

Emerging Trends and New Developments in Emergency Logistics

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ABSTRACT

This paper conducts a bibliometric analysis of emergency logistics research, providing an overview of the current state and future directions in the field. Emergency logistics (EL) plays a crucial role in responding to natural disasters, public health crises, and other emergencies by effectively reducing losses and injuries, enhancing response times, and bolstering social stability. However, there has been a recent lack of detailed discussions and review papers on emergency logistics, leading to an incomplete understanding of the existing research gaps in this area, which is essential for the development of the field. Therefore, this study aims to fill this gap. Through an in-depth review of authors, institutions, countries, co-citation patterns, and keyword clustering, we find that current research primarily focuses on disaster management, supply chain resilience, information technology, and social collaboration. Looking ahead, future research should prioritize proactive planning and humanitarian logistics, the integration of advanced technologies such as big data, artificial intelligence, and the Internet of Things (IoT), and the promotion of multi-sectoral cooperation. These insights aim to guide future research and decision-making, enhancing the efficiency and effectiveness of emergency logistics.

Keywords: Emergency logistics, distributive injustice, emergency response, artificial intelligence, internet of things.

INTRODUCTION

Emergency logistics management provides emergency support for materials personnel, and funds in response to emergencies like natural disasters, public health crises, security events, and military conflicts. EL shares similarities with regular logistics but emphasizes efficiency due to the urgent nature of its operations. It includes constructing emergency logistics mechanisms, developing technologies. Managing professionals, financing, storing, and managing materials, building logistics centers, and transporting and distributing materials.

Despite technological advancements, emergencies continue to cause significant human and economic losses. China, with its vast and complex natural environment. Frequently faces severe emergencies. Historical events like the 1976 Tangshan earthquake and the 2003 SARS epidemic highlight the devastating impacts and the need for efficient EL systems to mitigate secondary disasters.

The motivation for studying EL is to ensure public safety, maintain social stability, and promote economic recovery after disasters. Strengthening EL systems is crucial for effective response and minimizing losses.

This study aims to investigate the key research question: What are the future directions in emergency logistics research, and what is their significance?

METHODS

Data Extraction

In this study, we utilized CiteSpace software for bibliometric analysis and set the k value to 25. This choice is based on several considerations: First, k=25 strikes a balance between network complexity and readability, ensuring that the network is neither too dense nor overly simplified, thus making it easier to interpret. Second, this value effectively highlights the key themes and trends in the research field, allowing readers to quickly grasp the core content without being distracted by less significant nodes. Additionally, a lower 'k' value reduces computational burden, enhancing the speed and efficiency of processing large datasets. Furthermore, k=25 maintains consistency in the number of nodes across different time slices, facilitating cross-temporal comparisons and enabling the observation of evolving research trends while ensuring the reliability and comparability of results. Finally, k=25 is a commonly used heuristic in bibliometric studies, as many researchers have found this value to be

effective in revealing the key features of the research landscape while maintaining an appropriate level of network complexity. In summary, setting $k=25$ allows us to balance network complexity and readability, highlight key themes and trends, enhance computational efficiency, and ensure the consistency and comparability of our results.

The Web of Science (WOS) is a representative source of citation data typically used for bibliometric analyses because it is a reliable bibliographic-indexing tool for scientific knowledge (Chen et al, 2006 ; Chen and Liu, 2020 ; Azam et al., 2021). Thus, based on the guidelines provided by existing studies (Chen and Liu,2020 ; Azam et al., 2021), the WOS was considered as the source of EL-related literature data in this study. Note that the data collection date was 26 June 2024.

Specifically, the main data sources used in our study were the Social Science Citation Index (SSCI), Science Citation Index Expanded (SCIE), Emerging Science Citation Index (ESCI), and Arts & Humanities Citation Index (A&HCI) provided by the WOS Core Collection (WOSCC) databases.

For document types, we selected "full record and cited reference". Moreover, solely articles written in English were selected. To offer more precise bibliometric analysis results, twenty years data were evaluated, and thus, only articles published between 2014 and 2024 were selected.

According to the points mentioned above, we searched for documents on the WOS (Table 1). Then, following the guidelines of prior studies (Chhabra et al., 2021; Di Vaio et al., 2022; Hassan et al., 2022), we executed the process outlined in Table 2 to collect 1500 EL articles for our analysis.

Table 1: Parameter settings used in CiteSpace.

