# Characteristic Analysis of Emergency Collaboration Network for Public Crisis Events
## Based on the Whole Network Data Analysis of the "7 · 20" Heavy Rain in Zhengzhou, Henan Province

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**Abstract.** Taking the "July 20" rainstorm event in Zhengzhou, Henan Province as an example, this paper uses the social network analysis method to quantitatively analyze the emergency cooperation network in public crisis events from the perspectives of network density, point degree centrality, middle centrality, and core-edge analysis. The findings are as follows: the relationship between the organizations involved in emergency cooperation is not close; The government plays an important role in the leading position in the cooperation; Social organizations play a bridging role in emergency coordination. Finally, combined with the findings of the research, the corresponding optimization suggestions are further proposed.

**Keywords:** public crisis events · Emergency cooperation network · Social network analysis

## 1  Introduction

Due to the suddenness of the outbreak, the responsibility to bear, the urgency of time, the continuity of the process and the extensive damage, public crisis events have attracted wide attention at home and abroad. Public crisis events have a large impact and strong destructiveness, which requires extensive participation of the society in emergency coordination. Guangming Daily pointed out that "effectively mobilizing all forces to unite and cooperate in mass prevention and treatment is a basic strategy for China to cope with public emergencies" [1]. In public crisis events, not only the government needs to play an active leading role but also needs to extensively absorb forces from all walks of life, establish and improve the cooperation mechanism of information sharing, resource flow, and coordinated action, and promote the efficient and orderly cooperation of the government, enterprises, and social organizations. Taking the "July 20" rainstorm in Zhengzhou, Henan Province as an example, this paper adopts the social network analysis method to analyze the network characteristics of public crisis emergency cooperation and puts forward optimization suggestions according to the current situation.

## 2   Review of Public Crisis Management Research

Foreign countries started to study crisis management earlier. Steven Fink proposed the theoretical model of the crisis life cycle [2]. M. Regester and Michael put forward the 3 T principle of crisis management [3]. Crisis management in the public sector has attracted extensive attention from the academic circle, and the research field presents the characteristics of diversification. It involves political crisis research [4], disaster crisis management [5], comprehensive research [6], and other aspects. Scholars such as Uriel Rosenthal preliminarily proposed the decision-making, leadership, and coordination mechanism and theoretical framework of crisis management based on the international crisis events in the 1970s and 1980s [7].

The research on public crisis management started late in China but has obtained abundant research results. In terms of the definition of public crisis, Li Yanling [8], Zhang Xiaoming [9], and other scholars have made a definition of public crisis. In terms of the types of crises, scholars have divided them from multiple perspectives [10–12]. In terms of the construction of a public crisis management system, in traditional research directions, scholars mostly put forward strategies and opinions on public crisis management from the perspectives of "system theory", "public relations theory", "empirical theory" and "comprehensive integration theory" [13].

In recent years, collaborative governance has become an innovative research point in China's public crisis management model, emphasizing the coordinated response of multiple social forces to public crises. Zhang Lirong and other scholars put forward the idea of constructing the mode of collaborative governance of public crisis [14], Sha Yongzhong and other scholars elaborated on the content of collaborative governance of public crisis [15], and Jiao Keyuan constructed the system of social organizations participating in collaborative governance of public crisis [16].

## 3   Research Design

### 3.1   Study Object

On July 17, 2021, continuous heavy rain caused the dangerous situation in central and northern Henan Province, endangering public safety. In response to the disaster in Henan, the state immediately launched an emergency response. The Ministry of Emergency Management immediately launched a cross-regional reinforcement plan for fire and rescue teams, the Ministry of Transport and other government departments quickly coordinated, and social organizations, enterprises, and individuals actively participated in emergency response. The "7 · 20" rainstorm emergency cooperation in Zhengzhou, Henan Province reflects the following characteristics: (1) Caused by a natural disaster, it has the characteristics of a sudden outbreak, urgent processing time, wide range of impact, etc., which is typical. (2) It involves the participation of government, social organizations, enterprises, and other organizations, and there is a cooperative relationship between the organizations such as resource integration and information flow, forming a complex network. Social network analysis can be used to study the public crisis emergency cooperation network. (3) The network data is rich and easy to obtain, and the data comes from various media and social platforms to meet the data needs of social network

analysis. To sum up, the "July 20" rainstorm in Zhengzhou, Henan Province is taken as the research object in this paper.

### 3.2 Research Methods

A social network consists of nodes and the connections between nodes. Nodes in a social network generally represent actors, and the connections between nodes represent the relationships between actors. In the public crisis event emergency cooperation network, the nodes represent the organizations participating in emergency co-operation, and the lines between the nodes represent the cooperative relationship between the organizations.

