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Research on the Construction of Resilience Evaluation Index System for Tertiary General Hospitals

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ABSTRACT

Objective: To establish a resilience evaluation index system for tertiary general hospitals, providing scientific support for the dynamic assessment of hospital resilience and the formulation of precise improvement strategies. Methods: The initial draft of the resilience evaluation index system for tertiary general hospitals was constructed using the literature review method. Expert consultation was conducted using the Delphi method to form the final index system, and the weight of each level of indicators was determined using the analytic hierarchy process. Results: Two rounds of expert consultation were conducted, with 15 experts invited to participate. The positive coefficient of experts in both rounds was 100%; the expert authority coefficient Cr was all > 0.850; the coefficient of variation Cv ranged from 0 to 0.1675; the average importance score of the first round consultation was in the range of 3.8 to 5, and after adjustment, the average importance score of the second round consultation was in the range of 4.067 to 5. The final resilience evaluation index system for tertiary general hospitals includes 5 first-level indicators, 16 second-level indicators, and 55 third-level indicators. Conclusion: The resilience evaluation index system for tertiary general hospitals constructed through the Delphi method and the analytic hierarchy process in this study has certain scientificity and reliability, providing a theoretical basis for subsequent hospital resilience construction.

KEYWORDS

Delphi method; Analytic Hierarchy Process; Tertiary general hospital; Hospital resilience; Index system

1. INTRODUCTION

With the acceleration of globalization and urbanization, various infectious diseases and natural disasters have placed tremendous pressure on China's healthcare system. As the core institution for safeguarding public health, hospitals are now facing unprecedented challenges and opportunities [1]. Hospital resilience refers to the comprehensive ability of hospitals to resist, absorb, adapt, transform and recover promptly in the face of emergencies; resilience not only requires hospitals to have the ability to provide high-quality, effective and people-oriented medical services, but also to be able to respond to future novel coronavirus infections (Corona Virus Disease 2019, COVID-19) and other sudden public health events through a comprehensive, flexible and adaptable system [2]. To enhance the resilience of the healthcare service system, China issued the "Opinions on Further Improving the Healthcare Service System" in 2023, clearly stating that by 2035, a resilient integrated healthcare service system should be formed [3]. In hospital management in China, the attention to organizational resilience is still relatively limited, and many hospital managers are unfamiliar with this concept. Efficient and stable hospital operations are crucial for safeguarding public health and social economic stability. Hospitals lacking resilience may lead to public health crises and severe fluctuations in social order. Resilience governance is an upgraded form of governance that responds to the needs of the new era and complex situations. Therefore, enhancing hospital resilience has become an urgent task [4].

2. MATERIALS AND METHODS

2.1. Source of Data

2.1.1. Preliminary Establishment of the Evaluation Index System

The preliminary draft of the resilience evaluation index system for tertiary general hospitals was formulated using the literature review method. Firstly, based on the China National Knowledge Infrastructure (CNKI) and Wanfang Database, using search terms such as "tertiary general hospitals", "hospital resilience", and "index system", the time range was limited to the period from the establishment of the database to July 2025, and relevant literature on hospital resilience was retrieved. Secondly, literature screening was conducted, and the relevant literature that met the theme was summarized and organized to prepare for the establishment of the initial item pool. Finally, based on the principles of scientificity, independence, and operability, discussions and screenings were conducted on the index content, merging related duplicate indicators and deleting indicators that were difficult to obtain, to form a framework and initial indicators suitable for the resilience evaluation index system of tertiary general hospitals.

2.1.2. Final Establishment of the Evaluation Index System

Using the Delphi method, the final version of the resilience evaluation index system for tertiary general hospitals was established. From July to October 2025, experts from universities, tertiary general hospitals and other fields, with intermediate or higher professional titles, were invited for consultation. The inclusion criteria for experts were as follows: ① ≥ 5 years of work experience in related fields; ② Bachelor's degree or above, with intermediate or higher professional titles; ③ Voluntary and fully participating in this research, with high enthusiasm.

