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Visualizing the Knowledge Base and Research Hotspot of Public Health Emergency Management: A Science Mapping Analysis-Based Study

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Abstract: Public health emergency management has been one of the main challenges of social sustainable development since the beginning of the 21st century. Research on public health emergency management is becoming a common focus of scholars. In recent years, the literature associated with public health emergency management has grown rapidly, but few studies have used a bibliometric analysis and visualization approach to conduct deep mining and explore the characteristics of the public health emergency management research field. To better understand the present status and development of public health emergency management research, and to explore the knowledge base and research hotspots, the bibliometric method and science mapping technology were adopted to visually evaluate the knowledge structure and research trends in the field of public health emergency management studies. From 2000 to 2020, a total of 3723 papers related to public health emergency management research were collected from the Web of Science Core Collection as research data. The five main research directions formed are child prevention, mortality from public health events, public health emergency preparedness, public health emergency management, and coronavirus disease 2019 (COVID-19). The current research hotspots and frontiers are climate change, COVID-19 and related coronaviruses. Further research is needed to focus on the COVID-19 and related coronaviruses. This study intends to contribute inclusive support to related academia and industry in the aspects of public health emergency management and public safety research, as well as research hotspots and future research directions.

Keywords: public health; emergency management; public safety; research hotspot; bibliometrics; science mapping

1. Introduction

Since the beginning of the 21st century, public health emergencies have occurred frequently, and large-scale outbreaks of SARS-CoV-1 virus, H1N1 influenza virus, Ebola virus, Zika virus and SARS-CoV-2 virus (COVID-19) have been witnessed. The large-scale epidemic at the end of 2019 had a significant impact on the sustainable development of society. The definition of a public health emergency includes both its causes and triggers as well as its health consequences. A situation becomes an emergency when the health consequences of the situation may exceed the ability to handle it on a daily basis [1]. Therefore, public health emergencies are extremely unexpected and harmful. In fact, every large-scale outbreak of public health emergencies had a significant impact on the economic development and social stability and sustainability of all countries in the world. At the same time, countries with different levels of economic development have different capabilities of managing in response to public health emergencies. When public health
emergencies occur, countries with relatively low economic levels are vulnerable to greater impact, and their government management capacity, material reserves, and medical levels are relatively low. Countries with relatively advanced economic levels can often respond to incidents quickly, effectively control them and provide support to other countries. They can push their defense lines to other countries, learn the latest developments directly, gain prevention and control experience, and maintain and develop their own prevention and control capabilities. The impact of SARS-CoV-1 virus on the Chinese transportation industry has been enormous and is considered irreparable and unrecoverable [2]. The Ebola epidemic in West Africa from 2014 to 2016 caused 28,637 infections, resulting in approximately 11,000 deaths and economic losses of USD 6 billion in Africa, and more than USD 12 billion worldwide [3]. COVID-19 remains a massive epidemic today. As of early February 2021, there are more than 100 million infections and more than 2.31 million deaths worldwide, and these numbers are still increasing. Many countries have closed their main cities, suspended international flights, and people's daily work and life are subject to suspension. The economic losses and social sustainable development impacts that have been caused are incalculable. The damage caused by the unprecedented pandemic virus shows that public health emergency management capacity remains largely inadequate. It can be seen that the improvement of public health emergency management capability is urgent and should be paid attention to by society.

At present, there are some research results on various aspects related to public health emergency management. When public health emergencies occur, scholars have put forward some suggestions for improving the allocation of resources and manpower in medical institutions [4,5]. For the purchase of basic materials by ordinary people in emergencies, some researchers have conducted research on specific changes in behavior and the supply of materials [6–8]. When preparing for an unknown emergency, scholars have put forward more complete countermeasures in terms of personnel preparation, plan formulation, and management framework [9–12]. Some scholars have put forward specific plans for specific areas and management methods between multiple areas [13,14]. Many researchers believe that enhancing the transparency, accuracy, and ease of communication of information when emergencies occur can help facilitate effective responses to the events [15–17]. There has been a certain research foundation on public health emergency management. Researchers have conducted extensive research on different areas, groups, and solutions involved in public health emergency management, and the research results have provided greater theoretical and technical support for public health emergency management, which has also meant that public health emergency management research has entered the application stage. It is a relatively macroscopic understanding of the application of public health emergency management research by scholars, and it is difficult to express the latest information related to specific topics from the current understanding. In particular, the explosive growth rate of knowledge makes it more difficult to fully understand public health emergency management research. With the digitalization of scientific literature, it is possible to tap into research hotspots and make progress through scientific and technical literature. However, few scholars have conducted systematic analyses on the current research status of public health emergency management. Therefore, we used bibliometric and science mapping technology to understand the current situation and development trends of public health emergency management research from the perspective of bibliometrics.

Bibliometrics is an interdisciplinary science that uses mathematical and statistical methods, which can be used to quantitatively analyze knowledge carriers [18]. The approach has been used by many scholars in different fields, such as sustainable development [19], nanocatalysis [20], cybernetics [21] and medical big data analysis [22]. Additionally, bibliometric and science mapping technology has been introduced in SafeMetrics quantitative science studies for safety science, such as safety culture [23], road safety [24], process safety [25], emergency evacuation [26], risk communication [27], fire safety [28,29] and bibliographic synopsis analysis of safety science [30]. In particular, the Safety Science Journal has launched a special issue on Mapping Safety Science [31]; the publication of
relevant papers is influential in the communication of scholars. Therefore, it can be said that scholars may use this approach to understand how the data are connected, which can reveal the structure and development of research results in this field [32]. The development of computing technology makes it possible to process a large amount of data, and bibliometrics has developed to a new level [29]. Combined with visualization technology, we can intuitively show the development path and internal relations of related research fields.

