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Research on the Selection of Emergency Response Plans for Sudden Incidents Based on Uncertain Information

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Abstract: Emergency response plans are the core link in the process of dealing with unexpected incidents. However, the various types of information faced in responding to unexpected incidents are highly uncertain. Therefore, how to select a relatively satisfactory emergency response plan for unexpected incidents under uncertain information is an urgent problem to be solved in emergency management. To effectively select emergency response plans for unexpected events under uncertain information, this paper proposes a decision-making method based on the combination of the Analytic Hierarchy Process (AHP) and the fuzzy comprehensive evaluation method. Firstly, various influencing factors of emergencies are obtained through data collection and actual research. The AHP method is adopted to conduct weight analysis of the influencing factor indicators, and the key influencing factors of emergencies are obtained. Secondly, design alternative emergency response plans based on key influencing factors; Secondly, a fuzzy comprehensive evaluation model is constructed to conduct a comprehensive assessment of each alternative plan, and the best emergency response plan is determined based on the scores of the alternative plans. Finally, the feasibility of the proposed selection technology is illustrated through a research example of the campus fire emergency plan.

Keywords: Emergency; Uncertain environment; Emergency response plan; Fuzzy comprehensive evaluation method

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1. Introduction

With the accelerating pace of social development, the demand for various resources worldwide is growing larger and larger. Both the natural and social environments are facing unprecedented and huge threats. At the same time, the frequency and scale of various emergencies are also increasing dramatically. For the occurrence of emergencies, conducting scientific and effective emergency response plan planning can reduce the negative impact brought by emergencies[1]. Therefore, the selection of emergency response plans has received high attention. The research on the selection of emergency response plans is carried out by conducting in-depth analysis of various influencing factors of unexpected events and the purposes and requirements for formulating emergency response plans, and then choosing the best emergency response plan.

At the same time, with the advent of the information society, the information uncertainty characteristic of human society has become increasingly obvious. In traditional human thinking, uncertainty is often associated with risk. However, information is probabilistic, which also emphasizes the need to view uncertainty and uncertain information correctly. It is necessary to recognize both the potential dangers associated with uncertain information and its positive role and intrinsic value, and to regard it as a governance resource with objective characteristics that can be used to effectively respond to emergencies and quickly manage major crises. Emergency response plans for unexpected events often require the selection of relatively satisfactory emergency plans in an incomplete information environment. To optimize the utilization of resources, determining the importance of indicators that affect the selection of emergency response plans is particularly important for decision-makers to determine the focus of resource allocation.

A method for characterizing fuzzy language information based on the set of language terms is proposed[2]. Language vocabulary with fuzzy attributes is called fuzzy language, such as very good, excellent, unsatisfactory, very important and extremely expected, etc. A set of fuzzy languages with hierarchical differences and similar features is usually called a multi-dimensional fuzzy language set[3]. Uncertain language information refers to the information represented by two multi-dimensional fuzzy words, such as [relatively satisfied, very satisfied, which represents the uncertainty of the information between relatively satisfied and very satisfied, and also represents the boundary hesitation of things between these two states, or the hesitation of evaluators between the two evaluations[4]. For research on theories related to uncertain language information, a subscript symmetrical language assessment scale, where the middle language scale indicates an assessment value of "no difference", and the other language scales are symmetrical[5]. The concept of the set of hesitant fuzzy language terms was proposed, then the uncertain language expressions containing modifiers were presented, using weak modifiers to describe the degree of uncertainty of language information[6].

Therefore, in order to effectively solve the problem of choosing emergency response plans for unexpected events, this paper adopts a method combining the Analytic Hierarchy Process (AHP) and the fuzzy comprehensive evaluation method to study emergency response plans for unexpected events. The Analytic Hierarchy Process (AHP) hierarchies and systematizes the influencing factors of emergencies, identifies the key influencing factors of emergencies, and designs alternative emergency response plans based on this. Meanwhile, the fuzzy comprehensive evaluation method assesses and screens multiple alternative schemes, and finally obtains a relatively satisfactory scheme. It plays an important and positive role in both theoretical and practical aspects for the prevention of emergencies and the implementation of emergency plans.