This study conducted two rounds of Delphi expert consultations. During the consultation process, the expert questionnaires that had been preliminarily drafted after screening were sent to the experts via email or WeChat, and the experts were asked to evaluate the importance, familiarity and scoring basis of each indicator, and to propose modifications for the indicators. The consultation questionnaire consisted of three parts: questionnaire description, general information survey form for experts, and questionnaire body. In the first round of expert consultation, experts were invited to use the 1-9 scale proposed by Saaty to quantify the judgment matrix of each indicator and fill in the suggestions for item modifications and mark the items that needed to be added in the blank areas. After the first round of expert consultation, the expert opinions were summarized, and relevant items were modified and deleted to form the second round of consultation questionnaire. In the second round of expert consultation, experts were again invited to score the importance of the items and fill in the modification suggestions. After the second round of expert consultation, the questionnaire items were modified again based on the expert opinions. After two rounds of expert consultation, when the expert opinions became consistent, the final version of the resilience evaluation index system for tertiary general hospitals was formed.

2.2. Statistical Analysis

A database was established using Excel 2019 software, and the basic information of experts and their scoring data were entered. Statistical analysis was conducted using SPSS 26.0 software to calculate the expert's positive coefficient, expert authority coefficient, expert opinion concentration degree, and expert opinion coordination degree. The count data were expressed by the number of cases (n) and the composition ratio (%). The Yaahp analytic hierarchy process software was used to construct the judgment matrix and calculate the index weights. The definitions and evaluation criteria of each index are as follows: ① Expert positive coefficient is measured by the effective recovery rate of the questionnaire, and the calculation formula is: Expert positive coefficient = Number of valid recovered questionnaires / Total number of distributed questionnaires × 100%. Generally, a recovery rate of ≥ 70% indicates compliance with the research standards, and the higher the recovery rate, the higher the experts' attention and cooperation to this study. ② Expert authority coefficient (Cr), calculated by the arithmetic mean of the judgment basis coefficient (Ca) and the familiarity coefficient (Cs), is calculated by the formula: Cr = (Ca + Cs) / 2. Ca is calculated based on the experts' self-assessment of practical experience (50%), theoretical basis (30%), references (10%), and intuitive judgment (10%) [5-6]; Cs is calculated based on the experts' familiarity with the field of health communication (converting 1-5 points to 0-1 points). Generally, Cr ≥ 0.70 indicates reliable expert authority. ③ Expert opinion concentration degree is analyzed by the mean score of the index, and the degree of consensus on the importance of the index is indicated by the larger mean value. ④ Expert opinion coordination degree is quantified by the coefficient of variation (Cv), and the calculation formula is: Cv = Standard deviation / Mean [7]. Generally, a screening standard of Cv < 0.25 is used, and the smaller the Cv, the better the coordination of expert opinions. ⑤ Index weight assignment is based on the Analytic Hierarchical Process (AHP). Using the Yaahp software, a 1-9 scale judgment matrix is constructed, and the eigenvector and the maximum eigenvalue are calculated through the pairwise comparison method. Consistency ratio (CR) < 0.1 indicates passing the test, and the weights of each level of indicators are finally determined.

3. RESULTS

3.1. Basic Information of Experts

A total of 15 experts were included in this study for consultation, mainly from hospitals and universities. The gender ratio, the ratio of master's and doctoral degrees, and the ratio of senior and junior professional titles of the experts were all around 50%. The age distribution was that the number of experts in the 41-50 age group and the 51-60 age group accounted for the largest proportion (13 people, 86.67%). The experts' professional fields were diverse, and most of them had research in 2-3 professional fields. Over 80% of the experts were engaged in health management or health policy research. All 15 experts had worked in their professional fields for more than 10 years.

3.2. Expert Engagement Level

This is reflected by the expert participation coefficient (i.e., the effective response rate of the questionnaires) and the rate of expert suggestions provided. In the two rounds of consultation, 15 expert consultation questionnaires were distributed in each round, and all were effectively recovered. The expert participation coefficient was 100%. In the first round of consultation, there were 13 experts providing suggestions, and the expert suggestion rate was 86.67%. In the second round of consultation, there were 5 experts providing suggestions, and the expert suggestion rate was 33%. The expert participation coefficient was 100% in both rounds. The expert suggestion rate in the first round exceeded 85%, indicating that the experts attached great importance to this research and provided active support and suggestions.

3.3. Expert Authority Coefficient

The expert authority coefficient (Cr) = (Judgment basis Ca + Familiarity degree Cs) / 2. After calculation, in this study, the judgment basis Ca = 0.95, the familiarity degree Cs = 0.86, and the expert authority coefficient Cr = 0.91. This indicates that the expert's authority level is relatively high and the expert's consultation results are relatively reliable.

