ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
https://doi.org/10.17559/TV-20231116001115
Original scientific paper

Assessment of Urban Community Emergency Preparedness and Response Capacity Using Entropy Weight Method and Multilayer Fuzzy Comprehensive Model

Ningzhou SHEN, Xinyao GUO*, Jiawei CUI, Zhengqi WU

Abstract: Public emergencies are occurring with increasing frequency worldwide, leading to what is often referred to as a high-risk society. Amid various public emergencies, urban communities take on a more prominent role. However, studies on assessing the emergency preparedness and response capacity of urban communities are currently limited. To evaluate the essential factors, both inherent and external, that affect the emergency management capacities of urban communities, an index system for assessing community emergency preparedness and response capacity was developed by using the theory of the emergency management cycle. Acknowledging the complexity and ambiguity of emergency preparedness and response capacity within urban communities, a multilayer fuzzy comprehensive evaluation model was established using the entropy weight method. This model was then applied to assess the emergency preparedness and response capacity of communities against the backdrop of the COVID-19 public emergency. Results show that the assessment outcomes generated by the multilayer fuzzy comprehensive evaluation model, employing the entropy weight method, align with the real-world situation, signifying the soundness and effectiveness of the selected methods and index system. The conclusion offers a novel basis and methodology for evaluating the emergency preparedness and response capacity of urban communities, holding considerable practical value.

Keywords: emergency management; entropy weight method; evaluation system; fuzzy comprehensive evaluation; urban community

1 INTRODUCTION

An urban community refers to a social community with a relatively concentrated population, characterized by nonagricultural production activities in a specific urban area. An urban community is the most basic cell and social unit of a city and has the basic characteristics of sociality, regionality, autonomy, dependence, and heterogeneity [1]. With the rapid development of global urbanization, industrialization, and information and the acceleration of the environment, the occurrence of public emergencies has demonstrated an escalating trend. Global public emergencies occur with high frequency [2], such as the COVID-19 pandemic, bushfires in Australia, the SARS pandemic, the 2004 Indian Ocean tsunami, the September 11 terrorist attacks, and so on, which can substantially inhibit social and economic development and threaten people's lives and property. Urban communities have become the setting of and first line of defense against all types of public emergencies [3]. Improving the emergency management capacity of urban communities and reducing the probability of the occurrence of emergencies and the severity of their consequences has become an urgent problem to be solved by governments, experts, and scholars around the world [4].

The prerequisite for enhancing the emergency preparedness and response capacity of an urban community is the objective and accurate evaluation of its current emergency response capabilities. Emergency evaluation refers to the identification evaluation, and judgment of the state of things; the development trend of events; and the effect of the emergency efforts during the public emergency and emergency management. Therefore, the effective evaluation of emergency management capacity and the establishment of a set of scientific, reasonable, and efficient evaluation systems are the keys to the improvement of the emergency preparedness and response capacity of urban communities.

2 STATE OF THE ART

Regarding emergency management in urban communities, the World Health Organization first proposed the concept of a "safe community" at the first International Congress on Accident and Injury Prevention in 1989. The "Safe Community Declaration" pointed out that everyone has a right to have good health and safety, which received widespread attention and recognition worldwide [5]. Since the announcement of the declaration, many countries have conducted emergency management research and activities in urban communities based on their national conditions, such as the "Community for Disaster Reduction" and "Sustainable Community" programs proposed by the Federal Emergency Management Agency (FEMA) of the United States [6], the "Community Business Plan for Disaster Prevention and Welfare" launched by Japan [7], the multiparty mutual assistance and cooperation model proposed by the United Kingdom [8], the "resilience" emergency management strategy issued by the Department of Public Security of Canada, and so on [9]. By contrast, community governance in such countries is endowed with certain independent planning rights, thereby emphasizing the joint efforts of the community residents, government, and relevant organizations to deal with public emergencies. Meanwhile, the government focuses on the assessment, management, and supervision of community development [10].

To appraise the emergency management of urban communities, the United States established the Federal Emergency Management Agency (FEMA) in 1979 and subsequently formulated an assessment form for evaluating emergency preparedness and response capabilities. The form focuses on 13 management functions, 56 elements, 209 attributes, and 1,014 indicators in emergency management, constituting a disaster response capability system consisting of the government, enterprises, the community, and families, which has a far-reaching influence on and reference significance to the practical work of emergency management evaluation in various countries [11, 12]. Horowitz et al. [13] believed that emergency risk management is complex and built an emergency risk management model. Examining how a community mitigates, adapts to, and recovers quickly from a disaster, Steiner et al. [14] presented a community resilience evaluation framework and optimized it through case studies. Meanwhile, Akter et al. [15] investigated the use of big data in emergencies and argued that big data can be employed to visualize and predict disasters.

