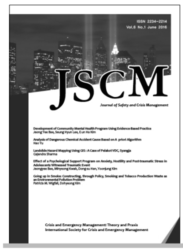

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Construction of China's Earthquake Emergency Response Capability Evaluation Index System

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A B S T R A C T

Based on a review of the relevant literature and by tracking research on earthquake emergency response events in China and internationally, this paper constructs an index system for the evaluation of China's earthquake emergency response capability. From the government, community, rescue force and public response perspectives, the system includes four first-level evaluation indicators, 14 second-level evaluation indicators, and 48 third-level evaluation indicators. Based on two questionnaires, the analytic hierarchy process (AHP) is used to calculate the weight of each indicator. This paper proposes a set of scientifically rigorous and objective indicators for evaluating China's earthquake emergency response capability. This is of great practical significance for improving the ability of earthquake emergency response, reducing casualties and property losses, forcing the construction of earthquake emergency preparedness, improving the ability of earthquake prevention and disaster reduction, and improving the construction of emergency management system.

Key words: earthquake, emergency response, capability evaluation, index system, AHP

Introduction

Earthquake disasters in China are widely distributed and large in magnitude, and they have shallow sources and severe impacts (Wang, *et. al.,* 2018). After the Wenchuan earthquake in 2008, the Yushu earthquake, Lushan earthquake, and Jiuzhaigou earthquake, which reached magnitudes greater than seven, occurred successively in China. After each earthquake, governments and departments at all levels needed to make scientific and reasonable assessments of emergency response capabilities; however, at present, there is no scientifically based and objective evaluation method with indicators for evaluating all aspects of the emergency response after an earthquake. Based on a study of the existing evaluation indicators, such as urban earthquake prevention and mitigation capability and emergency preparedness capability, in China and internationally, this paper focuses on the emergency response stage after an earthquake. Additionally, from the perspectives of various

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subjects of emergency response, i.e., the government, the community, rescue forces and the public, this paper constructs a system composed of four first-level evaluation indicators, 14 second-level evaluation indicators and 48 third-level evaluation indicators. Based on two questionnaires, the weight of each index is calculated using the analytic hierarchy process (AHP), and a scientific and objective evaluation index system for evaluating China's earthquake emergency response capability is proposed.

Previous scholars have conducted research on evaluation indicators for the assessment of urban earthquake disaster mitigation capability and earthquake emergency preparedness capability. Among them, Zhang & Xie (2001) and Zhang & Xie (2002) used the AHP to construct the "Evaluation Index System of Urban Earthquake Disaster Reduction Ability" and proposed seismic risk analysis capability, monitoring and forecast capability, urban engineering seismic defence capability, urban political, economic and human resources capability, urban non-engineering defence capability, and emergency, rescue and recovery capability, yielding a total of 6 primary indicators and 25 secondary indicators. Song & Han (2011) used the AHP and the fuzzy comprehensive evaluation method to propose four first-level evaluation indicators for emergency management capability: emergency prevention and preparedness management, emergency monitoring and warning management, emergency response management, and recovery and reconstruction management. They also proposed 18 secondary indicators. For example, the secondary indicators included in emergency response management are decision-making efficiency, on-site command and control, evacuation and settlement, information communication ability, monitoring and evaluation. Wu & Gu (2007) proposed the evaluation of urban disaster emergency response capability based on three aspects: disaster risk assessment, urban vulnerability assessment and urban disaster emergency management capability. Deng, *et. al.* (2010) considered the evaluation of county (city)-level earthquake emergency capability and proposed five first-level evaluation indicators, i.e., environmental support ability, emergency resource support ability, social control ability, psychological coping ability and action execution capability, as well as 17 second-level evaluation indicators. Liu, *et. al.* (2016) proposed an earthquake emergency capability evaluation for Xinjiang Province with first-level indicators including emergency rescue capability, infrastructure conditions, basic human, material, and financial resources, special project capability and special experience, and the basic environmental background. Huang, *et. al.* (2015) proposed an earthquake emergency capability assessment for Guangdong Province with the following first-level indicators at the county or city levels: governmental organizational capability, earthquake information collection capability, rescue forces, material support capability, and financial security capability. Yang & Ma (2014) proposed an earthquake emergency capability evaluation for Shanxi Province with the following first-level indicators: the natural environment, infrastructure, human resources, material resources, governmental organization, earthquake disaster collection capability, and emergency response capability. Zhang, *et. al.* (2009) proposed an evaluation index for community earthquake emergency response with five first-level indicators, including community organization emergency response capability, community emergency response capability, community engineering earthquake resistance capability, community emergency preparedness capability, and community emergency rescue capability, as well as 23 secondary indicators. The above scholars used the AHP to construct an evaluation index system for earthquake (urban disaster) emergency capabilities at different scales and for different regions. There are also scholars who have studied a specific earthquake emergency response capability. For example, Li, *et. al.* (2011), who are engaged in the field of earthquake emergency rescue, used the AHP to propose an evaluation index for earthquake emergency rescue capability. The first-level evaluation indicators are the development level of emergency planning, the capability of the emergency rescue team, the level of construction of an emergency command system, the capability of emergency disaster acquisition, and the capability of emergency rescue support. The United States developed the National Emergency Preparedness Assessment System (Capability Assessment for Readiness) in 1997 (Fema, 2000) and revised it in 2000, adopting a self-assessment model with 13 first-level evaluation indicators to assess weaknesses in national emergency preparedness capability. These 13 primary evaluation indicators are laws and authorities; hazard identification and risk assessment; hazard mitigation; resource management; planning; direction, control, and coordination; communications and warning; operations and procedures; logistics and facilities; training; exercises, evaluations, and corrective actions; crisis communication, public education, and information; and finance and administration. In his doctoral dissertation, Wu (2006) also proposed an evaluation index for urban earthquake emergency preparedness capability and used the AHP to divide the primary evaluation indicators into organizational guarantee, emergency planning, earthquake and disaster rapid reporting, command and communication technology guarantee, resource guarantee, and social mobilization ability, as well as 25 secondary evaluation indicators and 41 tertiary evaluation indicators.

