Evaluation Model of the Campus Emergency Management Capacity Based on Principal Component Projection Method

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Abstract

Campus emergency management capacity guarantees the public security of colleges, and it's an important subject for all colleges and universities to build up a scientific and rational system to evaluate the campus emergency management capacity. The paper describes systematic measurable index system with four parts, emergency prevention capability, basic security capability, emergency response capability and recovery capability, and build-up a measurable index system model for the evaluation of campus emergency management capacity based on principal component project method.

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Key words: Campus emergency management capacity; Principal component projection method; Evaluation model

1 Introduction

With considerable social changes and the deepening reform, the ecological environment of our colleges and universities has undergone tremendous changes, consequently all kinds of emergent public events happened gradually with an increasing trend. Society has paid great attention to the emergent public health events in colleges and universities, for it not only influences the normal order of teaching and research, but also affects social stability as it can be spread quickly to the society. Therefore, to enhance the campus emergency management
capacity is an important task facing all levels of government and colleges and universities. [1]Foreign research of campus emergency management is focused on establishing contingency plans, training emergency management professional teams, and classifying, sorting, learning from emergency events. However in China, it was in 2003 that the concept of campus emergency management was proposed. To further enhance campus emergency management, the evaluation of campus emergency management capabilities is particularly important, so as to master the basic situation of the university, identify its shortcomings and key weaknesses, to help colleges and universities to control in practice the actual situation of their own improvement and enhancement of emergency management, while at the same time provide a scientific basis for the universities and departments in charge of decision-making for the construction of a safe and harmonious campus environment, provide a useful reference.

2 Construction of the Index System of Campus Emergency Management Capability

It is generally believed that most campus events are caused suddenly due to natural, man-made or social-political reasons. It interferes on-campus teaching, work and life, even resulting in property damage and casualties. [2] Therefore campus emergency response management is supposed to take the concrete actions and measures to reduce or mitigate the effects of the event, to resume their normal running order in the event of unexpected incidents before, during and after the colleges and departments in charge. Campus emergency management usually includes two parts; first, to avoid the occurrence of unexpected events, the second is to reduce the losses caused by emergencies. Emergency management capacity is a macroscopic description of the control capabilities of sudden hazardous events. It requires that campus emergency management staff members should acquire a certain amount of capacity factors, including the resources, knowledge, skills, and thus having the ability to avoid unexpected events and reduce the losses caused by the of the ability.

With an increasingly complex social environment, the threat to the personal safety of teachers and students increased as colleges and universities have many young students. The high population density, frequency of aggregation, and multi-cultural exchange etc., easily lead to emergencies. Therefore, the emergency management of colleges and universities is essential, and the level of management directly determines the public safety in colleges and universities, and even in the whole society. Colleges and universities should have a full range of understanding and awareness in order to improve the emergency management. First of all they should deal with all aspects of their emergency management resources, knowledge, skills, mechanisms, to find their strengths and weaknesses through a comprehensive evaluation of the campus emergency management capabilities. Campus emergency management capability assessment is a complex system work. Many factors affect the campus emergency management capabilities, however the most important point is to select the scientific evaluation method. [3] Therefore on the basis of the relevant research both domestic and abroad, the paper describes the systematic measurable index system with four parts, emergency prevention capability, basic security capability, emergency response capability and recovery capability, and build-up a measurable index system model for the evaluation of campus emergency management capacity based on principal component project method.
Table 1. Campus emergency management capability evaluation index