To sum up, most countries have developed an urban community emergency management model that is suitable to their national conditions. Such models can be divided into three types, namely, a leading type, an autonomous type, and a mixed type, and their development trend is changing gradually, from being led by the government to being led by pluralistic cooperation and co-governance, with the government involved mainly in the planning, guidance, and supervision. Most current studies introduced international advanced management concepts, experiences, or case studies, but a systematic theoretical framework has yet to be created. In the evaluation of the emergency preparedness and response capacity of urban communities, the influencing factors can be considerably affected by the regional development level, the quality of the residents, and local government policies. Thus, the established theoretical models are not universal. In addition, most existing studies conducted qualitative analysis; hence, a certain degree of deviation can be seen in the artificial subjective factors, and the coupling effect of each index system can be improved further.

Utilizing the emergency management cycle theory as its foundation, this study develops an index framework for appraising the emergency readiness and response capabilities within urban communities. It further establishes a multilayer fuzzy comprehensive assessment model founded on the entropy weight methodology, presenting a consolidated evaluation framework that can serve as a benchmark for assessing and enhancing the emergency capacity of urban communities.

3 METHODOLOGY

3.1 Modeling

Considering the intricate and indistinct nature of assessing the emergency readiness and response capabilities of urban communities, this research integrates the entropy method with the theory of fuzzy comprehensive evaluation to conduct a comprehensive evaluation. The entropy weight method is an objective weighting technique based on the principle of information entropy according to the variability of indices, which can effectively reduce subjective deviation in artificial valuation [16, 17]. The fuzzy comprehensive evaluation method takes fuzzy mathematics as the theoretical basis, constructs an evaluation matrix by establishing the membership function, and transforms the qualitative evaluation into a quantitative analysis. The fuzzy comprehensive evaluation method uses the advantages of fuzzy mathematics to quantitatively deal with the complexity and fuzziness of the index system [18]. The combination of the theory and method can not only transform qualitative analysis into quantitative analysis but also reduce the influence of abnormal data caused by subjective factors on the evaluation results and increase the objectivity and accuracy of the evaluation results to provide a decision-making basis for improving the emergency preparedness and response capacity of urban communities [19]. The entropy weight fuzzy comprehensive evaluation model flow chart is shown in Fig. 1.

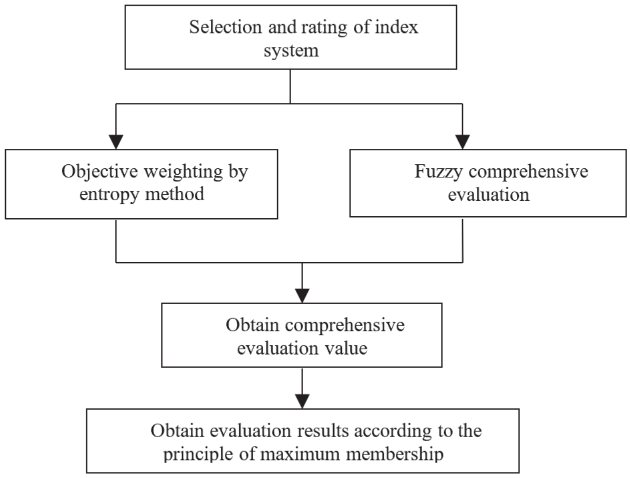

Figure 1 Multilevel fuzzy evaluation model of urban community emergency management capacity

3.2 Index Framework for Emergency Response in Urban Communities

The primary objective in assessing the emergency preparedness and response capacity of an urban community is the meticulous development of the index system. Urban community emergency management capacity building is complex and can be affected by a variety of internal and external factors, which can jointly restrict community emergency management capacity building. This study is based on an in-depth investigation and the literature [20-25], but because many variables can affect the emergency management level of urban communities, some types of data are difficult to collect. In the construction of the index system, this study follows the principles of the scientific nature, comprehensiveness, applicability, and maneuverability of the index system and screens the emergency preparedness and response capacity indicators of urban communities from four aspects: the prevention and preparation mechanism, monitoring and early warning mechanism, response and rescue mechanism, and recovery and reconstruction mechanism. The four dimensions reflect the concepts of pre-disaster prevention, early warning, disaster management, and post-disaster recovery, which are closely related to and influence one another in space. Together, the factors constitute the systematic framework of community emergency response capacity evaluation from the perspective of time and space. The indicator system constructed in this study is generally applicable to the evaluation of emergency management capabilities in Chinese urban communities.

(1) Prevention and Preparation Mechanism

Public emergencies are typically sudden and unpredictable, and their mode, time and place of occurrence, and degree of harm are difficult to grasp accurately. The prevention and preparation mechanism can continuously enhance the ability of urban communities to deal with emergencies by taking precautionary measures, improving their construction of an organizational system, and strengthening their emergency preparedness. The prevention and preparedness mechanism mainly involves five aspects: the construction of an emergency organization system, the ability to investigate hidden dangers, the publicity of emergency knowledge and training, the formulation and implementation of emergency plans, and the ability to guarantee emergency resources.