2. Data Sample and Research Methods

2.1. Data Collection

SSCI and SCI-E in the Web of Science Core Collection were selected as the target database. The search formula was set to TS = (Emergency) AND TS = (Public health) in the advanced search. The retrieval time was from 2000 to 2020 (as of November 2020). The search language was “All languages” and the document type “All document types”. After the initial search, the search results were refined through the Web of Science category “Public Environmental Occupational Health”. The 3723 search records finally obtained were used as the research samples of this paper. The retrieval strategy and retrieval process for the data set are shown in Table 1.

Table 1. Data sample retrieval strategy and retrieval process.

<table>
<thead>
<tr>
<th>No.</th>
<th>Retrieval Formula</th>
<th>Data Set</th>
<th>Number of Records</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TS = (Emergency)</td>
<td>A</td>
<td>229,933</td>
<td>2000–2020</td>
</tr>
<tr>
<td>2</td>
<td>TS = (Public health)</td>
<td>B</td>
<td>287,972</td>
<td>2000–2020</td>
</tr>
<tr>
<td>3</td>
<td>TS = (Emergency) NOT TS = (Public health)</td>
<td>A,~B</td>
<td>217,303</td>
<td>2000–2020</td>
</tr>
<tr>
<td>4</td>
<td>TS = (Public health) NOT TS = (Emergency)</td>
<td>B,~A</td>
<td>275,345</td>
<td>2000–2020</td>
</tr>
<tr>
<td>5</td>
<td>TS = (Emergency) OR TS = (Public health)</td>
<td>A∪B</td>
<td>505,279</td>
<td>2000–2020</td>
</tr>
<tr>
<td>6</td>
<td>TS = (Emergency) AND TS = (Public health)</td>
<td>A∩B</td>
<td>12,630</td>
<td>2000–2020</td>
</tr>
<tr>
<td>7</td>
<td>TS = (Emergency) AND TS = (Public health)Public Environmental Occupational Health</td>
<td>-</td>
<td>3723</td>
<td>2000–2020</td>
</tr>
</tbody>
</table>

A∪B: joint dataset with articles from dataset A and B; A∩B: dataset with articles found both in dataset A and B,~A: articles from the dataset were excluded.

2.2. Methods and Visualization Tools

VOSviewer and CiteSpace were used for bibliometric analysis. Van Eck and Waltman proposed a new visualization method for node similarity [33,34] and integrated this algorithm into VOSviewer software. The foundation of this algorithm enables VOSviewer to visually express the correlation strength between two nodes in the visual analysis, and the visual effect is intuitive. Therefore, VOSviewer will be used when it is necessary to highlight the clustering relationship and the closeness of the connection between nodes. In addition, CiteSpace was used to display the evolution of literature information more intuitively over time [35–38]. The methods and processes used in the research are shown in Figure 1.
3. Results and Discussion

3.1. Temporal Distribution

The time distribution of the publication volume of public health emergency management research literature is shown in Figure 2. It can be seen that only a small fluctuation occurred during the period 2008–2013. In general, the annual publication volume is on the rise. The data cut-off was November 2020. The number of posts published in 2020 was higher than other years. The average annual publication amount is 177.29. Combining the small fluctuations in the volume of publications from 2008 to 2013, the development of public health emergency management research is divided into three stages.

The preliminary development stage (2000–2007). A total of 510 papers were published in the eight years during this stage, accounting for 13.70% of the statistical data, and...
63.75 papers were published annually. Moreover, the annual number of publications in the eight years was lower than the average level, and the growth rate was relatively slow.

The stable development stage (2008–2013). A total of 1050 papers were published during the six years at this stage, accounting for 28.20% of the statistical data. The average annual publication of 175 papers is very close to the overall average annual publication volume, and the overall publication volume shows up and down fluctuations, with the 2010 and 2012 publication volumes exceeding the overall average.

The rapid development stage (2014–2020). A total of 2163 papers were published in the seven years during this stage, accounting for 58.10% of the statistical data. An average of 309 papers were published every year, growing rapidly. In terms of the annual growth rate of the number of publications, the years with higher growth rates at each stage of development are often associated with major public health emergencies. The change in growth rate is shown in Figure 3. It can be seen that in the preliminary development stage, the global pandemic of the SARS virus in 2003 resulted in extremely high publication growth rates in 2004 (50.00%) and 2005 (60.31%). In the stable development stage, the growth rate was extremely high in 2012 (22.35%), when respiratory syndrome broke out in the Middle East. In the rapid development stage, the number of publications increased at a higher rate in 2014 (40.25%) and 2020 (21.73%), with the Ebola outbreak in West Africa in 2014 and the COVID-19 pandemic that began in late 2019.

