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Investigating the Level of Preparedness of Iranian Hospitals against CBRN Incidents: A Case Study of Hospitals in West Azerbaijan Province

Saeid Beikmohammadi[1], Bagher Amirheidari[2,3,*], Tania Dehesh[4], Mahmood Nekoei-Moghadam[5], Vahid Yazdi-Feyzabadi[6], Ebrahim Hassani[7] and Hossein Habibzadeh[8]

[1]Miandoab School of Medical Sciences, Miandoab, Iran
[2]Department of Pharmaceutical Biotechnology, Faculty of Pharmacy, Kerman University of Medical Sciences, Kerman, Iran
[3]Extremophile and Productive Microorganisms Research Center, Kerman University of Medical Sciences, Kerman, Iran
[4]Health Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[5]Health in Disasters and Emergencies Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[6]Health Services Management Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[7]Urmia University of Medical Sciences, Urmia, Iran
[8]School of Nursing and Midwifery, Urmia University of Medical Sciences, Urmia, Iran

[*]*Corresponding author*: Department of Pharmaceutical Biotechnology, Faculty of Pharmacy, Kerman University of Medical Sciences, Kerman, Iran. Email: baheidari@gmail.com

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Abstract

Background: Hospitals are the front line of dealing with Incidents. Chemical, biological, radiological, and nuclear (CBRN) incidents are alarming for governments' healthcare providers and the public. Therefore, they must make the necessary preparations to deal with these incidents.
Objectives: This study aimed to evaluate the preparedness of hospitals against chemical, biological, radiological, and nuclear incidents and the related influential factors.
Methods: The present study was a cross-sectional survey in northwest Iran, 2020-2022. The statistical population was the hospitals of West Azerbaijan province. The inclusion criteria were that hospitals must be university or therapeutic affiliated with the West Azerbaijan University of Medical Sciences, and at least one year had to be passed since the hospital's operation. Also, the exclusion criteria were that the hospitals were on the verge of closing or changing their use. In this way, 26 hospitals in West Azerbaijan were studied. The "Canadian Center for Emergency Preparedness" evaluation checklist research tool was used to determine the level of preparedness of the studied hospitals in CBRN incidents. The data was collected for 5 months, from January to May 2021. Cronbach's alpha score for this checklist was 0.94. Descriptive and analytical statistics indicators were used for data analysis using SPSS 20 software.
Results: The study showed that the hospitals lacked the preparation, capacities, and abilities to deal with CBRN incidents. In the single-variable mode, in the chemical dimension, the number of morgues of the deceased ($P = 0.006$); in the biological aspect, per capita educational factors in the biological domain ($P = 0.03$), the number of facility personnel ($P = 0.04$), the number of infectious disease specialists ($P = 0.02$), the number of equipment with optimal laboratory capabilities ($P = 0.04$), and the number of morgues of the deceased ($P = 0.006$); in the radiological and nuclear dimensions per capita of nuclear education ($P = 0.01$) and dosimeter ($P = 0.03$), and the general dimension the CBRN training per capita ($P = 0.004$), the number of personnel ($P = 0.015$), and laboratory equipment ($P = 0.006$) had a significant relationship with the preparedness of hospitals against CBRN incidents ($P < 0.05$).
Conclusions: Overall, this study's results showed that hospitals' preparedness against CBRN incidents was unsatisfactory, and appropriate policies needed to be adopted to improve it.

Keywords: Disasters, Incidents, CBRN, Health, Hospital, Preparedness.

1. Background

Every year, millions of people in different parts of the world are affected by disasters (1). Disasters, whether natural or man-made, disrupt infrastructure and public facilities (2). The unpredictability of disasters imposes many social and economic problems on people and governments (3). One type of disaster is chemical, biological, radiological, and nuclear (CBRN) incidents that create dangerous conditions for humans, living organisms, and the environment in the short and long term (4). CBRN incidents can be accidental or intentional. An accidental CBRN incident occurs due to human error or natural or technological causes such as spills or accidental releases. On the other hand, CBRN materials are used aggressively in wars in the form of nuclear weapons or chemical and biological warfare agents (5).

