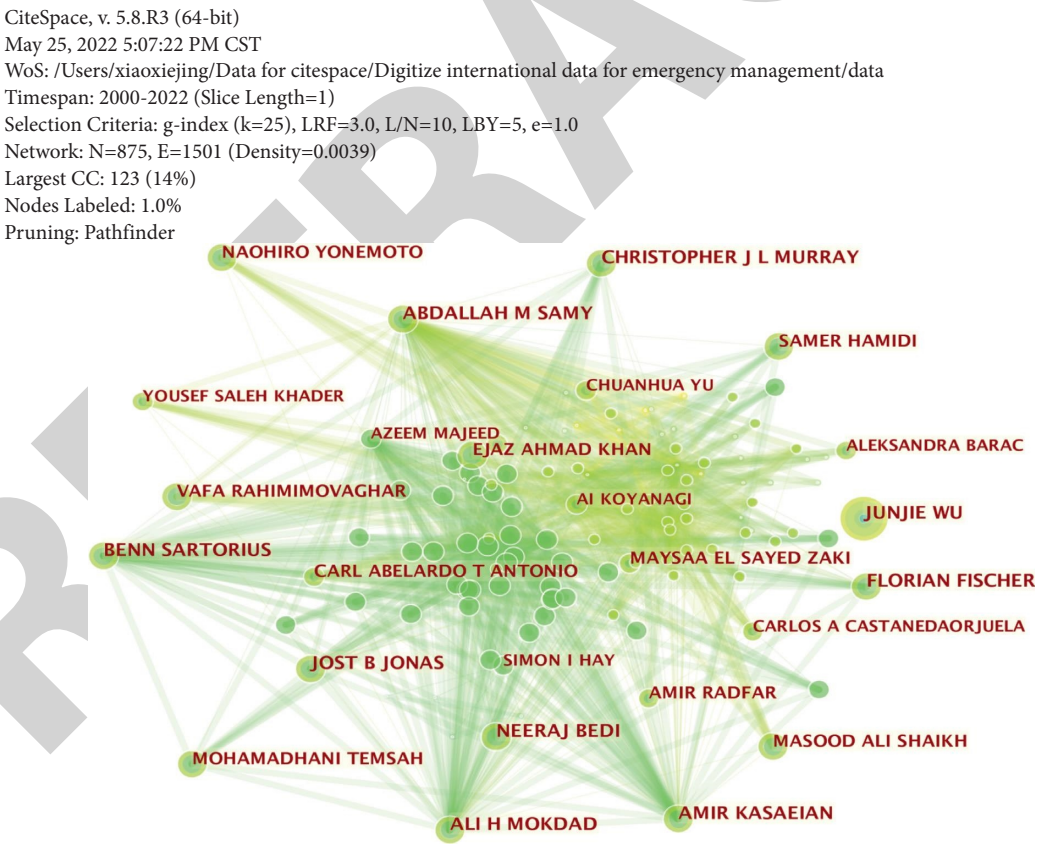

Figure 8: Authors' cooperation network of international DEM research.

creation of a global system of digital information, known as the digital earth [20]. The popularisation of digital information facilities also promotes the comprehensive digital transformation of emergency management. DTs provide increasing convenience to the whole process of emergency management for prevention, preparation, response, and recovery. The co-word of Chinese DEM research mainly includes #2 emergency rescue, #5 information sharing, #6 contingency plan, and #11 emergency response. Chinese scholars began research on emergency management with a

Figure 9: Authors' cooperation network of Chinese DEM research.

preference for a legal perspective [21], and early research focused on optimising management procedures [22]. Digital contingency plan technology is a new research direction. In practice, it has experienced different stages such as electronics, visualisation, and intellectualisation of contingency plan, which effectively improves the ability to deal with emergency events. For example, the consequences of different policy choices are evaluated by algorithms, and contingency plans are refined based on the results [23]. Emergency rescue and response are dynamic management activities aiming at "efficiency, effectivity, benefit, and equity," and require an enhanced use of DTs to improve the quality and speed of information transmission to reduce the harm degree levels of emergencies.