2. The construction of a multi-objective satisfaction evaluation model

In the process of selecting emergency response plans, clarifying the significance of the influencing factors of unexpected events is a crucial step. Only in this way can a more satisfactory emergency response plan be chosen from multiple alternative options to prioritize the allocation of resources. Due to the numerous and constantly changing factors influencing emergencies, the collected information is always in an uncertain environment. To reduce the uncertainty in the research process, a determination method combining AHP and fuzzy comprehensive evaluation analysis is proposed.

(1) According to the idea of the Analytic Hierarchy Process, the evaluation objective is set by the research object of the emergency response plan for unexpected events. Then, several first-level influencing factors are set based on the possible influencing factors of the unexpected events. Among them, there are several second-level influencing factors under the first-level influencing factors. Through data collection and actual research, various influencing factors of emergencies were obtained and input into the analytic hierarchy process model. The risk assessment index system is obtained through the analytic hierarchy process (AHP) model. Based on this, AHP is used to conduct pairwise comparisons of risk factors at all levels to construct a judgment matrix, and the eigenvector corresponding to the maximum eigenroot of the matrix is solved as the weight value of the risk assessment index.

$$a_{ij}*a_{ji}=a_{ik},\ i,j,k=1,2,\ldots,n \quad (1)$$

If the obtained judgment matrix is A consistent matrix, for example A, then it is natural to take the normalized eigenvector corresponding to the eigenroot n to represent the weights of each factor U to the upper-level factor. This vector is called the weight vector. If the judgment matrix A is not a uniform matrix but is within the allowable range of inconsistency, then the eigenvector (normalized) corresponding to the maximum latent root of A (denoted as λ) is taken as the weight vector w by using Equations (2) and (3).

$$\overline{\mathcal{R}}(\omega)=\frac{1}{I}\sum_i\overline{\mathcal{R}}_i(\omega) \quad (2)$$

$$D_M(\breve{a},\breve{b})=\frac{1}{2[V(x_\tau)-V(x_{-\tau})]}\left(|\Delta^-(s_i^*,\alpha_1^*)-\Delta^-(s_i,\alpha_1)|+\left|\Delta^-(s_j^*,\alpha_2^*)-\Delta^-(s_j,\alpha_2)\right|\right) \quad (3)$$

In practical application scenarios, judgment matrices are often not consistent, and it is necessary to ensure that the degree of inconsistency is within an acceptable range. From this theorem and the fact that λ continuously depends on a_{ij}, it can be known that the greater λ is than n, the more severe the inconsistency of A becomes, and the greater the judgment error caused by using the feature vector as the weight vector. Based on the constructed judgment matrix, the weights of each factor in the first-level and second-level indicators are obtained, the comprehensive weight values of each factor for the evaluation target are calculated, and the weight ranking is listed.

(2) According to the ranking of the importance of the influencing factors of emergencies, the key factors affecting emergencies are obtained. Based on this, alternative emergency response plans for emergencies are designed. Then, through the fuzzy comprehensive evaluation method, the designed alternative emergency response plans are comprehensively evaluated to select the best emergency response plan. The calculation formulas for this stage are as follows:

$$S_M(\breve{a},\breve{b})=1-D_M(\breve{a},\breve{b}) \quad (4)$$

$$E=\sum_{k=1}^{K}\left[\frac{1}{M\times N}\sum_{m=1}^{M}\sum_{n=1}^{N}D_M(c_t^k,c_t^{k'}\ )\right] \quad (5)$$

3. Examples and analysis of results

This chapter mainly conducts research on emergency plans for campus fires by using the Analytic Hierarchy Process (AHP) and the fuzzy Comprehensive Evaluation method. Firstly, through the query of event materials and data, select the campus fire cases that have occurred for analysis to identify various influencing factors of campus fire risks. Subsequently, by using the AHP concept in combination with the fuzzy comprehensive evaluation method, the fire risk analysis of the buildings in the university dormitory area was conducted based on the selected fire risk influencing factors. Then, based on the analysis results, the campus fire emergency plan analysis of this dormitory area was carried out.

