Title: Assessment the level of Preparedness of Hospitals in Guilan province in facing Biological Threats

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Abstract

Background: Among the various dangers posed by disasters, biological hazards hold particular significance, and healthcare institutions serve as the frontline defense against biological threats. Many hospitals lack sufficient readiness to manage biological hazards effectively. The objective of this study was to evaluate the state of preparedness among hospitals in Guilan province for confronting biological threats.

Material & Methods: This research employed a cross-sectional analytical design. A census approach was used for data collection, incorporating all hospitals (33) within the province. The assessment instrument was the "Hospital Preparedness Assessment Checklist in Biological Events," consisting of 147 items with a total possible score ranging from 0 to 294. Standardized scores were classified into three levels: poor (0–33%), medium (34–66%), and good (67–99%). Analysis was performed with SPSS16 software, applying descriptive statistics, the Friedman test, and the Mann-Whitney test, with statistical significance set at $P < 0.05$.

Results: The average overall preparedness score for facing biological threats was 32.8, situating it near the lower end of the medium category. Analysis using the Friedman test demonstrated a significant variation among the scores of the different preparedness dimensions (χ^2 (7) = 193.5, $P < 0.001$). The dimensions of "laboratory system" (43.4) and "resilience" (41.3) received the highest scores, while "education & training" (22.9) and "management structures" (25.1) received the lowest. No statistically significant disparity in preparedness was detected between government and private hospitals, or between general and specialized hospitals.

Conclusion: In light of the generally insufficient preparedness of Guilan's hospitals for biological threat response, it is imperative that health administrators prioritize and enact essential interventions to improve readiness levels.

Keywords: biological threats; hospital; preparedness; response

Introduction

Biological threats represent a paramount category of disaster-related hazards, potentially arising from natural, accidental, or deliberate causes, and they present substantial risks to public health (1). Bioterrorism is characterized as the intentional and broad-scale use of biological agents against civilian populations to inflict illness or poisoning, with objectives including the instigation of terror, infliction of mass casualties, or the disruption of economic stability (2). Such acts can be purposefully and extensively deployed against civilian groups to cause disease or poisoning (3).

As the core components of the healthcare system, hospitals function as the principal responders to biological threats, making such hazards among the most formidable challenges facing the healthcare system (4). Preparedness efforts are complicated by the variety of potential biological events, the intricacy of required response operations, and the difficulty in promptly identifying their source. While awareness of biological threats and the allocation of resources to address them have grown considerably in the last twenty years, preparedness strategies must continue to evolve, as emerging biological epidemics present unique features (5).

Preparedness within hospitals for biological events constitutes a dynamic, complex, and multi-faceted process. It encompasses the development of capacities and capabilities for anticipating, mitigating, withstanding, responding to, and recovering from biological incidents (6). The recent advent of new diseases, exemplified by COVID-19, underscores the critical value of proactive preparedness in the healthcare system (7). Surge capacity is a key component of a hospital's readiness for biological threats. However, shortcomings such as inadequate communication and coordination, both internally and with external agencies, can hinder resource accessibility, impede timely forecasting, and restrict information flow (8).

Evidence suggests that existing training programs frequently lack adequate capability and efficacy. A notable challenge involves training that staff undertake primarily to fulfill task requirements and accumulate credit points. Concerns for healthcare workers, which also impede their duties, include insufficient supplies of personal protective equipment (PPE), substandard PPE quality, and unsafe work environments. Research further indicates that nurses' inclination to respond to biological events is influenced not only by their clinical skills but also by considerations for personal and family safety, a factor that must be acknowledged (6).

A significant number of hospitals globally demonstrate inadequate preparedness for managing biological threats. Separate investigations in the United States and China have both documented

insufficient hospital readiness against biological threats (9, 10). A study conducted in Iran also reported poor preparedness for biological incidents among hospitals in the central province (11). Therefore, owing to the critical nature of this issue and the lack of a specific evaluation of preparedness levels in Guilan province's hospitals regarding biological threats, this study was initiated to address this gap.