(3) DEM Objects. The co-word of international DEM research emphasises the diversification of research objects, including #2 social media, #5 humanitarian logistics, #6 geographic information system, and #8 middle east. The DEM not only eliminates the disadvantages of traditional emergency management mode, but also produces a new risk overflow, which has given rise to two major research fields. First, international DEM research continues to pay attention to traditional issues, such as humanitarian logistics, and geographic information systems and regions. Among them, humanitarian logistics research started to focus on digital volunteers, emphasising that volunteers can save many lives by cooperating with one another and using information, communication, and computer technology in a collective and innovative way. In this way, first responders can effectively perform rescue tasks and provide aid resources [24]. Second, it begins to pay attention to emerging digital risk issues, such as social media. Social media expands the existence and path of digital emotional infections and increases the susceptibility of positive and negative emotions [25]. Chinese DEM research includes #0 city safety, #3 epidemic prevention and control, and #9 earthquake disaster. The development of DEM research has profound background of socioeconomic change [26]. With the deepening of the fourth industrial revolution and the social change driven by the information technology revolution, the development of emergency management is objectively required to be carried out under the background of the digital wave, which has derived many new research topics. As the focus of Chinese governance began to sink to the grassroots level, urban safety and grassroots emergency

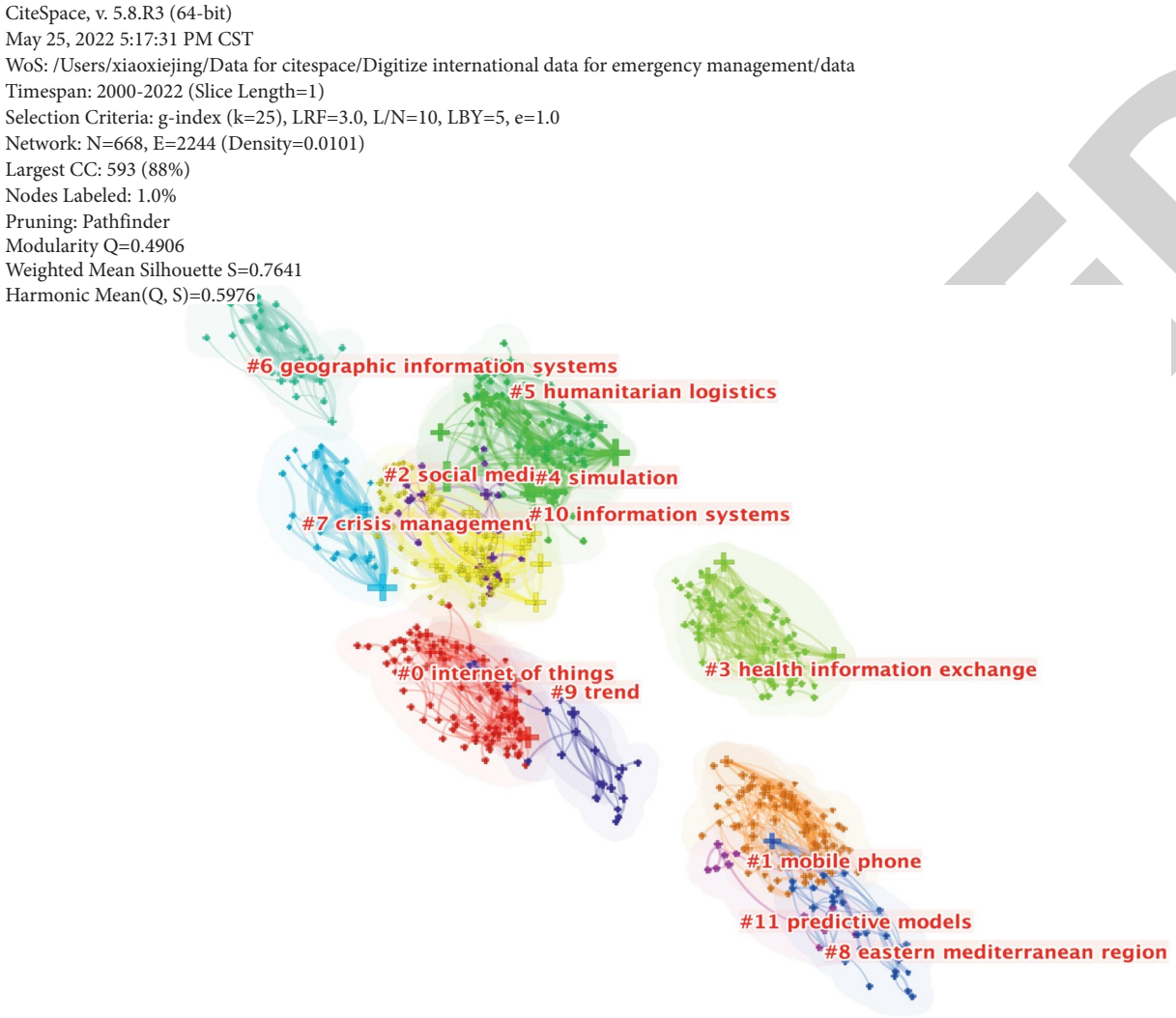

Figure 10: Co-word clustering map of international DEM research.

management became the research focus, and COVID-19 and earthquake disasters often became the social research background.