Parameters	Conceptualization
Time slicing	One year data for all
Pruning	Pathfinder and pruning sliced networks
	Keyword,Institution,country,Cited author,citedjournal,or Reference
	Default
Selection criteria	g-index (k= 25)
Visualization	Static cluster view and merged network

Table 2: Data extraction process

Data source	Wob of science databases
Search query	Topic="emergencylogistics"OR"distributiveinjustice"OR"emergency response"OR"emergencydepartment"OR"citespace"
Retrieved time	Documents type:Full Record and Cited Reference
	Document language:English
	Publication years:2014-2024
Selection criteria	26-Jun-24
Number of articles	1500

Data Analysis

CiteSpace is one of the most prominent information visualization tools.(Abbas et al., 2019; Ye et al., 2020) This tool is designed to highlight the structure and dynamics of specific field . Furthermore, compared with other bibliometric software such as Vos viewer and Gephi, CiteSpace provides a wide range of functions for network analysis and visualization. (Cobo et al., 2011 ; Che et al., 2022)

Notably, the latest version of CiteSpace (CiteSpace 6.3. R3.) was used in this study. Table 2 lists the parameter settings employed in our analysis. After setting the parameters for our co-citation analysis, CiteSpace was used to obtain information on networks and details regarding authors, literatures, and journals with citation counts.

Time Distribution Analysis

The change in the output of literature over time reflects, to some extent, the development trend in the field. Given that the amount of research has maintained its upward trend (Fig.1), this paper argues that 2014 is the first year of academic study of global EL, and this period of rapid development is still ongoing.

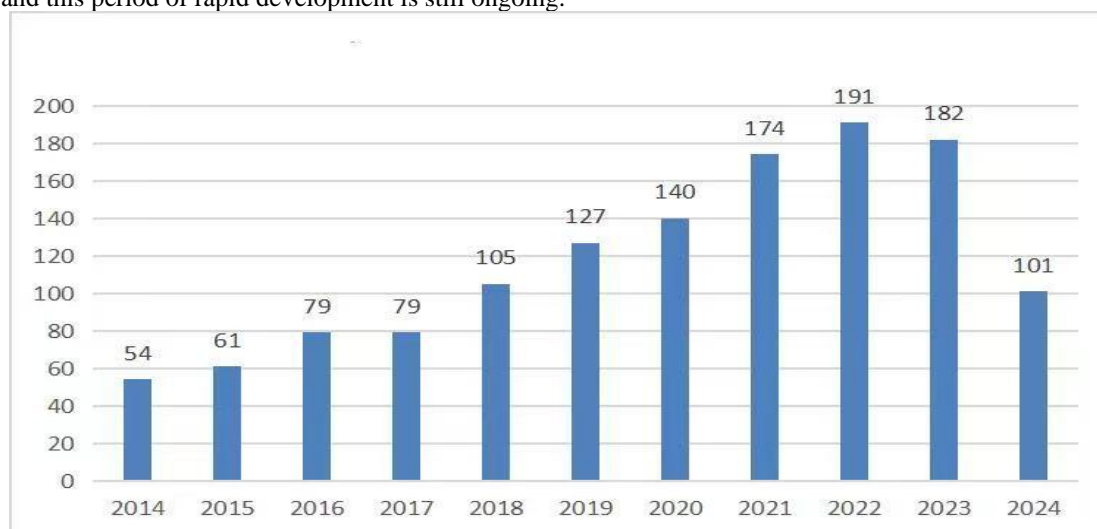


Fig. 1 Number of publications per year from 2014 to 2024

RESULTS AND DISCUSSION

Productive Authors, Institutions, and Countries/Regions

As already indicated by several scholars (Chen and Liu, 2020; Azam et al., 2021), the key research forces in a specific field can be identified as productive authors, institutions, and countries/ regions. From this viewpoint, this study first attempted to investigate the core research forces in the EL Field at the author, institutional, and national levels.

Author Analysis

The top 11 most productive authors ranked based on the number of published papers are listed in Table 3. Among these, Jiang, Nan and Katayama, Yusuke and Kitamura, Tetsuhisa contributed three or four papers each in the EL Field. These results indicate that the aforementioned three authors are the most productive scholars in the EL Field.

Table 3: Top 11 most productive authors ranked by the number of published papers.