In this paper, social network analysis is mainly adopted, and Ucinet-6 and NetDraw are used to carry out the visual operation and quantitative analysis of the public crisis event emergency collaborative network. Density analysis can quantify the closeness of the connections within the collaborative network, degree centrality analysis can judge which nodes are in the central position of the network, intermediate centrality can study the ability of an actor not controlled by other activities, and the core edge is a quantitative analysis of the location structure of the collaborative network. Based on the analysis of network density, point centrality, middle centrality, and core edge, this paper conducts multi-dimensional research on the public crisis emergency collaborative network.

### 3.3 Data Acquisition and Processing

In terms of data acquisition, in order to obtain effective information as much as possible, this study extensively collected data about the "July 20" rainstorm in Zhengzhou, Henan Province from the official government website, official media platform, social media platform, WeChat public account, and other media social platforms. From the perspective of data validity and adequacy, this paper intercepted the data from July 19, 2021 (Zhengzhou Meteorological Bureau has issued the red warning signal of rainstorm, disaster outbreak) to August 2, 2021 (The State Council established the "July 20" rainstorm disaster investigation team in Zhengzhou, Henan, indicating that the emergency cooperation stage was basically over and the post-disaster investigation stage was entered).

In terms of data processing, a matrix is established in this study according to whether there is a cooperative relationship between organizations. According to Mr. Kang Wei's research results, this paper holds that the "cooperative relationship" among subjects should be "in major emergencies, in order to achieve security goals, all actors (including the government, enterprises, social organizations, etc.) through cross-subject, cross-level, and cross-regional cooperation and coordination. The network structure and relationship formed by governance behaviors such as resource integration and information flow under certain rules and mechanisms" [17].
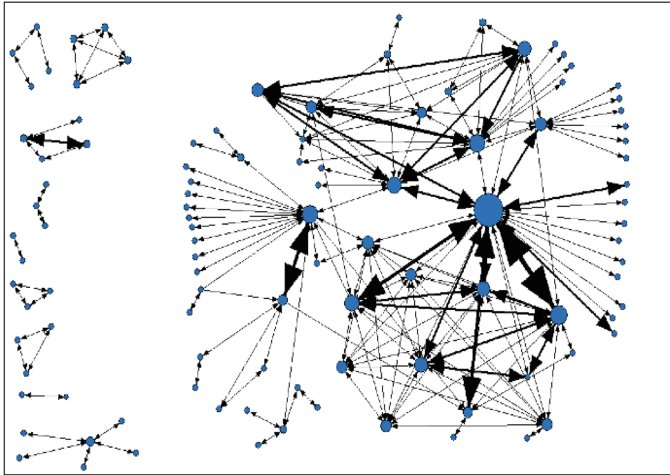
**Fig. 1.** Diagram of the emergency collaboration network for the "7 · 20" heavy rainstorm event

## 4  Analysis of Characteristics of Emergency Cooperation Network

### 4.1  Visualization of an Emergency Collaborative Network

In this study, Ucinet-6 and NetDraw were used to draw the emergency collaborative network diagram, as shown in Fig. 1. The size of the node represents the total number of times the node participates in emergency cooperation. The larger the node is, the more times the organization participates in emergency cooperation. The thickness of the line between nodes corresponds to the cooperation relationship between nodes, and the thicker the line is, the more times of cooperation between two organizations.

As shown in Fig. 1, 107 nodes represent a total of 107 organizations participating in emergency cooperation during the "July 20" rainstorm in Zhengzhou, Henan Province. In general, some of them are located in the center of the network, with larger nodes and more and thicker connections with other nodes. However, some nodes are not closely connected with the whole network and are located at the edge of the network, with smaller nodes and fewer connections. The larger nodes, such as the Ministry of Emergency Management and the Red Cross Society of China, indicate that the total number of times the above-mentioned organizations participated in the collaboration is larger. Some nodes, such as the Ministry of Emergency Management and the State Flood Control and Drought Relief Headquarters, had thicker connections, indicating that there were more times of cooperation between the corresponding organizations.

### 4.2  Density Analysis

Density refers to the closeness of connections between nodes in a network. In this study, the density of the emergency collaboration network diagram is 0.2175 by using the density calculation function of Ucinet-6. The results showed that during the "July 20" rainstorm in Zhengzhou, Henan Province, the cooperation among organizations was not close enough, and there was a problem of loose emergency cooperation.

### 4.3   Degree Centrality Analysis

Degree centrality analysis is a key indicator to analyze the importance of each node in a social network. In a social network, an actor has a variety of associations with other actors, occupies a central position, and often holds more power. Based on the number of cooperative relations between a node and other nodes, the point degree centrality can be calculated, and the nodes in the central position in the network can be seen simply and directly.