4.1.2. Evolution Analysis of Research Hotspots. Based on WOS and CNKI data, the time zone maps of international and Chinese DEM research are illustrated in Figures 12 and 13, respectively.

In Figure 12, DEM research shows the evolution characteristics of progressive innovation. International DEM research can be divided into three stages. The first is the embryonic stage (2000–2010), and keywords mainly include system, management, model, and geographic information. In this stage, emergency management and DTs are still studied along two paths, management and technology, and are less integrated with each other. Existing cross-sectional research mainly focuses on improving emergency management efficiency by optimising DTs. For example, Pareschi pointed out that the geographic information remote sensing system should be used to improve the scientific nature of emergency decision making and optimise land planning to reduce the negative impacts of emergencies [27]. The second is the development stage (2011–2016), and keywords mainly include decision making, emergency response, and disaster response. Although DTs, such as information and communication, are highly utilised in the emergency response network [28], core organisations have not made full use of them and have failed to play their due role. Thus, the scholars gradually realise that DEM is not a simple information technology + emergency management. DTs are a "force multiplier" [29], and participating in emergency management produces new risks while playing positive roles [30]. Therefore, digitally reengineering the emergency management process and promoting the construction of the DEM mode are necessary [31, 32]. The third is the deepening stage (2017–2022), and keywords mainly include big data analysis. Based on previous research, the DEM mode is optimised and adjusted with the help of DTs. For example, a risk response and governance cycle system has been established in public health and other fields, which has improved risk response capacity and governance effectiveness [25]. The rapid