However, these studies propose no index system for evaluating the earthquake emergency response stage from the perspective of the agent performing the response. In China's emergency response system, government departments are the absolute main body of earthquake emergency response. Emergency agencies at all levels

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are involved in investigating and evaluating earthquake disasters, the deployment of rescue forces, the dispatch of materials, and the coordination of disaster relief on site. Professional rescue forces represent the main force of emergency relief after an earthquake, and their timely deployment after an earthquake determines the efficiency and effectiveness of disaster relief. As the basic unit and main supporting actor in earthquake emergency response and as the object directly affected by an earthquake disaster, the community is also a main body of response to an earthquake disaster. The response capability of the community and of the public is key to carrying out self-rescue and mutual rescue and reducing the loss of life and property in the first stage after an earthquake. Therefore, according to the earthquake emergency response stage, this study draws on the achievements of previous Chinese and international scholars regarding the index system for evaluating the emergency response following an earthquake. It uses questionnaires for expert consultation as well as the AHP, a mature and widely applicable method in the study of emergency response capability evaluation, to initially construct the response body as a first-level indicator of the evaluation index system and to evaluate China's earthquake emergency response capability.

The Connotation of Earthquake Emergency Response Capability

The concept of an earthquake emergency refers to the emergency response actions taken in response to sudden earthquake events, such as pre-earthquake emergency preparedness, near-earthquake emergency prevention, emergency command during an earthquake, and emergency rescue after an earthquake (Cao & Chen, 2009). The concept divides earthquake emergency work into four phases over time: the pre-earthquake period, the period immediately preceding an earthquake, the period during an earthquake, and the post-earthquake period. The evaluation indicators proposed in this paper are for the two periods of time during and after an earthquake. The connotation of earthquake emergency response capability in this article refers to a definition included in the National Preparedness Goal of the United States. The definition of response is "the capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred" (Homeland Security, 2019), that is, after an earthquake has occurred.

Construction of an Evaluation Index System for Earthquake Emergency Response Capability

Analytic Hierarchy Process

The AHP is a multi-criteria decision-making method that combines qualitative and quantitative analysis and was proposed by the well-known American operations researcher TL Saaty and others in the 1970s (Du, *et. al.,* 2015). The specific implementation steps are as follows: (1) the construction of the hierarchical analysis structure, (2) the construction of a judgement matrix, (3) consistency testing of the judgement matrix, (4) the single order of the hierarchy, (5) the total order of the hierarchy, and (6) decision making. The literature review shows that most scholars have adopted the AHP to evaluate emergency capabilities. It is a mature and usable method, but it also has some problems. This article addresses the following related issues:

Issue 1: The AHP can choose only the best out of a selection of given strategies, not a new strategy.

Issue 2: The AHP method needs the support of an expert evaluation system. If the indicators given are not reasonable, the results obtained will not be accurate.

This paper conducted two questionnaire surveys, solicited expert opinions, and revised the index system to extract reasonable, comprehensive and optimal indicators. The experts consulted were mostly engaged in emergency rescue, emergency management, emergency technology or natural disaster risk management and were authoritative experts, managers, personnel or researchers in emergency management departments, seismic bureaus and related scientific research institutes. Their views have authoritative and reference value.

Issue 3: When making multiple layers of comparison, the indicators must be comparable and consistent; if the consistency requirements are not met, the AHP will not function.

When the text was calculated, all matrices passed the consistency check. If the consistency check of a matrix failed, the relationship between the judgement matrix and its derived matrix was analysed (Wu, *et. al.,* 2002) to modify the element with the largest absolute value in the deviation matrix and its corresponding element, and then, the judgement matrix was modified to address the problem.

Selection of Indicators

In this paper, four response subjects are used as the first-level evaluation indicators: the government, the community, rescue forces

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and the public. The indicators are divided according to the responding subject rather than according to the work content because in China's emergency response system, the government plays a leading role in the entire disaster relief organization process, including vertical, horizontal and policy coordination. Thus, the government is the most authoritative decision-making body in disaster relief. Moreover, the army and troops are directly dispatched by the government and are the main force for disaster relief. The special status of the army makes it an extension of the government in terms of management (Xu, 2014). The community is the basic unit and main support of earthquake emergency response work. The public, as objects directly affected by an earthquake disaster, also represents the main body responding to the earthquake disaster. Rescue forces can be seen as an external aid that assists the main body in responding to an earthquake disaster. Selecting the evaluation subject from this perspective can facilitate a more specific evaluation of the emergency response capabilities of different responding subjects in implementing the tasks for which they are responsible. Better understanding these issues can help improve the weak links and enhance China's earthquake emergency response capabilities.