| First level indexes | Second level indexes | Weight |
|---------------------|----------------------|--------|
| Prevention and early warning | Regulations formulation and implementation i1 (0.0875) |        |
|                     | Establishment of Contingency plans i2 (0.0741)      |        |
|                     | Contingency knowledge training and publicity education i3 (0.0648) |        |
|                     | Early Warning System i4 (0.0393)                     |        |
|                     | Public opinion, concern and guidance i5 (0.0356)     |        |
| The basis of protection ability of I2 | Emergency plan exercise i6 (0.0311) |        |
|                     | Preparation of emergency resources i7 (0.0684)       |        |
|                     | Preparation of emergency funds i8 (0.0235)           |        |
|                     | Establishment of emergency response agencies i9 (0.0318) |        |
|                     | Emergency professional team building i10 (0.0429)    |        |
|                     | Emergency professional information platform building i11 (0.0186) |        |
|                     | Trust of staff members and students on schools i12 (0.0375) |        |
| Capacity of responding to the disposal I3 | Emergency assessment and decision of rapid analysis i13 (0.0892) |        |
|                     | The rapid implementation of contingency plans i14 (0.0428) |        |
|                     | Command and control of the scene i15 (0.0578)       |        |
|                     | Staff rescue and resettlement i16 (0.0307)          |        |
|                     | Information dissemination, coordination and communication i17 (0.0639) |        |
|                     | Acquisition of support of external professional institutions i18 (0.0317) |        |
| Capacity of restoration and reconstruction I4 | Accident Analysis and learning i19 (0.0343) |        |
|                     | Responsibility investigation and disposal i20 (0.0107) |        |
|                     | Restore of school order and the damaged facilities, equipment i21 (0.0176) |        |
|                     | Psychological guidance and legal aid i22 (0.0176)    |        |
|                     | School image recovery i23 (0.023)                     |        |
|                     | Revising and improving the emergency plan of original management regulations i24 (0.0254) |        |

Note: the number between parentheses is the weight of the factor

3. Construction of evaluation model based on the principal component projection method

The evaluation ability is usually done by comparison to determine a relative standard. Without it, it is difficult to define whether it is of high or low ability. In view of this, this paper uses the principal component projection method to evaluate the ability to assess objects.

Define X corresponds to the evaluation P (in this case P = 24) and universities sample matrix n, the evaluation of campus emergency management capabilities \( X = (X_{ij})_{np} \), \( X_{ij} \) is the \( i \) sample and \( j \) target value, \( p, n \) respectively be sample integer and target integer. Quantitative indicators can be achieved by improving the efficiency coefficient method. Different indicator value is hardly comparable mainly due to each indicator's diverse measurement unit and dimensionality, thus we can't process original data directly and appropriate pretreatment is necessary. In order to eliminate negative effects caused by measurement unit divergence of different indicators, it's obliged to dimensionless original data, matrix \( X_{np} \), with first normalization and then standardization.

Qualitative indicators are those indicators without the measured values of indicators. Combing the Delphi method and the fuzzy comprehensive evaluation method, we first divide the various indicators of the evaluation criteria into five scales excellent, good, fair, poor, and then invite experts to evaluate each college and university according to the standards set at 1.00, 0.80, 0.60, 0.40, 0.20, matching it with the function coefficient method of evaluation scores. Finally synthesizing the opinions of experts, we can get a qualitative evaluation of the index score.
Set $f_{ij}$ is appraised the object the target value proportion of the matrix $X$, and $f_{ij}$ is described as the $j$th target $i$th value, then $f_{ij} = y_{ij} = \frac{x_{ij}}{y_{ij}}$ ($i=1,2,\cdots,n$, $j=1,2,\cdots,p$). Make $H_j$ for the $j$th entropy value, then

$$H_j = -k \sum_{i=1}^{n} f_{ij} \ln f_{ij} \quad (k = \frac{1}{\ln n})$$

(1)

Calculates various targets the weight $w_j$, computation like $w_j = \frac{(1 - H_j)}{\sum_{j=1}^{p} (1 - H_j)}$ command $z_{ij} = w_j y_{ij}$, so that, to obtain the weighted sample matrix $z = (z_{ij})_{n \times p} = (w_j y_{ij})_{n \times p}$

The campus emergency management capacity indexes are closely tied, and it will result in information overlap and interference, making it difficult to objectively reflect the relative position of the evaluation object. The use of the orthogonal transformation is required in order to filter out the duplicate information.

Set $M = Z^T Z$ characteristic value for $\lambda_1, \lambda_2, \cdots, \lambda_p$ ($\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p$). The corresponding unit characteristic value vector respectively is $\alpha_1, \alpha_2, \cdots, \alpha_p$. Command $d^* = (d_1, d_2, \cdots, d_p)$ makes the sample matrix to the orthogonal transformation, that is $U = ZA$, obtains the new sample evaluation matrix $U = (u_{ij})_{n \times p}$

Regarding each sample as a one-dimensional vector, and constructing the ideal evaluation vector $d^* = (d_1, d_2, \cdots, d_p)$, among $d_j = \max\{u_{ij}\}$, $(j=1,2,\cdots,p)$. Carries $d^*$ on unit processing to be possible to result in $d^* = \frac{1}{\sqrt{d_1^2 + d_2^2 + \cdots + d_p^2}} d^*$

Set the sample matrix in the ideal evaluation direction projection value is $D = [D_1, D_2, \cdots, D_p]^T$.