![Figure 3. Growth rate of the number of publications by year.](image)

3.2. Institutional Distribution

Through the analysis of the sample data, we have obtained 3932 institutions that have published related literature on public health emergency management. The top 10 institutions are listed in Table 2. Based on the data listed in Table 2, eight of the top ten institutions are from the United States, accounting for a large proportion, and the remaining two are from Canada and a multinational institution. It can be seen that the United States have the strongest scientific research capabilities in the field of public health emergency management. The top three institutions are the Centers for Disease Control and Prevention (231), Harvard University (78) and Columbia University (65). The three institutions with the highest average cited frequency are all from the United States, including University of California, San Francisco (51.09), Johns Hopkins University (28.63) and University of California, Los Angeles (27.86).

It can be seen that the Centers for Disease Control and Prevention has the highest volume of publications among all institutions. The research in public health emergency
management was paid attention to earlier by this institution, and the research content is extensive. Arnon [39], Dennis [40], Inglesby [41] and Borio [42] respectively studied and discussed the medical and public health management issues of botulinum toxin, tularemia, plague and hemorrhagic fever viruses as biological weapons. Keim [43] and Subbarao [44] argued that public health problems that may be caused by climate change or sudden natural disasters can be reduced by educating the population or gaining insight into the emergency response capacity of the community.

Hutchins [45] believes that protecting disadvantaged groups in society during the influenza pandemic is an important strategic task. Wray [46] and Khan [47] believe that when major public health incidents occur, managers should try to communicate better with the public about health threats so that the public can take the initiative to take self-protection measures. The latter even believes that better integration of public health information and social networks will be the next public health revolution. The public health countermeasures related to traumatic brain injury made by Taylor [48] and Coronado [49] have also received a lot of attention. In response to the COVID-19 pandemic, Perio [50], Koonin [51] and Dirlikov [52] respectively proposed strategies for basic materials, medical equipment, and emergency response from related health departments. It can be seen that the overall research content of the Centers for Disease Control and Prevention pays more attention to macro public health issues.

**Table 2.** Top 10 quantity of publications by institutions on related information in public health emergency management studies.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Institution</th>
<th>Country</th>
<th>Quantity</th>
<th>Total Link Strength</th>
<th>TCF</th>
<th>ACFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centers for Disease Control and Prevention</td>
<td>USA</td>
<td>231</td>
<td>123</td>
<td>3195</td>
<td>13.83</td>
</tr>
<tr>
<td>2</td>
<td>Harvard University</td>
<td>USA</td>
<td>78</td>
<td>80</td>
<td>1716</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>Columbia University</td>
<td>USA</td>
<td>65</td>
<td>57</td>
<td>1665</td>
<td>25.62</td>
</tr>
<tr>
<td>4</td>
<td>Johns Hopkins University</td>
<td>USA</td>
<td>64</td>
<td>49</td>
<td>1832</td>
<td>28.63</td>
</tr>
<tr>
<td>5</td>
<td>Emory University</td>
<td>USA</td>
<td>59</td>
<td>47</td>
<td>984</td>
<td>16.68</td>
</tr>
<tr>
<td>6</td>
<td>University of Toronto</td>
<td>Canada</td>
<td>54</td>
<td>29</td>
<td>796</td>
<td>14.74</td>
</tr>
<tr>
<td>7</td>
<td>University of Washington</td>
<td>USA</td>
<td>54</td>
<td>31</td>
<td>875</td>
<td>16.20</td>
</tr>
<tr>
<td>8</td>
<td>World Health Organization</td>
<td>Global</td>
<td>54</td>
<td>29</td>
<td>538</td>
<td>9.96</td>
</tr>
<tr>
<td>9</td>
<td>University of North Carolina</td>
<td>USA</td>
<td>52</td>
<td>20</td>
<td>1126</td>
<td>21.65</td>
</tr>
<tr>
<td>10</td>
<td>University of California, San Francisco</td>
<td>USA</td>
<td>46</td>
<td>26</td>
<td>2350</td>
<td>51.09</td>
</tr>
</tbody>
</table>

TCF: Total Cited Frequency; ACFP: Average Cited Frequency of Publication.

Among the institutions listed in Table 2, University of California, San Francisco has the highest sum of times cited, and the research content is relatively extensive. The research on the risk of HIV infection with injecting drug users as the key factor by Rhodes [53] has attracted the most attention among statistical data. Smoking [54,55], alcoholism [56,57], drug use [58] and such addiction-related health problems are paid attention to the most by institutions. Enteen [59] and Banta-Green [60] discussed overdose related to two kinds of drugs. It can be seen that the overall research content organization is close to matters related to the daily life of people.

VOSviewer was used to screen out institutions with a starting volume of less than 15 and obtained 66 institution records. The knowledge map of the organization co-authored network is shown in Figure 4. The node diameter has a positive correlation with the literature amount, and the node connection width has a positive correlation with the cooperation intensity. It can be seen that the cooperation between the Centers for Disease Control and Prevention and Johns Hopkins University is the most frequent. Each color
in Figure 4 represents a cluster, and the calculation generates four clusters. The red and green clusters are relatively large clusters, while the yellow cluster has only one node. The red cluster contains 35 nodes and has the largest node, for the Centers for Disease Control and Prevention, in the entire graph. The research content of the institutions in the cluster involves public health problems with different age groups [61–63], global public health emergency response capabilities [64–66], the use of modern methods to improve public health response speed [67,68] and hot issues [69–72]. The largest node in the green cluster is Harvard University; the institutions in the cluster mainly focus on public health issues caused by climate change [73–75], air environmental issues [76–78], and hot social issues [79,80]. There are eight nodes in the blue cluster, and the University of Toronto is the largest node among them. Institutions within the cluster have conducted extensive research on information transmission in the event of a public health event [81–83], improving response and recovery capabilities [84–86].

