BRIEF REPORT

Evaluation Model for Hospital Response Capability for Public Health Emergency

Yan-shang Wang, PhD; Hua-jun Sun, PhD; Jia-chen Zou, PhD; Jie Ning, PhD; Yue Du, PhD

ABSTRACT

Objectives: We aimed to explore and create an evaluation model to assess hospital response capability for a public health emergency (PHE).

Methods: Grounded theory was used to construct a comprehensive evaluation index system. Combining with the index system and previous studies and policy documents, we investigated surge capability of hospitals in a PHE. The factor analysis method was used to establish the model.

Results: The comprehensive evaluation system with 11 primary and 30 secondary indicators was constructed. A total of 89 secondary and tertiary hospitals were surveyed in China. The evaluation model ($C = 0.587C1 + 0.151C2 + 0.140C3 + 0.122C4$) was established. Four factors were identified, namely, preparation factor, treatment factor, emergency awareness factor, and prehospital first-aid factor.

Conclusions: A public health emergency could bring huge losses and a capable hospital response was necessary. There was an urgent need to evaluate hospital capability for a PHE.

Key Words: evaluation model, hospital response capability, public health emergency

A public health emergency (PHE) refers to any major infectious disease outbreak, group of unexplained illnesses, major food and occupational poisoning, or other incidents that seriously affected public health, all occurring suddenly and causing or might cause serious harm to public health.[1]

PHEs have challenged the world's preparedness and response capabilities for decades.[2] Hospitals are important institutions to first respond to a PHE,[3] they play the main role of providing health services to people.[4] Therefore, it was particularly important to conduct a scientific assessment of the hospital response capability for a PHE.

It was difficult to assess hospital response capability for a PHE. First, building a comprehensive evaluation system had a certain degree of difficulty; an indicator system should not only accurately measure the hospital response capability to a PHE, but also establish the sensitive factors. Second, the establishment of a comprehensive evaluation model was a challenge.[5] There are no standardized instruments to assess hospital response capability for PHEs.[6] To date, most evaluation strategies were based on subjective methods, such as analytic hierarchy processes and expert ratings.[7]

This study used grounded theory to extract the evaluation index, which provided guidance for the assessment of hospital preparedness for PHE. The factor analysis method was used to construct the model.

METHODS

Study Design

We have selected 90 hospitals in 30 provinces in China from October 2016 to April 2017. Each province included 2 secondary hospitals and 1 tertiary hospital. Grounded theory was used to construct the index system. Then, we designed the questionnaire according to the evaluation index and some literatures, and we did a presurvey to revise the questionnaire based on data, the comprehensive assessment model was constructed by the factor analysis method.

Establishment of Evaluation Index System

Grounded theory method was first proposed by Glaser and Strauss.[8] In this study, we selected 36 experts and practitioners in China. They had high professional background and more than 5 years of working experience in medical and health institutions. Semi-structured interviews were conducted to get information. Interviews were conducted at the workplaces of the participants, and each interview took between 30 and 60 min.

Data Collection and Design of Questionnaire

Within 24 h after each interview, the recording materials were transcribed literally in a timely manner to form text information. This research was based on the analysis steps given by Corbin and Strauss, namely, open coding, axial coding, and selective coding.

Finally, we established a comprehensive evaluation index system. According to the index system, we designed the questionnaire with reference to the Tennessee Health Department Annual Hospital Anti-Terrorist Response Questionnaire and the US Federal Emergency Management Agency and other relevant literatures.

Survey on the Status Quo of Hospital Response Capability to PHE

We dealt with 2 classification variables (the answer is "yes" or "no") by taking the score system, with "yes" for 1 point, "no" for 0 points. Finally, 90 questionnaires were distributed and 89 valid questionnaires were collected. Five medical institutions were selected for the pilot study to check the comprehension of the questionnaire. After completion of investigations, 6 questionnaires were taken for retesting.

Data Analysis

Members who collected data were asked to input data twice independently, and we set the corresponding logic control and verification procedures. This process of data collection was in accordance with EPIDATA version 3.1. We analyzed data with SPSS version 24.0. THe factor analysis method was used to establish an evaluation model.

RESULTS

Establishment of the Evaluation Index System

First, this study carried out word-of-speech analysis of the original interview data for conceptualization. In this study, we considered the relationship between the 66 initial categories generated by open coding and finally grouped 66 initial categories into 30 main categories. Finally, we summed up 11 core categories. The 11 core categories were used as primary indicators, 30 main categories were used as secondary indicators, and 66 initial categories were used as the main observation points. It established an evaluation index system, as shown in Figure 1.