Over time, various CBRN incidents have threatened various communities (4). SARS, influenza, and Covid-19 outbreaks are natural (random) biological events (5). Regarding chemical incidents, the world's worst industrial disaster was a chemical plant explosion in Bhopal, India, in 1984, which killed 2,500 people and injured 200,000 people (6). Among the chemical terrorist incidents, we can mention the Sarin gas attack in 1944, in which more than 5,000 people were injured, 11 lost their lives, and more than 300 injured were employees and emergency service responders (7). In the eight-year Iran-Iraq war, more than 50,000 military and civilian people were directly and indirectly affected by chemical attacks. In the summer of 1987, the Iraqi army attacked the civilian city of Sardasht, one of the cities of West Azerbaijan province, with mustard sulfur gas, which resulted in the death and injury of 4500 people (8). Another catastrophic CBRN event was the 9-magnitude earthquake and subsequent tsunami on March 11, 2011, in Japan, which caused the release of radioactive materials, forced about 160,000 people to leave their homes, and had a great psychological impact on the community (9). Also, the Chornobyl nuclear incident on April 26, 1986, with 28,000 deaths, one year after, is considered one of the most important nuclear incidents (10).

However, the common approach to disasters is generally reactive and focused on post-disaster relief and rehabilitation, and less attention has been paid to prevention, mitigation, and preparedness. Pre-disaster preparation by various organizations is very important and necessary (5) because planning and preparedness to deal with disasters play a significant role in ensuring the proper functioning of organizations when disasters occur and reducing social and economic costs caused by them (11). Considering that health is the first and most important demand of people in incidents and disasters, the performance of the health field has a special place among all the elements involved in the management of accidents and disasters (12). In this regard, one of the main concerns of the World Health Organization (WHO) at the time of disasters is the preparation of hospitals against disasters and incidents (13) because hospitals play a very important role in reducing the suffering of injured people and the death rate caused by incidents (3, 14). For this reason, determining hospitals' preparedness level against disasters is a very important and fundamental issue in crisis management (15).

2. Objectives

Due to Iran's political geography and location in the strategic region of the Middle East, this country has always been affected by crises related to neighboring countries, and man-made disasters such as war, chemical, microbial, and especially nuclear pollution always threaten the country. Therefore, providing appropriate measures to minimize these incidents' effects is considered a priority of Iran's health system. This study evaluated hospitals' preparedness levels against CBRN incidents and the factors affecting them.

3. Methods

This study was a cross-sectional and field study to investigate the preparedness of hospitals against CBRN incidents from 2020 to 2022. The research community in this study was the hospitals of West Azerbaijan, which were selected by the census method. The inclusion criteria were that hospitals must be educational-therapeutic or therapeutic affiliated with the West Azerbaijan University of Medical Sciences. At least one year should have passed since the operation of the hospital. Also, the exclusion criteria were the hospital is on the verge of closing or changing its use. In this way, 26 hospitals in West Azerbaijan were studied. All these hospitals were government-funded and have not been exposed to CBRN incidents. Table 1 indicates the characteristics of the included hospitals.

The data collection was done using the assessment checklist of the "Canadian Center for Emergency Preparedness" (16, 17). After obtaining the consent of the main designers of the checklist above, the steps of its translation were carried out. First, the checklist used in the research was translated from English to Farsi by two experts in English-to-Farsi translation who had sufficient knowledge and familiarity with the specialized vocabulary of the research subject. In the next step, the first translated versions were reviewed by another translator with sufficient command of both the original and target languages and the research topic. The first translated versions were compared, and their differences and inconsistencies were corrected. Finally, the final version of the Persian translation was created by merging the translations. In the next step, the final version of the checklist translated into Farsi was returned to the original language by two other translators who did not participate