Figur 4. Cooperation between institutions in public health emergency management studies.

3.3. Research Knowledge Base

According to Henry Small’s co-citation relationship, if two documents are cited by a third document at the same time, then the two documents are co-cited [87]. Documents with co-citation constitute the knowledge foundation of the research field. The journals published by these articles with co-citation relationships are the carriers of the knowledge foundation in the area. Meanwhile, journals with high co-citation are also the core journals at the forefront of research in this field [88]. Through the analysis of co-cited references and their sources by VOSviewer, the obtained data showed that the references and journals with high co-citation frequency could be considered as the knowledge foundation and core journals in the research field of public health emergency management.

3.3.1. Co-Citation Analysis of the Literature

The closeness of the relationship between the study contents can be reflected by co-citation; the higher the frequency, the closer it is [89]. The minimum frequency is set to 13 and plotted with VOSviewer to obtain 64 nodes, as shown in Figure 5. The node diameter is positively correlated with the frequency, and the closer the node spacing, the stronger the relationship. A total of four clusters are formed: red cluster (30), green cluster (14), blue cluster (12) and yellow cluster (8). Four clusters were analyzed.

Red cluster: Covello [90] (18 co-citations) published the earliest paper in the cluster, briefly introducing the theory and basic model of risk communication and providing ideas for improving the perception of disease outbreak risk. Nelson’s paper [1] (41 co-citations) on the concept of public health emergency preparedness received the most attention. The paper explored the composition of public health emergencies, the main body of responsibility,
and the required capabilities. Qureshi [91] (28 co-citations) studied the various abilities and willingness barriers that may exist in the relevant medical staff during a major disaster, which can be improved by intervention. Glik [92] (24 co-citations) defined crisis risk communication, traced its origin to many fields, and explored how to incorporate the basic principles of communication into emergency preparedness and crisis risk communication to promote public health. Norris [93] (21 co-citations) proposed achieving a certain public health event resistance through the four types of adaptability in the community. Emergency preparedness is the most basic work of public health emergency management. Standards, material preparation, material information, material distribution and other aspects of emergency preparation work should be improved. In addition, long-term investment in public welfare, the training of professionals and education of the general public are also crucial. The establishment and improvement of the emergency preparedness system is a long-term systematic project that requires the joint participation of the whole of society and is combined with modern information means to improve overall efficiency. With the background of globalization, international cooperation in emergency preparedness can be continuously promoted so that lower economically developed countries can have a certain standard of emergency response capacity while the impact of public health emergencies that may affect the world can be further reduced.

Figure 5. High co-citation publications in public health emergency management studies.

Green cluster: Braun [94]'s (26 co-citations) article was the most frequently cited one in the cluster, and found that topic analysis was an effective and flexible method in psychological research, which can be combined with some parts of public health emergency management. Moher [95] (21 co-citations) found that systemic reviews and meta-analyses are becoming more and more important in health care, and developed a system of Preferred Reporting Items for Systemic Reviews and Meta-analyses to explore the practical effects of existing research topics. Andersen [96] (19 co-citations) points out that the Behavioral Model of Health Services Use has been in use for many years and assesses the implications for sustainability. This cluster discusses the introduction of more research and analysis methods or models into public health emergency management through interdisciplinary and cross-cutting approaches.

Blue cluster: Knowlton [73] (27 co-citations) thought the 2006 California heat wave had a significant impact on the incidence of heat-related causes among all age groups. By understanding these effects and the vulnerability of specific populations, people can prepare for heat waves to adapt to global warming. Semenza [97] (21 co-citations) found that among the people who died in the Chicago heat wave in 1995, those who were at the greatest risk were those with disease. Interventions for these people can reduce deaths.
related to high temperatures. Anderson [98] (15 co-citations) thought that many factors had not been well considered when discussing the relationship between weather and mortality. Research has found that adaptability, individual susceptibility, and community characteristics all affect weather-related mortality. It can be seen that the public health problems caused by the climate environment are the focus of the highly co-cited papers in this cluster. Climate change was considered one of the most important threats to human health. In addition to increasing the incidence of heat-related diseases, rising temperatures will accelerate the reproduction of some hosts that can carry the virus, while vulnerable groups in populations such as those with chronic diseases will be more affected. In addition, extreme weather such as heavy rain days will also lead to an increased risk of water-borne diseases. In the future, we should strengthen the assessment of the impact of climate change on public health, formulate specific policies according to the specific situation, focus on identifying vulnerable groups, and carry out key prevention and control.

Yellow cluster: Huang [99] (29 co-citations) reported on the epidemiological, clinical, laboratory and radiological characteristics, treatment and clinical results of COVID-19, which received extremely wide attention. Zhu [100] (22 co-citations) reported the emergence and isolation of a previously unknown β-coronavirus in Wuhan, China, the seventh coronavirus to infect humans, and the actual conditions of three patients are described in the paper. Chen [101] (18 co-citations) tried to clarify the epidemiology and clinical characteristics of COVID-19 through known cases. The paper published by Slovic [102] (13 co-citations) is the earliest one in the cluster. It explains that risk perception and correct decision-making after perception play a vital role when encountering risks. This cluster focuses on the virus research after the COVID-19 outbreak, including the virus’s structure, disease pathological characteristics, and epidemiological investigation. Due to the continuous changes, the research results in this cluster will be developed rapidly.