Rank	Number of Dapers	Authors
1	4	Jiang, Nan
2	3	Katayama, Yusuke
3	3	Kitamura, Tetsuhisa
4	3	Ly, Chuanzhu
5	3	Nakagawa, Yuko
6	3	Nakao, Shunichiro
7	3	Shimazu, Takeshi
8	3	Carbone, Jason T
9	3	Holzer, Katherine J
10	3	Vaughn, Michael G
11	3	Bassett, MG

Author's Country Distribution



Fig. 2 Clustering of Authors' Countries

Based on the distribution map (Fig.2) of countries where authors publishing papers in the field of EL are affiliated, we observe that China and the United States lead in the number of publications, with other countries predominantly being those with strong comprehensive national power. This suggests that the reasons these countries prioritize EL are primarily due to their elevated levels of economic development, large populations with urbanization demands, frequent natural disasters, and a strong emphasis on risk management. Particularly, as the world's two largest economies, China and the U.S. have vast economic scales and complex supply chain networks. Their extensive territories and diverse climates expose them to various natural disaster threats. Government authorities in both countries attach significant importance to the construction of emergency management systems, recognizing the significance of efficient EL systems for ensuring the stable operation of their economies. These combined factors propel these nations to advance research and development in the EL field.

Institutional Analysis

The top 15 affiliations of authors ranked by the number of published papers are listed in Table 4. The results revealed that the Harvard University of Rome ranked first, contributing 36 articles, followed by the University of London (22 articles), the University of California System (18 articles), and the Brigham & Women's Hospital (16 articles).

Table 4: Top 15 institutes ranked by the number of published papers.

Rank	Number of papers	Affiliations
1	36	Harvard University
2	22	University of London
3	18	University of California System
4	16	Brigham & Women's Hospital
5	16	Harvard Medical School
6	16	Seoul National University(SNU)
7	15	University of Michigan
8	15	University of Michigan System
9	13	Yonsei University
10	13	McMaster University
11	12	University of Toronto
12	12	Johns Hopkins University
13	11	Massachusetts General Hospital
14	11	Sichuan University
15	11	University System of Ohio

Country/Regional Analysis

The top 10 countries/regions ranked by the number of published papers are reported in Table 5. The Peoples R China had the highest number of published papers (358), followed by United States (USA) (318), England (89), South Korea (66), and Canada (60). These results indirectly reveal the leading position of China and the United States in the field of EL. We also

discovered that most of these countries/regions were economically developed. This phenomenon can be attributed to the active business operation and the complete and efficient EL system (Li T et al.,2024) .

Table 5: Top 10 countries/regions ranked by the number of published papers.

Rank	Number of paper	Country/region
1	358	PEOPLES R CHINA
2	318	USA
3	89	ENGLAND
4	66	SOUTH KOREA
5	60	CANADA
6	54	AUSTRALIA
7	51	GERMANY
8	50	JAPAN
9	48	ITALY
10	35	TAIWAN

Co-Citation Network Analysis

Typically, when two or more articles, journals, and authors are simultaneously cited by a third article, they show a co-citation association (Chang et al., 2015). In this regard, co-citation analysis is a method adopted to construct a structure of specialties and investigate the level of interrelationships between these specialties (Small, 1973 ; Sun et al., 2022). In the current research, we conducted a co-citation analysis at the journal, author, and literature levels in the EL Field.

Journal Co-Citation Network Analysis

Two journals are considered co-cited if at least one of their respective articles is simultaneously cited in the citing article (McCain, 1991). In our research, applying CiteSpace, a journal co-citation network analysis was performed, and the top ten journals ranked based on the citation counts are presented in Table 6. Eur J Oper Res had the highest citation counts (301) in the EL Field. This journal was followed by the Transport Res E-Log (277), Journal of Ann Emerg Med (260), and Journal of Acad Emerg Med (255). Therefore, the Journal of Eur J Oper Res is one of the most crucial journals in the EL area.

Table 6: Results of the journal co-citation analysis: top 10 journals ranked based on the citation counts.

Rank	cited counts	journal name
1	301	EUR J OPER RES
2	277	TRANSPORT RES E-LOG
3	260	ANN EMERG MED
4	255	ACAD EMERG MED
5	231	PLOS ONE
6	225	COMPUT IND ENG
7	225	JAMA-J AM MED ASSOC
8	206	LANCET
9	202	NEW ENGL J MED
10	198	ANN OPER RES