In the process of selecting secondary and tertiary indicators, we conducted 2 questionnaire surveys. First, based on extensive research and a literature review as well as many years of accumulated experience in conducting research on earthquake emergency response in China and internationally, we proposed a comprehensive evaluation index of earthquake emergency response capability and constructed a first draft of the system. This questionnaire survey was widely distributed, and 499 responses were obtained. Based on the opinions of some experts, the first draft of the system was refined and revised, and the indicator system constructed in this paper was determined (see <Table 1>). Subsequently, we conducted the second questionnaire survey and obtained 276 responses. The scores from this questionnaire were used as the raw data for index weight calculation.

Meanings of Indicators

In terms of the government response, first, China's earthquake emergency plan system is complete. What needs to be evaluated during the response phase is the ability of governments at all levels and in all departments to initiate the emergency response according to the earthquake emergency plan, including the start time and the ability to determine the response level based on the severity of the disaster. Second, the emergency management capabilities of the emergency management departments at all levels and the response capabilities of the earthquake relief headquarters at various levels that are set up shortly after the occurrence of an earthquake must be evaluated in terms of the speed of establishment, organizational structure, command, leadership, coordination, decision-making, resource scheduling, etc. These two kinds of departments are collectively referred to as emergency response agencies. Third, regarding the earthquake and disaster situation, it is necessary to evaluate the timing of the report of an earthquake, which indicates the area and region affected and the intensity and activity of the earthquake. In addition, whether there is an earthquake early warning system and whether the early warning is effective must be determined. The ability to rapidly assess the disaster situation must also be evaluated, including the estimated intensity at the epicentre, estimated death toll, estimated number of injuries, estimated number of homes lost, estimated direct economic loss, estimated seismic intensity distribution map, pre-judgement earthquake type, prediction of seismic trends, pre-judgement of the earthquake level, recommended earthquake response level, and emergency decision-making recommendations (He, *et. al.,* 2014). In addition, the ability to deliver and update information, including preliminary seismic information, detailed seismic information, basic disaster estimates and detailed disaster information, must be assessed. Furthermore, secondary disaster monitoring and early warning capabilities must be evaluated; these capabilities include the ability to control public opinion, including control of the release of fake news, false news on the internet, disinformation and other information that undermines social stability. Fourth, the resource deployment capability of the entire response process must be evaluated; this aspect includes the emergency material dispatch capability of emergency services, emergency logistics support capability, emergency fund allocation capability, and emergency shelter. Fifth, regarding the evaluation of the lifeline engineering repair capability in the disaster relief process, scholars have calculated that the weights of the lifeline system are as follows: power supply system 0.35, communication system 0.2, transportation system 0.2, water supply system 0.2, and gas supply system 0.05 (Zhang & Xie, 2003). According to the rational allocation of rescue forces, the ability to deal with secondary disasters on the spot and to provide emergency medical services, including the medical capability of health preservation and epidemic prevention in the disaster area itself and in the surrounding areas, must be evaluated. Sixth, the capability to address public needs must be evaluated; this capability includes the ability to maintain security in the disaster area, to temporarily resettle victims, to distribute disaster relief materials in an orderly manner, and to provide psychological intervention for victims to preserve their emotional stability and eliminate stress-related disorders. In addition, rescue team members should refer to the "DB/T 55-2013 earthquake disaster emergency rescue team work site disposal procedures for the remains of victims"

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<Table 1> The Earthquake emergency response capability evaluation index system.

Evaluation objectives	First-level indicators	Secondary indicators	Tertiary indicators
Earthquake emergency response capability	A Government response	A1 Earthquake emergency plan	A11 Launch earthquake emergency plan
		A2 Emergency response agencies	A21 Response from emergency management departments at all levels
			A22 Responses to earthquake relief headquarters at all levels
		A3 Earthquakes and disasters	A31 Speed report of seismic condition
			A32 Earthquake warning
			A33 Rapid assessment of the disaster
			A34 Release and update of disaster information
			A35 Monitoring and early warning of secondary disasters
			A36 Public opinion control
		A4 Resource allocation	A41 Emergency material dispatch
			A42 Emergency logistics guarantee
			A43 Distribution of emergency funds
			A44 Emergency shelter services
		A5 On-site disaster relief	A51 Lifeline engineering repair (electricity, transportation, communications, water supply, gas supply)
			A52 Traffic control
			A53 Rescue force deployment
			A54 Secondary disaster disposal
			A55 Medical first aid
		A6 Public care	A61 Security and stability in the disaster area
			A62 Temporary resettlement of victims
			A63 Distribution of disaster relief materials
			A64 Psychological intervention for victims
			A65 Disposal of the remains of victims
	B Community response	B1 Community earthquake emergency plan	B11 Launch of the community earthquake emergency plan
		B2 Community disaster relief	B21 Community emergency evacuation
			B22 Community emergency shelters
			B23 Community self-help and mutual rescue
		B3 Community-assisted disaster relief	B31 Disaster collection and reporting
			B32 Assisting in rescue
			B33 Assisting in public care
	C Rescue force response	C1 Team response	C11 Disaster investigation and decision-making
			C12 Action plan
			C13 Team structure for mission
			C14 Personnel and equipment build-up speed
			C15 Remote motive
		C2 On-site rescue	C21 Search capability
			C22 Rescue capability
			C23 Medical capability
			C24 Continuous job time
		C3 On-site management	C31 Security management
			C32 Construction and operation of operational bases
			C33 Communications support
			C34 Equipment support
			C35 Logistics
	D Public response	D1 Family earthquake emergency plan	D11 Ability to respond quickly in accordance with household earthquake emergency plans
		D2 Individual preparedness and self-rescue	D21 Scientific preparedness
			D22 Self-help after the earthquake
			D23 Mutual rescue after the earthquake

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and respect local customs, maintain the dignity of victims, and prevent the occurrence of epidemics in the disaster area caused by the improper disposal of remains.