Table 1. Characteristics of the Included Hospitals

Number	Hospital	City	Type of the Hospital	The Number of Personnel	The Number of Beds
1	Imam Khomeini	Urmia	Specialty	825	658
2	Shahid Rasi	Shahin Dej	General	166	109
3	Shohada	Shut	General	65	42
4	Hazrat Fatemeh	Naqadeh	Specialty	55	52
5	Imam Khomeini	Naqadeh	General	189	130
6	Shahid Ghoulipour	Bukan	General	332	277
7	Seyedoshohada	Urmia	Specialty	272	154
8	Hazrat Zahra	Miandoab	Specialty	192	241
9	Shahid Abasi	Miandoab	General	155	158
10	Imam Khomeini	Mahabad	General	375	285
11	Shahid Motahari	Urmia	Specialty	409	371
12	Ayatollah Taleghani	Urmia	Specialty	330	204
13	Razi	Urmia	Specialty	67	94
14	Imam Khomeini	Piranshahr	General	136	95
15	Madani	Khoy	Specialty	165	125
16	Imam Khomeini	Khoy	General	292	215
17	Ghamar Bani Hashem	Khoy	General	275	200
18	Ayatollah Khoei	Khoy	Specialty	410	295
19	Nabi Akram	Oshnavieh	General	84	74
20	Imam Khomeini	Chaypareh	General	61	41
21	Shahid Beheshti	Children	General	56	59
22	Fajr	Maku	General	194	177
23	Imam Khomeini	Poldasht	General	55	38
24	Shohada	Takab	General	154	98
25	Khatamolanbia	Salmas	General	232	203
26	Imam Khomeini	Sardasht	General	125	133

in the previous stage. In the continuation of this stage, a third person compared the translations with the original version and compared them, creating a ready checklist for the next steps.

The validity of the checklist was assessed using face validity. The face validity was examined and confirmed by 8 experts. Cronbach's alpha was used to obtain the reliability of the data collection tool. This method measured the correlation between each questionnaire item and other items. An alpha score higher than 0.7 is good evidence to prove the level of internal consistency, but 0.8 is better. Cronbach's alpha score of the checklist used in this research was 0.94. The data collection tool was a 226-question checklist in seven-part that includes general (basic considerations, planning, education and awareness, and methods) (58 questions), a biological incident preparation model (85 questions), an incident preparation model Chemical (44 questions), the preparation model for a radiological or nuclear incident (39 questions). For each question, four options of yes and no, not applicable, and not sure were considered. In this way, each dimension's lowest and highest score was zero and equal to the number of questions, respectively. Also, the minimum total score of each hospital was zero, and the maximum score was 226.

The researcher completed the checklist with the cooperation of the most knowledgeable person or persons in four hospitals, and ambiguous and suspicious parts were identified. These hospitals were randomly selected, and data was collected within one month. After correcting ambiguous items, it was used by the entire research community. Furthermore, in addition to the guidance and training and completing the checklist, the researcher was available to those completing the checklist to answer possible questions during the data collection period. After completing the checklist, the collected data was again verified with the information available to the university's vice-chancellor. In case of problems and ambiguities, contact or correspondence was made with the completing person again, and possible ambiguities and problems were resolved. The data were collected over 5 months, from January to May 2021.

After entering the information, the final score was obtained from the sum of points. A score of one was given for a positive answer to each question, and a score of zero was given for a negative answer to the questions in a manner that the lowest score of each dimension was zero and the highest score of each dimension was equal to the number of questions. To analyze the results, each checklist dimension was divided into quartiles. Based on that, the hospitals were classified into weak (rank 4), average (rank 3), good (rank 2), and excellent (rank 1) quartiles. Descriptive and analytical statistics indicators were used for data analysis using SPSS 20 software. Univariate and multiple regression were used for statistical analysis at a significance level of 0.05.