Reliability and Validity of the Questionnaire

Reliability

This study examined the internal and external reliability of the questionnaire. *Internal reliability:* In this study, Cronbach's alpha of hospital response capability for PHE ranged between 0.724 and 0.965. *External reliability:* Because the coincidence rate of the results of the investigation and sampling retest was close to 100%, the external reliability was considered to meet the requirements.

Validity

In this study, the factor analysis method was used to evaluate the construct validity of the questionnaire, and the structural validity of the questionnaire was judged according to the cumulative contribution rate and the factor loading.

Evaluation Model for Hospitals' Comprehensive Response Capability to a PHE

The evaluation model was established using factor analysis method to make an in-depth analysis of the emergency ability.

Testing for Appropriateness

The yielded Kaiser-Meyer-Olkin (KMO) value was 0.806, indicating a strong correlation between variables. And the Bartlett's test of sphericity was highly significant ($\chi^2 = 354.710$; $P < 0.001$), which means factor analysis was feasible.

Determination of Common Factors

The principal component analysis method was used to calculate the eigenvalue, the variance contribution rate and the cumulative contribution rate of the common factors. The number of common factors was determined by the eigenvalue, the gravel map, and the cumulative contribution rate. Table 1 reflected the contribution rate and the cumulative contribution rate of the common factors. The cumulative contribution of the first 4 common factors was 70.502%.

Explanation of the Common Factors

The maximum variance was used to rotate the factor axis, and the original variables was reallocated to each common factor (Table 2).

After rotation, the loading size of each factor was analyzed in the factor load matrix. The interpretation was made as follows: The common factor 1 was labeled "Basis Preparation Factor"; The common factor 2 was considered as a "Clinical Therapeutic Factor"; The common factor 3 was identified as "Emergency Consciousness Factor"; The common factor 4 was called "Prehospital First Aid Factor."

Calculation of the Common Factor Score

According to the common factor score coefficient matrix. The linear expressions of the 4 common factors were: $C1 = -0.146X1-0.168X2-0.120X3-0.010X4+0.275X5+0.355X6+0.094X7+0.335X8+0.528X9-0.059X10-0.182X11$; $C2 = -0.067X1+0.377X2+0.547X3+0.421X4-0.063X5+0.008X6-0.101X7-0.168X8-0.103X9-0.073X10-0.058X11$; $C3 = -0.085X1+0.082X2-0.196X3-0.008X4-0.148X5-0.040X6+0.266X7+0.122X8-0.176X9+0.565X10+0.451X11$; $C4 = 0.807X1+0.086X2-0.022X3-0.191X4+0.300X5-0.180X6+0.097X7-0.028X8-0.133X9-0.280X10+0.143X11$; where Ci is the ability of the common factor score and Xi is the ability to deal with the original score.

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FIGURE 1

Evaluation Index System.

