Preplanned Studies

Construction of a Competency Evaluation Indicator System for Emergency Response Staff in Disease Control and Prevention Institutions — China, 2023

Zhaohe Li[1,2,&]; Xijiang Wang[3,&]; Wenqing Bai[1,2]; Haoliang Liu[1,2,4]; Yue Gu[1,2]; Jiayi Zhang[1,2]; Huimin Li[1,2,4]; Hongtao Wu[1,2]; Ruiqi Ren[1,2]; Chao Li[1,2]; Qi Wang[1,2]; Zainawudong Yushan[5,#]; Lei Zhou[1,2,#]

Summary

What is already known about this topic?

Currently, there is no established scientific standard to guide disease control and prevention organizations in the selection of emergency response personnel. Given the growing risk of significant infectious disease outbreaks, it is imperative to develop an evaluation system for assessing emergency response capabilities.

What is added by this report?

Drawing from competency theory, this study developed an assessment framework for evaluating the emergency response capabilities of staff at disease control and prevention institutions focused on major infectious diseases. Utilizing the Delphi method, the framework comprises 4 first-level indicators: *Knowledge base, Professional skills, Personal qualities, Personality and Motivation*. Further, it includes 10 second-level and 46 third-level indicators. The reliability and validity of this evaluation system were examined through a questionnaire survey. The results show that the indicator system has good reliability, acceptable discriminant and convergent validity, and that competency can be evaluated scientifically.

What are the implications for public health practice?

The system provides an efficient tool for selecting and organizing emergency personnel for response tasks, thereby enhancing the CDC staff's capacity for emergency management.

With increasing complexity in natural and social environments, the frequency of emerging and re-emerging infectious diseases and public health emergencies have risen. Recent outbreaks of H1N1 influenza, H7N9 influenza, coronavirus disease 2019 (COVID-19), and monkeypox (Mpox) exemplify this trend, underscoring the need for rapid, high-quality emergency responses (*1*). This situation necessitates enhancing emergency response capacity and improving disease control and prevention systems to ensure high-quality development. During major public health crises like pandemics, challenges often include inefficient organization of health emergency personnel, mismatches between job roles and professional skills sets, and suboptimal emergency response outcomes (*2*–*3*). Effective health emergency response management thus requires a comprehensive understanding of emergency staff capabilities to maximize individual and team effectiveness. Currently, a comprehensive, systematic, and scientific set of evaluation criteria or indicators for assessing the competency of health emergency staff, particularly those in disease control and prevention during significant infectious disease outbreaks, is lacking. This paper proposes using the Delphi method, informed by past experiences with infectious disease epidemics and public health emergencies, to develop a competency evaluation system for emergency response personnel in disease control and prevention institutions. This system aims to enhance health emergency management and contribute to developing a skilled workforce within the disease control and prevention system.

This study employed a two-round Delphi method to solicit expert consultations. Experts were eligible if they possessed at least an associate senior title or higher, a master's degree or higher, and a minimum of 5 years of experience in fields such as epidemic prevention, emergency response, health policy, health management, and infectious disease epidemiology theory and practice. Following established Delphi method guidelines and computational approaches (*4*–*5*), the study aimed to recruit 50 experts. Qualitative methods, including literature reviews and interviews, informed the development of an initial competency indicator system and a subsequent expert consultation questionnaire. The questionnaire encompassed aspects such as the theoretical foundation, framework description of the indicator system, assessment of each indicator, experts' basic information, and evaluations of familiarity with and authority over the questionnaire. Indicator screening in each consultation phase employed the boundary value method (*6*). Indicators not meeting the boundary criteria were reviewed by the research group, and decisions regarding inclusion were made based on expert feedback and research group deliberations. Valid expert recommendations were incorporated, resulting in indicator modifications (Supplementary Figure S1, available at https://weekly.chinacdc.cn/).

To determine whether the system could serve as a competency evaluation tool, an empirical study was conducted using a questionnaire survey scale. Cronbach's α coefficient reliability testing, confirmatory factor analysis (CFA), and convergent and discriminant validity testing were performed.