Author Co-Citation Network Analysis

Author co-citation analysis is among the most representative methodologies for mapping influential authors, or key contributors, within a specific academic field. Typically, a high frequency of citations shows an author's prominence within a particular scholarly domain. In our study, we employed CiteSpace to conduct an author co-citation network analysis (Fig 3), ranking the top 11 authors by citation count; detailed results are presented in Table 7. The analysis proves that these 10 authors have made pivotal contributions to the Emergency Logistics (EL) field, laying the foundation for its future development. Notably, SHEU JB (with 132 citations) appears as the most critical contributor in the EL domain, followed closely by BALCIK B (110 citations) and ÖZDAMAR L (97 citations). These authors are thus recognized as the most influential figures within the EL field. It is particularly noteworthy that a multitude of lesser-known scholars from around the globe (UNKOWN) (461 citations collectively) have also made substantial and indispensable contributions to the field of emergency logistics. In summary, through an in-depth analysis of the author co-citation network, we have not only confirmed the leading scholars with significant impact in the EL domain but also illuminated their crucial role in shaping the research trajectory and theoretical frameworks in EL. The work of SHEU JB (Sheu Jb et al.,2022) and fellow prominent researchers has not only propelled the frontiers of EL research but also had far-reaching implications for practice, facilitating the global dissemination and adoption of EL principles.

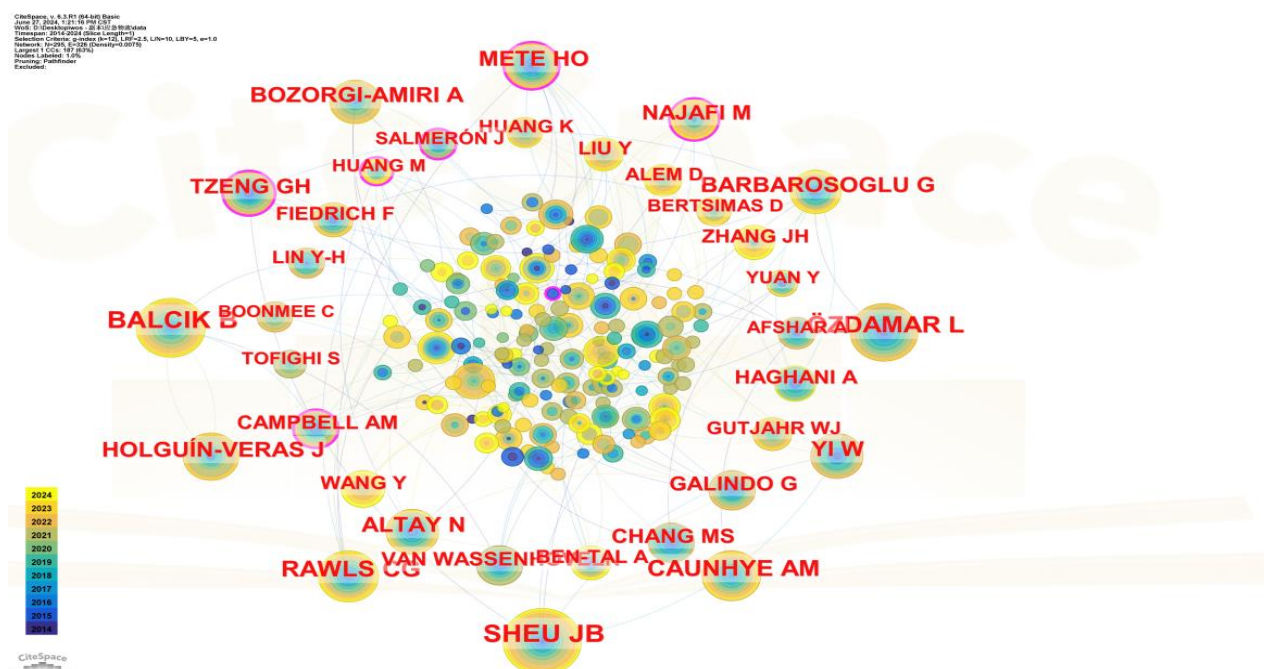


Fig. 3 The co-citation network of the most influential authors

Table 7: The co-citation network of the most influential authors

Rank	Cited counts	Author
1	461	UNKNOWN-
2	132	SHEU JB
3	110	BALCIK B
4	97	ÖZDAMAR L
5	84	RAWLS CG
6	82	CAUNHYE AM
7	65	YI W
8	64	HOLGUIN-VERAS J
9	63	BARBAROSOGLU G
10	61	BOZORGI-AMIRI A

Literature Co-Citation-Based Cluster Analysis

Table 8: Major clusters.