(1) During the process of fires in university buildings, different fire protection targets will have varying degrees of impact on various factors. Therefore, this paper adopts different perspectives and analytical methods to establish a risk assessment system for student dormitories, in order to evaluate the safety status of university student dormitory buildings. This is of great significance for the emergency management of universities. This research mainly focuses on densely populated buildings such as dormitory areas. Based on the analysis of the causes of campus fires that occurred in the past, the constituent factors of the campus fire risk assessment system can be obtained. The fire risk assessment of university dormitory buildings includes the following five first-level indicators: the nature of the building: fire-resistant materials, evacuation routes and facilities, fire compartments, etc. Human factors: the density of people, their educational level, self-rescue ability and fire safety awareness, etc. External environment: including building spacing, fire lanes, outdoor fire hydrants and water sources; Fire protection facilities: fire extinguishers, alarm systems, indoor fire hydrants, automatic fire extinguishing systems, etc. Fire management: safety training, personnel on duty, maintenance and inspection of fire protection facilities, fire prevention regulations, etc. The evaluation table of risk factors involved in campus fires was obtained, and a list of risk factor indicators for campus fire projects was constructed in combination with the first-level judgment matrix. The summary is shown in **Table 1**

Table 1. The weight of campus fire risk factor indicators

First-level indicators	first-level indicator weights	second-level indicators	second-level indicator weights
The nature of the building	0.140	Refractory materials	0.200
		Evacuation routes and facilities	0.600
		Fire compartment	0.200
Human factors	0.420	Personnel density	0.160
		Self-rescue ability	0.360
		Educational attainment	0.080
		Fire safety awareness	0.410
External environment	0.175	Fire lane	0.429
		Outdoor fire hydrants and water sources	0.429
		Building spacing	0.143
Fire protection facilities	0.175	Fire extinguisher	0.300
		Alarm system	0.395
		Indoor fire hydrant	0.173
		Automatic fire extinguishing system	0.132
Fire management	0.090	Safety training	0.210
		On duty	0.090
		Inspection and maintenance of fire protection facilities	0.483
		Fire prevention system	0.212

(2) Based on the comprehensive ranking of various factors calculated earlier, the key influencing factors of the emergency are fire safety awareness, self-rescue ability, evacuation routes and facilities, fire lanes, outdoor fire hydrants and water sources, alarm systems, and personnel density, etc. According to these factors, alternative emergency response plans are designed. Generally speaking, the degree of influence of different levels and factors on the final outcome varies. Now, five expert representatives (M1 to M5) are randomly selected from the university dormitory area to score the alternative plans, and the weights of the expert representatives (ω1 to ω5) are obtained by using the weighted average method as ω=(0.23, 0.20, 0.18, 0.22, 0.17). The evaluation information of each alternative plan is as follows respectively.

$$H_1=\begin{bmatrix}0.1 & 0.3 & 0.3 & 0.1 & 0.2\\ 0.2 & 0.2 & 0.4 & 0.1 & 0.1\\ 0.2 & 0.3 & 0.2 & 0.2 & 0.1\\ 0.3 & 0.2 & 0.3 & 0.2 & 0.1\\ 0.3 & 0.3 & 0.2 & 0.1 & 0.2\end{bmatrix}, H_2=\begin{bmatrix}0.2 & 0.3 & 0.1 & 0.2 & 0.2\\ 0.1 & 0.3 & 0.2 & 0.1 & 0.3\\ 0.3 & 0.2 & 0.2 & 0.2 & 0.1\\ 0.2 & 0.4 & 0.1 & 0.1 & 0.2\\ 0.1 & 0.3 & 0.3 & 0.1 & 0.2\end{bmatrix}, H_3=\begin{bmatrix}0.4 & 0.1 & 0.1 & 0.2 & 0.2\\ 0.3 & 0.2 & 0.1 & 0.1 & 0.3\\ 0.3 & 0.1 & 0.2 & 0.3 & 0.1\\ 0.2 & 0.3 & 0.1 & 0.2 & 0.2\\ 0.3 & 0.2 & 0.2 & 0.1 & 0.2\end{bmatrix}.$$

