Scientific and Social Research, 2024, Volume 6, Issue 6
https://ojs.bbwpublisher.com/index.php/SSR

Construction of a Monitoring Ability Evaluation Indicator System for Emerging Diseases

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Abstract: *Objective*: To construct a monitoring ability evaluation indicator system for emerging infectious diseases. *Methods*: This study adopted two rounds of expert consultation among 11 senior public health professionals using the Delphi method and the analytic hierarchy process (AHP) to determine the indicators and their weight coefficients. *Results*: The experts were aged 45.18 ± 8.44 years and had worked for 20.45 ± 9.97 years. All had a bachelor's degree or above. The expert active coefficients for both rounds of consultation were 100%. The coefficient of expert authority was 0.861, and the coefficient of expert coordination was 0.4 for the first and second rounds of consultation ($P < 0.01$). After two rounds of expert consultation, the constructed monitoring ability evaluation indicator system consisted of 5 first-level indicators, 17 second-level indicators, and 45 third-level indicators. The five first-level indicators were epidemic discovery ability, epidemic report ability, laboratory testing ability, monitoring system operation guarantee, and comprehensive personnel ability. The top five secondary indicators were timely identification of infected persons, epidemic report time, timely laboratory testing, normalized monitoring ability, and funding. The maximum eigenvector (λ_{max}) was 5.069, the consistency index (CI) was 0.017, the consistency ratio (CR) was 0.016, and CR < 0.1. *Conclusion*: The evaluation index system for monitoring the capability of emerging infectious diseases has scientific validity and rationality, and it can be used to evaluate the monitoring capability of emerging infectious diseases.

Keywords: Emerging infectious diseases; Monitoring ability evaluation index system; Delphi method; Analytic hierarchy process

Online publication: July 9, 2024

1. Introduction

Emerging infectious diseases are new types of infections resistant to drugs. They are characterized by rapid transmission, a wide range, high morbidity, and high mortality. These diseases are prone to cause social panic, seriously affecting social stability and economic development, and bringing significant challenges to the public health system in the epidemic areas [1–2]. After SARS, the development of China's infectious disease monitoring system entered a new stage, leading to the establishment of a nationwide monitoring system. This system includes a statutory infectious disease epidemic monitoring and reporting system as the main body, supplemented by a key infectious disease monitoring system [3–4].

Few studies have focused on evaluating the monitoring capabilities of emerging infectious diseases, both domestically and internationally. This scarcity is due to the research still being in the exploratory stage. The previous monitoring models need to be improved and adjusted before they can be applied to emerging infectious diseases. Based on the actual needs of emerging infectious disease prevention and control, this study explores constructing an evaluation index system for monitoring capabilities through the Delphi and hierarchical analysis methods. It aims to form a comprehensive evaluation model for monitoring capabilities, providing a reference for the scientific, standardized, and effective prevention and control of emerging infectious diseases.

2. Materials and methods

2.1. Expert information

A total of 11 experts participated in this study. They worked in health administrative departments, disease prevention and control centers, colleges and universities, and medical institutions. The average age was 45.18 ± 8.44 years. All had more than 10 years of work experience in infectious disease prevention and control, with an average professional experience of 20.45 ± 9.97 years. The group included 4 chief physicians, 1 chief technician, 1 professor, and 5 deputy chief physicians. All experts held a bachelor's degree or above, with 8 holding master's or doctoral degrees. Eight experts specialized in infectious disease prevention and control, 2 in health administrative management, and 1 in health emergency management.

2.2. Delphi expert consultation method

A questionnaire preparation team with 4 members was established for this study. Based on the work plan, literature, and previous research results, combined with group discussions and in-depth interviews with experts, the team listed possible evaluation dimensions and indicators. These were compiled into questionnaires and distributed to experts by delivery or email. The experts rated the feasibility and importance of the indicators on a 5-level scale and modified or supplemented the indicators, ultimately forming an emerging infectious disease surveillance capability evaluation indicator system.