ClusterID	Size	Silhouette	Label(LSI)	Label (LLR)	Label(MI)	Average Year
0	68	0.976	humanitarian logistics	emergency response (97.4,1.0E-4)	age-based multi-group platelet (1.65)	2012
1	53	0.869	emergency logistics	type-2 fuzzy theory(58.72,1.0E-4)	regional-scale dynamic planning (1.19)	2019
2	31	0.784	humanitarian logistics	resource allocation (101.4, 1.0E-4)	achieving equity (1.03)	2016
3	30	0.891	future research	emergency logistics (48.03,1.0E-4)	emergency commodities(1.36)	2018

In order to explore the main themes in the field of emergency logistics, we conducted a cluster analysis of the literature co-citation network and found seven clusters (Fig 4). The labeling of these clusters is based on the log-likelihood ratio (LLR) algorithm. In particular, LLR can be used as a threshold to filter the results of other correlation measures, thereby preventing overfitting. By setting a high LLR threshold, you can keep only those pairs of items or events that have significant similarities and ignore those that are less correlated. Of the generated clusters, cluster #0(humanitarian logistics) (Faiz T I,2022), cluster #1(emergency logistics), cluster #2(resource allocation), and cluster #3(future research) are considered to be the most important clusters in the field of EL (Table 8). The reasons for this are as follows: First, all their contour values are greater than 0.8, which indicates that their clusters have an excellent fit. Second, the size of these clusters ranks among the highest of all

clusters. Overall, based on the findings, we believe that the role of EL in humanitarian logistics (cluster # 0), the role of EL in emergency logistics (cluster #1), and the relationship between future research and EL performance (cluster #3) constitute the main themes in the EL field.

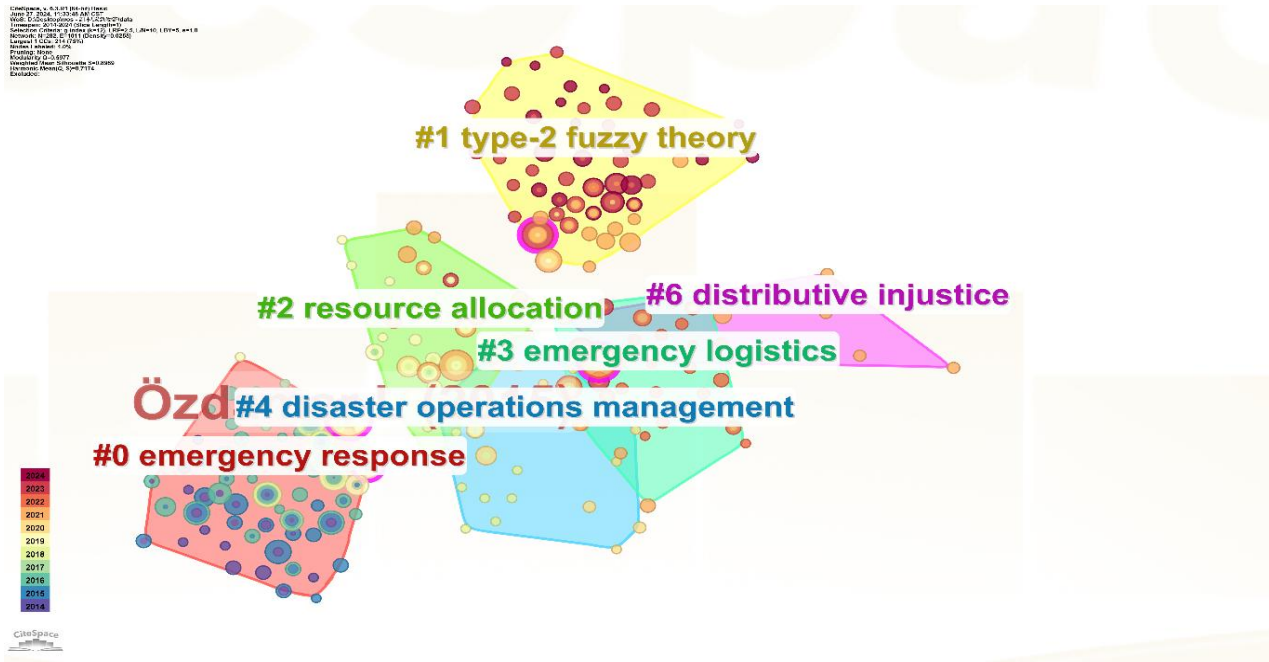


Fig.4 Results of our literature co-citation-based cluster analysis

Literature Citation Burst Analysis.

