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Scenario Evolution Analysis of Unconventional Emergencies Based on Social Network Analysis

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Abstract

In recent years, unconventional emergencies have occurred frequently in China, which have seriously threatened people's life and property safety. It is beneficial to analyze the scenario evolution of unconventional emergencies to grasp the focus of emergency management. In this paper, a questionnaire survey was conducted on a factory in the "5.12 Wenchuan Earthquake", and the accident was divided into four scenarios: ten minutes before the earthquake, during the earthquake and the escape process, the local self-rescue process, and the external rescue process. Social Network Analysis method is used to explore the scenario evolution law of unconventional emergencies, and relevant suggestions are made in combination with the rules.

Key words: Unconventional emergencies; Scenario evolution; Social network analysis; Evolutionary law

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1. INTRODUCTION

Unconventional emergencies are a collective term for natural hazards and accidental disasters with characteristics such as inconspicuous precursors, irregular evolutionary processes, and complex effects of derived disasters (Jiang, et al, 2020; Zhang, She, & Geng, 2017). In recent years, unconventional emergencies have occurred frequently, such as earthquakes, mudslides, forest fires, transportation explosions, and so on, which have caused serious threats to people's lives and property safety. The scenario of unconventional emergencies provides the reference to the emergency decision maker. Therefore, it is conducive to decision makers to grasp the core elements of unconventional emergencies and do a good job in the mode of "scenario-response" management by exploring the scenario evolution law of unconventional emergencies and restoring the scenarios of unconventional emergencies.

In the study of scenario evolution of sudden disaster events, scholars mainly use case inference, Bayesian networks, knowledge meta, system dynamics, and coloring petri nets to conduct research. Qie Zijun and Rong Lili (2020) constructed a network model reflecting the characteristics of the affected region to describe regional disaster scenarios with the core of disaster-bearing bodies and their associations (Qie & Rong, 2020). Chao Yu et al. (2020) used the theoretical knowledge of dynamic Bayesian network model to construct a scenario evolution model for unconventional events and verified the feasibility of the model by using the water pollution event caused by the leakage of Lanzhou Petrochemical pipeline as an example (Yu, et al, 2020). Zhang Zhixia et al. (2020) used the knowledge meta-representation to describe the four elements of the scenario state, emergency activities, breeding environment and disaster-bearing body of an emergency event, and constructed a Bayesian network-based scenario extrapolation model (Zhang, Hao, & Zhang, 2020). Lian Huiqing et al. (2019) proposed a multi-stage emergency decision mechanism for mine flooding accidents with "golden 72 hours" and "8 days and 8 nights" as time nodes (Lian, et al, 2020).

Social Network Analysis (SNA) is an analysis method that explores the location of nodes in a network and the association between nodes, and can be used for text analysis. By using centrality analysis, cohesive subgroup analysis, core-edge analysis and other indicators, the key information in the text can be identified more accurately, so as to "know the big with the small".

In terms of the application of social network analysis method for emergencies, current research mainly focuses on using social network analysis to study the network structure of public opinion dissemination of emergencies, the cooperation and connection among subjects, as well as to explore the causes of emergent disaster events and the common roles among the causes. Liu Shuhua et al. (2017) used social network analysis to study the local government microblogs of the Tianjin explosion and found that there were three types of subgroups, namely, the subgroup of information providers, the subgroup of information transfer bridges, and the subgroup of communication amplification groups, which play different roles in policy dissemination (Liu, Pan, & Wei, 2017). Kang Wei (2012)] took the 7.23 moving train accident as an example and used social network analysis methods to study the key nodes in online opinion dissemination, and proposed that the key nodes could be guided by changing the centrality and clustering coefficients to reduce the spread of rumors and panic (Kang, 2012). Song Yinghua (2019) et al. used social network analysis methods to explore the key causes in major traffic accidents and the combination of causes with the strongest ability to cause accidents, to construct a risk assessment system for major traffic accidents, and to verify the usability of the assessment system with empirical analysis (Song, et al, 2019).

In conclusion, the social network analysis method has rarely been utilized to explore scenario evolution studies in emergencies. The social network analysis method can obtain the key situational words in unconventional emergencies, with which the scenario at that time can be accurately portrayed to advance the scenario evolution. In this paper, we take the Wenchuan earthquake H plant of 5.12 as the research object, dividing the accident into four stages according to the time dimension and using the questionnaire method to obtain the description of each stage of the scenario by the employees of the H plant. Then,we use the social network analysis method to extract the key scenario words in each stage, which can be used to portray the whole scenario, so as to study the scenario evolution process of the whole unconventional emergency accident.