2.3. Observation indicators

The positive coefficient of expert consultation is the questionnaire recovery rate. The authority coefficient of expert consultation (Cr) is calculated as (judgment basis coefficient Ca + familiarity coefficient Cs) ÷ 2. The degree of coordination of expert opinions is expressed by the coefficient of variation (CV), which is the standard deviation of each indicator ÷ mean value, and the Kendall coordination coefficient (W) [5].

2.4. Indicator selection criteria

Indicators were retained if the mean comprehensive score was greater than 3.0, the CV was less than 0.25, and in combination with expert opinions.

2.5. Analytical hierarchy process (AHP)

Based on the Delphi expert consultation results, this study calculated the weights of indicators at all levels using the Mysore AHP software [6]. A three-layer structure model for evaluating indicators of emerging infectious disease surveillance capabilities was established.

2.6. Statistical analysis

Excel 2019 and SPSS 19.0 software were used for data statistical analysis. The hierarchical analysis method (AHP) V1.82 software was used to construct the hierarchical structure of the emerging infectious disease surveillance capability indicator system and analyze the indicator weights.

3. Results

3.1. Expert positivity coefficient

Eleven questionnaires were distributed in both the first and second rounds of expert consultation, achieving a 100% response rate.

3.2. Expert authority coefficient

In this study, Ca = 0.927, Cs = 0.795, and Cr = 0.861. The authority coefficients of each expert are shown in **Table 1**.

Table 1. The authority of the 11 experts

Expert No.	Judgments based				Ca	Cs	Cr
	Experience	Theoretical analysis	References to domestic and foreign literature	Intuition			
1	0.500	0.200	0.100	0.100	0.900	0.750	0.825
2	0.400	0.100	0.100	0.100	0.700	0.500	0.600
3	0.500	0.200	0.100	0.100	0.900	0.750	0.825
4	0.500	0.300	0.100	0.100	1.000	1.000	1.000
5	0.500	0.300	0.100	0.100	1.000	1.000	1.000
6	0.500	0.200	0.100	0.100	0.900	0.750	0.825
7	0.500	0.200	0.100	0.100	0.900	0.750	0.825
8	0.500	0.300	0.100	0.100	1.000	1.000	1.000
9	0.500	0.200	0.100	0.100	0.900	0.500	0.700
10	0.500	0.300	0.100	0.100	1.000	1.000	1.000
11	0.500	0.300	0.100	0.100	1.000	0.750	0.875
Average	0.491	0.236	0.100	0.100	0.927	0.795	0.861

3.3. Expert coordination coefficient

The coordination coefficients for the first and second rounds of expert consultation were both 0.4, with χ^2 values of 222.83 and 220.56, respectively, and a *P* value < 0.001. This indicates that the experts' opinions tended to be consistent.

3.4. Determining the evaluation index system

The first round of consultation questionnaires was conducted to assess the "emerging infectious disease monitoring capability." It included 5 first-level indicators, 23 second-level indicators, and 51 third-level indicators, covering "epidemic detection capability," "epidemic reporting capability," "laboratory detection capability," "comprehensive personnel capability," and "monitoring system operation guarantee." The results of the first round of expert consultation analysis showed that the CV of 21 indicators was greater than 0.25, and the average value of 4 indicators was less than 3, which did not meet the indicator selection criteria. According to expert consultation and feedback results, these 25 indicators that did not meet the selection criteria were deleted. Simultaneously, expert opinions were incorporated, and 18 new indicators were added, forming a new questionnaire with 72 indicators for the second round of expert consultation. The results of the second round showed that the CV of 5 indicators was greater than 0.25, which did not meet the selection criteria, while the CV of 67 indicators ranged between 0.061 and 0.23, indicating consistency and reliability in the experts' evaluations. Ultimately, an evaluation indicator system for monitoring the capability of emerging infectious diseases with 5 first-level indicators, 17 second-level indicators, and 45 third-level indicators was established.