Data entry and cleaning were performed using Excel (Microsoft Office Home and Student Edition 2016, Microsoft Corporation, Redmond, USA). The expert authority coefficient, degree of concentration, and coefficient of variation (CV) for expert opinions were calculated, along with indicator screening in the Delphi method. Discriminant and convergent validity were assessed through empirical research. SPSS software (version 26.0, IBM, Armonk, NY, USA) was used to analyze the expert coordination coefficient and consultation reliability within the Delphi method, followed by calculating Cronbach's α coefficient for the empirical research. CFA was conducted using R software (version 4.2.3, R Core Team, Vienna, Austria). The significance level was set at $\alpha \leq 0.05$.

This study developed an indicator pool to evaluate the competency of emergency response staff in disease control and prevention institutions. This pool was established by synthesizing indicators from relevant literature and conducting qualitative interviews with professionals. The organizational framework of the pool was structured based on epidemiological investigations and emergency response processes in China (*7*) and the McClellan competency dictionary. This process created a preliminary competency evaluation indicator system, including 4 first-level indicators, 10 second-level indicators, and 47 third-level indicators (Table 1). These indicators generated the first-round questionnaire for the Delphi consultation.

In the initial consultation round, 48 of 50 distributed questionnaires were effectively completed, representing a 96% response rate. The participating experts were highly qualified, possessing extensive experience in disease prevention and control, emergency response, and epidemiological investigations. Of these experts, 97.92% had experience managing significant infectious disease outbreaks. The distribution of experts was relatively even across regions: 24.32% from eastern, 29.73% from central, and 32.43% from western provincial-level administrative divisions (PLADs). Additionally, 64.58% of experts held a master's degree or higher, 77.08% held at least an associate senior title, and 93.75% had over 10 years of professional experience (Supplementary Table S1, available at https://weekly.chinacdc.cn/). In the subsequent round, the same 48 experts were consulted, yielding 45 effective responses.

Statistical analysis showed that the CVs for the importance scores in the first and second consultation rounds were 0.123 and 0.109, respectively, with the lower CV in the second round indicating increased consensus among experts regarding the indicators. The reliability of the expert consultations across both rounds was high, with Cronbach's α values of 0.957 and 0.948, respectively, both exceeding the threshold of 0.7, suggesting good internal consistency among expert opinions. During initial consultation, the coordination coefficients for the first, second, and third-level indicators were 0.354, 0.400, and 0.201, respectively; in the subsequent round, these values were 0.394, 0.353, and 0.160, respectively. All coefficients reached statistical significance at $P<0.001$, indicating consistent expert opinions across the two rounds and effective coordination of opinions. However, a decrease in the coordination coefficients for the second- and third-level indicators in the second round prompted further investigation. Analysis revealed that 16 experts assigned scores of 3 or lower to eight indicators, including variables like *Environmental and food hygiene*, *Other basic medical knowledge*, *Recent research updates*, *humanistic adaptability*, *Good at innovation*, *Self-directed learning*, *Job recognition*, and *motivation for achievement*. The coordination coefficient for these scores was 0.258 with a notable coordination point (*4*). Consequently, follow-up telephone interviews with these 16 experts revealed that their assessments reflected the current situation and showed a minimal requirement for capability enhancement. In contrast, the remaining 29 experts displayed greater anticipation for future skill development. The research team decided to adopt the perspective of the latter group.

The initial consultation phase yielded average

TABLE 1. Development and modification of the competency evaluation indicator system for emergency response staff in disease control and prevention institutions.