2. OBJECTS AND METHODS

2.1 Research Subjects

The 8.0 magnitude earthquake that occurred at 14:28 on May 12, 2008 in Wenchuan, Sichuan had caused 69,227 deaths, 374,643 injuries and 17,923 people missing, making it the most devastating earthquake since the founding of the People's Republic of China. More than ten years have passed since the Wenchuan earthquake, and the damage it brought to people is still palpitating. This study was conducted in October 2018 through in-depth interviews with all the grassroots employees of Plant H. With reference to the overall network research object selection requirements, the grassroots employees of each department of Plant H were randomly selected as research subjects. This study divided the whole earthquake into four scenario "slices", which were ten minutes before the earthquake, during the earthquake and the escape process, in situ self-help process, and external rescue process. Different questions were set at different stages, and the respondents could describe the situation in detail according to the examples and the questions.

2.2 Research Methods

2.2.1 Survey

This study was conducted by means of survey, which was divided into two parts: (1) General information questionnaire, which included: name, age, gender, education, department, branch, division, section and functional group.The organization's personnel were grouped by this basic information. (2) The main body of the questionnaire is divided into ten minutes before the earthquake, during the earthquake and the escape process (when the earthquake started, the escape process until it was confirmed that they were safe), in-place self-help process and external rescue process. The main focus of the questionnaire was on "the escape route as a clue, recall the earthquake and the escape process until you confirm your safety, and make a corresponding process description". In the process of implementation, the respondents were interviewed in person with their consent, and the interview time was limited to 20 minutes. This questionnaire can only be accessed by the sender of the questionnaire, in order to protect the privacy of the respondents. A total of 601 questionnaires were distributed, and 601 valid questionnaires were collected, with a valid return rate of 100%.

2.2.2 Social Network Analysis Method

In this paper, we mainly use Netminner4.0, the social network analysis software ,to quantitatively analyze the nodes in the constructed network and the relationship between the nodes. Meanwhile,using the 1-mode network diagram to visualize the scenario, the main analysis methods used include the following two.

(1) Centrality analysis

Point degree centrality describes the ability of a node to directly interact and connect with other nodes. The stronger the ability to interact directly, the higher the point degree centrality, and the closer the node is to the core of the social network. Intermediate centrality measures the extent to which a node acts as a bridge, namely, the extent to which two other points are connected through that node. Proximity centrality measures the sum of the geodesic distances of all nodes, and the greater the proximity centrality of a node, the more the node is at the core of the network.

(2) Cohesive subgroup analysis

When certain individuals in a network have relatively strong, direct, and close positive relationships with each other to the point of combining into a sub-group, such a group is called a cohesive subgroup in social network analysis (Lin, 2009). Cohesive subgroup analysis allows categorizing situational factors and portraying scenarios in different degrees.

2.3 Data Processing

The high-frequency key words in the description of the earthquake scenario in the questionnaire were counted, and a total of 116 high-frequency words with a word frequency of not less than 10 times were counted. Some pronouns, count words and nouns that were not related to the scenario, and semantic repetitions were excluded, leaving 73 high-frequency scenario words. If two situational words appeared in the same respondent's description, they were recorded as 1. On the contrary, they were recorded as 0, forming a 73*73 co-word matrix. The co-word matrix was imported into Netminner 4.0 social network analysis software for data processing and visualization analysis.

3. RESEARCH RESULTS

3.1 Scenario 1: 10 Minutes Before the Earthquake

The statistics of the questionnaire data showed that 389 people were dealing with daily work ten minutes before the earthquake, accounting for 65%; 44 people were in a meeting, accounting for 7%; and 24 people were dealing with temporary affairs, accounting for 4%. As shown in Table 1.

Table 1
Affairs handled 10 minutes before the earthquake

	Affairs	Quantity	Weight
A	Daily work	389	65%
B	Meeting	44	7%
C	Temporary Services	24	4%
D	Others	121	20%
E	No answer	23	4%
Total		601	100%

3.2 Scenario 2: During the Earthquake and the Escape Process (When the earthquake starts and the escape process)

3.2.1 Centrality Analysis

The co-word matrix was imported into Netminer for centrality analysis. The degree centrality, intermediate centrality, and near centrality were obtained respectively. Then,the top ten scenario words obtained from centrality analysis were listed, as shown in Table 2.