A1: The construction of an emergency organization system refers to the soundness of and cooperation in the construction of a community emergency organization structure and the authority of rules and regulations. An emergency organization system is composed mainly of the government, social organizations, enterprises and institutions, residents, and so on, which are the prerequisites for the efficient and orderly handling of emergencies.

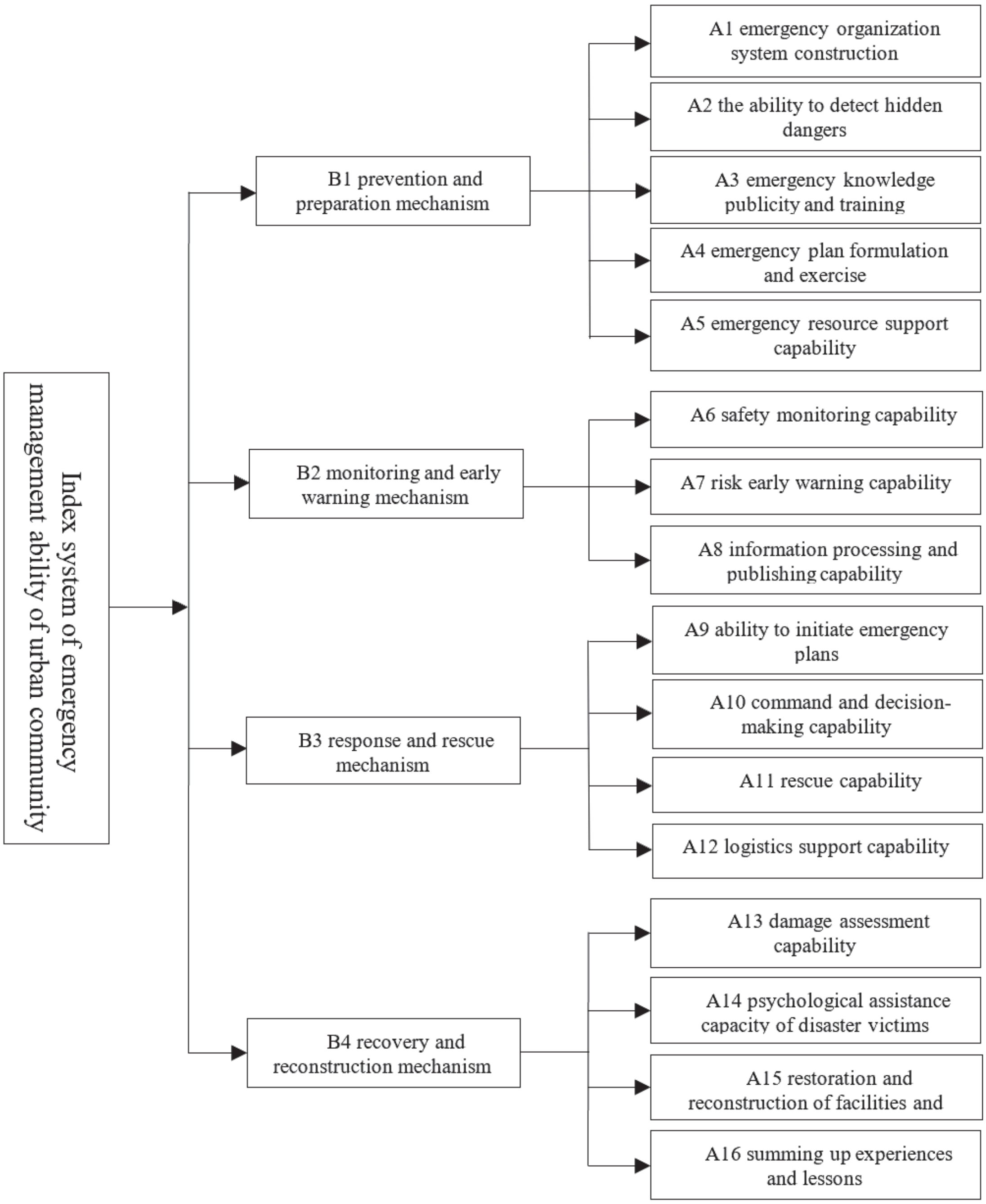

Figure 2 Index system for evaluating the emergency preparedness and response capacity of an urban community

A2: The ability to investigate hidden risks and dangers refers to the ability to identify existing risks in the community based on daily data collection and onsite inspection and to conduct risk assessment and risk elimination.

A3: Emergency knowledge publicity and training involves the improvement of the emergency cognitive ability of the community residents through targeted publicity and training to master self-rescue and mutual rescue knowledge and skills in the event of an emergency.