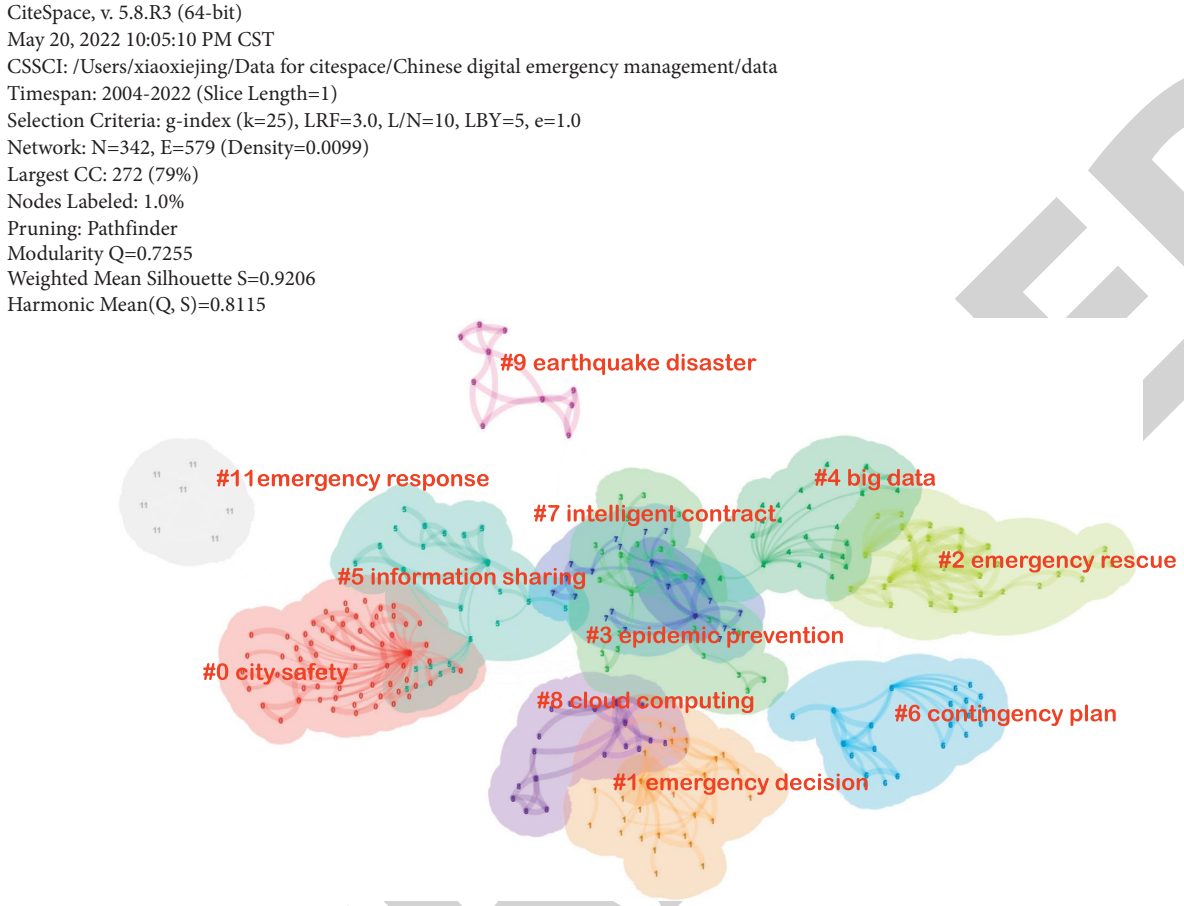

Figure 11: Co-word clustering map of Chinese DEM research.

development of new generation DTs, such as blockchain and artificial intelligence technology, promotes its wide application in emergency management, accompanied by the application risks of technologies, such as digital inequality and information overload pressure [4, 33]. Therefore, the research focus must be shifted from subject digitisation to stakeholder digitisation, which uses virtual reality technology to train people to correctly understand and use crisis information, reduce the deviation between intention and behaviour, and not simply promote technological development [34]. It is gradually forming the digital collaboration of multiple subjects of emergency management to improve the DEM mode.

In Figure 13, Chinese DEM research can be divided into three periods. The first is the embryonic stage (2004–2012), and keywords mainly include emergency rescue, intelligent emergency response, and natural gas. In this stage, there are few papers, most of the keywords are still focused on emergency management, and the research questions are mainly around the basic concepts, characteristics, and applicability of DTs, for example, the optimisation of the emergency management structure of urban power grid by designing the power grid emergency management support platform [35]. The second is the development stage (2013–2017), and keywords include cloud computing, big data, Internet+, information sharing, and crisis management. DEM research has increased significantly in this stage, and most high-frequency keywords have appeared, which plays an important role in guiding and diffusing the follow-up development. Meanwhile, China is stepping into the big data era, which poses application challenges to the Chinese emergency management system in terms of data capacity construction, warning and prediction, information transmission, and related application [36]. China urgently needs to build a personalised DEM model. The third is the deepening stage (2018–2022), and keywords include epidemic prevention. Research in this stage has obvious policy and problem orientations. In October 2019, the Fourth Plenary Session of the 19th Central Committee of the Communist Party of China (CPC) stressed the need to adhere to and improve the socialist system with Chinese characteristics and advance the modernisation of China's system and capacity for governance. Subsequently, research on digital government, digital governance, and smart city has emerged rapidly. DTs can carry out technological supply innovation in three dimensions—organisational structure, technical hardware, and decision basis—and promote the modernisation of risk management system and capacity [37]. The COVID-19 outbreak has also given birth to research on emergency intelligence, big data governance capability evaluation, and intelligent emergency in the public health emergency context [38].