3.3.2. Journals Co-Citation Analysis

To evaluate academic journals, we applied journal co-citation analysis to conduct quantitative analysis. Journal co-citation is shown in Figure 6, with a total of 72 nodes. The node diameter is positively correlated with frequency, and the closer the nodes are spaced, the stronger the relationship.
For the three clusters of red, green and blue, the number of red cluster nodes is the largest. Among them, the journals with higher numbers of co-citation were the American Journal of Public Health (1618 co-citations), Jama-journal of The American Medical Association (1311 co-citations), Annals of Emergency Medicine (806 co-citations), Pediatrics (631 co-citations), and Disaster Medicine and Public Health Preparedness (584 co-citations), and their focuses were on improving public health. The green cluster is based on Lancet (1724 co-citations), New England Journal of Medicine (1228 co-citations), Emerging Infectious Diseases (804 co-citations), Social Science & Medicine (709 co-citations), and PLoS ONE (698 co-citations). The cluster focuses on papers that are likely to change clinical practice or innovative research on certain diseases. The main journals in the blue cluster are Environmental Health Perspectives (753 co-citations), American Journal of Epidemiology (425 co-citations), International Journal of Environmental Research and Public Health (399 co-citations), Epidemiology (347 co-citations), and Journal of Epidemiology and Community Health (326 co-citations). The focus is mainly on epidemics. In terms of the number of co-citations, the American Journal of Public Health, Lancet, and Environmental Health Perspectives were the highest in each cluster and could be considered core journals with different research orientations.

3.3.3. Analysis of High Citation Frequency Literature

We used the total cited frequency as the evaluation criterion to sort the papers, and the top 10 papers are listed in Table 3. Literature with a high citation frequency can reflect academic influence from the perspective of literature citation, which is an important indicator for evaluating the development of a discipline, the research ability and academic reputation. At present, it is generally used to evaluate the international academic level and influence of academic institutions and scholars [26].

Smith [103] has the highest total number of citations in the statistics. His research mentioned that Bangladesh was the country with the largest number of poisoning incidents caused by arsenic contamination of groundwater in history. Improving the quality of drinking water at the national level could reduce the morbidity and mortality of gastrointestinal diseases. Therefore, the arsenic content in drinking water should be tested all over the world to protect people's health. Hanna-Attisha [104] also paid attention to the problem of drinking water, and found that in places where the social economy is relatively challenged, the lead content in children's blood will be higher than the average level due to poor water quality. The paper published by Taylor [48] ranks second in the total number of citations in statistics, and it is mentioned that traumatic brain injury (TBI) could bring adverse clinical consequences, including death and disability. There are many possibilities for causing TBI, such as motor vehicle collisions, falls, or attacks. In recent years, sufficient progress has been made in the prevention of motor vehicle crashes to reduce the number of cases associated with traumatic brain injury. Wang's research [105] has the highest number of citations per year in statistical data, focusing on the adverse psychological effects and psychiatric symptoms during the COVID-19 epidemic. Additionally, Liu [106] and Rodriguez-Morales [107] have conducted research on COVID-19 compared with SARS virus and its clinical conditions, which have also received a lot of attention in a short period.

As can be seen from the data in Table 3, there were three articles related to the topic of COVID-19, and the AACF index was quite high due to the close time of publication. It could be seen that the research in the field of public health was close to the social hotspots.
Table 3. Top 15 quantity of cited publications on related information in public health emergency management studies.

<table>
<thead>
<tr>
<th>Rank</th>
<th>TCF</th>
<th>AACF</th>
<th>Title</th>
<th>Authors</th>
<th>Journal</th>
<th>Year</th>
<th>IQ</th>
<th>CQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1195</td>
<td>56.90</td>
<td>Contamination of drinking-water by arsenic in Bangladesh: a public health emergency</td>
<td>Smith et al. [103]</td>
<td>Bulletin of the World Health Organization</td>
<td>2000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>645</td>
<td>161.25</td>
<td>Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths—United States, 2007 and 2013</td>
<td>Taylor et al. [48]</td>
<td>MMWR Surveillance Summaries</td>
<td>2017</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>580</td>
<td>36.25</td>
<td>The social structural production of HIV risk among injecting drug users</td>
<td>Rhodes, et al. [53]</td>
<td>Social Science &amp; Medicine</td>
<td>2005</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>448</td>
<td>448</td>
<td>The reproductive number of COVID-19 is higher compared to SARS coronavirus</td>
<td>Liu, et al. [96]</td>
<td>Journal of Travel Medicine</td>
<td>2020</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>389</td>
<td>27.79</td>
<td>Effect of Body Mass Index on pregnancy outcomes in nulliparous women delivering singleton babies</td>
<td>Bhattacharya, et al. [109]</td>
<td>BMC Public Health</td>
<td>2007</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>376</td>
<td>31.33</td>
<td>The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits</td>
<td>Knowlton, et al. [73]</td>
<td>Environmental Health Perspectives</td>
<td>2009</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

TCF: total cited frequency; AACF: average annual cited frequency; IQ: institutions quantity; CQ: countries quantity.