Preliminary indicator system	Indicator system after the 2nd-round (final)
A1 Knowledge structure	A1 Knowledge base
B1 Professional knowledge	B1 Professional knowledge
C1 Field epidemiology	C1 Epidemiology
C2 Health statistics	C2 Health statistics
C3 Lemology	C3 Lemology
C4 Pathogeny microbiology	C4 Pathogeny microbiology
C5 Fundamentals of clinical medicine	C5 Environmental and food hygiene
C6 Recent research updates	C6 Other basic medical knowledge
	C7 Recent research updates
B2 Criteria and standards	B2 Criteria and standards
C7 Legal documents	C8 Legal documents
C8 Administrative regulations	C9 Administrative regulations
C9 Normative documents	C10 Normative documents
A2 Professional skills	A2 Professional skills
B3 Field investigation	B3 Field investigation
C10 Preparation for investigation	C11 Preparation for investigation
C11 Personal protection	C12 Personal protection
C12 Epidemiological investigation	C13 Case investigation
C13 Test results Interpretation	C14 Hygienic investigation
C14 Sample-sampling and delivery	C15 Sampling and delivery
C15 Field prevention and control	C16 Test result interpretation
	C17 Field prevention and control
B4 Information processing	B4 Information processing
C16 Use of system	C18 Use of information systems
C17 Report and feedback	C19 Data administration
C18 data administration	C20 Use of statistical software
C19 Use of statistical software	C21 Report writing
C20 Analysis chart-making	
C21 Induction and expression	
B5 Analysis and judgment	B5 Analysis and judgment
C22 Sorting out transmission chains	C22 Sorting out transmission chains
C23 Inferring the Source of Infection	C23 Inferring the Source of Infection
C24 Epidemic trend analysis	C24 Epidemic trend analysis
C25 Risk judgment	C25 Risk assessment
C26 Risk assessment	
A3 Personal qualities	A3 Personal qualities
B6 Professional qualities	B6 Professional qualities
C27 Adaptability	C26 Adaptability to position
C28 Risk identification ability	C27 Humanistic adaptability
C29 Systems thinking ability	C28 Systems thinking ability
C30 Environmental awareness ability	C29 Ability to detect problems

Continued

Preliminary indicator system	Indicator system after the 2nd-round (final)
C31 Stress tolerance	
B7 Comprehensive qualities	B7 Comprehensive qualities
C32 Physical quality	C30 Physical quality
C33 Interpersonal communication ability	C31 Stress tolerance
C34 Execution	C32 Communication and coordination ability
C35 Comprehension	C33 Execution
C36 Team working	C34 Comprehension
C37 Presentation	C35 Team working
	C36 Presentation
B8 Attitudes and values	B8 Attitudes and values
C38 Vision of overall situation	C37 Overall consciousness
C39 Rules and authority awareness	C38 Rules and authority awareness
C40 Devotion	C39 Passionate and devote to one's job
A4 Personality and Motivation	A4 Personality and Motivation
B9 Personality and character	B9 Personality characteristics
C41 Responsibility	C40 Take the initiative to undertake
C42 Rigorous and careful	C41 Attention to details
C43 Flexibility and Innovation	C42 Good at innovation
C44 Initiative study	C43 Self-directed learning
B10 Motivation	B10 Intrinsic motivation
C45 Job recognition	C44 Motivation for achievement
C46 Social responsibility	C45 Job recognition
C47 Motivation for achievement	C46 Social responsibility

Note: Numbers starting with (A) are 1st-level indicators, (B) are 2st-level indicators and (C) are 3st-level indicators.

authority coefficients of 0.929, 0.927, 0.875, and 0.848 for the 4 primary indicators: Knowledge base, Professional skills, Personal qualities, and Personality and Motivation, respectively. These values shifted slightly to 0.908, 0.908, 0.878, and 0.850, respectively, in the subsequent consultation round. All experts' authority coefficients were above 0.7, indicating a high level of expert authority. Analysis of indicator importance scores prompted the identification and modification of several indicators, as detailed in Supplementary Table S2 (available athttps://weekly.chinacdc.cn/). These modifications included adding indicators such as *Environmental and food hygiene, Place investigation,* and *Report writing.* Conversely, indicators like *risk judgment, risk identification ability, analysis chart-making,* and related expressions were simplified or removed, resulting in a refined set of indicators for the second round. This updated indicator system provided a more comprehensive and clearer definition and positioning of each element, demonstrating a more structured workflow progression and alignment with the competency onion model. Further consultation and analysis led to enhancements in the definitions of each third-level indicator, ultimately establishing a framework of 4 first-level indicators, 10 second-level indicators, and 46 third-level indicators (Table 1). This structure aligns with the competency evaluation indicator system for emergency response personnel, as illustrated in Figure 1, based on the competency onion model theory.