4. Results

Table 2 shows the number of questions, the minimum and maximum scores obtained, and the mean and standard deviation of 26 hospitals affiliated with Urmia University of Medical Sciences by the dimensions of the checklist. As can be seen, in the chemistry dimension, the lowest score obtained was 4, and the highest score was 23 out of 44. Furthermore, the average score was 11.56, with a standard deviation of 5.01. In the biological aspect, the lowest score obtained was 26, and the highest was 60 out of 85. Also, the average score of this dimension was 42.70, with a standard deviation of 9.19. In the nuclear and radiological dimensions, the lowest score was 4, and the highest was 26 out of 39. Also, the average score was 11.80, with a standard deviation of 5.14. In the general dimension, which included four dimensions (basic considerations, planning, education, awareness, and methods), the lowest score obtained was zero, and the highest was 41 out of 58. Also, the average score was 11.19, with a standard deviation of 6.59.

Table 2 shows the preparedness of the studied hospitals based on quartiles in different dimensions. The results showed that from the total of 26 hospitals studied, 12 hospitals (46.2%) were at a poor level, 13 hospitals (50%) were at an average level, and only one hospital (3.8%) was at a good level. Also, in terms of hospital readiness in the biological dimension, 10 hospitals (38.5%) were at the average level, 16 hospitals (61.5%) were at a good level. 12 hospitals (46.2 percent) were at a poor level, 13 hospitals (50 percent) were at an average level, and 1 hospital (3.8 percent) was at a good level. In terms of the state of hospital preparedness in the general dimension, 21 hospitals (80.8%) were at a poor level, 4 hospitals (15.4%) were at an average level, and 1 hospital (3.8%) was at a good level (Table 3).

In the following, the factors affecting the preparedness of hospitals against chemical, biological, radiological, nuclear, and public incidents were investigated in univariate and multiple models. In the chemical dimension, the results showed that in the univariate model, only the number of dead morgues had a significant relationship with the chemical dimension of hospitals' preparedness against CBRN incidents ($P < 0.05$) (Table 3). In the field of biology, the results showed that in the univariate model, the per capita educational factors in the biological field were the number of facility personnel, the number of infectious disease specialists, the number of laboratory equipment with optimal capabilities, and the number of deceased morgues, and in the multiple models, only the per capita education in the biological field. They had a significant relationship with the biological dimension of hospitals' preparedness against public, chemical, biological, radiological, and nuclear incidents ($P < 0.05$) (Table 3). In the radiological and nuclear dimensions, the results showed that in the univariate model, the per capita factors of nuclear training and dosimeter had a significant relationship. In the multivariate mode, only nuclear training per capita had a significant impact on the radiological and nuclear dimensions of hospitals' preparedness against public, chemical, biological, radiological, and nuclear accidents ($P < 0.05$). According to Table 4, in the univariate model, the per capita CBRN training factors, the number of facility personnel, and laboratory equipment were effective. In the multiple models, the per capita CBRN training factors and laboratory equipment were effective on the general dimension of hospital preparedness against the public; chemical, biological, radiological, and nuclear have had a significant relationship ($P < 0.05$).

5. Discussion

The study results showed that the average score of the studied hospitals in the chemical dimension was 11.56 (± 5.01) out of 44 scores. In other words, according to these results, the studied hospitals scored 26.3%, and their level of preparedness against chemical incidents was assessed as weak. Based on the results, 46.2%

Table 2. Descriptive Statistics of Questionnaire Dimensions in all West Azerbaijan Hospitals

Dimensions	Number of Questions	The Minimum Score Obtained	The Maximum Score Obtained	Mean ± SD
Chemical	44	4	23	11.56 ± 5.01
biological	85	26	60	42.70 ± 9.19
Nuclear and radiological	39	4	26	11.80 ± 5.14
General/basic (includes four dimensions)	58	0	41	11.19 ± 6.59

Table 3. The Preparedness Status of West Azerbaijan Hospitals in CBRN Dimensions [a]