Ucinet6 was used to calculate the degree of centrality of each node in the emergency cooperation network, and it was concluded that the organizations with a higher degree of centrality were the Ministry of Emergency Management, the Ministry of Water Resources, the Red Cross Society of China and other organizations. Among them, the Ministry of Emergency Management has the highest degree of centrality, indicating that it has a variety of associations with other organizations in the "July 20" rainstorm emergency coordination network in Zhengzhou, Henan, and has greater influence and power. Among the top several organizations in the average degree of observation, it can be found that government departments account for a large proportion. It shows that government departments play an important role in the emergency cooperation of public crisis events, which has an important impact on emergency cooperation.

### 4.4   Analysis of Intermediate Centrality

Intermediate centrality measures the extent to which actors control resources [18]. A high degree of intermediate centrality means that an organization is on the shortest path of many other point pairs in a collaborative network. Because of the nature of the intermediate centrality, it can be used as an indicator to measure the mediating role of nodes in the network. Through the intermediate centrality, nodes that play a bridging role in the cooperative network can be found [19].

In this study, Ucinet6 is used to calculate the intermediate centrality of actors in the network. The nodes with higher intermediate centrality are the Red Cross Society of China, the Ministry of Emergency Management, the Tencent Foundation, the Henan Red Cross Society, and other organizations, indicating that they play a bridging role in the emergency cooperation network. In the nodes that play intermediary roles, the Red Cross Society of China, Tencent Foundation, Henan Red Cross Society, and other organizations are social organizations, indicating that some social organizations play the role of bridge and bond in the emergency cooperation network.

### 4.5   Core-Edge Analysis

This study draws on the analysis framework of the "relationship core-strength core" established by Zhang Haibo [20]. Based on binary matrix and multi-valued matrix, the location of each node is divided into core region, semi-edge region, and edge region, and core-edge analysis is conducted for relationship network and strength network.

**Core-Edge Analysis Based on Relational Network.**
In this study, a binary matrix is used to represent the relational network. If there is a

|  | Number of tissues (s) | The proportion of (%) |
|---|---|---|
| core | 15 | 14.02 |
| Half edge | 5 | 4.67 |
| border | 87 | 81.31 |
| amount to | 107 | 100 |

**Fig. 2.** Distribution of regional departments of core-edge structure based on "relational network"

cooperative relationship between two subjects, the value is 1; if there is no cooperative relationship, the value is 0. Ucinet-6 was used to process the data, and the positions of each subject in the "relational network" were divided through calculation, as shown in Fig. 2.

Among the 107 organizations, 15 departments, including the Ministry of Water Resources and the Ministry of Emergency Management, are located in the core area of the network, accounting for about 14.02%. They have rich cooperative relations with other departments and occupy an important position in the "relationship network". Through further analysis, it can be seen that 13 of the 15 core departments are government departments, indicating that in the "July 20" rainstorm emergency coordination "relationship network" in Zhengzhou, Henan, most of the core positions are government departments.

**Core-Edge Analysis Based on Intensity Network.**
In terms of core-edge analysis of strength networks, this study represents strength networks with a multi-valued matrix, taking into account the strength of interorganizational collaboration. Ucinet-6 is used to process the data, and through calculation, the position of each subject in the "strength network" is divided, as shown in Fig. 3.

Among the 107 organizations, 13 departments, including the State Flood Control and Drought Relief Headquarters and the Ministry of Emergency Management, are located at the core of the "intensity network", accounting for about 12.15%. They have strong cooperation with other departments and occupy a relatively important position in the "intensity network". Further analysis shows that 11 of the 13 core departments are government departments, indicating that in the "7 · 20" rainstorm emergency coordination "intensity network" in Zhengzhou, Henan, most of the core positions are government departments.

**Based on the Above Two Types of Core-Edge Cross Analysis.**
In relation to networks and strength networks, there are differences in core departments,

|  | Number of tissues (s) | The proportion of (%) |
|---|---|---|
| core | 13 | 12.15 |
| Half edge | 7 | 6.54 |
| border | 87 | 81.31 |
| amount to | 107 | 100 |

**Fig. 3.** Regional sector distribution of core-edge structure based on "strength network"

but there is also the possibility of a crossover. For example, the Ministry of Emergency Management is located in both the core position of the relationship network and the core position of the strong network, which indicates that it has rich cooperative relations with other departments and relatively high relationship intensity.