In the empirical study, self-assessment data from 383 from national, provincial, municipal and county level CDCs individuals were analyzed. The constructed competency self-assessment scale demonstrated a Cronbach's α coefficient greater than 0.8, indicating good reliability (Supplementary Table S3, available at https://weekly.chinacdc.cn/). CFA was performed using a second-order factor model, yielding the following fit indices: χ^2/df=2.675, CFI=0.901,

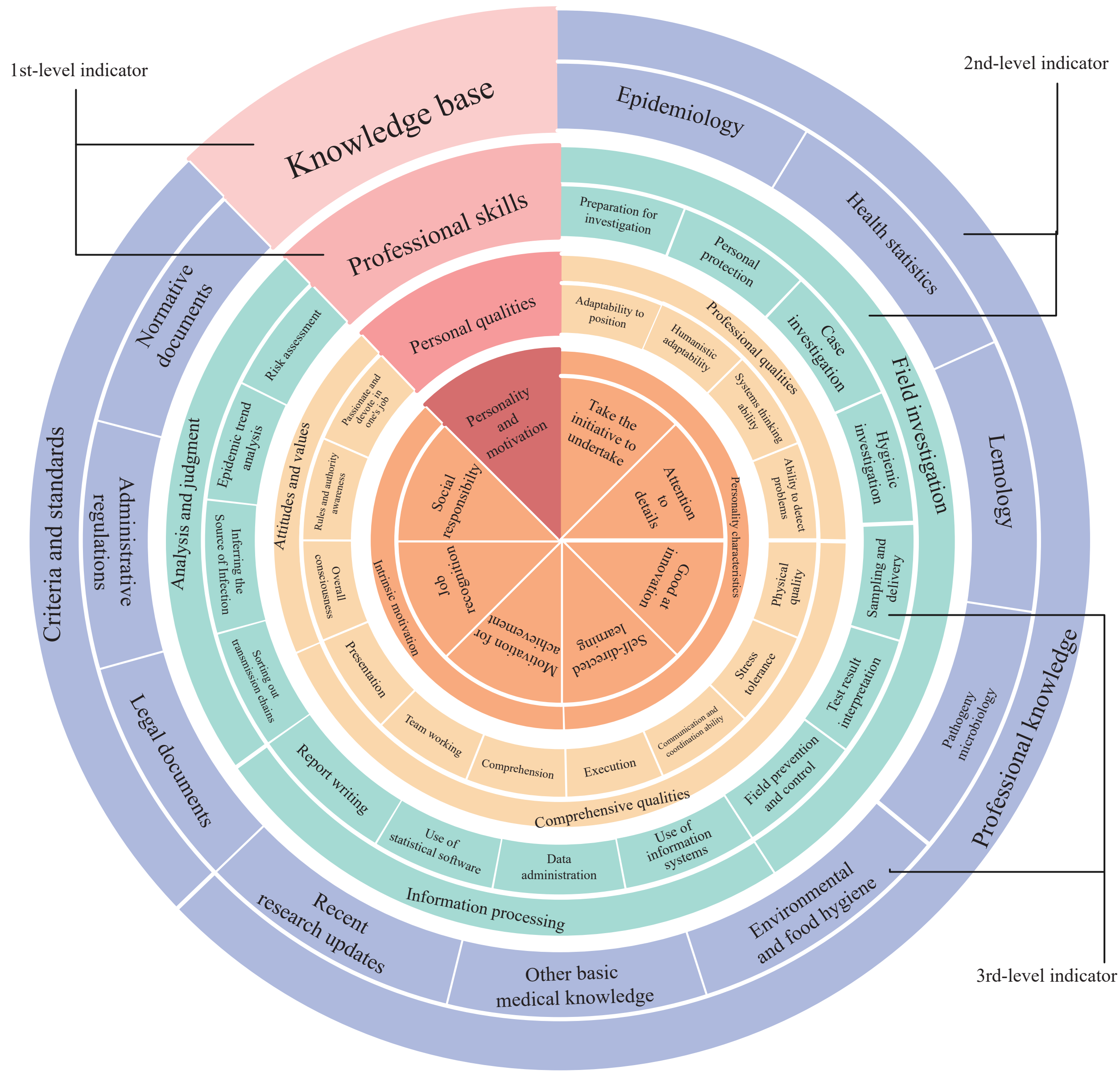

FIGURE 1. Structure of the competency evaluation indicator system for emergency response personnel in disease prevention and control institutions.

IFI=0.902, and RMSEA=0.066, suggesting an acceptable overall model fit. Convergent validity was confirmed with all CRs (Composite Reliability) greater than 0.7, AVEs (Average Variance Extracted) for first-level indicators all exceeding 0.5, and 90% of the second-level indicators with AVEs also above 0.5, indicating that the convergent validity of the model was acceptable (*8*–*9*). For discriminant validity, the model comparison approach (*10*) was employed, comparing the original four-factor model against various reduced-factor models. The four-factor model showed superior fit compared to all three-factor, two-factor, and one-factor models, thus confirming the discriminant validity of the first-level indicators designed by the indicator system (Supplementary Table S4, available at https://weekly.chinacdc.cn/).

DISCUSSION

The Delphi consultation indices for the indicator system satisfy all necessary criteria, demonstrating robust reliability and validity in the empirical study. This research comprehensively addresses the variations in human resource and capacity requirements across different economic regions and administrative levels by incorporating experts from CDCs of varying ranks and localities. Additionally, aligning with China's "three public (industrial) integration" strategy for infectious disease prevention and control, it includes contributions from experts in police departments, industry and information technology sectors, and health administration. Unlike other studies (*9*), this research considers the extensive demand, broad scope, and elevated competence requirements for personnel in emergency situations within its indicator framework. It intentionally softens rigid criteria such as professional titles, positions, and years of experience, centering the evaluation on the intrinsic competence of the staff. This approach aims to minimize the impact of such rigid indicators on managerial decisions.