The community response is evaluated based on three aspects. First, the community's ability to initiate a response according to its earthquake emergency plan is evaluated. Second, the community's ability to respond to the earthquake, including the ability to organize an emergency evacuation of community residents, is considered according to whether there is an evacuation road map, whether there is an evacuation site, whether the evacuation can be carried out in an orderly fashion, whether the community can provide emergency shelter, whether it can provide emergency services, whether community residents can be organized to carry out self-help and mutual rescue, etc. Third, the community's ability to assist in disaster relief is evaluated, including the ability to collect related information and report disasters, to assist rescue efforts, and to assist disaster relief departments in carrying out care-type operations.

The response of rescue forces is evaluated based on three aspects. First, the team's response is evaluated according to its ability to study and judge the disaster situation, to decide whether to dispatch a team, to formulate an action plan based on the disaster situation, to formulate a reasonable team structure, to rapidly assemble team personnel and equipment, to prepare away from the disaster area and to quickly reach the disaster area. Second, the team's ability to rescue victims on-site must be evaluated. This aspect refers to the team's search, rescue, and medical care ability and its continuous operation, which requires a reasonable internal division, grouping, and rotation system that allows the team to operate continuously and to carry out uninterrupted rescue operations. Third, the on-site management of rescue teams is evaluated. The team's own security management is a priority; this aspect concerns the dynamic tracking of personnel, the formulation of security plans, etc.; the ability to build and operate the operation base; and the team's own communication equipment and logistics support.

The response of the public is evaluated based on two aspects. First, it is necessary to evaluate whether the public has the ability to respond quickly according to the family earthquake emergency plan. Ordinary people should check for and repair potentially dangerous weaknesses in their homes during their everyday lives, keep earthquake emergency kits, plan escape routes, conduct drills, etc. By remaining prepared according to plan, people can respond quickly to an earthquake without panicking. Second, people's ability to avoid danger and to rescue themselves must be evaluated; this aspect includes the ability of those at the epicentre to avoid danger in various situations. People's ability to rescue themselves and each other after an earthquake involves the mastery of basic first-aid methods, simple rescue knowledge, an understanding of burial methods and self-help during the resettlement phase.

Calculation and Ranking of Indicator Weights

In the second questionnaire, a total of 276 valid responses were collected. The respondents represented 26 of China's provincial-level administrative regions and some foreign regions. Among them, in terms of expertise, 54.35% were involved in earthquake response and rescue, 16.3% in emergency management and related research, and 29.35% in other disciplines. Regarding the nature of the work of the respondents, 42.39% came from public institutions, 29.35% came from social organizations, 9.06% came from corporations, 7.25% came from emergency rescue teams, 2.9% came from local governments, 1.45% came from ministries, and 7.61% came from other units. Regarding the titles of the respondents, 28.62% held intermediate-level positions, 26.09% held no title, 18.12% held junior-level positions, 14.86% held deputy senior positions, and 12.32% held senior positions. Regarding the educational level of the respondents, 31.88% held a bachelor's degree, 22.46% had a postgraduate level of education, 19.2% were junior college graduates, 17.39% held a doctoral degree, and 9.06% had a high school education or below. A total of 72.46% of the respondents were located in non-earthquake-prone areas, and 27.54% were in earthquake-prone areas.

The questionnaires were mainly distributed to experts in emergency rescue, emergency management, emergency technology, and natural disaster risk management, emergency management department managers, researchers in earthquake bureaus and related scientific research institutes, members of the armed police, fire protection and other professional rescue teams for earthquake disasters, rescue volunteers on the Blue Sky Rescue Team and the Shenzhen public welfare rescue team, and a small number of people from other industries. Due to the strong professionalism of the experts solicited in the second questionnaire, there were as many as 71 questions. Although the second questionnaire received fewer responses than the first questionnaire, by comparing the respondents' professional direction, work, title, and academic qualifications, it can be seen that the proportion of experts and the degree of specialization among the questionnaire respondents were significantly greater; thus, the quality of the questionnaire responses was also higher. For this reason, we consider the scoring results of these 276 questionnaires.

The results of all responses to the questionnaire were averaged to obtain a maximum difference of 0.71 points for the average

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scores of all indicators. The maximum average score was 8.29 points for the indicator "A Government response", and the minimum average score was 7.58 points for the indicator "B33 Assisting in public care". Nearly 0.1 points were set to a scale, and the value was assigned according to the difference. When the difference was (-0.04)-(+0.04), a positive value was assigned 1, and a negative value was assigned 1; when the difference was 0.05-0.14, a positive value was assigned 2, and a negative value was assigned ½, and so on. For example, the difference between "A Government response" with 8.29 points and "B Community response" with 8.05 points is 0.24 points; that is, A and B are assigned a value of 3, and B and A are assigned a value of 1/3.