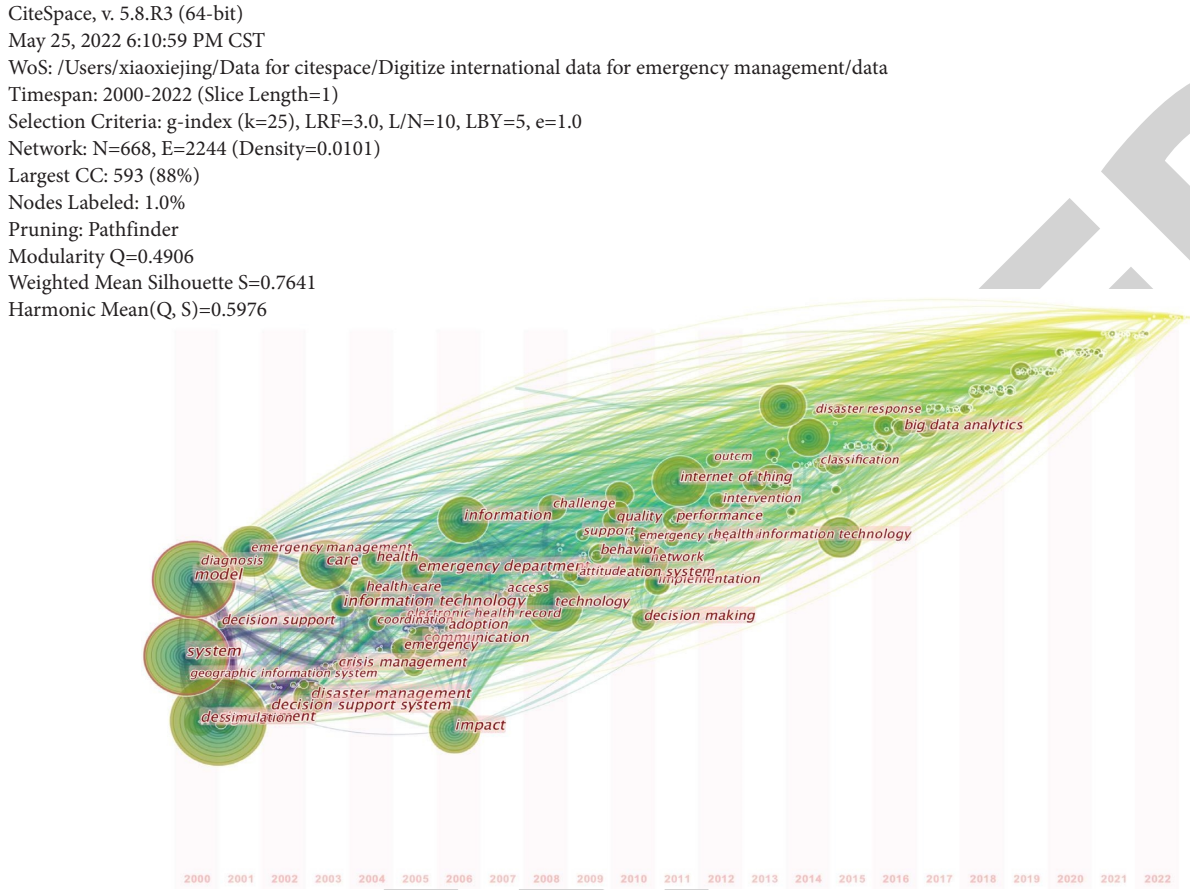

Figure 12: Time zone map of keywords of international DEM research.

Comparing the time zone maps of keywords, international and Chinese DEM research has experienced three stages of embryonic, development, and deepening, but international DEM research follows the technology orientation, gradually recognising the "double-edged sword" characteristics of technologies in the construction of the DEM mode and eliminating the negative effects of technologies through technical iteration. Meanwhile, Chinese DEM research follows the management path. Through the gradual system reform, the practical gap between technology and management is eliminated, and DT effectiveness in solving practical problems is enhanced.

4.2. Trends Analysis. Research trends are analysed with burst words in CiteSpace. By comparing the strength of burst words, it is possible to predict which hotspots will continue the explosive trend in the future. Based on WOS and CNKI data, the keywords with the strongest bursts of international and Chinese DEM research are illustrated in Figures 14 and 15, respectively. Figure 14 shows the 25 strongest burst keywords during 2001–2020, and Figure 15 displays the 20 strongest burst keywords during 2004–2020. The higher the value of burst keywords, the higher the frequency change rate of the keywords in this period. The blue line represents the time interval, and the red line represents the time interval in which the word occurred.

International DEM research trends include decision support system, information management, information technology (IT), access and information system, geographic information, emergency management, implementation, and health information technology. In terms of citation cycle, the decision support system has the longest burst cycle (13 years), and location has the shortest burst cycle (1 year). From the burst intensity, IT is the keyword with the strongest explosive power, followed by artificial intelligence, machine learning, information system, geographic information, and healthy information technology. Through the analysis of burst keywords, the research trends of international DEM research in recent years can be predicted.