Method and Material

This investigation is a cross-sectional analytical study carried out in 2023. Data were gathered through a census, with the study population comprising all hospitals (33) in Guilan province. The research instrument utilized was the "Hospital Preparedness Assessment Checklist for Biological Events," which was designed and its validity established by Mohsen AminiZadeh. This checklist contains 147 items organized according to three core themes: capacity, capability, and competence. The questionnaire's first section, with 16 items, collected general hospital profile information. The subsequent section covered eight main dimensions divided into 20 sub-dimensions: development of management structures (15 items, score 0–30), capacity building (33 items, score 0–66), education and training (11 items, score 0–22), communication and information management (12 items, score 0–24), safety and security (30 items, score 0–60), care and laboratory system (15 items, score 0–30), patient management (19 items, score 0–38), and hospital resilience (12 items, score 0–24).

Each item was rated using a 3-point Likert scale with the options: completely (2), somewhat (1), and not at all (0). To aid in score interpretation and to enable comparison across the questionnaire's various dimensions, raw scores were converted to a scale of 0–100. The aggregate potential score for the entire instrument ranged from 0 to 294. The preparedness level for each hospital was determined by converting the total score into a percentage, which was then categorized as poor (0–33%, equivalent to a score of 0–98), medium (34–66%, equivalent to 99–196), or good (67–99%, equivalent to 197–294). Higher percentage scores indicated a greater degree of hospital preparedness for biological events.

The instrument's scientific validity was established through a sequential mixed-methods exploratory study conducted in two qualitative and quantitative phases, as detailed in a doctoral dissertation by Aminizadeh et al. (2019). Construct validity pertaining to hospital preparedness for biological events was evaluated using the known-groups technique. The tool's reliability was assessed through inter-rater and intra-rater reliability methods, supplemented by an intra-cluster

correlation test. Following the verification of face and content validity for the initial tool, the average content validity index for the full 147-item instrument was determined to be 0.92. The inter-rater reliability, measured by intra-class correlation (ICC), was 0.92 (95% CI: 0.88 to 0.96). Furthermore, intra-rater reliability, assessed by an observer over a two-week interval in 10 hospitals (intra-rater reliability); intra-rater test (ICC) f 0.94 (95% CI: 0.89 to 0.97), confirming the instrument's suitable reliability. To substantiate construct validity, this instrument was previously completed by 400 hospitals across the nation. Consequently, given that the instrument is a validated checklist, its validity and reliability were not reassessed in this study.

Data collection commenced after receiving ethical approval (code: IR.GUMS.REC.1402.218) from the Research Ethics Committee of Guilan University of Medical Sciences, supported by an official letter from the university's Vice Chancellor for Research and Technology. Researchers visited each hospital in Guilan province. Following the developer's protocol, the checklist was filled out during an interview with the secretary of the hospital's disaster committee, with input from other committee members as required, and in the presence of the researcher.

For data presentation, continuous variables are reported as mean (standard deviation, SD) and median (interquartile range, IQR), while categorical variables are expressed as frequency (percentage). The Friedman test was applied to compare the mean scores across the different dimensions of the Hospital Preparedness Questionnaire for Biological Threats. To examine differences based on hospital ownership (government/non-government) and service type (general/specialized), the Mann-Whitney test was used on both the total and dimensional scores. Statistical analysis was conducted using SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA), and boxplots were generated using GraphPad Prism, Version 8.0.1 (GraphPad Prism Software Inc., San Diego, CA, USA). A P-value of less than 0.05 was deemed statistically significant.

Findings

The distribution of hospitals by ownership was as follows: 72.7% government, 24.2% private, and 3% social security. By service type, 78.8% were general hospitals and 21.2% were specialized. On average, these hospitals had 137 approved beds and 120 active beds, with a mean annual admission count of 17,709.

The mean total score reflecting hospital preparedness against biological threats in Guilan province was 32.8 (SD: 7.9), with a median score of 32.0 (IQR: 28.2–32.8). In general, both the total score

and the scores for individual preparedness dimensions were below 50 (refer to Table 1 and Figures 1 and 2).