A4: The formulation and implementation of emergency plans to effectively prevent and respond to emergencies indicate that formulating a scientific and effective emergency plan is necessary. Emergency drills can not only test the practicability and maneuverability of all types of emergency plans but also summarize experiences and shortcomings through simulations and effectively improve the emergency response and handling level and capability.

A5: Emergency resource guarantee capacity refers to the ability of urban communities to absorb and reserve personnel, materials, funds, infrastructure, and all types of equipment to deal with emergencies in the process of emergency preparation.

(2) Monitoring and Early Warning Mechanism

The monitoring and early warning mechanism is the core of emergency management, which mainly includes three aspects: safety monitoring capability, risk early warning capability, and information processing and release capability.

A6: Safety monitoring capability refers mainly to the ability to monitor emergencies with the help of various types of resources. Effective monitoring can help urban communities detect emergencies in time and take timely measures.

A7: Risk early warning capability refers to the grade assessment of the risk of emergencies with the help of analytical and preplanning methods.

A8: Information processing and release capability refers to the ability to process, examine, report, and release risk information to community residents using information technology.

(3) Response and Rescue Mechanism

The emergency response and rescue mechanism mainly evaluates the measures taken by an urban community to deal with public emergencies, including its emergency plan implementation capability, command and decision-making capability, rescue capability, and logistics support capability.

A9: The ability to initiate an emergency plan refers to the response level selected by an urban community based on the type of emergency, degree of harm, development trend, and its ability to select and implement an appropriate emergency plan.

A10: Command and decision-making capability includes personnel evacuation, standardized management, inter-departmental coordination, resource mobilization, and so on and is the key factor for effectively dealing with emergencies.

A11: Rescue capability refers to the ability to take action at the scene of the emergency to protect the lives and property of the residents of the affected community.

A12: Logistics support capability refers to the ability to distribute emergency medical, equipment, and food resources to stranded residents and rescue teams during an emergency.

(4) Recovery and Reconstruction Mechanism

After controlling or eliminating the threat and harm caused by an emergency, urban communities should take the necessary measures to prevent secondary and derivative events and actively help restore production, life, work, and social order. This mechanism mainly includes four aspects: damage assessment capability, the ability to provide psychological assistance to the victims, the recovery and reconstruction of facilities and equipment, and the summary of experiences and lessons.

A13: Damage assessment capability involves the post-disaster community assessment of personal and family losses caused by an emergency and the provision of relief, compensation, comfort, placement, and follow-up efforts to prevent contradictions and disputes.

A14: The ability to provide psychological assistance to disaster victims involves the considerable impact that an emergency can have on the mental health of the affected individuals or groups. To maintain social stability and protect the mental health of the public, communities should organize a team of experts that can provide psychological assistance.

A15: The restoration and reconstruction of facilities and equipment involve the rehabilitation and reconstruction of damaged buildings and transportation, communication, water, and electric facilities.

A16: The summary of experiences and lessons involves the identification of the causes of an emergency in time and the formulation of improvement measures.

3.3 Entropy Weight Fuzzy Comprehensive Evaluation Method

A fuzzy comprehensive evaluation model based on the multilevel and multiobjective entropy weight method is adopted in this study based on the characteristics of the index system for evaluating the emergency preparedness and response capacity of an urban community.

3.3.1 Entropy Weight Method

(1) The judgment matrix is constructed according to the importance of each index $\boldsymbol{X}$.

$$\boldsymbol{X}=\left(x_{ij}\right)_{m\times n}, \tag{1}$$

where i = 1, 2, …, n and j = 1, 2, …, m represent m evaluation objects and n evaluation indices, respectively.

(2) The elements of the normalized matrix $\boldsymbol{X'}$ are calculated by standardizing the judgment matrix.

$$x'_{ij}=\frac{x_{ij}-x_{\min}}{x_{\max}-x_{ij}}. \tag{2}$$

(3) The entropy value H_i of the evaluation index is calculated.

$$H_i=-\frac{1}{\ln m}\sum_{j=1}^{m}\frac{1+x'_{ij}}{\sum_{j=1}^{m}\left(1+x'_{ij}\right)}\ln\frac{1+x'_{ij}}{\sum_{j=1}^{m}\left(1+x'_{ij}\right)} \tag{3}$$

(4) The entropy weight vector $\boldsymbol{W}$ of the evaluation index is calculated.

$$\boldsymbol{W}=w_i=\frac{1-H_i}{n-\sum_{i=1}^{n}H_i} \tag{4}$$

3.3.2 Fuzzy Comprehensive Evaluation Method

(1) A set of evaluation objects and a set of rating grades are constructed.

A collection of evaluation objects is built, as follows: $U=\{u_1, u_2, \ldots, u_n\}$, where $u_1, u_2, \ldots, u_n$ represents the n evaluation indicators of the evaluation objects.