Table 2
Centrality analysis

	Scenario words	Degree centrality	Near centrality	Intermediate centrality
1	Collapse	0.986	0.986	0.012
2	Dust	0.986	0.986	0.012
3	Shake	0.986	0.986	0.011
4	Vibration	0.986	0.986	0.010
5	Concentration	0.985	0.960	0.010
6	Unsteady standing	0.985	0.960	0.011
7	Stop	0.944	0.947	0.009
8	Severe	0.944	0.947	0.010
9	Rush	0.931	0.935	0.009
10	Spaciousness	0.917	0.923	0.009
11	Injury	0.917	0.923	0.009
12	Serious	0.917	0.911	0.008
13	Swing	0.903	0.911	0.008
14	Quick	0.875	0.889	0.007
15	Nonstop	0.861	0.878	0.007
16	Permeat	0.847	0.867	0.006
17	Shout	0.847	0.867	0.007
18	Call	0.806	0.837	0.006
19	Loud noise	0.792	0.828	0.004
20	Organise	0.792	0.828	0.005

3.2.2 Cohesive Subgroup Analysis

If all nodes in a subgroup are connected to at least K other nodes in the graph, such a subgroup is called a K-core network (Kang, 2012). The larger the K value in the K-core analysis, the more connected the network graph is.It shows that the maximum K value of the scenario network graph is 36, and the number of nodes is 56, as shown in Table 3. The data indicates that there is a "cohesive subgroup" in the scenario network graph, which accounts for more than 76% of the whole scenario network, and these nodes are more central in the whole network. Therefore, it can be assumed that this "subgroup" occupies an important position in the scenario network diagram and can represent a large amount of scenario information.

Table 3
K-core analysis

Coreness	#Of nodes	#Of components
36	56	1
35	65	1
34	67	1
33	68	1
31	69	1
30	71	1
25	**72**	**1**
23	**73**	**1**

3.2.3 Scenario Summary

The centrality analysis and cohesive subgroup analysis showed that the earthquake was accompanied by strong shaking, and the respondents were unable to stand still and ran quickly to the open area after realizing it was an earthquake. During the escape process, accompanied by loud noises, houses and buildings gradually collapsed. Dust filled the air, some interviewees were seriously injured during the escape process, and the surrounding area was filled with shouts and cries for help. The interviewees who escaped successfully were the first to contact and ascertain the safety of their families by phone, but communication was interrupted after the earthquake. Throughout the escape process, the leaders of Factory H exerted good organizational command and were able to quickly organize the escape of their employees.

3.3 Scenario 3: In-Place Self-Rescue Process (Starting from confirming safety and continuing to the in-place self-rescue process of unified arrangement and dispatch of h-factory)

After a successful escape, from the sensory perspective, the survey found that 77% of respondents saw the dust filled, 72% saw the collapse of the house, 83% saw the crowd gathered, and 7% saw a different scene; 64% heard the sound of crying, 33% heard the sound of distress, 76% heard the sound of shouting， and 11% heard other sounds. 80% felt that a big disaster had happened, 57% felt that Factory H was seriously affected, 8% felt that they could not protect themselves, 6% felt that the problem was not serious, 30% felt helpless, and only 10% were other feelings; 82% of people's judgment at the time was that the disaster was serious and how the casualties among family members or colleagues were, 38% of people's judgment at the time was how the information would be delivered, 39% of people's judgment at the time was that there would definitely be aftershocks, and 54% of people's judgment at the time was to see how their family members were doing first.

Table 4
Centrality analysis

	Scenario words	Degree centrality	Near centrality	Intermediate centrality
1	Security	1.000	1.000	0.061
2	Ensure	1.000	1.000	0.061
3	Situation	0.929	0.933	0.044
4	Families	0.929	0.933	0.050
5	Phone	0.929	0.933	0.048
6	Colleagues	0.929	0.933	0.008
7	Impassability	0.786	0.824	0.026
8	Mobile	0.643	0.737	0.001
9	Unit	0.643	0.737	0.004
10	Workshop	0.571	0.700	0.007
11	leader	0.571	0.700	0.004
12	Branch	0.500	0.667	0.004
13	Parents	0.500	0.667	0.002
14	Office	0.429	0.636	0.001
15	Friends	0.429	0.636	0.002

The next question was what respondents did spontaneously without any leadership. 51.9% contacted others, 78.5% first confirmed their family's well-being, 32.1% gave immediate help, and 8.9% did something else. Centrality analysis was conducted by Netminer, and the first 15 situational words were intercepted to obtain Table 4, which shows that the majority of respondents who first spontaneously contacted others first contacted their families by phone to ascertain their family's security. Secondly, they looked for their colleagues and friends in the factory to confirm their safety.