4.2.1. Information Technology. DTs commonly used in emergency management include Internet technology, wireless technology, remote sensing technology, emergency management decision system, disaster analysis, simulation technology, and warning system [39]. One or several of them can be integrated into different technology platforms and applied in emergency management. In natural disaster management, IT is used to monitor the representation information of natural disasters, obtain data, and predict natural disaster events through model simulation and deduction [40]. In community crisis management, IT can be used to establish a basic community resource database,

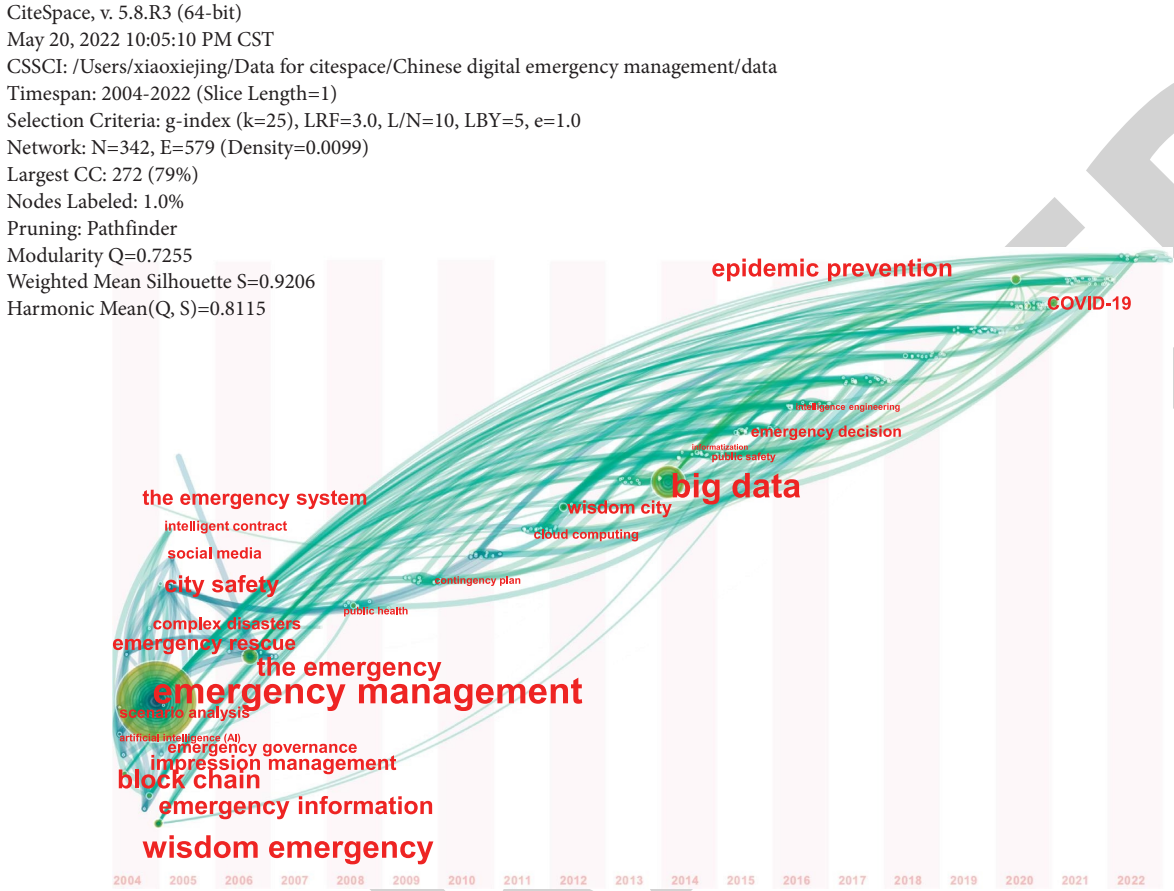

Figure 13: Time zone map of keywords of Chinese DEM research.

supporting crisis communication, crisis response, crisis decision making, and crisis recovery in community crisis management [41]. IT, including computer networks, digital libraries, satellite communications, remote sensing, geographic information systems, and decision support systems, has facilitated the worldwide exchange of disaster information. Moreover, effective data sharing and retrieval methods make the acquisition of crisis information beyond the boundaries of region, country, and discipline [42]. With the wide application of the Internet, online public opinion has been paid increasing attention by crisis managers. IT has been used to monitor the spread of crisis information in online communities and track the development of crisis events. At the same time, the application of IT in crisis management has encountered some obstacles. Information filtering in crisis and other factors affecting this application, such as organisational culture, personnel, structure, and other factors, have attracted varying degrees of attention [43].