Taking the primary indicators as an example, the average scores of A, B, C, and D are 8.29, 8.05, 8.1, and 7.87, respectively. The constructed matrix A is as follows:

$$A=\begin{bmatrix}1 & 3 & 3 & 5\\ 1/3 & 1 & 1/2 & 3\\ 1/3 & 2 & 1 & 3\\ 1/5 & 1/3 & 1/3 & 1\end{bmatrix}$$

Using MATLAB for calculation, the function of [V,D]=eig(A) is adopted to return the characteristic value and feature vector of matrix A, and max (eig(A)) returns the maximum characteristic root of matrix A: λ_{max}. The corresponding column in V is the desired feature vector, which is normalized to obtain matrix W.

$$\lambda_{max}=4.1042$$

W is a feature vector after naturalization processing:

$$W=\begin{bmatrix}0.5167\\ 0.1682\\ 0.2382\\ 0.0769\end{bmatrix}$$

Introduce the negative average value of the remaining feature roots other than the maximum feature root of the judgement matrix as an index to measure the consistency deviation of the judgement matrix, which is CI, as follows:

$$CI=\frac{\lambda_{max}-n}{n-1}=\frac{4.1042-4}{4-1}=0.0347$$

To measure whether the different order judgement matrices have satisfactory consistency, it is necessary to introduce the average random consistency index RI value of the judgement matrix, and for the 4th-order judgement matrix, the value of RI is 0.90.

Introduce the negative average value of the remaining feature roots other than the maximum feature root of the judgement matrix as an index to measure the consistency deviation of the judgement matrix, which is CI.

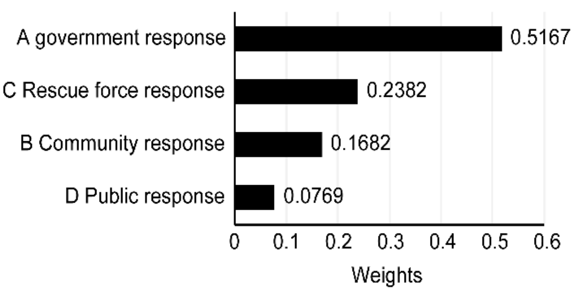
The ratio of the consistency index CI of the judgement matrix to the average random consistency index RI of the same order is called the random consistency ratio, which is denoted as CR. When CR is less than 0.10, it is considered that the judgement matrix has satisfactory consistency; otherwise, the judgement matrix needs to be adjusted to obtain satisfactory consistency.

$$CR=\frac{CI}{RI}=\frac{0.0347}{0.90}=0.0386<0.10$$

The consistency check is passed.

In this way, the weight of all indicators is calculated with the same means, and the total order of the hierarchy is obtained, as shown in <Figures 1-4>.

According to the calculation results shown in <Figure 1>, we conclude that the government response is the most important of all levels of earthquake emergency response capability. The reason is that China still has a government-managed disaster management system. Many decision makers in government agencies still retain the emergency management thinking of "big government, small society". Government departments are the key subject of emergency management, supplemented by social participation. This situation is different from the emergency management thinking in other countries, with multiple subjects and social participation. The second most important emergency response subject is the rescue force. The reason is that an earthquake disaster has characteristics that are different from those of general emergencies. The rescue activities during an earthquake are dangerous and require a large number of rescue team members who are highly professional and have technical expertise. A rescue team needs to use high-tech search and rescue equipment, including rope rescue technology, narrow space rescue technology, and collapsed building search and rescue technology. To achieve efficient rescues, a professional team must



<Figure 1> Ranking of the weights of the first-level evaluation indicators.

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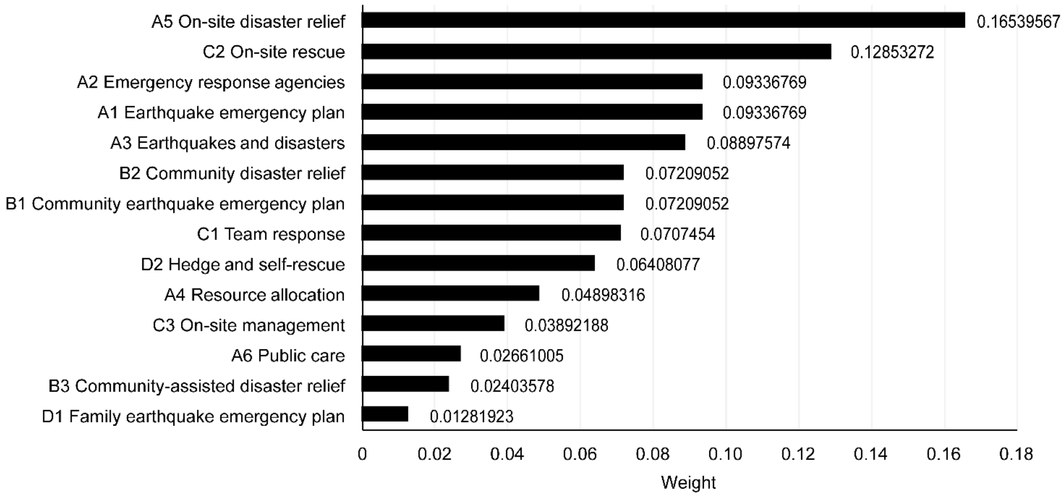

<Figure 2> Ranking of the weights of the second-level evaluation indicators.

be available. Finally, the response by the community and the public is important. This arrangement is also in line with the current Chinese emergency management model but differs from the American model. For example, in the American model, the emergency capabilities of communities, families, and individuals are more heavily emphasized. The National Preparedness Goal clearly states that "the individual and community preparation plan is the basis for the success of the entire national preparation plan and is fundamental to our national success".