The framework developed in this study addresses the organizational and labor divisions necessary during significant infectious disease outbreaks. This model includes second-level indicators of professional skills tailored to specific job roles. In emergency situations, the framework allows managers to swiftly and accurately identify the capabilities and specializations of each staff member, facilitating prompt preliminary selection and task allocation. Conversely, during non-emergency periods, it enables the assessment of individual and collective competency levels to identify skill gaps and understand the overall human resources landscape. Consequently, an emergency response competency database for staff can be established, supporting targeted training, personnel selection, and job assignment. Although primarily developed for managing infectious disease outbreaks, a representative type of public health emergency, this indicator system is applicable to other public health crises, given the similarities in response content and procedures among various events managed by disease control and prevention entities. Thus, this system is invaluable for enhancing response capabilities for infectious diseases and public health emergencies and for advancing the overall quality of disease control and prevention systems. It provides a reference for emergency personnel during both routine operations and crises, thereby reinforcing the operational capacity of health systems during such events.

However, the current index is based solely on the core competencies required for emergency response personnel managing significant infectious diseases. It does not encompass the specialized skills needed by various experts responding to diverse public health emergencies. Future research should explore the demand for highly specialized professionals across various types of public health crises. It should also broaden empirical studies to include both self-assessment and peer evaluation, enhance evaluation frameworks using qualitative and quantitative metrics, and improve the objectivity and precision of competency assessments for emergency response staff.

Conflicts of interest: No conflicts of interest.

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[#] Corresponding authors: Lei Zhou, zhoulei@chinacdc.cn; Zainawudong Yushan, znwdys@chinacdc.cn.