4.2.2. Public Health. DTs can effectively enhance the resilience of the public health system and reduce the destructive power of public health emergencies. The vulnerability of the public health system also requires people to reshape the concept of crisis, from emphasising crisis response to a comprehensive cycle of preparation, response, and recovery [44]. Reeder and Turner found that in response to public health emergencies, public health practitioners are allowed to participate in the creation and optimisation of an information design, which is conducive to quickly and accurately assess the availability of labour forces in adverse and changing circumstances to support routine and emergency public health activities [45]. Duan et al. applied artificial intelligence and other technologies to the emergency management of public health emergencies to achieve the optimal allocation of protection and treatment resources [46]. Using COVID-19 in Hong Kong as an example, Chan used computerised random digit dialling and found that there was a lack of awareness of health risks; in addition, there were significant differences in people's attitudes and behaviours [47]. Due to the sudden, serious, and urgent characteristics of public health emergencies, the public encounter psychological problems, such as panic and anxiety. As frontline personnel, community workers know local residents well. Their work easily gains trust and may become the main force to solve residents' psychological problems during public health emergencies [48].

Chinese DEM research trends include smart contract, scenario analysis, social media, emergency rescue, natural gas, emergency linkage, emergency response, emergency disposal, data mining, and smart city. Scenario analysis has

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2000 - 2022
decision support system	2000	5.51	2001	2014	
information management	2000	4.17	2004	2014	
information technology	2000	9.71	2007	2014	
access	2000	3.72	2007	2015	
information system	2000	8.74	2008	2013	
gi	2000	7.46	2009	2014	
emergency management	2000	4.06	2009	2013	
implementation	2000	4.25	2010	2013	
health information technology	2000	6.83	2012	2017	
emergency response	2000	6.59	2012	2014	
cloud computing	2000	5.61	2013	2014	
disaster	2000	3.92	2013	2016	
quality of life	2000	3.67	2013	2016	
sensor network	2000	3.62	2013	2017	
uncertainty	2000	3.86	2014	2015	
electronic health record	2000	5.89	2015	2017	
quality	2000	4.6	2015	2017	
preparedness	2000	4.17	2015	2018	
community resilience	2000	3.76	2018	2020	
resilience	2000	3.67	2018	2020	
location	2000	3.86	2019	2020	
artificial intelligence	2000	9.31	2020	2022	
machine learning	2000	9.04	2020	2022	
digital health	2000	3.71	2020	2022	
public health	2000	3.56	2020	2022	

Figure 14: Top 25 keywords with the strongest citation bursts of international DEM research.

the longest citation period (6 years), whereas emergency linkage has the shortest (1 year) among the 25 keywords. From the burst intensity, the strongest keyword is emergency decision making, followed by intelligence system, emergency response, smart contract, intelligence, social media, and COVID-19. Analysing the burst keywords in Figure 15, the research trends of Chinese DEM research can be predicted.

4.2.3. Emergency Decision Making. In the direction of emergency decision making research, typical topics include emergency resource scheduling and allocation, emergency storage location, and emergency response and warning. Under the background of the gradual establishment of the emergency management system and mechanism, research on emergency decision making can provide scientific and reliable theoretical support for decision makers.

4.2.4. Scenario Analysis. As a research method and forecasting technology, scenario analysis is a potential research hotspot in the future. Scenario construction research is based on the idea of risk management, aiming at the highly destructive events of "small probability and large consequence" that cannot be dealt with by the conventional management mode, to provide guidance and objectives for emergency work. Its working principle can be summarised as follows: based on the analysis of possible emergency scenarios and consequences, study the key nodes that need emergency disposal, consequence mitigation, and prevention preparation; reasonably select the emergency disposal opportunity window and assign work tasks; and make targeted emergency plans, preparation strategies, and development of a set of technical routes and working methods of capacity in advance [49]. In the current situation that huge disasters are difficult to predict and manage, the construction of a corresponding scenario mode can clarify the occurrence process of emergencies to take targeted measures for reducing the probability of accidents and ensuring the safe operation of production. At present, scholars have explored the scenario construction technology in the fields of blowout, flood, earthquake, and pipeline leakage. Future studies on the construction of various disaster scenarios will become research hotspots in the field of emergency management.

4.2.5. Public Health. Public health events are accelerated by population growth, urban development, migration, and other issues brought about by globalisation [50]. The outbreak of public health events, such as COVID-19, has also driven the emergency management process to put public health emergency management in the first place [51]. The digitalisation of public health emergency management is a relatively new field, which utilises specific knowledge, techniques, and organisational principles in emergency management and involves the planning, organisation, leadership, coordination, control, assessment, prevention, preparation, and response of public health emergencies [52, 53]. At present, scholars have studied smart medicine, medical digital resources, health codes, digital empowerment, and other specific issues. Future research on the innovation of governance mode and application of digital governance means in the background of public health emergencies will become research hotspots in this field.