A collection of evaluation grades is built, as follows: $V = \{v_1, v_2, \ldots, v_m\}$, where V represents the m evaluation grades of the evaluation objects.

(2) A fuzzy relation matrix and a comprehensive evaluation matrix are constructed.

The degree of the different evaluation grades of each evaluation object in the evaluation grade set is determined, which is called the membership degree and expressed as r_{ij}, and the fuzzy relation matrix $\boldsymbol{R}$ is obtained.

$$\boldsymbol{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}. \tag{5}$$

Then, the evaluation matrix $\boldsymbol{B}$ is obtained, as follows:

$$\boldsymbol{B} = \boldsymbol{W} \times \boldsymbol{R}, \tag{6}$$

where $\boldsymbol{W}$ is the objective weight vector of each index. To eliminate the artificial interference of each index weight, the entropy weight method is used for the objective weighting.

(3) The comprehensive evaluation value of the evaluation objects is calculated.

$$F = \boldsymbol{B} \cdot V^{\mathrm{T}}. \tag{7}$$

The model obtains the evaluation results according to the weighted average principle.

4 RESULTS ANALYSIS AND DISCUSSION

To test the scientific nature and maneuverability of the evaluation model, this study selects the Yonghong community in Changzhou City of China as an example, takes the COVID-19 public emergency as the context, and conducts an empirical study on the evaluation of emergency preparedness and response capacity. Yonghong community is located at the center of a major urban area and has an area size of about 0.78 square kilometers; developed commerce; three new residential areas consisting mostly of high-rise buildings, with 4765 permanent residents and a total population of 14 352 people; and a high population density.

4.1 Evaluation Process

4.1.1 Entropy Weight Method

In this study, four emergency management experts and two community managers are interviewed, and a "1-9" scale is used to score the importance of the indicator system, as shown in Fig. 2, and the higher the score, the more important the index system. The initial judgment matrix is obtained by taking the first-level index system as an example.

$$\boldsymbol{X} = \begin{bmatrix} 7 & 8 & 7 & 8 \\ 8 & 6 & 8 & 7 \\ 6 & 8 & 9 & 7 \\ 8 & 8 & 7 & 6 \\ 8 & 7 & 9 & 7 \\ 8 & 7 & 7 & 7 \end{bmatrix}.$$

According to Eqs. (2), (3), and (4), the entropy weight vector $\boldsymbol{W}$ = [0.2624, 0.2568, 0.3152, 0.1656] of the first-order index system is obtained using MATLAB R2016a. Similarly, the entropy weight of each evaluation index is obtained by calculating the secondary index system, as shown in Tab. 1.

Table 1 Entropy weight value of assessment indices

First-level index	Entropy weight	Secondary index	Entropy weight
B1 prevention and preparation mechanism	0.2624	A1 emergency organization system construction	0.0991
		A2 ability to detect hidden dangers	0.0509
		A3 emergency knowledge publicity and training	0.0528
		A4 formulation and exercise of emergency plan	0.0586
		A5 emergency resource support capability	0.0312
B2 monitoring and early warning mechanism	0.2568	A6 safety monitoring capability	0.0664
		A7 risk early warning capability	0.0666
		A8 information processing and publishing capability	0.0837
B3 response and Rescue Mechanism	0.3152	A9 ability to initiate emergency plans	0.0840
		A10 command and decision-making capability	0.0897
		A11 rescue capability	0.0894
		A12 logistics support capability	0.0621
B4 recovery and reconstruction mechanism	0.1656	A13 damage assessment capability	0.0377
		A14 psychological assistance capacity of disaster victims	0.0428
		A15 restoration and reconstruction of facilities and equipment	0.0582
		A16 summing up experiences and lessons	0.0269

4.1.2 Fuzzy Comprehensive Evaluation of Emergency Preparedness and Response Capacity in Yonghong Community

Community research and in-depth interviews are conducted to collect data for a report on the emergency preparedness and response capacity of Yonghong community during the COVID-19 pandemic. A set of evaluation grades is established, that is, V = {Good, General, Poor, Very Bad}, then, five emergency management experts, five community managers, and 20 community residents are selected for the interviews. The previous reports are explained to each interviewee. The investigators select the grade according to the criteria based on the previous reports and their personal experience to fully understand the emergency performance of Yonghong community to ensure the accuracy of the data.

The fuzzy relation matrix $\boldsymbol{R}$ can be obtained based on Tab. 2. After the normalization, MATLAB R2016a is used to program the evaluation matrix $\boldsymbol{B}$ = [0.5656, 0.3836, 0.0368, 0.0141] using Eq. (6).