[1] Public Health Emergency Center, Chinese Center for Disease Control and Prevention, Beijing, China; [2] National Key Laboratory of Intelligent Tracking and Forecasting for Infectious Diseases, Chinese Center for Disease Control and Prevention, Beijing, China; [3] Xinjiang Uygur Autonomous Region Center for Disease Control and Prevention, Urumqi City, Xinjiang Uygur Autonomous Region, China; [4] School of Public Health, Nanjing Medical University, Nanjing City, Jiangsu Province, China; [5] Chinese Center for Disease Control and Prevention, Beijing, China.
[&] Joint first authors.

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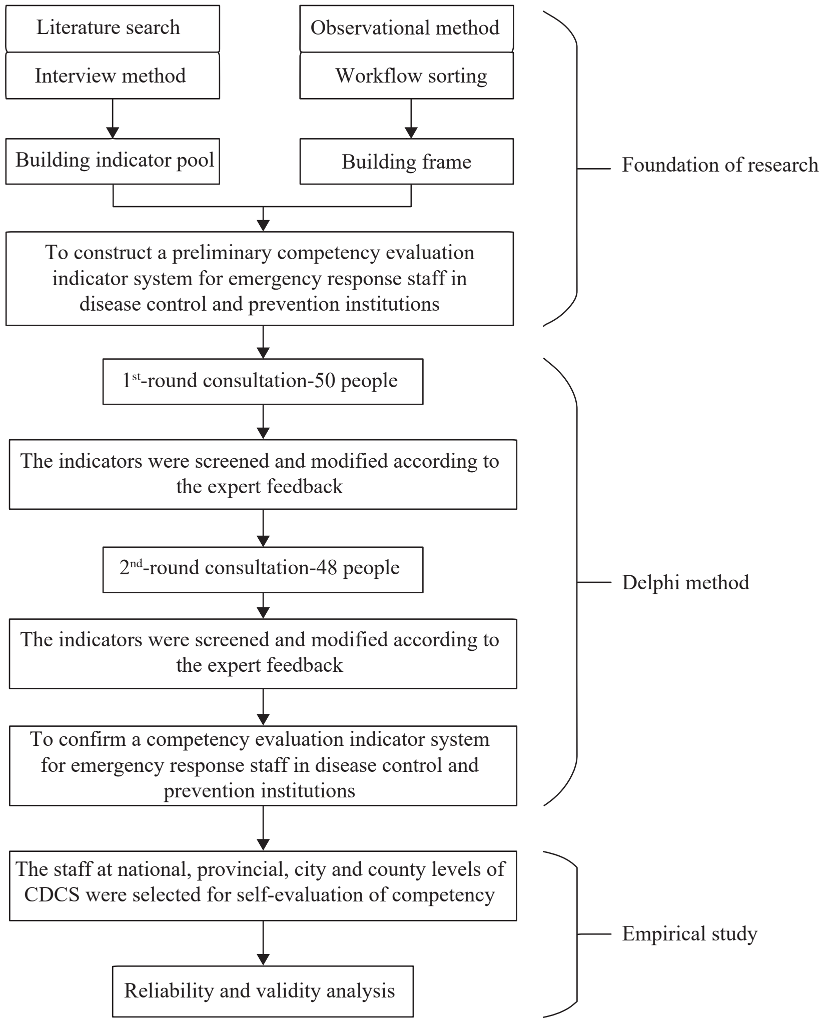
SUPPLEMENTARY MATERIAL



SUPPLEMENTARY FIGURE S1. Technical roadmap for constructing a competency evaluation indicator system for emergency staff at disease prevention and control institutions.

SUPPLEMENTARY TABLE S1. Delphi expert basic information (*n*=48).