By sorting the weights of the second-level indicators in <Figure 2>, we reaffirm the above perspective. In the disaster relief model of the United States, Japan and other countries, family emergency preparedness is very important; however, in the case of China, we rank this aspect last. The models of other countries attach great importance to post-disaster public care work, such as the disposal of the remains of victims, but this work is not highlighted in China. The concept of community resilience, which is relatively common worldwide, is not a priority here.

Combining the ranking results of the second-level evaluation indicators and the third-level evaluation indicators by category weights in <Figure 2> and <Figure 3>, it can be seen that in government response, on-site disaster relief is the most important. The emergency repair of lifeline projects, including the restoration of electricity, transportation, communications, water supply and gas supply, is the top priority of on-site disaster relief and is the basis for ensuring the smooth progress of rescue operations. On-site medical first aid is also very important and must receive attention in the plan and daily emergency preparedness, and emergency medical capabilities need to be strengthened. On-site rescue capability is the most important part of the rescue force's response. The search and rescue capabilities of on-site rescue capability are more important than medical treatment ability and continuous operation. Therefore, the construction, technical training, drills, and assessment of earthquake rescue teams are important tasks. For the community, the ability to initiate a plan is as important as the ability to respond to disasters in the community. This finding illustrates the importance of building resilient communities. Communities are required to have emergency plans, present emergency preparedness, and respond quickly according to plan, rather than stopping at the level of organizing disaster relief after the earthquake. In community disaster relief, organizing residents to carry out self-help and mutual rescue is the highest priority, which shows that before the professional rescue team arrives at the disaster relief site, the community's self-help and mutual rescue ability directly determines how many lives can be saved within the first 72 hours following the occurrence of an earthquake. It is necessary to focus on strengthening self-rescue and mutual rescue training and drills in the daily emergency preparedness stage. For the public, rational risk-avoidance and self-rescue capabilities are more important than plans and mutual rescue capabilities after an earthquake. This finding shows that for the public, the primary concern is self-rescue capabilities, which need to be strengthened through daily training and exercises.

China's emergency management adopts a one-case, three-system framework. From <Figure 4>, the ranking of the third-level indicators clearly shows the important position of China's "vertical end to end, horizontal side to side" planning system, which ranks in the top two positions. By analysing the third-level evaluation indicators at the rescue force level, it can be seen that on-site search and rescue technical capabilities are emphasized, while the rescue team's own security and logistical support are ignored. The concept that has been emphasized internationally is that a rescue team must

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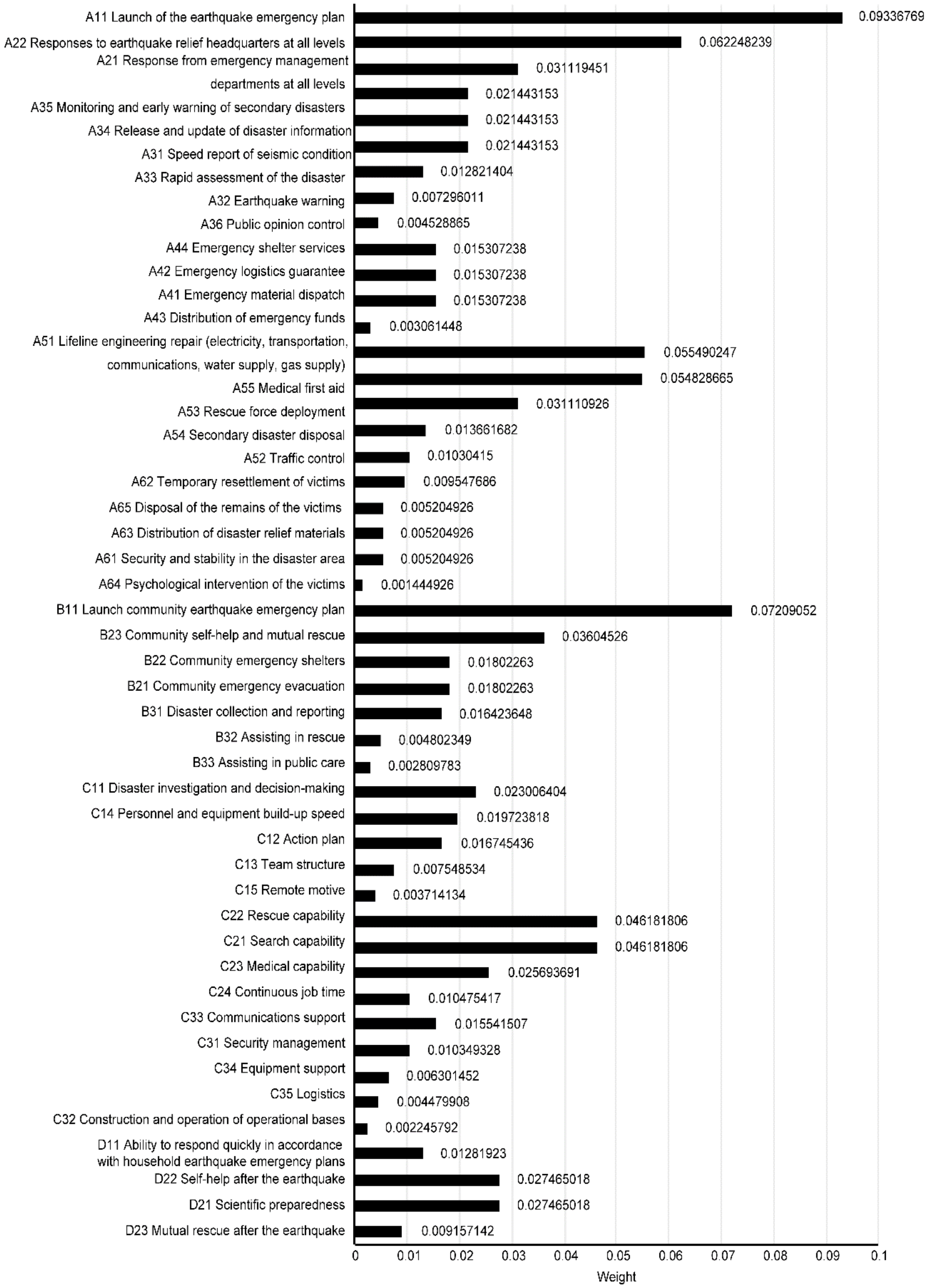