Respondents who contacted their families first confirmed the safety of their families and second determined the damage to their homes. Centrality analysis was performed using Netminer to construct a 1-mode network diagram, as shown in Fig.1. It can be seen that the respondents' family members are basically safe, only a few are injured, and the house is severely damaged.

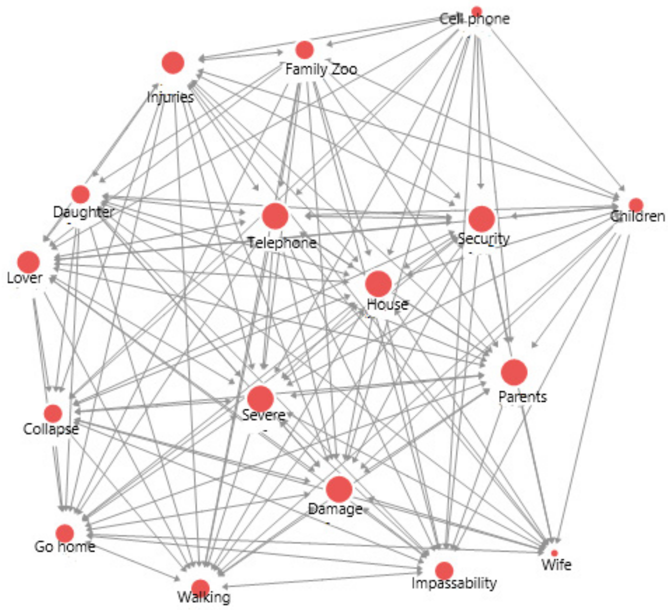

Figure 1
1-mode network diagram

In the case of having an organization in place, 18.8% viewed the disaster situation in their units, 38.8% organized rescue, 26.5% passed information to their superiors and reported the situation, 9.5% sought external rescue, 31.6% transported the injured, and 44.8% rescued supplies. In the process of participating in the rescue, 52.7% encountered the problem of poor information, respectively, through verbal inquiries, cell phones, radio, walking and running to inquire and spread the news; 42.4% encountered the problem of lack of rescue tools and equipment, respectively, by taking local materials, making simple tools, using their hands to solve the problem; 19.6% encountered the problem of lack of medical supplies, taking to find medicine, find friends, send to hospital, and wait to solve the problem;

18.6% encountered the problem of disorderly rescue, 19.6% encountered the problem of insufficient personnel, 14.9% encountered the problem of physical exhaustion, and solved these problems by taking shifts, resting or overcoming; only 1.1% encountered other problems.

The overall feelings of respondents about the information they were exposed to at work during the beginning of the life rescue phase were: 21.83% thought it was difficult to obtain the necessary information for the emergency rescue work; 15.33% thought the sources of information were confusing and difficult to distinguish; 7.5% thought there was distortion of information during the rescue process; 31.17% thought information was passed from the top of the company to the bottom quickly; 10.17% thought that some information was not fully disclosed during the rescue process; 40% thought that the transmission of information within the company was effective at this stage.

3.4 Scenario 4: External Rescue Process (External rescue starts to life rescue ends)

When the external rescue force arrived, respondents' intuitive feelings about the changes in the life rescue process were respectively expressed as follows: 43.17% felt that the rescue was more orderly; 48.67% felt that the external rescue force was enhanced; 33.67% felt that the disaster information was more complete; 34.5% felt that the public was more understanding and cooperative; 46.17% felt that the confidence of the workers was increased, and 44.5% felt that the workers' emotions were more stable.

The main ways respondents received information were verbal communication from colleagues, cell phone or telephone, leadership, meetings and documents, etc. At this stage, respondents communicated with external rescue forces mainly by verbal communication and telephone. 11.17% felt it was difficult to obtain necessary information in emergency rescue work; 9% felt that the sources of information were confusing and difficult to distinguish; 6.5% felt that in the rescue process there was distortion of information in the rescue process; 34% thought that information was passed from the top of the company to the grassroots quickly; 9.33% thought that some information was not fully disclosed during the rescue process; 44.83% thought that the transmission of information within the company was effective at this stage.