Table 2 Evaluation of emergency management capacity for the Yonghong community

Index \ Grade	Good	General	Poor	Very bad
A1	16	13	1	0
A2	13	15	1	1
A3	15	14	0	1
A4	14	15	1	0
A5	14	14	2	0
A6	17	10	2	1
A7	15	9	6	0
A8	18	10	1	1
A9	20	10	0	0
A10	19	11	0	0
A11	23	6	0	1
A12	13	15	2	0
A13	13	15	1	1
A14	15	14	0	1
A15	22	8	0	0
A16	14	14	2	0

To visually depict the emergency management level of the Yonghong community, V = {Good, General, Poor, Very Bad} is assigned a score of 90, 70, 50, and 30. The comprehensive evaluation value F of the evaluation objects is calculated according to Eq. (7) and using the weighted average principle.

$$F = \boldsymbol{B} \cdot V^{\mathrm{T}} = 80.019. \tag{8}$$

The evaluation score of each index can be calculated by the same token, as shown in Fig. 3.

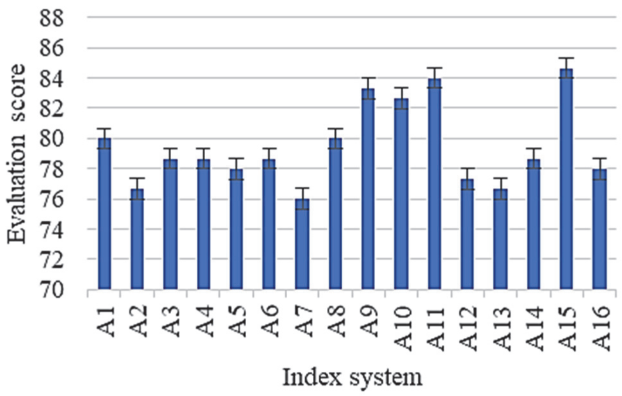

Figure 3 Evaluation score of each secondary index

4.2 Discussion

(1) The final score of the evaluation is 80.019, which indicates that the emergency preparedness and response capacity of Yonghong community during the COVID-19 pandemic is between "average" and "good", which meets the basic requirements. However, room for improvement remains in the level of emergency management.

(2) Based on the score of each index, to further improve the emergency management ability of Yonghong community, the four aspects of "A2, A7, A12, and A13", that is, the ability to investigate hidden risks and dangers, risk early warning, logistics support, and damage assessment, which received the lowest score, should be improved. The results are consistent with the conclusions obtained in reference [26] and [27]. In addition, Yonghong community must strengthen its risk management and early warning, improve the guarantee level of emergency resources, effectively conduct a community damage assessment after the public emergency, and pertinently provide relief, compensation, comfort, resettlement, and follow-up efforts.

(3) The calculation results of the model are consistent with the actual situation of the Yonghong community during the COVID-19 pandemic, which shows that the model has high rationality, a scientific nature, and manoeuvrability in terms of not only the construction of the index system but also the selection of the theoretical methods. The results are consistent with the conclusions obtained in reference [28] and [29].

5 CONCLUSIONS

For the assessment of an urban community's emergency preparedness and response capacity in the context of a public emergency, and drawing upon extensive research and literature, this study develops an index framework to evaluate such capacity. In addition, an empirical study is conducted using the fuzzy comprehensive evaluation model, and the importance of the factors that may influence the evaluation results is determined. The conclusions of this study are as follows:

(1) The emergency management level of an urban community can be impacted by a multitude of variables, and the collection of certain data types may present challenges. As a result, this study establishes an evaluation index for community emergency preparedness and response capacity, drawing upon the theory of the emergency management cycle. The index mainly includes the prevention and preparation mechanism, monitoring and early warning mechanism, response and rescue mechanism, and recovery and reconstruction mechanism. The four dimensions reflect the concepts of pre-disaster prevention, early warning, disaster management, and post-disaster recovery and are closely related to and influence one another in space, constituting a systematic framework for the evaluation of community emergency preparedness and response capacity from the perspective of time and space.

(2) The multilayer fuzzy comprehensive evaluation model, utilizing the entropy weight method, offers an effective solution to tackle the intricacies and uncertainties associated with the emergency preparedness and response capacity of urban communities. In addition, the transformation of qualitative evaluation into quantitative analysis can effectively reduce the subjective deviation in the artificial valuation, increase the objectivity and accuracy of the evaluation results, and help provide a decision-making basis for improving the emergency preparedness and response capacity of urban communities.

(3) The empirical study on the multilayer fuzzy comprehensive evaluation model based on the entropy weight method shows that the consistency between the assessment outcomes and the recommendations for enhancement with the real-world scenario underscores the effectiveness and rationality of both the index system and

the chosen methodologies. This study can provide a useful reference and theoretical support for the evaluation of the current emergency preparedness and response capacity of urban communities and thus has certain application value.

The contribution of this study is a fuzzy comprehensive evaluation model of the emergency preparedness and response capacity of an urban community based on the entropy weight method, which is reasonable and effective. However, in reality, the characteristics of different public emergencies differ, and each index system may have a specific focus. Thus, the depth and breadth of research in this field should be expanded further to maintain the effectiveness and versatility of the model.