3.5. Modeling a hierarchy

This study considers "emerging infectious disease surveillance capability" as the decision-making target, with five first-level indicators: "epidemic detection capability," "epidemic reporting capability," "laboratory testing capability," "surveillance system operation guarantee," and "comprehensive personnel capability." The 17 second-level indicators include "timely detection of infected persons," "location of infected persons," "routine monitoring capability," "epidemic reporting time," "epidemic reporting agency," "epidemic reporting channel," "epidemic reporting quality," "laboratory category," "selection of laboratory testing reagents," "timely laboratory testing," "professional," "technical title," "training status," "supervision status," "system and mechanism," "funding," and "system platform and equipment." The bottom-level elements comprise 45 third-level indicators. The hierarchical structure model was constructed using the MySite AHP V1.82 hierarchical analysis software, as shown in **Figure 1**.

3.6. Index system weight analysis

The second round of expert consultation scores were input into the AHP V1.82 hierarchical analysis software, and the original weight matrix was calculated. After automatic correction by the AHP V1.82 software, the output results were $\lambda_{max} = 5.069$, CI = 0.017, and CR = 0.016. Since CR < 0.1, it indicates that the expert evaluation was consistent. Thus, this study successfully constructed an evaluation index system for the surveillance capacity of emerging infectious diseases using the Delphi and hierarchical analysis methods. The specific indicators are shown in **Table 2**.

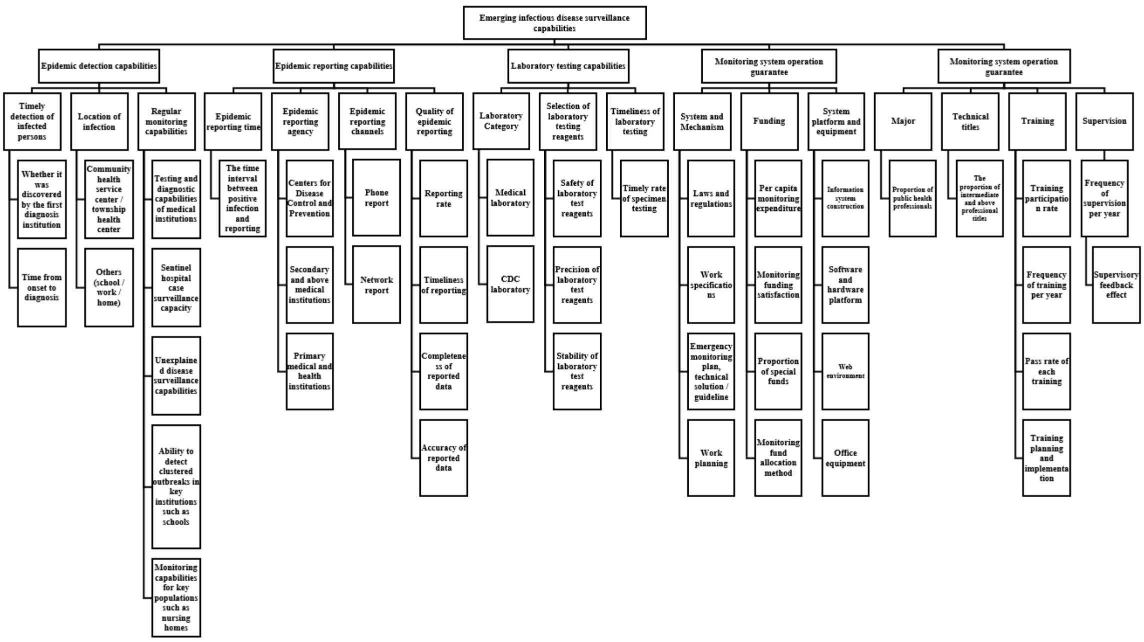

Figure 1. Hierarchical model of emerging infectious disease surveillance capabilities

Table 2. Weights of evaluation indicators for emerging infectious disease surveillance capabilities (N = 11)