Characteristics	Group	Number	Proportion (%)
Economic regions	Eastern regions	9	24.32
	Central regions	11	29.73
	Western regions	12	32.43
Sex	Female	17	35.42
	Male	31	64.58
Age, years	<30	0	0.00
	30–39	10	20.83
	40–49	26	54.17
	50–59	11	22.92
	≥60	1	2.08
Working years	<5 years	0	2.08
	5–9 years	3	6.25
	10–14 years	11	22.92
	15–19 years	12	25.00
	≥20 years	22	45.83
Types of Working units	National CDC	6	12.50
	Provincial CDC	13	27.08
	Municipal CDC	10	20.83
	Country CDC	8	16.67
	Health administration	2	4.17
	Police	3	6.25
	Information	1	2.08
	Medical university	5	10.42
Qualifications	Vocational	2	4.26
	Bachelor	15	31.25
	Master	19	39.58
	Doctor	12	25.00
	Others	0	0.00
Professional titles	Senior	21	43.75
	Associate senior	16	33.33
	Middle	6	12.50
	Others	5	10.42
Working fields	Field emergency response	41	85.42
	Prevention and control of infectious disease	39	81.25
	Health emergency management	27	56.25
	Infectious disease epidemiology	35	72.92
	Others	9	18.75
Whether they have experience in prevention and control of major epidemics	Yes	47	97.92
	No	1	2.08

SUPPLEMENTARY TABLE S2. Screening of the competency indicator's cutoff value based on the importance score.

Round of delphi	Score results	$\bar{x}$	SD	Cut-off level
1st-round	$\bar{x}$	4.630	0.246	4.384
	Proportion of full score	0.706	0.176	0.530
	CV	0.123	0.051	0.174
2nd-round	$\bar{x}$	4.687	0.191	4.496
	Proportion of full score	0.729	0.155	0.573
	CV	0.109	0.038	0.146

Abbreviation: SD=standard deviation; CV=coefficient of variation.

SUPPLEMENTARY TABLE S3. Internal consistency of the competency self-rating scale for emergency response staff in disease control and prevention institutions.

1st level	2nd level	Indicator number	Cronbach's α
A1 Knowledge Base		10	0.903
	B1 professional knowledge	7	0.859
	B2 criteria and standards	3	0.901
A2 professional skills		15	0.933
	B3 field investigation	7	0.875
	B4 information processing	4	0.862
	B5 Analysis and judgment	4	0.935
A3 personal qualities		14	0.945
	B6 professional qualities	4	0.925
	B7 comprehensive qualities	7	0.926
	B8 Attitudes and values	3	0.930
A4 Personality and Motivation		7	0.926
	B9 personality characteristics	4	0.908
	B10 intrinsic motivation	3	0.857
Total		46	0.973

SUPPLEMENTARY TABLE S4. Comparison of confirmatory factor analysis results across multiple models.

No.	Model	χ^2	*df*	χ^2/ *df*	IFI	CFI	RMSEA	Model comparison	$\triangle\chi^2$	△*df*
1	Original model	2,487.681	930	2.675	0.902	0.901	0.066			
2	Three-Factor model 1	2,496.561	933	2.676	0.901	0.901	0.066	2vs1	8.88*	3
3	Three-Factor model 2	2,665.253	933	2.857	0.891	0.89	0.07	3vs1	177.572***	3
4	Three-Factor model 3	2,603.87	933	2.791	0.895	0.894	0.068	4vs1	116.189***	3
5	Two-Factor model 1	2,609.165	935	2.791	0.894	0.894	0.068	5vs1	121.484***	5
6	Two-Factor model 2	2,687.19	935	2.874	0.89	0.889	0.07	6vs1	199.509***	5
7	Two-Factor model 3	2,849.155	935	3.047	0.879	0.879	0.073	7vs1	361.474***	5
8	One-Factor Model	2,868.229	936	3.064	0.878	0.877	0.073	8vs1	380.548***	6

Note: * indicates P<0.05, *** indicates P<0.001 (two-tailed test).Original model: A1, A2, A3, A4; Three-Factor model 1: A1+A2, A3, A4; Three-Factor model 2: A1, A2+A3, A4; Three-Factor; model 3: A1, A2, A3+A4; Two-Factor model 1: A1+A2, A3+A4; Two-Factor model 2: A1+A2+A3, A4; Two-Factor model 3: A1, A2+A3+A4; One-Factor model: A1+A2+A3+A4.
Abbreviation: IFI=incremental fit index; CFI=comparative fit index; RMSEA=root mean square error of approximation.