Acknowledgements

This study was funded by the National Natural Science Foundation of China (No. 72304253) and Humanities and Social Sciences Research Project of the Ministry of Education of China (No. 22YJC630027).

6 REFERENCES

[1] Liao, M. L., Su, Y., & Li, F. F. (2018). Urban community construction under framework of resilience system. *Chinese Public Administration*, *394*(4), 57-62. https://doi.org/10.3782/j.issn.1006-0863.2018.04.09
[2] Kapucu, N. (2012). Disaster and emergency management systems in urban areas. *Cities*, *9*(1), 41-49. https://doi.org/10.1016/j.cities.2011.11.009
[3] Mashrur, R. U. B., Farzana, K., Ishrat, I., & Rezwana, R. (2018). Participatory vulnerability reduction (PVR): an urban community-based approach for earthquake management. *Natural Hazards*, *93*(3), 1479-1505. https://doi.org/10.1007/s11069-018-3364-2
[4] Caro-Carretero, R. & Jiménez, F. G. (2022). How to strengthen preparedness for a future natural disaster. *Dyna*, 97(6), 574-574.https://doi.org/10.6036/10612
[5] Nesoff, E. D., Pollack, P. K. M., Bailey, M., & Gielen, A. C. (2018). Knowledge and beliefs about pedestrian safety in an urban community: implications for promoting safe walking. *Journal of Community Health*, *44*, 1-9. https://doi.org/10.1007/s10900-018-0559-0
[6] Assche, J. V., Block, T., & Reynaert, H. (2010). Can community indicators live up to their expectations? the case of the flemish city monitor for livable and sustainable urban development. *Applied Research in Quality of Life*, *5*(4), 341-352. https://doi.org/10.1007/s11482-010-9121-7
[7] Lu, X. H. (2015). Pattern, concept and structure of community governance in Japan with analysis focused on hybrid model. *Japan Studies*, (2), 52-61. https://doi.org/10.16496/j.cnki.rbyj.2015.02.007
[8] Bovaird, T. (2007). Beyond engagement and participation: user and community coproduction of public services. *Public Administration Review*, *67*(5), 846-860. https://doi.org/10.1007/978-3-030-53705-0_2
[9] Rostis, A. (2007). Make no mistake: the effectiveness of the lessons-learned approach to emergency management in Canada. *International Journal of Emergency Management*, *4*(2), 197-210. https://doi.org/10.1504/IJEM.2007.013990
[10] Fang, B. & Bin, L. Y. (2018). The urban community governance modes in the USA, the UK, and Japan: a comparative perspective. *Urban Planning International*, *33*(4), 93-102.https://doi.org/10.22217/upi.2016.136
[11] Feng, K., Xu, Z. S., Feng, C. Y., & Wang, D. S. (2005). Comprehensive study on urban community safety plan and disaster emergency management. *Journal of Natural Disasters*, *14*(4), 85-89. https://doi.org/10.1111/j.1744-7909.2005.00184.x
[12] Engelman, A., Ivey, S. L., Tseng, W., Dahrouge, D., Brune, J., & Neuhauser, L. (2013). Responding to the deaf in disasters: establishing the need for systematic training for state-level emergency management agencies and community organizations. *BMC Health Services Research*, *13*(1), 1-10. https://doi.org/10.1186/1472-6963-13-84
[13] Horowitz, Y. Y., Haimes, Kenneth, C., & Barry, M. (2008). Homeland security preparedness: balancing protection with resilience in emergent systems. *Systems Engineering*, *11*(4), 287-308. https://doi.org/10.1002/sys.20101
[14] Steiner, A., Woolvin, M., & Skerratt, S. (2018). Measuring community resilience: developing and applying a "hybrid evaluation" approach. *Community Development Journal*, *53*(1), 99-118. https://doi.org/10.1093/cdj/bsw017
[15] Akter, S. & Wamba, S. F. (2019). Big data and disaster management: a systematic review and agenda for future research. *Annals of Operations Research*, *283*(2), 939-959. https://doi.org/10.1007/s10479-017-2584-2
[16] Awasthi, A. & Chauhan, S. S. (2012). A hybrid approach integrating affinity diagram, AHP and fuzzy TOPSIS for sustainable city logistics planning. *Applied Mathematical Modelling*, *36*(2), 573-584. https://doi.org/10.1016/j.apm.2011.07.033
[17] Btoush, M. H. & Dawahdeh, Z. E. (2018). A complexity analysis and entropy for different data compression algorithms on text files. *Journal of Computer & Communications*, *06*(01), 301-305. https://doi.org/10.4236/jcc.2018.61029
[18] Akter, M., Jahan, M., Kabir, R., Karim, D. S., Haque, A., Rahman, M., & Salehin, M. (2018). Risk assessment based on fuzzy synthetic evaluation method. *The Science of the Total Environment*, *658*, 818-829. https://doi.org/10.1016/j.scitotenv.2018.12.204
[19] Fan, X. Y., Jia, Z. X., Bai, X. L., Yang, T. D., & Liu, Y. (2019). Classification of extremely soft rock tunnels using comprehensive evaluation model of entropy-weighted fuzzy. *Journal of Engineering Geology*, *27*(06), 1236-1243. https://doi.org/10.13544/J.CNKI.JEG.2018-310
[20] Zhao, P. X., Zhu, W., & Wang, Y. F. (2018). Assessment framework and emergency system and mechanism design of resilient community and discussion on its construction path in Xiongan New Area. *Journal of Safety Science and Technology*, *14*(7), 12-17. https://doi.org/10.11731/j.issn.1673-193x.2018.07.002
[21] Guo, X. Y., Zeng, Z., Li, M. X., & Fu, S. (2022). Simulation of Aircraft Cabin Evacuation Strategy Based on Exit Flow Equilibrium, *International Journal of Simulation Modelling*, *21*(2), 261-272. https://doi.org/10.2507/IJSIMM21-2-601
[22] García-Hernández, C., Calvete-Aguilar, J. L., & Ubieto-Artur, P. (2023). Graphical tools to the rescue. High resolution aerial photography for the location of missing persons. *Dyna*, *98*(1), 51-56. https://doi.org/10.6036/10631
[23] Koch, H., Franco, Z. E., O'Sullivan, T., DeFino, M. C., & Ahmed, S. (2017). Community views of the federal emergency management agency's "whole community" strategy in a complex US City: Re-envisioning societal resilience. *Technological Forecasting and Social Change*, *121*, 31-38. https://doi.org/10.1016/J.TECHFORE.2016.12.009
[24] Lu, J., Yang, N., Ye, J., Liu, X., & Mahmood, N. (2015). Connectionism Strategy for Industrial Accident-Oriented Emergency Decision-Making: A Simulation Study Based on PCS Model. *International Journal of Simulation Modelling*, *14*(4), 633-646. https://doi.org/10.2507/IJSIMM14(4)6.315
[25] Alamdar, F., Kalantari, M., & Rajabifard, A. (2016). Towards multi-agency sensor information integration for disaster management. *Computers, Environment and Urban Systems*, *56*, 68-85.