Comparing the burst keywords of international and Chinese DEM research, both have experienced the

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2004 - 2022
intelligent contract	2004	4.06	2004	2009	
scenario analysis	2004	3.51	2004	2010	
social media	2004	3.26	2004	2009	
emergency rescue	2004	2.8	2004	2007	
natural gas	2004	2.73	2004	2010	
emergency linkage	2004	2.46	2009	2010	
emergency response	2004	4.07	2010	2012	
emergency disposal	2004	2.42	2010	2014	
data mining	2004	2.36	2010	2011	
the smart grid	2004	2.13	2011	2013	
the simulation	2004	1.79	2011	2014	
artificial society	2004	2.56	2012	2015	
Internet	2004	2.03	2012	2014	
emergency command	2004	2.4	2013	2015	
the information society	2004	2.22	2013	2014	
emergency decision	2004	4.8	2015	2016	
intelligence system	2004	4.69	2015	2016	
intelligence	2004	3.75	2015	2016	
wisdom city	2004	2.9	2015	2016	
intelligence service	2004	1.87	2015	2016	
COVID-19	2004	5.87	2020	2022	
digital governance	2004	4.25	2020	2022	
public health	2004	2.84	2020	2022	
health code	2004	2.64	2020	2022	
research hot spot	2004	2.11	2020	2022	

Figure 15: Top 25 keywords with the strongest citation bursts of Chinese DEM research.

transformation from information technology to emergency management and then to digital management, which shows that the research perspective of DEM research has experienced transformation at micro, macro, and middle levels. Moreover, the research paradigm shows the transformation of technology orientation, management orientation, and technical management orientation. This dual transformation is related not only to the rapid development of social environment and science and technology but also to the development process of DEM research from paying attention to practical application to theoretical construction, and then to both. However, due to the differences between international and Chinese social backgrounds and practical problems, great differences between trends of international and Chinese DEM research remain. The main difference between the two is that international DEM research pays attention to the construction of the emergency management system, whereas Chinese DEM research focuses on the solutions to practical problems.

5. Conclusion

Facing the dual background of risk society and the fourth scientific and technological revolution, DEM research came into being and developed rapidly. To systematically summarise the overall picture of DEM research, first, CiteSpace is used to analyse the spatiotemporal distribution of DEM research. Second, the co-word clustering map reveals the research hotspots. Thirdly, according to the time zone map of keywords, the evolution of research hotspots is summarised. Finally, DEM research trends are predicted on the basis of burst keywords. The specific conclusions are as follows:

(1) *Temporal Ditribution*. Based on descriptive statistics, DEM research shows a spiral growth. In addition, future international papers have a large growth rate, whereas the trend of Chinese papers is relatively flat. From the distribution of highly cited references, existing research is mainly conducted from the perspective of management or technology.

(2) *Spatial Distribution*. From the distribution of countries, a complex countries' cooperation network has been formed from the USA, China, Australia, England, Australia, Canada, Italy, South Korea, Spain, and India. From the distribution of institutions, the complexity of institutions' cooperation networks of international and Chinese DEM research must be strengthened. The former shows small-group characteristics, while the latter shows single-line characteristics. From the distribution of disciplines, DEM research has significant interdisciplinary properties. From the distribution of author, the authors' cooperation networks of international and Chinese DEM research show different characteristics. The former is less dense and loosely

structured, while the latter shows the characteristics of small groups.

(3) *Research Hotspots*. The hotspots of international and Chinese research can be divided into three categories: DEM means, processes, and objects. Not only that both can be divided into three stages: initial, development, and deepening stages, but also that the research contents of international and Chinese DEM research in each stage show certain differences. In general, the former follows a technical orientation, while the latter follows a managerial route.

(4) *Research Trends*. The focus of future research is still on how to build a relatively complete DEM system. However, due to different social backgrounds and research foundations, the trends of international DEM research focus on information technology, artificial intelligence, and machine learning. Meanwhile, Chinese DEM research pays attention to emergency decision making, scenario analysis, and public health.

Data Availability

The data used to support the findings of the study are available from the corresponding author upon request.

Disclosure

Rui Nan and Wenjun Zhu are the co-first authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Rui Nan and Wenjun Zhu contributed to the work equally.

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