<Figure 3> Weights of the third-level evaluation indicators sorted by category.

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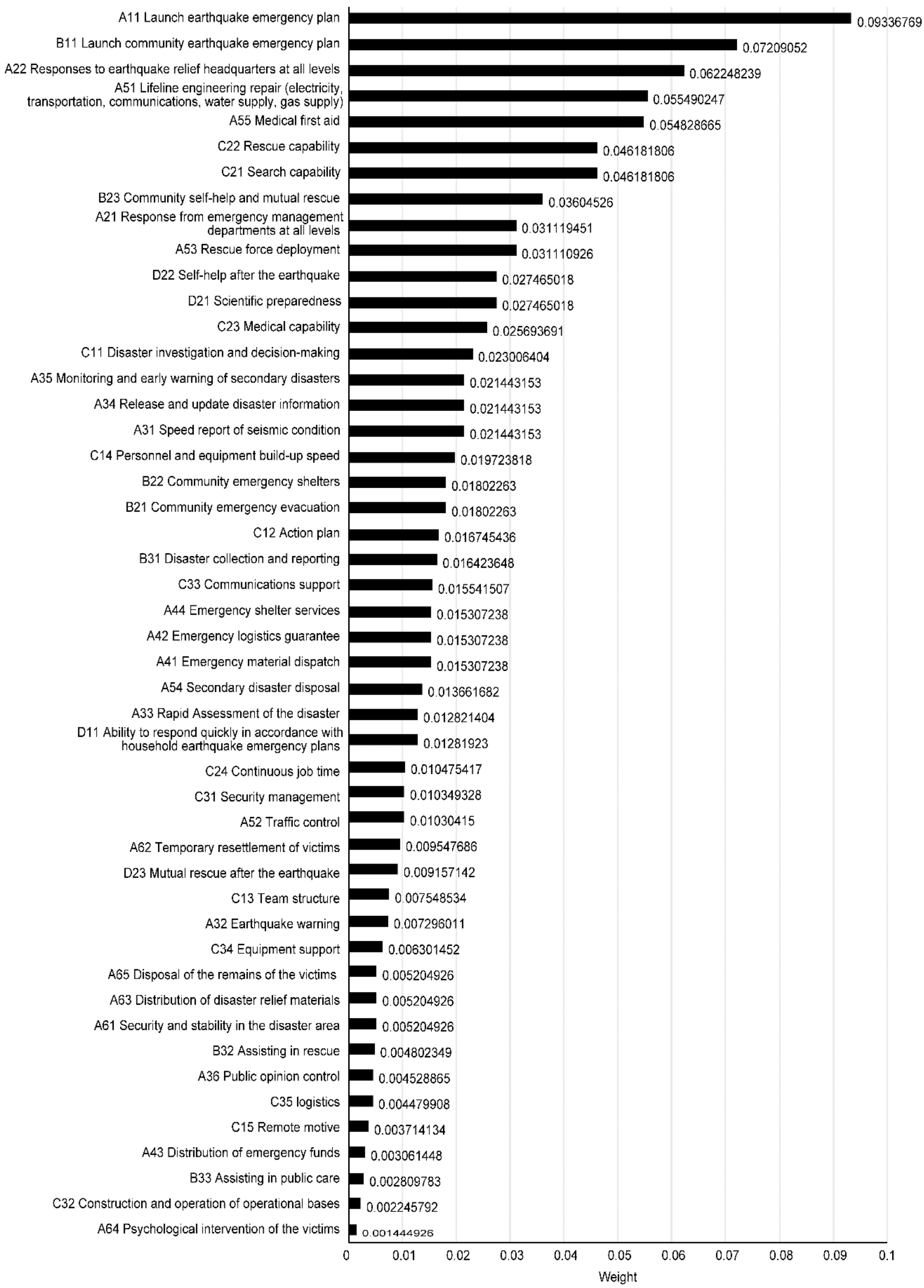

<Figure 4> Ranking of the third-level evaluation indicators by overall weight.

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first ensure the safety of the rescuers. Compared with rescuers in some developed countries, rescuers in China pay more attention to rescuing victims than to ensuring their own protection.