3.3.4. The Journal Dual-Map Overlay Analysis

The dual-mapped overlay view of the cited journal type and the number of focus papers is shown in Figure 7. The labels in the figure represent the research content of each journal. The cited journal labels are on the left side of the figure, and the cited journals are on the right. The trail of citation links provides an understanding of the relationships between disciplines. The change in the trajectory from one field to another indicates that one discipline is influenced by the papers of another [28,110].
In general, the published papers are mainly targeted journals in medical, clinical, psychological, educational, and health-related fields, while the cited journals are mainly concentrated around molecular biology genetics, health and nursing medicine and psychology and education-related fields. It can be seen that the cited journals mainly provide the relevant basic knowledge of the published literature.

3.4. Research Hotspots and Frontiers

In this section, we will explore the research hotspots and research frontiers of public health emergency management. The research direction refers to the current research content of research topics with a clear development context and complete development process. The research hotspots are those with higher degrees of attention in the current research direction. The research frontier is a forward-looking, potential and leading research direction in the process of scientific development.

3.4.1. Research Hotspot

The core content of the article can be reflected by keywords and can be used to identify research frontiers [111]. A total of 8715 keywords were selected with a frequency of more than 30 and they were checked one by one. After proper editing, 100 keywords were obtained. Table 4 was obtained by extracting the data from the top 10 keywords in the frequency ranking. We can see that “public health”, “health” and “care” are words with high occurrence and total link strength, which are closely related to public health.

Table 4. Top 10 occurrence frequency keywords in public health emergency management studies.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Keywords</th>
<th>Occurrences</th>
<th>Total Link Strength</th>
<th>Rank</th>
<th>Keywords</th>
<th>Occurrences</th>
<th>Total Link Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Public Health</td>
<td>462</td>
<td>1090</td>
<td>11</td>
<td>Children</td>
<td>135</td>
<td>387</td>
</tr>
<tr>
<td>2</td>
<td>Health</td>
<td>245</td>
<td>603</td>
<td>12</td>
<td>Epidemiology</td>
<td>130</td>
<td>346</td>
</tr>
<tr>
<td>3</td>
<td>Care</td>
<td>238</td>
<td>594</td>
<td>13</td>
<td>Surveillance</td>
<td>126</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>United-States</td>
<td>192</td>
<td>560</td>
<td>14</td>
<td>COVID-19</td>
<td>110</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>Mortality</td>
<td>182</td>
<td>497</td>
<td>15</td>
<td>Disaster</td>
<td>101</td>
<td>267</td>
</tr>
<tr>
<td>6</td>
<td>Emergency Preparedness</td>
<td>177</td>
<td>388</td>
<td>16</td>
<td>Management</td>
<td>92</td>
<td>252</td>
</tr>
<tr>
<td>7</td>
<td>Preparedness</td>
<td>170</td>
<td>409</td>
<td>17</td>
<td>Prevention</td>
<td>88</td>
<td>257</td>
</tr>
<tr>
<td>8</td>
<td>Risk</td>
<td>162</td>
<td>461</td>
<td>18</td>
<td>Services</td>
<td>79</td>
<td>197</td>
</tr>
<tr>
<td>9</td>
<td>Impact</td>
<td>156</td>
<td>477</td>
<td>19</td>
<td>Outbreak</td>
<td>77</td>
<td>183</td>
</tr>
<tr>
<td>10</td>
<td>Emergency</td>
<td>140</td>
<td>338</td>
<td>20</td>
<td>Emergency Department</td>
<td>76</td>
<td>192</td>
</tr>
</tbody>
</table>
The keyword co-occurrence analysis was performed in VOSviewer, and the keyword co-occurrence knowledge graph obtained. As can be seen from Figure 8, each node represents a keyword. The node size has a positive correlation with frequency, and the connection width of the node connection has a positive correlation with the relation between keywords. Four clusters were formed in total, which were red, green, blue and yellow, in the order of volume.

Red cluster: As shown in Figure 8, “Public health” (462) is the most frequent node in this cluster. “Emergency preparedness” (177), “preparedness” (170), “emergency” (140), and “COVID-19” (110) are other keywords with a high frequency. It can be considered that the cluster as a whole revolves around the keywords “public health” and “emergency preparedness”, focusing on the continuous improvement of public health emergency management capabilities. Pestronk [112] earlier proposed that funds should be fully utilized to train talents, which can provide reserves for both emergencies and government public health departments. Nelson [113] reviewed the previous public health emergency management methods and proposed adding some emerging technologies to better respond to emergencies. Bochenek [11] proposed a new conceptual framework that integrates public health and traditional emergency management so that it can be applied more dynamically and flexibly according to the actual situation. Bardosh [114] proposed that social science-related knowledge should be incorporated into the prevention and response to epidemics. Through comparison of the response to COVID-19 and Ebola, many gaps were found and recommendations were made. COVID-19 has become a subject of much concern in clustering in the past year, and scholars from different countries have studied it from different angles, including the psychological state of medical workers [115], basic cognition of medical workers [116,117], port management [118] and drug use management [119]. After a period of anti-epidemic struggle, He [120] found that he could better prepare for and respond to the pandemic through experience. Ortega [121] proposed countermeasures to improve the health equality problem caused by language differences.