Usually, due to the breakthrough of academic research, the change of research hotspot and the promotion of academic communication, the number of citations of a specific literature in a certain period of time suddenly increases, which often reflects the change of the attention, influence, or research hotspot of the literature in the field. These enhancements are called "burst references." Burst citations identify the most key areas of research interest. Thus, scholars and stakeholders can identify core research topics or areas at a particular point in time by investigating temporal trends in burst citations. Related fields and topics vary in intensity and duration, while the content of their research is constantly evolving and changing. The results of our literature citation outbreak analysis on EL research are shown in Fig 5 The main findings of our literature burst analysis can be summarized as follows: First, it is clear that the explosion of EL related research began in 2010. This result means that since 2010, the EL field has become the focus of the basic research community with significant academic achievements. Second, the subject study conducted by Galindo G (2013) was identified as the hottest, with the strongest burst intensity (8.37) and a longer burst time (2015-2018). Third, Ozdamar L (2015) has the second highest burst intensity (7.45) and has the longest burst time (2016-2020).

Top 10 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2014 - 2024
Sheu JB, 2010, TRANSPORT RES E-LOG, V46, P1, DOI 10.1016/j.tre.2009.07.005, DOI	2010	7.17	2014	2015	<div><div></div></div>
Caunhye AM, 2012, SOC. ECON. PLANN. SCI., V46, P4, DOI 10.1016/j.seps.2011.04.004, DOI	2012	7.13	2014	2017	<div><div></div></div>
Mete HO, 2010, INT J PROD ECON, V126, P76, DOI 10.1016/j.ijpe.2009.10.004, DOI	2010	6.61	2014	2015	<div><div></div></div>
Ben-Tal A, 2011, TRANSPORT RES B-METH, V45, P1177, DOI 10.1016/j.trb.2010.09.002, DOI	2011	5.6	2014	2016	<div><div></div></div>
Galindo G, 2013, EUR J OPER RES, V230, P201, DOI 10.1016/j.ejor.2013.01.039, DOI	2013	8.37	2015	2018	<div><div></div></div>
Bozorgi-Amiri A, 2013, OR SPECTRUM, V35, P905, DOI 10.1007/s00291-011-0268-x, DOI	2013	6.15	2015	2018	<div><div></div></div>
Özdamar L, 2015, EUR J OPER RES, V244, P55, DOI 10.1016/j.ejor.2014.11.030, DOI	2015	7.45	2016	2020	<div><div></div></div>
Tofghi S, 2016, EUR J OPER RES, V250, P239, DOI 10.1016/j.ejor.2015.08.059, DOI	2016	7.1	2018	2021	<div><div></div></div>
Alem D, 2016, EUR J OPER RES, V255, P187, DOI 10.1016/j.ejor.2016.04.041, DOI	2016	5.65	2019	2021	<div><div></div></div>
Boonmee C, 2017, INT J DISAST RISK RE, V24, P485, DOI 10.1016/j.ijdrr.2017.01.017, DOI	2017	6	2020	2022	<div><div></div></div>

Fig.5 Top 10 literatures ranked by the beginning year of burst.