Table 1: Descriptive indicators of the total preparedness scores of hospitals to face biological threats and its dimensions scores

Hospital preparedness dimension	**Range**	**Mean (S. D.)**	**Median (Interquartile Range)**
Management structures	16.7 - 53.3	25.1(7.6)	**23.3(20.0-26.7)**
Surge capacity	19.7 - 53.0	28.4(0.7)	**27.3(24.2-29.5)**
Education and training	13.6 - 63.6	22.9 (9.9)	**22.7(18.2-22.7)**
Information and communication	25.0 - 62.5	34.6(7.6)	**33.3(29.2-37.5)**
Care system and laboratory	35.0 - 86.7	43.4(9.6)	**41.7(38.3-45.0)**
Safety and security	23.3 - 66.7	35.3(7.4)	**33.3(31.7-36.7)**
Patient management	18.4 - 57.9	27.1(8.4)	**26.3(22.4-28.9)**
Resilience	25.0 - ٩٥.8	41.3(12.1)	**41.7(37.5-41.7)**
Overall score	**25.5 - 67.0**	**32.8(7.9)**	**32.0(28.2-32.8)**

Application of the Friedman test to compare scores across the preparedness dimensions revealed a statistically significant difference (χ^2 (7) = 193.5, P < 0.001). The dimensions "care system and laboratory" and "resilience" received the highest mean rank scores, whereas "education and practice" and "management structures" received the lowest.

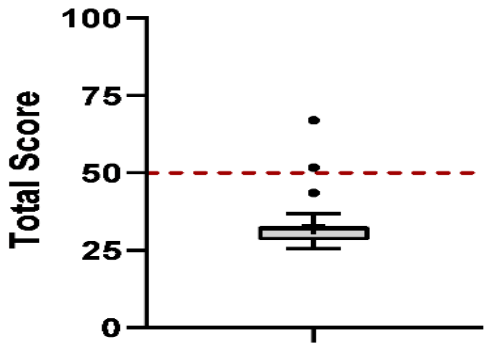

Figure 1. Box plot of the total score of hospitals' preparedness to face biological threats.
Note. Box plot shows minimum, first quartile (Q_1), median, third quartile (Q_3), and maximum values. The outliers are shown by the black dots (●).

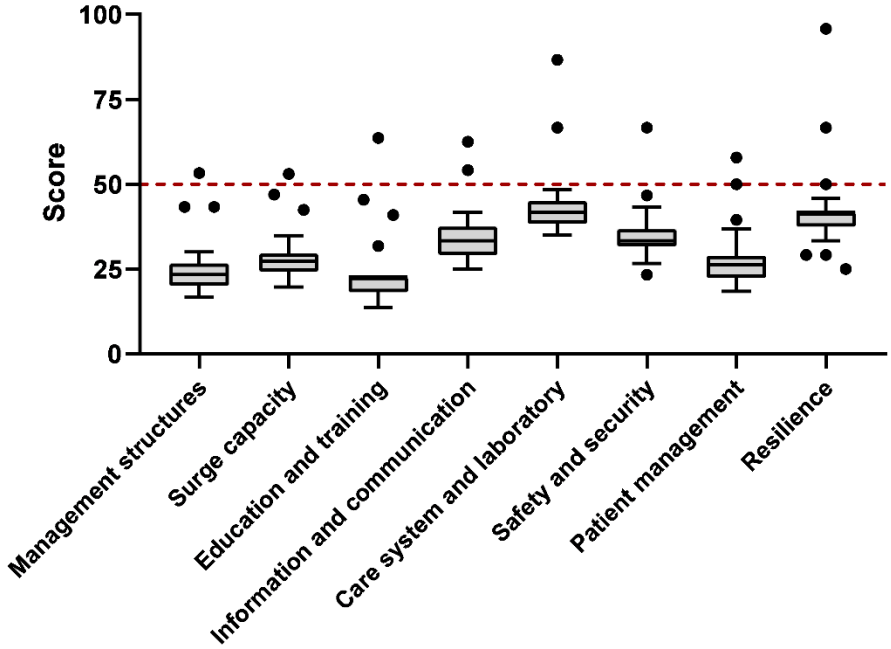

Figure 2. Box plot of hospital preparedness dimension scores in the face of biological threats

Note. Box plot shows minimum, first quartile (Q_1), median, third quartile (Q_3), and maximum values. The outliers are shown by the black dots (●).

Using the Mann-Whitney test to compare preparedness based on hospital ownership and type showed that although non-government hospitals had higher total and dimensional scores on average than government hospitals, this difference was not statistically significant for the total preparedness score (P = 0.486). Similarly, no statistically significant difference was found between general and specialized hospitals (P = 1). These non-significant results were consistent across all individual dimensions of the questionnaire (all P > 0.05) (see Table 2).