The projection value of the sample matrix on the ideal evaluation vector:

$$D = u \cdot d^* = \frac{1}{\sqrt{d_1^2 + d_2^2 + \cdots + d_p^2}} \sum_{j=1}^{p} d_j u_{ij}$$

(2)

The samples can be directly sorted and comparatively analyzed according to the size of the projection. The greater the projection is, the stronger that the campus emergency management capabilities is.

4. Empirical study

Practice proves that the evaluation index system of emergency managerial ability in the college mainly focuses on qualitative appraisal. In this paper, we firstly invited about 20 specialists to evaluate the weights of evaluation index. Based on those weights, we evaluate the emergency managerial ability of seven colleges which attaches to Ministry of Industry and Information technology. For certain reasons, we hide the name of those colleges, and substitute for S1, S2, S3, S4, S5, S6, S7, etc.

Based on the index weight evaluated by specialists, we calculate the index weight of evaluation index system, which is listed in Table 1. For each evaluation index, evaluation specialists grade them according to A, B, C, D, and E, where A represents for excellence, and E stands for inferior. Assigning those five grades as 1, 0.8, 0.6, 0.4, and 0.2, we calculate the arithmetic mean value of each index for each college, and utilize those mean values as the score of each college in related index to construct an evaluation matrix. The new equation $z_{ij} = w_j y_{ij}$ comes from the product of multiply evaluation matrix by weight matrix.
Table 2. Arithmetic mean value of each index for each college

|   | i1  | i2  | i3  | i4  | i5  | i6  | i7  | i8  | i9  | i10 | i11 | i12 |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| S1| 0.525 | 0.3599 | 0.3703 | 0.2583 | 0.2746 | 0.1688 | 0.4299 | 0.1611 | 0.2817 | 0.3432 | 0.1169 | 0.2143 |
| S2| 0.5 | 0.3446 | 0.3703 | 0.2021 | 0.2441 | 0.2044 | 0.3127 | 0.1544 | 0.2635 | 0.2819 | 0.1063 | 0.2786 |
| S3| 0.475 | 0.4658 | 0.3703 | 0.247 | 0.2746 | 0.231 | 0.3713 | 0.1748 | 0.2817 | 0.2942 | 0.1329 | 0.2679 |
| S4| 0.45 | 0.4023 | 0.3147 | 0.247 | 0.2238 | 0.2044 | 0.3909 | 0.141 | 0.209 | 0.2942 | 0.1275 | 0.225 |
| S5| 0.45 | 0.5505 | 0.4073 | 0.2583 | 0.2238 | 0.1777 | 0.4104 | 0.1544 | 0.209 | 0.2451 | 0.1275 | 0.2036 |
| S6| 0.525 | 0.5081 | 0.3518 | 0.247 | 0.2238 | 0.2044 | 0.4495 | 0.1477 | 0.2181 | 0.2697 | 0.1116 | 0.2143 |
| S7| 0.575 | 0.4869 | 0.3518 | 0.247 | 0.2746 | 0.2044 | 0.4299 | 0.1343 | 0.2181 | 0.2942 | 0.1063 | 0.2571 |

According to theory at the mention of section 3, we can get the projection value of emergency managerial ability of each college. $S=(1.4416, 1.3320, 1.4035, 1.3591, 1.4740, 1.4408, 1.4294)$

It can be perceived from the projection value that the emergency managerial ability of s1, s3, s5, s6, and s7 are sharing the same performance. Comparing with those five colleges, there is still a disparity in s2 and s4. Meanwhile, s2 is mainly deficient in the maturity and practice of emergency plan, and the construction of emergency organization and professional emergency team of s4 is insufficient obviously.

5. Conclusion

How to evaluate the campus emergency management capacity scientifically and quantitatively is still a difficult problem. This paper analyzes the characteristics of the campus emergency management system, and the relationship between different elements, thus building a campus emergency management ability evaluation index system. It is favorable for the government and colleges to develop the emergency management policy and system to support colleges, provide a valid scientific basis for the development and management decision-making to promote and guide the campus emergency management capabilities.

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