Key Words Cluster Analysis

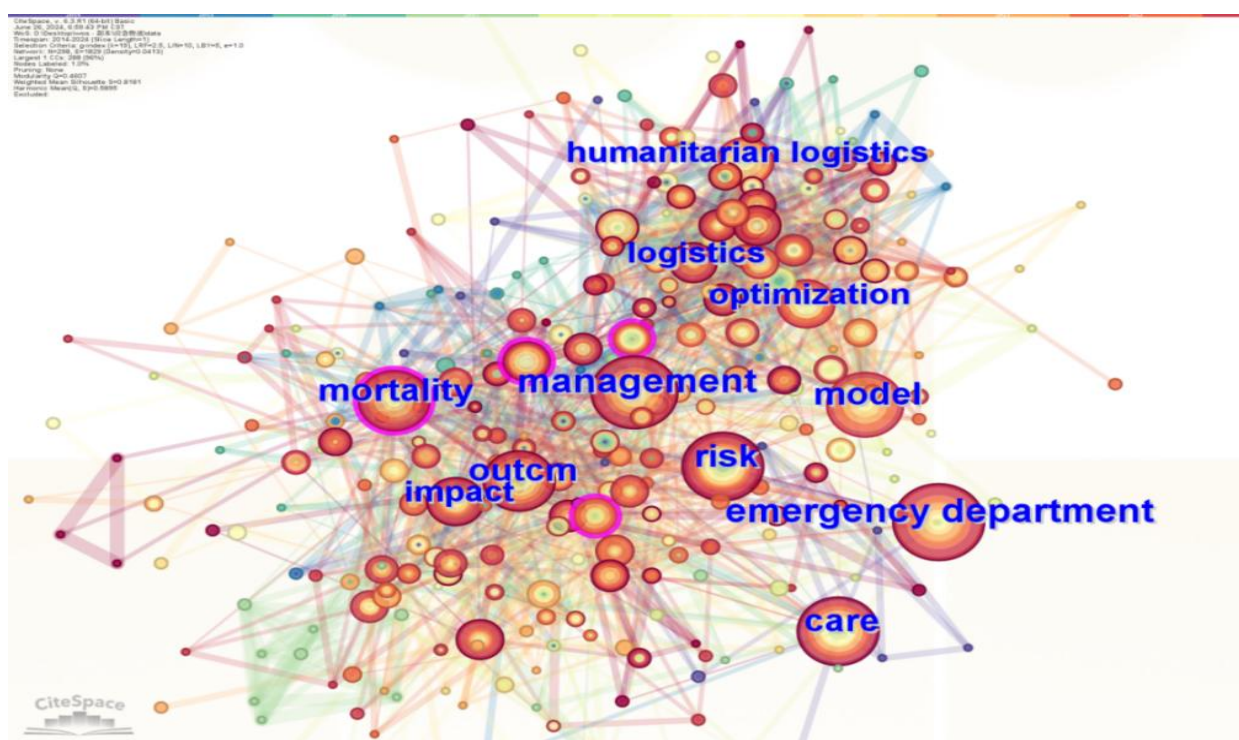


Fig.6 Key words cluster

By applying keyword analysis through CiteSpace (Fig 6), we obtained a graphical representation of keywords that are most prevalent in the literature we referenced. Keywords such as "humanitarian logistics," (Faiz T I,2022) "management", "emergency department", "mortality", and "risk" are those most commonly encountered. Through our analysis, we can discern that Emergency Logistics (EL) exerts a substantial influence in areas such as humanitarian logistics, emergency departments, and responses to emergencies.

Key Themes and Their Interconnections

The co-word network map revealed several interconnected clusters of key terms, indicating the main themes in humanitarian logistics research and their relationships. Some major findings include:

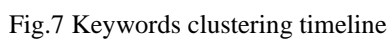
- **Integration of Humanitarian and Emergency Logistics:** This cluster includes terms such as "humanitarian logistics," "emergency logistics," "logistics optimization," and "management." These keywords indicate that researchers are actively exploring how to apply concepts and techniques from emergency logistics to improve overall response efficiency in humanitarian contexts.
- **Risk Assessment and Emergency Management:** Another prominent theme is risk assessment and emergency management, represented by keywords like "risk," "impact," and "emergency preparedness." There is a growing focus on quantifying risks associated with disaster events and developing strategies to mitigate their impact, emphasizing the importance of emergency management for rapid response.
- **Emergency Response Planning and Implementation:** The third significant cluster concerns emergency response planning and actual implementation, characterized by keywords such as "emergency response," "logistics network design," and "supply chain resilience." This area highlights the importance of proactive planning and preparedness measures to minimize casualties and damage during crises, as well as the need to build more resilient logistics networks to handle uncertainties.

Interdisciplinary Approaches and Future Directions

The results suggest that humanitarian logistics research is becoming increasingly interdisciplinary, particularly in practices related to emergency logistics, integrating concepts from operations research, management science, public health, and engineering. This trend reflects the complexity of modern humanitarian challenges and the need for collaborative efforts across multiple disciplines. Emergency logistics not only focuses on the efficient allocation of resources but also on establishing systems capable of quickly adapting to changing circumstances, which is crucial for successful humanitarian operations.

Insights and Implications for Future Research and Practice

In summary, this bibliometric analysis provides valuable insights into the evolving landscape of humanitarian logistics research, with a particular focus on the role of emergency logistics. By identifying key themes and their interrelationships, we



To delve deeper into the developmental history of EL, we produced a timeline chart of keyword clusters (Fig.7), revealing that tags like "emergency department," "emergency physician," and "humanitarian logistics" have been continuously prominent from 2014 to 2024. This suggests that these themes have remained focal points within the EL domain throughout the last ten years and constitute essential parts of the field. The following is an analysis of this image.

Major Research Themes

Several distinct research themes can be observed in the map, represented by clusters of nodes. For example:

- **Right Red Section:** This area appears to focus on the "emergency department" research direction, encompassing multiple research topics within emergency medicine. The dense connections indicate a strong conceptual interrelation within this field.
- **Central Green Section:** This section revolves around "emergency physician" and "humanitarian logistics," highlighting the association between emergency medicine and humanitarian aid, particularly in the context of logistical support during emergencies.
- **Left Blue Section:** This part is related to "emergency call" and shows research connected to emergency response systems.
- **Far Left Pink Section:** This area is associated with "South African emergency," possibly exploring the development and challenges of emergency medicine in a specific region (South Africa).