3.4. Degree of Expert Opinion Coordination

In the first round of expert consultation, the Cv range for all indicators was 0 to 0.203, all of which were less than 0.25. The expert's written opinions suggested retaining the first-level indicators and proposed modifications for the second-level and third-level indicators. After adjustment, in the second round of expert consultation, the Cv range for all indicators was 0 to 0.167.

3.5. Expert Consultation Results

In the first round of expert consultation, the experts believed that the framework of the indicator system was clear. Based on the written opinions, some indicators were merged, the expressions were adjusted, and some were added or reduced. A total of 1 indicator was deleted, 15 indicators' expressions were adjusted, and 3 indicators were combined into 2 indicators. A three-level comprehensive hospital resilience indicator system consisting of 5 first-level indicators, 16 second-level indicators and 55 third-level indicators was formed. In the second round of consultation, the opinions of all experts tended to be consistent. They basically reached an agreement on the indicator framework and indicator content, and no indicators were deleted.

3.6. Determination of Index Weights

After two rounds of expert consultation, the final evaluation index system for the resilience of tertiary general hospitals consists of 5 first-level indicators, 16 second-level indicators and 55 third-level indicators. The specific contents and weights of the indicators are shown in the table (Table 1).

Table 1. The resilience evaluation index system and weight for tertiary general hospitals

Primary indicator	Secondary indicator	Weight	Combination weight	Third-level indicators	Weight	Combination weight
A1 Core Medical Service Resilience (0.3794)	B1 Critical service scenario guarantee	0.1111	0.0422	C1 Outpatient and emergency service guarantee	0.3674	0.0155
				C2 Surgical service guarantee	0.3674	0.0155
				C3 Medical technical service support	0.0566	0.0024
				C4 Intensive care services are stable	0.1257	0.0053
				C5 Special Population Service Assurance	0.0829	0.0035
	B2 Medical process service adaptation	0.4444	0.1686	C6 Efficiency of emergency patient transfer	0.1335	0.0225
				C7 Medical staff respond collaboratively across disciplines and departments	0.2111	0.0356
				C8 Emergency adjustment of service process	0.6554	0.1105
	B3 Medical emergency response capability	0.4444	0.1686	C9 Emergency mechanism construction	0.0967	0.0163
				C10 Multidisciplinary skills reserve for medical staff	0.1910	0.0322
				C11 Medical emergency response speed	0.3974	0.0670
				C12 Dynamic Adaptation of Medical Staff Resources	0.3149	0.0530
A2 Building and Infrastructure Resilience (0.1997)	B4 Structural Disaster Resistance Safety Assessment and Management Mechanism	0.1998	0.0399	C13 Compliance of structural design	0.4436	0.0177
				C14 Building material compliance	0.4436	0.0177
				C15 Structural Safety Dynamic Assessment	0.1102	0.0044
	B5 Infrastructure emergency operation and maintenance	0.6004	0.1199	C16 Core facility repair timeliness	0.1977	0.0237
				C17 Improve resource security level	0.3118	0.0374
				C18 Preventive maintenance of infrastructure	0.4904	0.0588

Continued Table 1 The resilience evaluation index system and weight for tertiary general hospitals

	B6 The adaptability and conversion capability of medical spaces in emergency situations	0.1998	0.0399	C19 Functional expansion redundancy	0.1429	0.0057
				C20 The efficiency of rapid functional transformation of medical spaces in emergency situations	0.3333	0.0133
				C21 Design for protection and safety guarantee of the key medical functional area	0.5263	0.0210
A3 Resource reserve and allocation resilience (0.0660)	B7 Emergency material reserve management	0.4606	0.0304	C22 Redundant procurement channels for materials	0.3322	0.0101
				C23 Material reserve quota met the standard	0.3322	0.0101
				C24 Supply chain risk management	0.1678	0.0051
				C25 Material shortage warning	0.1678	0.0051
	B8 Emergency maintenance and allocation capabilities of medical equipment	0.2727	0.0180	C26 Critical medical equipment redundancy configuration	0.0778	0.0014
				C27 Equipment preventive maintenance	0.1611	0.0029
				C28 Equipment emergency dispatch	0.3167	0.0057
				C29 The feasibility of emergency allocation of medical equipment within the region	0.4445	0.0080
	B9 Human resources reserve and allocation	0.1803	0.0119	C30 Emergency human resource reserve team	0.3025	0.0036
				C31 Personnel cross-departmental transfer	0.3025	0.0036
				C32 Emergency coordination of external professional medical personnel	0.0925	0.0011
				C33 Human resources logistical support	0.3025	0.0036
	B10 External medical and social resource collaborative linkage mechanism	0.0879	0.0058	C34 Collaborative response by government and enterprises	0.1896	0.0011