4. DISCUSSION

The whole scenario was divided into four stages, and each scenario profile was studied one by one. Mainly through word frequency statistics and centrality analysis, intercepting the key scenario words in each stage, eventually obtained the H plant life rescue scenario profile inscription table, as shown in Table5.

It can be seen that when a disaster occurs, people's first reaction is to escape quickly, at which time there is almost no information transmission and they can only rely on their own judgment.

After successfully escaping, people's first reaction is the safety of their families and colleagues and friends around them, and the first priority at this time is to confirm their safety. After confirming the safety of their families and colleagues, they then start to join in the rescue, implementing rescue for colleagues or people buried in the rubble, helping colleagues contact and find their families, and taking the initiative to clean up and check the facilities and equipment of the H plant, and the rescue actions at this time are spontaneously. But as a whole, the rescue actions at this time were unorganized and disorganized, the sources of information were confused, and the transmission of some information was ineffective.

When the external rescue force joined, the rescue force was obviously enhanced, the confidence of the workers was increased, the rescue information was more complete, and the transmission of information was effective.

The whole process, the psychological change process of the workers is: panic → helplessness → sadness → gradually stable emotions and increased confidence.

Table 5
Life saving scenario profile

Phase elements	Ten minutes before the earthquake	Earthquake and escape process	Self-help in place process	External rescue process
External Environment	No signs of disaster, as usual	Violent shaking; swaying from side to side; collapse of houses	Dusty skies; cries for help; cries; crowds gathering; houses collapsing and disorganization	Order is gradually restored, the organization is in a orderly manner and the rescue is carried out effectively
Psychological reactions	——	severe disaster; helpless feeling and strong desire to survive	Factory H was badly affected;very helpless, unable to protect themselves and worried about their family members' safety	Increased external rescue power; increased confidence of workers and more stable emotions
Actions	Handle daily work	Unstable standing and quick escape	Contact family members 、 close colleagues and friends through various means to confirm their safety and participate in the rescue	A united will and a united effort; Proactive participation in an orderly rescue process
Information	Colleagues verbal communication, telephone or cell phone, meetings, documents, etc., information is conveyed more smoothly	Lack of information, relying on self-judgment	Difficult access to information in the rescue process, a few sources of information are confusing, the vast majority of information is effectively communicated	More complete disaster information, fast and effective delivery

5. RECOMMENDATIONS

First, strengthen emergency preparedness and transform from a disaster-bearing body to a disaster-resistant body. The occurrence of unconventional emergencies is accompanied by suddenness, lack of warning and destructiveness, and the harm brought to people is huge. To effectively reduce the damage caused by disasters needs to start before the disaster. Enterprises, schools and other organizations should strengthen emergency training. Enhance the escape skills of the affected people, effectively avoid major casualties brought about by disasters, and transform smoothly from disaster-bearing body to disaster-resistant body.

Second, ensure the effective transmission of information. When unconventional emergencies occur, we find that information plays a very important role in them. The affected people who escape smoothly want to know the safety of their families urgently in the first place, and the people who join the rescue need accurate rescue information. After the disaster, the information system is almost destroyed, and the information source is mainly verbal transmission and announcement. The information at this time needs to be concise and easy to understand and structured. Meanwhile, each organization should build and restore the information system as soon as possible, and deliver effective information to employees through various forms.

Third, channel negative emotions and strengthen the supplement of positive psychological energy. After a disaster, most of the affected people will fall into a sad and helpless emotion, which will spread and pass on, gradually breeding complaints and even hatred. The energy of the affected people was gradually exhausted, constantly transmitting negative energy to the outside world. Therefore, it is especially important to continuously enhance and strengthen this psychological positive energy before the disaster. After the disaster, timely psychological guidance to supplement the psychological positive energy and enhance the resilience of organizations, groups and individuals.

Fourth, restore the original building and living environment before the disaster as soon as possible. When the original living environment is damaged after a disaster, the original environmental schema is maintained as much as possible in the rescue and re-settlement process. And the original pace and order of life is maintained by family and community as much as possible, which can largely alleviate the anxiety and strangeness of the affected people and give them the courage to cope with the disaster.

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