![Figure 8. Co-occurrence of keywords network in public health emergency management studies.](image)

Green cluster: The most frequently occurring keyword in this cluster is “care” (238). “United-states” (80), “risk” (55), “services” (79) and “prevalence” (75) are the other keywords with higher frequency. The main content of the cluster is the nursing situation under
various public health scenarios. Molyneux [122] mentioned that when hospitals in some developing countries encounter emergency situations and a large number of patients are admitted to the hospital, if a better nursing process is formed, the mortality rate can be reduced. At the same time, Whitten [123] found that patients’ distrust of care providers and the government were major obstacles to health services and need to be reasonably improved. Cormier [124] proposed that more health care emergency preparedness coalitions, which were composed of public health and public safety-related departments to deal with large public health incidents, should be established. During the COVID-19 pandemic, Rosario [125] discussed the trade-off between cancer care and the risk of infection, and Devillanova [126] discussed the health care of undocumented immigrants.

Blue cluster: “Children” (135) is the keyword with the highest frequency in this cluster. “Epidemiology” (45) and “surveillance” (126) are the other two keywords with high frequencies in this cluster. The public health problem of children in society is the focus of this cluster. Dziuban [127] found that children had unique needs in public health emergencies and the recovery from public health emergencies. Children’s differences in physiology, behavior, development, social and mental health should be treated with special attention. Bartenfeld [128] also found that the differences between children’s cognitive abilities and those of adults during public health emergencies would create unique needs, and that children’s characteristics should be fully considered when establishing public health emergency plans. Shah [129] conducted a study on emergency medical services for children and found that service providers should receive adequate training. Krass [130] conducted a study and found that children hospitalized in psychiatry are more susceptible to COVID-19 than the general population. Nicholson’s [131] research found that during the COVID-19 epidemic, the number of times children’s parents seek medical care due to safety concerns had significantly decreased. In fact, the reliability and safety of pediatric medical services could be reassuring.

Yellow cluster: “Health” (245) is the most frequently occurring keyword in this cluster, and it is also a component of the search sentence. “Mortality” (245) and “impact” (156) are the other two keywords with high frequency. The main content studied in the cluster is the mortality changes caused by various public health conditions. Knox [132] mentioned that suicide had always been a mental health problem and improved suicide prevention interventions. Zanobetti [133] found that among the three factors of gender, race, and social factors, the mortality rate of females to air pollution was higher than that of males only in terms of gender, and the other two factors had no significant impact. Wang [134] studied whether neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) were related to death through actual cases of COVID-19 infection and found that NLR was an effective biological indicator for predicting mortality. Monaghesh [135] found that improving telemedicine capabilities during the COVID-19 pandemic could reduce the mortality of patients with various diseases and ensure the safety of patients and medical service providers at the same time.

3.4.2. Identification of Research Frontiers

The keywords timeline is shown in Figure 9. Clustering analysis is carried out by using three different algorithms to identify the inner connection of the text data. They were the log-likelihood ratio (LLR), term frequency-inverse document frequency (TF-IDF) and mutual information (MI) [136–140]. In Figure 9, node and connection represent keywords and their relationships. The node size and frequency have a positive correlation. The connection strength between nodes can be used as a quantitative index to reflect the connection between nodes.
Eight clusters of studies in this field were calculated using CiteSpace, and the cluster labels by LLR, TF-IDF, and MI algorithms are presented in Table 5. We can obtain the centrality of each node by calculation. The centrality can quantify the importance of a node in the map. The larger the centrality is, the more important the node is in the map. The centrality of “emergency (0.29)”, “public health” (0.23), and “health” (0.19) are the highest. The seven timelines in Figure 9 represent different research directions, namely, child prevention, public health incident mortality, public health emergency preparedness, public health emergency management, bioterrorism, basic medical care in the United States, and COVID-19. Since public health emergency management is a research field that covers a wide range of content, there are many connections between the seven timelines, and a substantial number of scholars have combined different research contents or methods for research.

Table 5. Keywords’ clustering labels in public health emergency management studies.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Size</th>
<th>Silhouette</th>
<th>Cite Year</th>
<th>Label (TF × IDF)</th>
<th>Label (LLR)</th>
<th>Label (MI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#0</td>
<td>79</td>
<td>0.652</td>
<td>2008</td>
<td>public health</td>
<td>emergency preparedness</td>
<td>airport</td>
</tr>
<tr>
<td>#1</td>
<td>69</td>
<td>0.644</td>
<td>2005</td>
<td>emergency department</td>
<td>emergency department</td>
<td>anti-abortion groups/movement</td>
</tr>
<tr>
<td>#2</td>
<td>57</td>
<td>0.627</td>
<td>2005</td>
<td>surveillance</td>
<td>air pollution</td>
<td>adult and children injury</td>
</tr>
<tr>
<td>#3</td>
<td>27</td>
<td>0.637</td>
<td>2007</td>
<td>mental health</td>
<td>violence</td>
<td>disaster diplomacy</td>
</tr>
<tr>
<td>#4</td>
<td>23</td>
<td>0.759</td>
<td>2008</td>
<td>emergency planning</td>
<td>emergency planning</td>
<td>pollution</td>
</tr>
<tr>
<td>#5</td>
<td>21</td>
<td>0.777</td>
<td>2013</td>
<td>coronavirus</td>
<td>COVID-19</td>
<td>outcomes</td>
</tr>
<tr>
<td>#6</td>
<td>17</td>
<td>0.777</td>
<td>2007</td>
<td>public health</td>
<td>impact</td>
<td>referral patterns</td>
</tr>
</tbody>
</table>