Continued Table 2 The resilience evaluation index system and weight for tertiary general hospitals

				C35 Social force mobilization	0.4826	0.0028
				C36 Collaboration of peer resources	0.3103	0.0018
A4 Information System Resilience (0.0801)	B11 Information collection and sharing	0.4444	0.0356	C37 Real-time information collection	0.3118	0.0111
				C38 Cross-departmental information sharing	0.1966	0.0070
				C39 Stability of information transmission	0.4916	0.0175
	B12 Key information system operation guarantee and disaster recovery capability	0.1111	0.0089	C40 The stable operation capability of the information system under high load conditions	0.3371	0.0030
				C41 Core medical data disaster recovery backup and restoration	0.5731	0.0051
				C42 System failure recovery	0.1011	0.0009
	B13 Information Security Protection	0.4444	0.0356	C43 Data security protection	0.3118	0.0111
				C44 System security protection	0.1966	0.0070
				C45 Security incident handling	0.4916	0.0175
A5 Emergency management resilience (0.2748)	B14 Emergency mechanism construction	0.3202	0.0880	C46 The emergency plan is complete	0.1977	0.1740
				C47 Emergency drill is underway	0.4910	0.04320
				C48 Post-disaster recovery assessment	0.3114	0.0274
	B15 Emergency Decision-Making and Execution	0.5571	0.1530	C49 Crisis prediction and assessment	0.3508	0.0536
				C50 Emergency Command and Decision-Making	0.1091	0.0167
				C51 Decision implementation feedback	0.1894	0.0537
				C52 The timeliness of authoritative information release during emergencies	0.3508	0.0537
	B16 Crisis communication, information release and public opinion response capabilities	0.1226	0.0337	C53 Medical patient communication service	0.1630	0.0055
				C54 The ability to monitor and respond to public opinion during emergencies	0.2968	0.0100
				C55 Post-disaster public relations recovery	0.5402	0.0180

4. DISCUSSION

This study constructed the initial draft of the resilience evaluation index system for tertiary general hospitals through the literature review method. Then, the Delphi method and analytic hierarchy process were used to revise the initial draft, resulting in a three-level comprehensive hospital resilience evaluation index system consisting of 5 first-level indicators, 16 second-level indicators, and 55 third-level indicators, and determining the weights of each level of indicators.

This study conducted 2 rounds of Delphi expert consultations. The results showed that the expert active coefficient in both rounds was 100%, significantly > 70%, indicating that the research topic was highly attractive and the process design was highly effective. The expert authority coefficient was 0.90, indicating that the three-level comprehensive hospital resilience evaluation index system established in this study was scientific and reliable. In terms of the concentration of expert opinions, the mean value of importance scores remained stable, indicating that the index system was optimized successfully and the expert opinions were highly consistent. In terms of the coordination degree of expert opinions, the Cv value was always < 0.25. In conclusion, it can be considered that the three-level comprehensive hospital resilience evaluation index system constructed in this study is of great significance. Firstly, when constructing the index system, using the combined weighting strategy of the Delphi method and analytic hierarchy process helps to avoid the randomness of subjective weighting, and at the same time, through expert consultation, the possible theoretical deviations in the literature analysis can be corrected. By constructing the hospital resilience indicators, it can improve the hardware, software and institutional construction level of the hospital, enhance the hospital's resilience, and ensure the continuous and stable supply of medical services in complex situations [8]. Secondly, by constructing this evaluation index system, it not only provides guidance for the improvement of the resilience of tertiary general hospitals, but also promotes hospitals to better carry out resilience improvement work [9]. In addition, the construction of this evaluation index system also helps to optimize medical service quality, enhance the hospital's social influence, and help the hospital form unique advantages [10].

DECLARATION OF COMPETING INTEREST

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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