First level indicator	Weights	Secondary indicators	Peer weight	Global weight	Level 3 indicators	Peer weight	Global weight
Epidemic detection capabilities	0.337	Timely detection of infected persons	0.643	0.217	Whether the first diagnosis institution discovered it	0.203	0.044
					Time from onset to diagnosis	0.797	0.172
		Location of infection	0.119	0.04	Community health service center/township health center	0.203	0.008
					Others (school/work/home)	0.797	0.032
		Regular monitoring capabilities	0.238	0.08	Testing and diagnostic capabilities of medical institutions	0.2	0.016
					Sentinel hospital case surveillance capacity	0.201	0.016
					Unexplained disease surveillance capabilities	0.2	0.016
					Ability to detect clustered outbreaks in key institutions such as schools	0.2	0.016
					Monitoring capabilities for key populations such as nursing homes	0.2	0.016
Epidemic reporting capabilities	0.214	Epidemic reporting time	0.477	0.102	The time interval between positive infection and reporting	1	0.102
		Epidemic reporting agency	0.128	0.027	Centers for Disease Control and Prevention	0.332	0.009
					Secondary and above medical institutions	0.335	0.009
					Primary medical and health institutions	0.334	0.009
		Epidemic reporting channels	0.135	0.0299	Phone report	0.203	0.006
					Network report	0.797	0.023
		Quality of epidemic reporting	0.26	0.055	Reporting rate	0.249	0.014
					Timeliness of reporting	0.251	0.014
					Completeness of reported data	0.251	0.014
					Accuracy of reported data	0.25	0.014
Laboratory testing capabilities	0.168	Laboratory category	0.292	0.049	Medical laboratory	0.203	0.01
					CDC laboratory	0.797	0.039
		Selection of laboratory testing reagents	0.194	0.033	Safety of laboratory test reagents	0.332	0.011
					Precision of laboratory test reagents	0.335	0.011
					Stability of laboratory test reagents	0.334	0.011
		Timeliness of laboratory testing	0.514	0.086	Timely rate of specimen testing	1	0.086
Comprehensive ability of personnel	0.134	Profession	0.402	0.054	Proportion of public health professionals	1	0.054
		Technical titles	0.12	0.016	The proportion of intermediate and above professional titles	1	0.012
		Training	0.329	0.044	Training participation rate	0.249	0.011
					Frequency of training per year	0.251	0.011
					The pass rate of each training	0.251	0.011
					Training planning and implementation	0.25	0.011
		Supervision	0.15	0.02	Frequency of supervision per year	0.203	0.004
					Supervisory feedback effect	0.797	0.016

Table 1 (Continued)

First level indicator	Weights	Secondary indicators	Peer weight	Global weight	Level 3 indicators	Peer weight	Global weight
Monitoring system operation guarantee	0.148	System and mechanism	0.377	0.056	Laws and regulations	0.249	0.014
					Work specifications	0.251	0.014
					Emergency monitoring plan, technical solution/guideline	0.251	0.014
					Work planning	0.25	0.014
		Funding	0.39	0.058	Per capita monitoring expenditure	0.249	0.014
					Monitoring funding satisfaction	0.251	0.015
					Proportion of special funds	0.251	0.015
					Monitoring fund allocation method	0.25	0.014
		System platform and equipment	0.233	0.031	Information system construction	0.249	0.009
					Software and hardware platform	0.251	0.009
					Web environment	0.251	0.009
					Office equipment	0.25	0.009

4. Discussion

The quality of the emerging infectious disease surveillance system is directly related to the strength of epidemic prevention and control capabilities. It determines whether the public health goal of effectively controlling infectious disease outbreaks can be achieved [7–10]. Studies have shown that public health intervention measures during the COVID-19 epidemic are effective in preventing and controlling COVID-19 and other infectious diseases [11]. Therefore, it is necessary to construct evaluation indicators for the monitoring capability system of emerging infectious diseases, such as COVID-19, to improve work efficiency and cost-effectiveness, thus strengthening the monitoring function system.