Table 6 is obtained from burst detection in CiteSpace, and the 15 keywords with the highest burst strength and relevant information are listed below. Burst strength was used to describe the degree of a great increase in the occurrence frequency of a keyword. The higher the burst strength is, the greater the increase in the occurrence frequency of the keyword within a short time. It can be seen that the keywords with high outbreak intensity are constantly changing, and the strongest ones are “Bioterrorism” (17.5), followed by “Ebola” (11.96), “Public Health Preparedness” (10.7), “Health Care” (9.74), and “Influenza” (7.97). “Emergency” is one of the earliest burst times, and “Air Pollution” and “Bioterrorism” have the longest burst time. It can be seen that scholars have long focused on the themes of “air pollution” and “bioterrorism”, and that bioterrorism is no longer the focus of attention in today’s world. “Climate Change” related to “Air Pollution” is a keyword that is undergoing a sudden change. Due to the limitation of calculation and data, the keyword “COVID-19” is not reflected in the table. Combining the previous research shows that “COVID-19” will also become a keyword with great mutation intensity in the future.

Table 6. Keywords’ burst strength labels in public health emergency management studies.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Burst Strength</th>
<th>Keyword</th>
</tr>
</thead>
<tbody>
<tr>
<td>#0</td>
<td>17.5</td>
<td>Bioterrorism</td>
</tr>
<tr>
<td>#1</td>
<td>11.96</td>
<td>Ebola</td>
</tr>
<tr>
<td>#2</td>
<td>10.7</td>
<td>Public Health Preparedness</td>
</tr>
<tr>
<td>#3</td>
<td>9.74</td>
<td>Health Care</td>
</tr>
<tr>
<td>#4</td>
<td>7.97</td>
<td>Influenza</td>
</tr>
<tr>
<td>#5</td>
<td>7.63</td>
<td>Emergency</td>
</tr>
<tr>
<td>#6</td>
<td>6.37</td>
<td>Air Pollution</td>
</tr>
</tbody>
</table>

Figure 9. Keywords timeline of public health emergency management studies.
CiteSpace's Timezone function is used to calculate and sort the keyword time zone map for public health emergency management. As shown in Figure 10, the earliest keywords are "public health", "emergency" and "children", which can be regarded as the core keywords in the field of public health emergency management. The preliminary development stage ended in 2007, and hot keywords, such as "emergency department", "health", "mortality" and "emergency preparedness", appeared successively. After entering the stable development stage in 2008, there were very few hot keywords until 2013. Entering into the rapid development stage in 2014, keywords such as "public health preparedness", "ebola" and "mental health" appeared. Due to the outbreak of COVID-19 in 2020, the related keywords "COVID-19", "pandemic", "coronavirus", "emergency" and "SARS-CoV-2" also broke out.

Figure 10. TimeZone distribution of keywords in public health emergency management studies.
Health is the most basic requirement for human survival, and public health emergency management is an important part of it. Therefore, perfect public health emergency management is of great practical significance. It can be seen that scholars all over the world have conducted research on every link and aspect of public health emergency management and have continuously promoted the progress of public health emergency management. However, in the face of unprecedented large-scale emergencies such as COVID-19, there is still a lack of emergency management capabilities. In the future, the government or public welfare organizations should act as guides and investors to make the research of various types of public health emergencies more constructive and continuous. Through the study of large-scale emergencies that have occurred, on the basis of summarizing experience and lessons, the more severe situation is diligently predicted, key resources, professionals and emergency plans are prepared in advance, and emergencies can be dealt with as expected.

From the above analysis, it can be seen that the research on public health emergency management involved a wide range of fields and was intensively interdisciplinary. The overall knowledge structure can be divided into five main research directions, including emergency preparedness, emergency care, hospital admission, first response and major public health emergencies (see Figure 11). The corresponding knowledge bases and knowledge domains are shown in Figure 11.

4. Conclusions

We analyzed the related papers on public health emergency management research in the past 21 years from the Web of Science Core Collection using the bibliometric analysis method. The content covers the distribution of time dimension and space dimension, the analysis of the quantity of publications and co-citation of journals, and the analysis of co-occurrence and clustering of keywords. The conclusions are as follows:
(1) The development of public health emergency management research is divided into three stages: the preliminary development stage (2000–2007), the stable development stage (2008–2013) and the rapid development stage (2014–2020). The continuous improvement of public health emergency capacity, public health emergency care, child protection in public health systems, and changes in mortality due to public health conditions are the knowledge base of public health emergency management.

(2) The research on public health emergency management mainly revolves around the Infectious Diseases, Health Policy and Services and General and Internal Medicine disciplines. The main research directions in the current field are child prevention, mortality from public health events, public health emergency preparedness, and COVID-19. At present, a relatively complete theoretical research framework has been formed for the research on public health emergency management.

(3) Climate change, COVID-19, and related epidemics and coronaviruses are the current research hotspots and frontiers. The government or public welfare organizations should act as guides and investors to strengthen the constructive and forward-looking continuity of research.

(4) While paying attention to economic development, by optimizing the structure of fiscal expenditures and appropriately expanding the scale of government public health expenditures, a benign interaction between economic development and improvement of people’s livelihood can be achieved. At the same time, the United Nations and the World Health Organization should give more help to the construction of primary medical care in some underdeveloped areas.

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