(3) Then the fuzzy comprehensive evaluation information of each alternative scheme using Equation (5) can be obtained.

E_1=0.216*5+0.258*4+0.285*3+0.14*2+0.14*1=3.387;

E_2=0.181*5 +0.304*4+0.172*3+0.141*2+0.202*1=3.121;

E_3=0.23*5+0.20*4+0.18*3+0.22*2+0.17*1=3.198.

Since 3.387>3.198>3.121, it is easy to see that the alternative plan D_1 performs well and has the highest membership degree, accounting for 25.8%. Therefore, plan D_1 is considered good. Option D_2 performed well and had the highest membership degree, accounting for 30.4%, while Option D_2 was considered good. The alternative plan D_3 has the highest membership degree due to its excellent performance, accounting for 30.1%. Plan D_3 is considered excellent. However, the comprehensive scoring options D_1> D_3> D_2 indicate that the comprehensive importance of option D1 is higher. Therefore, option D1 should be selected.

4. Conclusions

This paper focuses on the design and selection of emergency response plans for unexpected events in reality. Combined with the current research status, it proposes an idea for the selection of emergency response plans for unexpected events based on the Analytic Hierarchy Process and the fuzzy comprehensive evaluation method. Take the design and selection of campus fire emergency response plans as an example to prove the feasibility and effectiveness of the proposed ideas. The key influencing factors are obtained by constructing an analytic hierarchy process model, and based on this, alternative emergency response plans are designed. Then, a fuzzy comprehensive evaluation model is constructed to conduct a comprehensive evaluation of the alternative plans, and the plan with the highest comprehensive score is selected as the optimal emergency plan.

The method proposed in this paper based on the AHP (Analytic Hierarchy Process) and the Fuzzy Comprehensive Evaluation method can fully determine the influence degree of the influencing factors of emergencies and reduce the uncertainty of the influence of key factors. In the process of designing and selecting emergency plans, it provides a reference for emergencies where it is difficult to grasp the importance of the influencing factors and cannot deal with uncertain information. The method proposed in this paper is simple and easy to implement. It uses quantitative methods to analyze the qualitative indicators of various influencing factors of emergencies, which improves the efficiency and accuracy of emergency plan selection.

References

[1] Wang H, Chen Z S, Liu Y, 2026, Enhancing risk management efficiency for building information modelling application via basic uncertain linguistic large-scale group decision making. Applied Soft Computing, 186(1): 114086.

[2] Demir E, Ak M F, Sari K, 2023, Pythagorean Fuzzy Based AHP-VIKOR Integration to Assess Rail Transportation Systems in Turkey . International Journal of Fuzzy Systems, 25(2): 620-32.

[3] Wongsuriyanan C, Tsuchida S, 2023, A Case Study of Disaster Risk Reduction in Schools for the Blind in Thailand. International Journal of Disaster Response and Emergency Management (IJDREM), 6(6): 1-14.

[4] Sakib N, Hyer K, Dobbs D, 2022, A GIS enhanced data analytics approach for predicting nursing home hurricane evacuation response. Health information science and systems, 10(1): 28.

[5] Wang Y, Sun B, 2022, Multiperiod equitab1e and efficient allocation strategy of emergency resources under uncertainty. International Journal of Disaster Risk Science, 13(5): 778-792.

[6] Squier J, 2023, Emergency Action & Operations Planning: At the Crossroads of OSHA & FEMA. Professional safety, 68(2): 35-40.

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