Based on the analysis framework of "relationship core – strength core", the members of the network can be divided into the following four categories: the absolute core department, which is located in the core position of both the relationship network and strength network; The absolute core department of strength: located in the core position of strength network, but not in the core position of relationship network; Relationship core department: located at the core of the relationship network, but not at the core of the strength network; Non-core departments: not located at the core of either the relationship network or the strength network.

As shown in Fig. 4, in the "July 20" rainstorm emergency coordination network in Zhengzhou, Henan Province, there are 11 departments as absolute core departments. They not only have rich cooperative relations with other departments but also have relatively high relationship intensity. Most of the absolute core departments are government departments, indicating that in the "7 · 20" rainstorm emergency cooperation in Zhengzhou, Henan Province, government departments cooperated more closely with other departments and played a core role with higher intensity. However, social organizations are less in the core position in the collaboration network, which indicates that it is necessary to promote social organizations to participate in emergency cooperation more equally and widely in the face of public security incidents.

| | |
|---|---|
| Absolute core department | Ministry of Water Resources, Henan Provincial Flood Control Office, Henan Provincial Emergency Department, Ministry of Emergency Management, State Flood Control and Drought Relief Headquarters, Ministry of Transport, Ministry of Natural Resources, State Grid, Ministry of Housing and Urban-Rural Development, Health Commission, Energy Administration, China Anneng Construction Group Co., Ltd |
| Strength core department | the Ministry of Finance |
| Relationship with core departments | Henan Provincial Department of Water Resources, Henan Provincial Meteorological Bureau, Henan Provincial Department of Natural Resources |
| Non-core departments | There are 92 departments including Xinxiang Emergency Management Bureau, China Unicom, China Telecom, Henan Surveying, Mapping and Geographic Information Technology Center, ThePaper.cn, Aide Foundation CCTV News, Air Force Aviation Arm of the Central Command Zone, Ministry of National Defense, Central Military Commission, State Grid Henan Corporation, etc |

**Fig. 4.** Core sector cross classification

# 5 Conclusions and Suggestions

## 5.1 Research Conclusions

This study is mainly based on the social network analysis method, using Ucinet-6 and NetDraw for calculation and visualization. From the perspectives of density, degree centrality, middle centrality, and core-edge analysis, this paper takes the "July 20" rainstorm in Zhengzhou, Henan Province as an example to analyze the emergency cooperation network of public crisis events, and draws the following conclusions: First, the density of emergency cooperation network is low, and the closeness of cooperation among organizations needs to be strengthened in public crisis events. Secondly, the results of degree centrality analysis and core-edge analysis of emergency cooperation networks show that: in public crisis events, government departments often occupy the core position of emergency cooperation network and play a leading role in emergency cooperation. Finally, the centrality analysis shows that social organizations play an important bridging role in public crisis emergency co-operation.

## 5.2 Suggestions for Optimization

(1) Actively promote equal, orderly, and close participation of all social subjects. First, the concept of collaborative governance should be formed in the whole society, the relationship of mutual trust among social subjects should be established, and all kinds of subjects should be promoted to actively participate in the process of emergency coordination of public crisis events in an orderly way. Second, channels for multiple entities to participate in emergency response cooperation should be un-blocked and diversified participation channels should be established to provide support for social entities to participate in emergency response cooperation. Third, we should promote the sharing of information, build a modern platform for information exchange, promote the connection between the demand side and the supply side, and encourage social organizations and enterprises to participate in the emergency coordination of public crisis events in a timely and effective manner. Fourth, we should promote the full utilization of resources and encourage each entity to complement each other's strengths.

(2) We should give better play to the leading role of the government and promote the orderly development of emergency response coordination. First, the government should improve relevant systems and policies to support and guide multi-body participation in emergency coordination. Second, the government should play a coordinating and leading role, enabling all social entities to give full play to their respective capabilities and develop their strengths, so as to make emergency response cooperation complementary and coordinated. Thirdly, the government should attach importance to the sharing and utilization of information resources, promote the high-speed transmission of effective information, break the information barriers, and promote the effective participation of social subjects. Finally, the government should strengthen the construction of the public crisis emergency system, and strengthen risk prevention, research, and decision mechanism.

(3) Promote social organizations to play the role of a bridge and participate in emergency response cooperation efficiently. First of all, social organizations should be promoted to strengthen self-construction, cultivate professional personnel, improve the degree of specialization, expand the sources of funds, improve transparency, and adapt to the needs of The Times; Secondly, social organizations should focus on innovative development, build engines of development and innovation, and enhance their ability to participate in emergency response cooperation. Finally, social organizations should identify their own advantages and characteristics and give full play to their advantages to participate in the emergency cooperation of public crisis events.

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