Visual analysis of fire safety research from January 2015 to September 2020

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Abstract. In this paper, bibliometrics and visual analysis are used to analyze the fire safety related literature with the theme of "fire protection" and "safety" by CiteSpace software. The quality of fire safety management in China could be improved through the understanding of fire safety prominent risk and fire safety research hotspots. After searching, screening and exporting 2900 fire safety related literatures from China National Knowledge Infrastructure (CNKI), CiteSpace software was used to analyze the data exported from CNKI, and four kinds of visual maps including keywords, emergent words, authors and institutions were drawn. The atlas intuitively shows that the research hotspots from January 2015 to September 2020 are mainly focused on fire safety, countermeasures, high-rise buildings, fire hazards and so on. Many excellent authoritative authors have published articles, and different institutions have cooperated with each other, but the overall contact is less. Based on the overall situation, the investigation and treatment of fire hazards still need to be carried out in depth, and the fire safety management system needs to be further implemented.

1. Introduction

On March 30, 2019, 30 firefighters died in a forest fire in Muli County, Liangshan Prefecture, Sichuan Province; on September 29, 2019, 19 people died in a fire at Ruiqi Daily Necessities Co., Ltd., Ninghai County, Ningbo City, Zhejiang Province; and on March 30, 2020, a total of 19 people were killed when a forest fire broke out over an area of 1,000 hectares in Xichang, Sichuan Province. In recent years, fire safety accidents occur frequently, resulting in numerous disasters, fire safety is increasingly valued. In order to raise public awareness of fire safety, safeguard the safety of people's lives and property, and thoroughly implement Xi Jinping's Work Safety Directive, this study uses the time-sharing, dynamic and diversified citation visualization software CiteSpace V developed by Professor Chen Chaomei[1]. A visual quantitative analysis of 2900 fire safety related articles on CNKI was carried out. As a citation visualization analysis software based on the potential knowledge in the analysis of scientific analysis, with the background of scientific metrology and data visualization, CiteSpace enables the visualization of the structure, regularity, and distribution of scientific knowledge, generating an “atlas of scientific knowledge”[2]. By using this software, the hot spot of fire safety research in recent years can be seen intuitively, and the quality of fire safety management in China will be further improved.

2. Consequence

2.1. Time distribution

Enter the China Knowledge Web page, click on the homepage advanced search, with "fire safety" as the
theme of the literature, the papers published from January 2015 to September 2020 were selected for accurate retrieval. A total of 13294 articles were retrieved, and 2900 valid articles were obtained after excluding irrelevant articles. The number of articles and the number of annual articles were as shown in Figure 1. In the last five years, the fire safety research has been going on continuously, and the amount of relevant papers issued has been roughly the same. In 2016-2017, the research was paid more attention, the subject and the related literature reached the peak, the output was quite many, the contribution was outstanding.

Figure 1. Fire safety literature published from January 2015 to September 2020.

2.2. Analysis of key words

Word Frequency Analysis (CFA) is used to study the research focus, trend and future development in this field through the complete extraction and expression of the key words and subject words in literature[3]. By using CiteSpace to visualize data keywords, the keyword map is shown in Figure 2. Combining the word frequency and centrality, 509 nodes and 2190 lines in the graph are analyzed, and it is found that the words with higher centrality include fire safety, firefighting, countermeasures, high-rise buildings, etc., the above research has made outstanding contribution to the fire safety research during the period from January 2015 to September 2020, and is also an important part of it. The intermediate centrality is an important factor in the discovery and measurement of the importance of the literature. The point greater than 0.1 calculated by the calculation formula $BC_i = \sum_{s \in V} \frac{n_{ij}}{g_{ij}}$ is called the critical node[4]. Administration, fire hazards, fire prevention and control as critical nodes represent the core hot spots and main trends of fire safety research during this period.

Figure 2. Keywords of fire safety co-occurrence diagram.
With the development of time, the key turning points in different years and the new achievements of the research are expressed. Figure 3 shows a spectrum of emergent words drawn on the basis of keyword data. A total of 18 emergent words are obtained. "Year" represents the year of keyword emergence, "strength" represents the intensity of keyword emergence, and "begin" and "end" are the earliest and end time of keyword emergence respectively. Through the analysis of Figure 3, it is found that the emergence time of chemical industry park, subject responsibility, thinking, management system and other emergent words was the earliest, which appeared in 2015 and lasted until 2016. Between 2016 and 2018, the research focus has gradually shifted to petrochemical enterprises, solutions, fire safety. The fire safety of chemical industry has been targeted, and the fire hazards and explosion-proof problems in petrochemical enterprises are the top priority. The emergence of words such as intelligent fire control, emergency management department, general secretary Xi Jinping, and safety committee has lasted for three years, representing the focus and hotspots in the whole research process of fire safety. At the same time, it is found that the earliest emergence time of the safety committee, the fire station, the emergency management department and the NPC and CPPCC are related to the institutional reform of the State Council in the same year. In 2018, the State Council established the emergency management department as a constituent Department of the State Council. Part of its responsibilities include fire management responsibilities of the Ministry of public security, grassland fire prevention of the Ministry of agriculture, forest fire prevention related responsibilities of the State Forestry Administration, and responsibilities of the national forest fire prevention headquarters. After the system transformation of the public security fire forces and the armed police forest forces, the emergency rescue teams, together with the emergency rescue teams such as production safety, are managed by the emergency management department. Therefore, the fire safety research from 2018 to 2020 mainly focuses on these four aspects. Through the analysis of emergent words, to a certain extent, it is helpful to understand the hot trend of fire safety research. In the future, the research on the achievements after the reform of emergency management, work safety committee and fire station will be the trend.