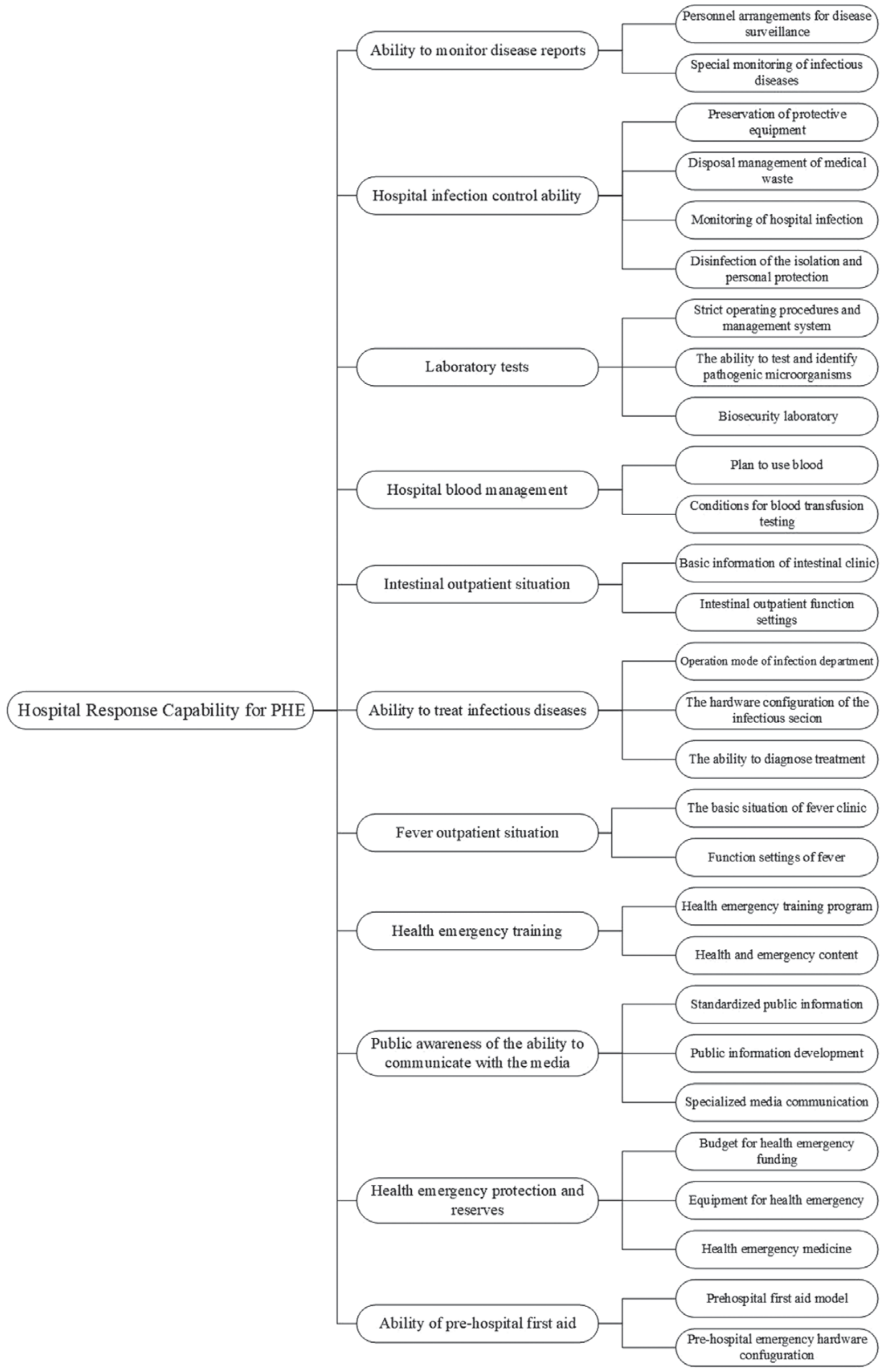

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TABLE 1

Analysis of Principal Components Using Variance Decomposition

Composition	Initial Eigenvalue			Exaction sums of squared loadings			Rotation sums of squared loadings		
	Eigenvalue	Variance Contribution rate(%)	Cumulative Contribution rate(%)	Eigenvalue	Variance Contribution rate(%)	Cumulative Contribution rate(%)	Eigenvalue	Variance Contribution rate(%)	Cumulative Contribution rate(%)
1	4.550	41.364	41.364	4.55	41.364	41.364	2.255	20.504	20.504
2	1.174	10.677	52.041	1.174	10.677	52.041	2.182	19.834	40.338
3	1.085	9.868	61.910	1.085	9.868	61.910	1.950	17.730	58.068
4	0.945	8.592	70.502	0.945	8.592	70.502	1.368	12.434	70.502
5	0.683	6.208	76.710						
6	0.603	5.482	82.191						
7	0.563	5.115	87.306						
8	0.441	4.013	91.319						
9	0.424	3.857	95.176						
10	0.367	3.336	98.511						
11	0.164	1.489	100.000						

TABLE 2

Rotational Matrix of Factor Load

Emergency Response Capability	Common Factors			
	1	2	3	4
1. Ability to monitor disease reports	0.807	0.140	−0.010	0.036
2. Hospital infection control ability	0.660	0.111	0.392	0.174
3. Laboratory tests	0.640	0.277	0.163	−0.005
4. Hospital blood management	0.627	0.234	0.095	0.485
5. Intestinal outpatient situation	0.154	0.866	−0.019	0.109
6. Ability to treat infectious diseases	0.313	0.780	0.240	−0.010
7. Fever outpatient situation	0.196	0.758	0.389	0.279
8. Health emergency training	0.118	0.104	0.814	−0.139
9. Public awareness of the ability to communicate with the media	0.059	0.160	0.739	0.293
10. Health emergency protection and reserves	0.422	0.186	0.575	0.295
11. Ability of pre-hospital first aid	0.104	0.115	0.111	0.905

Shaded areas indicate variables with the highest loads for each factor.

Establishing a Comprehensive Capability Evaluation Model

These 4 common factors reflected the overall level of hospital response capability from different perspectives. The results of the eigenvalue of each common factor divided by the sum of the 4 common factor eigenvalues were taken as the weight to calculate the comprehensive coping ability score. The comprehensive evaluation model was developed as follows: $C = 0.587C1 + 0.151C2 + 0.140C3 + 0.122C4$.

DISCUSSION

Application Value of Evaluation Model

PHEs threatened public health and affect social stability and economic development. Achieving the effective assessment of hospitals response capability for PHE could provide a clear orientation for the construction of health emergency system. In the era of large data, we should establish an objective comprehensive evaluation index system to achieve good management results. Some scholars also used different methods to build evaluation indicators.[9,10] Most of them were based on expert interviews or literature studies, and most of the experts came from health administrative departments or colleges. Their understanding of the hospital's emergency response capabilities was relatively insufficient. And the indicator system did not fully consider the coherence and comprehensiveness of the hospital in responding to a PHE. In this study, the interview was conducted by doctors who worked as a health emergency personnel in the hospital and participated in the rescue work for the PHE. They had a deep understanding of the hospital response capability.