We discovered that keyword clusters are not isolated but instead interconnect and impact one another. The advent of emergency departments, the improvement of emergency systems, and the support of international humanitarian logistics were crucial in addressing the South African emergency and addressing deficiencies in the emergency care system. (Faiz T I,2022 ; Binks F.2021) Additionally, the effective management of the South African emergency contributed to the fortification of emergency departments and systems.

Research Hotspots and Trends

The transition of colors from right to left reveals the evolution of research hotspots:

- **Early Period (Blue and Green, 1998-2010):** Research focused on foundational topics such as "emergency calls," "emergency physicians," and "humanitarian logistics," reflecting early studies in emergency medicine and response systems.
- **Mid-Period (Green to Yellow, 2010-2015):** Research hotspots shifted towards the management of emergency departments, patient condition assessments, and other aspects closely related to emergency practice.
- **Recent Period (Red, Post-2015):** The research focus has moved to more specific and detailed areas, such as "emergency departments," "patient flow," and "treatment protocols," addressing practical clinical challenges.

Summary and Future Directions

Overall, the map illustrates the trajectory of research in emergency medicine from 1998 to 2018, showing a gradual shift from foundational topics like the construction of emergency systems and the role of physicians to a greater focus on specific emergency practices and management, particularly in the operation of emergency departments and patient flow management. The density of the links also indicates a high degree of interconnectivity among different research themes, especially in the interdisciplinary linkages between emergency medicine and humanitarian logistics.

The Relationship with Emergency Logistics

The central green section, which focuses on "emergency physician" and "humanitarian logistics," is particularly relevant to the field of emergency logistics. This section highlights the critical role of logistical support in emergency medical responses, emphasizing the need for efficient and effective supply chain management, resource allocation, and coordination during crises. The strong connections between these nodes indicate a growing recognition of the importance of integrating emergency logistics into the broader framework of emergency medicine and humanitarian aid.

Future research should continue to focus on these specific and detailed areas, deepening the understanding of emergency department management and patient flow. Additionally, there is a need to explore the application of new technologies in emergency logistics, such as big data, artificial intelligence, and IoT, to enhance the efficiency and effectiveness of emergency responses. Strengthening interdisciplinary collaboration, particularly in the integration of humanitarian logistics and emergency medicine, will be crucial for addressing future challenges and improving the overall resilience and responsiveness of emergency systems.

CONCLUSION

This study has provided a comprehensive analysis of the current state and future directions in emergency logistics research, employing bibliometric analysis, co-citation network analysis, and keyword clustering. The findings underscore the critical role of emergency logistics in disaster response, with key areas of focus including disaster management and response, supply chain resilience, risk assessment and mitigation, and the integration of information technology and data analytics. China and the United States have been identified as leading contributors to this field, reflecting their economic and technological strengths, as well as the high frequency of natural and man-made disasters in these regions.

For future research, several important directions have been highlighted:

(1) Proactive Planning and Humanitarian Logistics: There is a need for increased emphasis on proactive planning and preparation, along with a greater focus on humanitarian logistics. This includes community engagement and psychosocial support, such as mental health assistance, to enhance the overall effectiveness of emergency responses.

(2) Integration of Advanced Technologies: The integration of advanced technologies, including big data, artificial intelligence, and the Internet of Things, is becoming increasingly important. These technologies can facilitate more accurate forecasting, real-time monitoring, and efficient resource allocation, thereby significantly improving the efficiency and effectiveness of emergency operations.

(3) Promotion of Multi-Sector Collaboration: Strengthening cross-sector collaboration is crucial for enhancing the effectiveness of emergency logistics. This involves fostering information sharing and technological exchanges across different industries to develop adaptable and flexible solutions that can effectively address various emergencies.

In conclusion, this study provides valuable insights into the current landscape and future trends in emergency logistics. It highlights the importance of interdisciplinary approaches and the integration of advanced technologies to address the complex challenges of disaster response. The findings offer essential guidance for researchers, policymakers, and practitioners, aiming to enhance the efficiency, effectiveness, and sustainability of emergency logistics. By focusing on these key areas, the field can be further developed to better prepare for and respond to disasters, ultimately saving lives and reducing the impact of emergencies.

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