Table 2: Comparison of hospital preparedness dimensions scores in the face of biological threats in terms of hospital type and service type

Preparedness Dimensions	Hospital		P*	Hospital		P*
	Government	non-government		General	Specialized	
Management structures			0.512			**0.169**
Mean (SD)	23.8(4.8)	28.5 (12.1)		25.9(25.9)	21.9(2.6)	
Median (IQR)	23.3(20.0-25.8)	23.3(20.0-36.7)		23.3(20.0-23.3)	20.0(20-23.3)	
Surge capacity			0.706			**0.590**
Mean (SD)	27.3(4.5)	31.3(11.1)		28.6(7.5)	27.9(4.7)	
Median (IQR)	23.3(24.6-28.8)	28.8(23.5-38.6)		26.5(24.2-28.8)	28.8(22.7-30.3)	
Education and training			0.619			**0.450**
Mean (SD)	21.6(5.6)	26.3(16.8)		23.8(23.8)	19.5(3.4)	
Median (IQR)	22.7(18.2-22.7)	18.2(18.2-34.1)		22.7(18.2-22.7)	18.2(18.2-22.7)	
Information & communication			0.921			**0.560**
Mean (SD)	33.5(4.7)	37.5(12.5)		35.1(8.1)	32.7(5.6)	
Median (IQR)	33.3(30.2-37.5)	33.3(29.2-45.8)		33.3(32.3-37.5)	33.3(29.2-37.5)	
Care system and laboratory			0.154			**0.682**
Mean (SD)	41.0(3.38)	49.6(16.7)		43.7(10.7)	42.4(4.5)	
Median (IQR)	40.8(38.3-45.0)	43.3(39.2-57.5)		41.7(38.3-45.0)	45.0(36.7-46.7)0	
Safety and security			0.131			**0.090**
Mean (SD)	33.6(4.3)	39.6(11.6)		33.6(7.7)	31.4(4.7)	
Median (IQR)	33.3(30.0-36.7)	36.7(33.3-43.3)		33.3(33.3-37.5)	30.0(30.0-36.7)	
Patient management			0.766			**0.780**
Mean (SD)	26.5(6.5)	28.7(12.6)		27.2(9.1)	26.7(5.4)	
Median (IQR)	26.3(21.7-28.9)	23.7(21.1-32.9)		26.3(21.1-28.9)	23.7(23.7-28.9)	
Resilience			0.370	23.8(4.8)		**0.330**
Mean (SD)	38.7(5.7)	48.1(20.4)		41.3(13.5)	41.1(4.5)	
Median (IQR)	39.7(37.5-41.7)	41.7(35.4-54.2)		39.6(36.5-41.7)	41.7(37.5-45.8)	
Overall score			0.486			**1**
Mean (SD)	31.3(3.8)	36.8(13.7)		33.2(8.7)	31.3(3.9)	
Median (IQR)	31.6(28.1-32.6)	32.3(27.9-43.0)		31.8(28.4-32.5)	32.0(27.2-34)	

Abbreviation. SD: Standard Deviation; IQR: Interqurtile Range

*Mann-whitney test

Discussion and Conclusion

The study sample included 33 hospitals from Guilan province: 24 government-owned, 8 private, and 1 social security hospital. Seventy-nine percent were general hospitals, and 21% were single-specialty institutions.

The average overall preparedness of Guilan's hospitals for biological incidents was poor range, albeit close to the medium threshold. This finding is partially consistent with the study by Heydaranloo et al., which rated the overall preparedness of selected hospitals as 37.25% (poor) (12). Other research, including studies by Mortelmans and Yarmohammadian in the Netherlands and Iran, also reported that hospitals were not sufficiently prepared for CBRN incidents (13, 14). Heydaranlou et al. further documented low mean operational preparedness scores in hospitals across several Iranian provinces (12). In contrast, Beikmohammadi et al. assessed the preparedness of hospitals in Azerbaijan province for CBRN incidents as moderate, with a mean score of 50.2 (15). Ayenew et al. reported a low level of emergency preparedness in public hospitals in northwestern Ethiopia (16). A study by Niska et al. indicated much higher preparedness levels in American hospitals for biological incidents (17).