Conclusion

Based on the earthquake emergency response stage, this paper draws on previous achievements in creating an index system for evaluating emergency capability and combines the knowledge gained from Chinese and international studies of earthquake emergency response to propose an evaluation of earthquake emergency response capability from the perspective of the responding subject. Through two questionnaire surveys that solicited opinions from experts, the AHP is used to preliminarily construct an evaluation index system for China's earthquake emergency response capability, and the indicator weights are calculated. The first-level indicators are ranked in terms of importance as follows: government response, rescue force response, community response, and public response. The rankings of the 14 second-level evaluation indicators and the 48 third-level evaluation indicators further provide a scientifically rigorous and objective index for evaluating China's earthquake emergency response capability.

Further classification of the results of the questionnaire will lead to different conclusions for different samples. For example, compared to personnel involved in social organizations, personnel involved in emergency management and related research may think that the community response is more important, yielding different opinions regarding the indicator weights. Respondents with different professional titles or academic qualifications may have different views of the weights of different indicators; for example, emergency rescue team personnel may think that on-site rescue is more important than initial planning. Further research may address the application of different evaluation indicators, such as qualitative indicators indicated by "yes" or "no" responses, or use the hierarchical forms of "good, average, poor" or "1, 2, 3, 4, 5" as quantitative indicators that can be calculated with data.

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References

Cao, K. and J. Chen. 2009. *Interpretation of the Law of the People's Republic of China on Earthquake Preparedness and Disaster Reduction.* Beijing, China: China Legal Publishing House.

Deng, Y., G. Nie, and G. Su. 2010. The Construction of the County (City) Earthquake Emergency Response Capacity Evaluation Index System. *Disaster Science.* 25(3): 125-129.

Du, D., Q. Pang, and Y. Wu. 2015. *Modern Comprehensive Evaluation Methods and Case Selection.* Beijing, China: Tsinghua University Press.

Fema, N. 2000. Capability Assessment for Readiness (CAR).

He, S., W. Chen, and Z. Zhou, *et. al.* 2014. Rapid Assessment of the 6.6 Magnitude Earthquake in Zhangxian County, Gansu, and Emergency Response Guarantee. *Earthquake Research.* 4(37): 588-593.

Homeland Security. 2019. National Preparedness Goal. 25 October 2019. https://www.fema.gov/media-

Huang, Y., X. Hu, and T. Huang, *et. al.* 2015. Construction and Analysis of the Seismic Emergency Response Capacity Evaluation Index System in Guangdong Province. *South China Earthquake.* 35(4): 59-65.

Li, Y., J. Wu, and Y. Zhang, *et. al.* 2011. Research on Evaluation Indexes and Calculation Methods of Earthquake Emergency Rescue Capability. *Earthquake Disaster Prevention Technology.* 6(2): 172-179.

Liu, J., G. Su, and J. Sun, *et. al.* 2016. The Establishment of the Earthquake Emergency Response Capacity Index System in Counties and Cities in Xinjiang Region is a Preliminary Exploration of Regional Differences. *Earthquake Defense Technology.* 11(4): 814-822.

Song, Y. and J. Han. 2011. A Comprehensive Evaluation of City Emergency Management Capacity Based on Analytic Hierarchy Process and Fuzzy Mathematics Method. 2011 International Conference on Management and Service Science. IEEE, Wuhan, China. 1-4.

Wang, W., H. Chen, and A. Xu. 2018. Research on the Construction of the Emergency Search and Rescue Team for Earthquake Hazards in China. *Journal of Safety and Crisis Management.* 8(1): 9-17.

Wu, X. 2006. *Urban Earthquake Disaster Risk Analysis and Emergency Preparedness Assessment System.* Institute of Geophysics, China Earthquake Administration.

Wu, X. and J. Gu. 2007. Advances in the Evaluation of Urban Disaster Emergency Response Capacity at Home and Abroad. *Journal of Natural Disaster.* 16(6): 109-114.

Wu, Z., W. Zhang, and X. Guan. 2002. Statistical Methods for Consistency Check and Correction of Judgment Matrix in AHP. *Systems Engineering.* 3(20): 68-71.

Xu, L. 2014. Analysis of Similarities and Differences between Chinese and American Governments' Natural Disaster Emergency Management

www.kci.go.kr

Mechanisms. *Journal of the Party School of Leshan Municipal Committee of the Chinese Communist Party (New Theory).* 4(16): 51-53.

Yang, B. and Z. Ma. 2014. Shanxi Earthquake Emergency Response Capacity Evaluation Index System Based on Basic Data of Earthquake Emergency is Built. *Earthquake Defense Technology.* 9(1): 118-125.

Zhang, F. and L. Xie. 2001. Urban Earthquake Prevention and Mitigation Capability Assessment Study. *Journal of Natural Disaster.* 10(4): 57-64.

Zhang, F. and L. Xie. 2002. Study on Determination of Index Weights for City's Ability in Earthquake Disasters Reduction. *Journal of Natural Disaster.* 11(4): 23-29.

Zhang, F. and L. Xie. 2003. Lifeline System Evaluation of Urban Earthquake Disaster Losses. *Journal of Civil Engineering.* 36(11): 99-105.

Zhang, Q., Y. Gao, and N. Gao, *et. al.* 2009. Construction of the Index System for Earthquake Emergency Response Ability Evaluation in Urban Communities. *Disaster Science.* 24(3): 133-136.

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