At present, many scholars have tried to build models to assess emergency capability. Some scholars have used the principal

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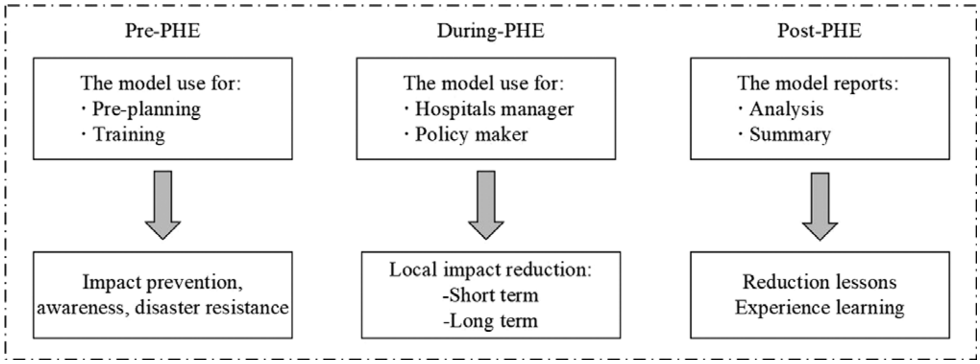
FIGURE 2

The Uses of the Model.



component analysis method to evaluate the emergency response ability of Centers for Disease Control and Prevention (CDC). However, it could not study the internal structure of the variables and examine the rationality of the indicators. Some scholars used the regression analysis method. However, for nonlinear regression, this method presented a significant problem in variable selection. In combination with the neural network method, although it was simple and the variable selection was more scientific, it could not be expressed as an equation model, which results in difficult interpretation. Therefore, it was limited in the field of management evaluation and even variable selection applications.

There were also scholars using the analytic hierarchy process to establish the assessment system,[11] but the calculation process was very complicated, and the problem of subjectively determining the weight has not been changed. The author used the factor analysis method to establish the model, which took into account the relationship between the various variables and the validity of the index analysis. It avoided the problem of variable selection, and objectively determines the weight. The regression model established in this study showed that the hospital should focus on a series of work, such as disease monitoring report, hospital infection control, laboratory testing, and hospital blood management. They contributed to ongoing surveillance and reporting during PHE outbreaks as well as triage and treatment of victims during and after incident.

Furthermore, this showed that critical resources, in terms of medical equipment, staff, medicine, and so on, were vital in the hospital response capability evaluation. Basis preparation ability could support appropriate medical treatment plans for patients in a timely manner. This study examined 89 hospitals' status of response capability for PHE in China by using the proposed evaluation index system and model. They helped in constructing plans and strategies to enhance hospital PHE capacity in the future. Through the model, it indicated that opportunities for improving the hospital response capacity for a PHE should focus, first, on the need for reinforcing supporting infrastructures and surveillance systems.

During and after a PHE, hospitals played the main role of providing health services to people, on time and without any interruption.[12] Figure 2 summarizes the potential uses of the model.

The model concisely yet comprehensively captures the emergency response activities of hospitals. It describes the processes within 3 time periods that can help hospital workers recognize how their daily work fits within an emergency response.[13] It has been positively evaluated for identifying the activities that were required at each stage of responding to a PHE.

This model can lead to sustainable and safe preplanning, in capacity building and in safety planning of facilities. After the PHE, "lessons learned" from evaluations of large-scale PHE may be translated into remedial actions within the structure of this model.

Limitations of the Study

Lacking of Dynamic Research

This study only investigated the status quo of hospital response capability to PHE during 2016. Being a cross-sectional survey, longitudinal investigation should be carried out. The horizontal and vertical research on the emergency capability, which helped reveal the existing problems, was conducive to comprehensive evaluation.

Respondent Reporting Bias

This study used a self-report method, in which the staff may have presented a favorable image of his or her hospital. The results are limited by the respondents' knowledge about specific topic areas. There also may be a tendency to over-exaggerate

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the true response capability; therefore, the hospitals may have been even less prepared than reported here.

CONCLUSIONS

In summary, this study showed the construction of the model to evaluate hospitals' emergency response capability taking 89 hospitals in China as an example. Our study provided a scientific and standardized idea for the construction of hospital emergency response capability to a PHE. Further well-designed studies are needed to strengthen our conclusions.

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Conflict of Interest

The authors declare that they have no competing interests.

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