The specific preparedness scores in the dimensions of "information and communication management", "care and laboratory systems", "safety and security", and "resilience" were at an average level, but in the dimensions of "management structures development", "surge capacity", "training and practice", and "patient management" were at a weak level. Private hospitals had a higher mean total score compared to government hospitals. For both ownership types, the highest preparedness was observed in "care system and laboratory", and the lowest in "education and training".

Our result on the dimension of preparedness for “development of management structures” (weak) is in line with the findings of Irannejad et al. (11). However, the studies of Heydaranloo et al. and Mortelmans et al. have reported this dimension at a desirable level (12, 13).

The "surge capacity" dimension score was poor in our study, whereas Heydaranlu et al. reported an acceptable level (12). Mortelmans et al. found that most hospitals could mobilize extra staff and equipment during emergencies (13). Our investigation identified structural deficits in surge capacity, even in newer hospitals, such as a lack of designated decontamination areas, inadequate CBRN rooms, and absent separate pathways, isolation spaces, and expanded capacity for beds (including ICU beds) post-COVID-19.

In our study, preparedness in the dimension of “training and practice” was poor wich consistent with other studies reporting low CBRN training levels (12, 14). Research emphasizes the need for evidence-based, recurrent, and documented training exercises to bridge the knowledge-practice gap and ensure competency (18-20). Azeem et al. also noted inadequate staff preparedness for large-scale NBC incidents (21).

The average readiness score for the "information and communication management" dimension in the present study was poor, similar to that of Irannejad et al. (11), but in other studies was at an upper-average level (12, 16). Most hospitals lacked backup communication systems, coordination plans, and wireless capabilities. Preparedness in "safety and security" was poor. Deficiencies were noted in physical/information security measures and PPE storage/provision, corroborating findings from other studies (12, 16, 24). Enhanced security protocols for disaster management are recommended (25).

The “care and laboratory system” dimension received a moderate score, with gaps in the implementation of biosafety protocols, safety monitoring, and early warning systems. However, it was better than the score reported in the study by Irannejad et al. (11). The mean preparedness score in the “patient management” dimension in the present study was poor, similar to the results of Irannejad et al. (11) but lower than Heydaranlu et al. (12). Issues included ill-equipped triage sites for biological events, no dedicated external triage areas, lack of separate rooms for suspected cases, and inadequate vaccination tracking.

The Preparedness in the “resilience” dimension scored better than the report by Irannejad et al. (11) but lower than the study by Heydaranloo et al. (12). Key shortcomings involved the absence of budget allocation, cost estimation, and business continuity plans for biological events.

Statistical comparison confirmed a significant difference among dimension scores. The highest-performing dimensions were "care system and laboratory" and "resilience," while the lowest were "education and practice" and "management structures." This contrasts with other studies where different dimensions ranked highest or lowest (11, 12).

Finally, no significant association was found between total preparedness score and hospital ownership or service type. This differs from a study where military hospitals showed higher preparedness than others (12).

Conclusion

The overall state of preparedness against biological threats among hospitals in Guilan province is weak. Significant variability exists across different preparedness dimensions. The areas of "care system and laboratory" and "resilience" demonstrated relatively higher performance, whereas "education and practice" and "management structures" were notably weaker. The type of hospital ownership (government/private) or the service category (general/specialized) did not significantly influence the overall preparedness level. Health system managers should therefore implement targeted strategies to address the identified deficits, particularly in education, training, managerial frameworks, surge capacity, and communication infrastructure.

It is also recommended to take steps towards greater preparedness by designing and implementing periodic training programs and practical simulations for staff, strengthening communication and information infrastructure, and allocating dedicated budgets for equipment and preparedness exercises against biological threats.

Ethical Considerations

This article is the result of a master's thesis in emergency nursing, the research project of which was implemented after approval and obtaining the code of ethics (IR.GUMS.REC.1402.218) from the Vice Chancellor for Research and Technology, Guilan University of Medical Sciences.

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Study Limitations

The potential for self-reporting bias by the secretary of the hospital disaster committee and also the investigation of the preparedness of hospitals in one province in the face of biological incidents, which may affect the generalizability of the results of the present study.

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