![Figure 3. Highlight word map.](image-url)
2.3. Author analysis

Figure 4 is the co-occurrence chart of the authors of the articles obtained by visual analysis of the authors by CiteSpace. In the figure, the connection indicates that the authors have cooperative relationship with each other and co-authored papers. The thickness of the connection indicates the cooperation frequency between the authors. The size of the node indicates the number of papers on fire safety published by the author. According to the formula of the minimum number of articles published by authors, the number of papers published is calculated by the formula:

$$N_{min} = 0.749 \sqrt{N_{max}}$$

of the minimum number of authors, and those who are greater than or equal to $N_{min}$ are called key authors[5]. The $N_{min}$ is 3.17, and the maximum positive integer is 3. According to the figure, Peng Li, Dong Dazheng, Hubei Fire Brigade Chief Zhang Fuhao, Xiao Fang, Wang Ying, Wang Kai, Qiu Peifang and other scholars who published more papers are the backbone of the research. As the editor of China fire protection magazine, Dong Dazheng insisted on giving accurate feedback on the new research process of fire safety in recent years, and published 25 relevant literatures. He has a thorough understanding of fire safety research and can guide readers to establish correct fire safety awareness, which is a link between researchers and readers. The analysis of Figure 4 shows that from 2015 to 2018, a collaborative group of authors with Dong Dazheng as the core has been formed, during which a large number of papers have been published and the most outstanding research contribution has been made. Research and analysis of the author's family, in-depth grasp of discipline research, the breadth and depth of activities, is conducive to the organization, management and coordination of scientific research activities[3]. At the same time, based on the whole, most of the authors have not yet established a cooperative group.

![Figure 4. Co-appearance of authors.](image)

2.4. Institutional analysis

As a new perspective to evaluate the academic influence of researchers, countries or institutions, the cooperation map shows the social relations among scholars, countries or research institutions in a certain research field [6]. Figure 5 shows the co-occurrence chart of issuing institutions. It is found that the Fire Brigade of Hubei Province, the Fire Rescue Brigade of Henan Province, the Fire Brigade of Shandong Province and the Municipal Party Committee have a large number of papers, which are important forces in fire safety research. At the same time, it can be seen intuitively that Henan Fire and Rescue Corps, Shanghai Fengxian Fire Detachment, Shanghai University of Applied Technology and other excellent institutions have established cooperative relations, which further ensure the scientificity and authority of the research. In view of the overall situation, there is less inter-inter-agency. Although the number of papers published by some departments is relatively high, there is no cooperation group and belongs to independent research institutions.
3. Conclusions

(1) Through the in-depth study and analysis of the Atlas, it is found that the research hotspots of fire safety from January 2015 to September 2020 mainly focus on countermeasures, high-rise buildings, fire hidden danger, fire prevention and control, it shows that the hot topics in recent years include fire safety problems and solutions. The research method of visual analysis can only show the development of fire safety in recent years, but cannot embody the details. For fire safety, researchers need to change research hotspots according to the dynamic changes of group, environment, time, etc., and dare to find the contradictions between fire safety and high-rise buildings and fire hazards. In the next step, the frequency of fire safety accidents can be reduced and the fire safety can be increased by means of strict fire prevention and control and focusing on the design of solutions.

(2) Excellent authors are the important guarantee of high-quality periodicals and academic research. Statistical analysis of the author's cooperation status reflects the academic research process in this field to some extent. The map analysis shows that the scientific research community system with Dong Dazheng as the core from January 2015 to September 2020 is the largest and has made outstanding contributions. We should encourage the formation of high-quality authors, so as to improve the scientific research and promote the further development of fire safety research.

(3) In addition to the cooperation group with the Henan Fire and Rescue Corps and the Fengxian District Fire Brigade of Shanghai as the core, based on the whole, although other institutions have a higher volume of documents, there is less cooperation and exchange among them, which is not conducive to the sharing and exchange of fire safety research results, and to a certain extent, the resultant effect of the study. Therefore, institutions should be encouraged to cooperate actively and establish cooperative groups with a certain scale, which is conducive to promoting the exchange of academic research, common growth and development, and laying the foundation for the improvement of fire safety quality.

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References
[1] Li, J., Chen, C.M. (2016) CiteSpace Technology Text Mining and Visualization (2nd Edition). Capital University of Economics and Business Press, The England.
[2] Li, J. (2015) CiteSpace Chinese guide. http://blog.sciencenet.cn./blog-554179-1066981.html.
[3] Wu, Q.Y., Zheng, L., Su, X.Y., Xu, H.L. (2019) Visualization analysis of chemical safety based on Citerspace. Edu. Modern., 6: 229-232.
[4] Li, J., Chen, C.M. (2017) CiteSpace Technology Text Mining and Visualization (2nd Edition). Capital University of Economics and Business Press. The England.
[5] Ye, G., Fu, Y., Wang, Y.H. (2019) Review of research on building safety based on CiteSpace from the perspective of behavior. Saf. Environ. Eng., 26: 127-134.
[6] Chen, Y., Chen, C.M., Liu, Z.Y. (2015) Methodological function of CiteSpace knowledge Atlas. Stud. Sci. Sci., 33: 242 – 253.