This study constructs an evaluation index system for the monitoring capability of emerging infectious diseases based on the Delphi method and the analytic hierarchy process (AHP). It transforms the subjective risk analysis method into an objective evaluation method and establishes an objective monitoring capability indicator system through scientific statistical and analytical methods, which have certain scientific validity and rationality.

In this study, 11 experts working in public health fields, such as health administration, health emergency management, and infectious disease prevention and control, were selected for expert consultation. The effective recovery rate of the two rounds of expert consultation questionnaires was higher than 70%, meeting the requirements of the Delphi method for statistical analysis [12]. The Cr of this study was ≥ 0.7, indicating that the experts had a high degree of authority [13]. The coordination coefficient of the two rounds of expert consultation was 0.4, showing consistency in the experts' opinions. The emerging infectious disease surveillance capability evaluation index system compiled in this study includes 5 first-level indicators, 17 second-level indicators, and 45 third-level indicators.

Among the 5 first-level indicators, "epidemic detection capability" has the highest weight (0.337), followed by "epidemic reporting capability," "laboratory detection capability," "surveillance system operation guarantee," and "comprehensive personnel capability," with weights of 0.214, 0.168, 0.145, and 0.134, respectively. This result shows that experts unanimously believe that "epidemic detection capability" plays the most significant role in the emerging infectious disease surveillance capability index system, consistent with relevant research results, which have shown that early detection and preparation can quickly and effectively control emerging infectious diseases [14–16].

From the perspective of global weight among the 17 secondary indicators, the top five are "timely detection of infected persons," "epidemic reporting time," "laboratory testing time," "normalized monitoring capability," and "funding." "Timely detection of infected persons" has the largest weight (0.217), indicating that timely detection is essential for monitoring emerging infectious diseases and is the basic premise for the healthy operation of epidemic monitoring. The second is "epidemic reporting time," with a weight of 0.102. Studies have shown that timely verification and reporting of epidemic-related information can help win valuable time to prevent the potential spread of the epidemic [17]. Ranked third is "laboratory testing time," weighing 0.086. "Laboratory testing time" is a basic requirement for monitoring emerging infectious diseases and is crucial for detecting infected persons and controlling the source of infection promptly [18]. Ranked fourth and fifth are "normalized monitoring capability" and "funding," with weights of 0.080 and 0.058, respectively. "Normalized monitoring capabilities" are important in epidemic prevention and control. Strengthening epidemic monitoring positively affects the prevention and control of infectious diseases, improves the timeliness and accuracy of reporting, and enhances the quality and efficiency of prevention and control [19]. The proportion of "funding" reflects the country's attention and support for emerging infectious disease monitoring. Adequate funding guarantees the basic operation of epidemic monitoring, making it easier to achieve the goal of controlling emerging infectious diseases [20].

Among the 45 third-level indicators, from the perspective of global weight, the first one is "the time from onset to diagnosis," with a weight of 0.172; the second one is "the time interval from positive infection to reporting," with a weight of 0.102; the third one is "the timeliness of specimen detection," with a weight of 0.086; the fourth one is "the proportion of public health-related professionals," with a weight of 0.054; and the fifth one is "whether it is discovered by the first diagnosis institution," with a weight of 0.044. The secondary indicators corresponding to these five indicators are "timeliness of infection discovery," "epidemic report time," "timeliness of laboratory detection," "professional," and "timeliness of infection discovery," which are consistent with the ranking of the secondary indicators.

Based on the comprehensive consideration of the feasibility and importance of the indicators, this study established a three-level indicator system through the Delphi method and the AHP. The final selected epidemic monitoring capacity indicators have clear concepts and can be quickly obtained through current technical means. They are highly operational and can provide a scientific basis and reference for preventing and controlling emerging infectious diseases. This study is subjective to a certain extent and needs to be tested in clinical practice for its reliability and validity. It will be further optimized and improved according to the changes in emerging infectious diseases.

Funding

Preliminary construction of evaluation indicators for monitoring capacity of novel coronavirus pneumonia in Banan District (2021-58)

Disclosure statement

The authors declare no conflict of interest.

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