https://doi.org/10.1016/j.compenvurbsys.2015.11.005

[26] Shang, L., Zhang, Y. Z., Zhang, D. Y., & Zhong, Y. (2023). Disaster resilience assessment of old communities under the perspective of rainstorm flood disasters: an empirical study based on PSR model and BPNN. *Science Technology and Engineering*, *23*(26), 11338-11348.

[27] Xu, B. G. & Tang, J. (2022). Research on old community emergency shelters planningof under earthquake disaster. *World Earthquake Engineering*, *38*(4), 8-17. https://doi.org/10.19994/j.cnki.WEE.2022.0077

[28] Chen, S. S., Zhai, G. F., Ge, Y. F., & Yang, H. F. (2023). Research on community governance and resilience improvement under epidemic risk of infectious diseases based on QRH philosophy. *Urban Planning International*, *38*(3), 54-62. https://doi.org/10.19830/j.upi.2020.719

[29] Xu, B. G. & Tang, J. (2022). Research on old community emergency shelters planningof under earthquake disaster. *World Earthquake Engineering*, *38*(4), 8-17. https://doi.org/10.19994/j.cnki.WEE.2022.0077

Contact information:

Ningzhou SHEN, PhD, Lecturer
1) School of Safety Science and Engineering,
Changzhou University, Changzhou
2) School of Emergency Science and Engineering,
Changzhou University
3) Institute of Public Safety and Emergency Management,
Changzhou University, Jiangsu, China
E-mail: shennz@cczu.edu.cn

Xinyao GUO, PhD, Lecturer
(Corresponding author)
School of Civil Aviation,
Zhengzhou University of Aeronautics,
Zhengzhou, Henan, China
E-mail: xyguo@zua.edu.cn

Jiawei CUI, Master's degree, Experimentalist
1) School of Safety Science and Engineering,
Changzhou University, Changzhou
2) School of Emergency Science and Engineering,
Changzhou University
3) Institute of Public Safety and Emergency Management,
Changzhou University, Jiangsu, China
E-mail: jiawei_cui@cczu.edu.cn

Zhengqi WU, PhD, Lecturer
1) School of Safety Science and Engineering,
Changzhou University, Changzhou
2) School of Emergency Science and Engineering,
Changzhou University
3) Institute of Public Safety and Emergency Management,
Changzhou University, Jiangsu, China
E-mail: wzq0323@cczu.edu.cn