Dimensions	Excellent	Good	Average	Poor
Chemical	0 (0)	1 (3.8)	13 (50)	12 (46.2)
biological	0 (0)	16 (61.5)	10 (38.5)	0 (0)
Nuclear and radiological	0 (0)	1 (3.8)	13 (50)	12 (46.2)
General/basic (includes four dimensions)	0 (0)	1 (3.8)	4 (15.4)	21 (80.8)

[a] Values are expressed as No. (%).

of hospitals were evaluated as poor, 50% as average, and only one hospital (3.8%) was evaluated as good in the chemical dimension. The results showed that in 35 out of 44 cases (79.5 percent), hospitals in West Azerbaijan had an average or poor condition to deal with chemical incidents and were identified as their needs. Also, the results showed that the number of deceased morgues was the only effective factor on the chemical dimension of hospitals' preparedness against CBRN incidents ($P < 0.05$). The study of Seyedin et al. has shown that the preparedness plan for chemical incidents should be based on the capacities of hospitals, leveling of hospital preparedness, current knowledge, personal protective equipment, and sufficient decontamination. They considered it necessary to provide a suitable platform for creating hospital preparedness, reducing the adverse consequences of chemical incidents, avoiding the security of chemical incidents, and raising the risk perception of managers, officials, and people (18). Of course, it is also important that the hospital preparedness plan for chemical incidents should be compatible with other hospital plans for incidents and disasters (19).

In the biological aspect, the study's results showed that the average scores of the studied hospitals were 42.7 (±9.19) out of 85. In other words, according to these results, the studied hospitals scored 50.2%, and therefore, their level of preparedness against biological incidents was evaluated as average. Based on the results, 38.5% of hospitals were evaluated as average and 61.5% as good in the biological dimension. The results showed that West Azerbaijan hospitals in 41 out of 85 cases (48.2 percent) had an average or weak condition to deal with biological incidents. A study in Tehran showed that the average percentage of preparedness of all studied hospitals in biological incidents was 36.9%, which was assessed as insufficient and weak. In this study, hospitals had the highest level of preparation in wave capacity management and communication, with 68.75%. However, they had the least preparation in having biological consultants, meeting management, and post-incident recovery (20). However, a study by Irannejad et al. showed that these hospitals' preparedness level was weak (score 26 out of 100) (21). Therefore, the preparedness of these hospitals was weaker in dealing with biological incidents compared to the present study. The key point in dealing with biological incidents is the ability to detect biological incidents in hospitals because the diagnosis of biological incidents is an effective factor in the hospital's operation and is the first step in controlling a biological emergency in the hospital (22).

Furthermore, the results showed that the per capita educational factors in the field of biology, the number of facility personnel, the number of infectious disease specialists, the number of laboratory equipment with optimal capabilities, and the number of the mortuary for the deceased affect the biological dimension of hospitals' preparedness against the public, chemical, biological, radiological, and nuclear incidents were significant ($P < 0.05$). In another study, staff training was recognized as one of the main elements in hospitals' performance in biological incidents (22). Other studies have also considered education a key factor in preparing for crises, including CBRN incidents (17, 23). The studies of Kollek et al. in Canada and Yarmohammadian et al. in Iran have demonstrated a low percentage of training received by hospital staff regarding CBRN incidents (6, 24). Based

Table 4. Factors Affecting the Readiness of Hospitals against CBRN Incidents

Dimensions/Factors	Univariate Regression				Multiple Regression			
	β	The Confidence Interval of 95%		P-Value	β	The Confidence Interval of 95%		P-Value
Chemical								
The number of treatment staff	0.001	-0.01	0.01	0.57	-	-	-	-
Number of pulmonologists	0.01	-2.5	2.6	0.96	-	-	-	-
Number of oncology doctors	0.29	-1	5.9	0.16	0.13	-2.7	4.87	0.55
Number of dermatologists	0.04	-3	3.7	0.85	-	-	-	-
Number of ophthalmologists	0.019	-1.16	0.06	0.57	-	-	-	-
Number of neurologists	0.00	-1.17	1.7	0.99	-	-	-	-
Number of ventilators	0.01	-0.04	0.07	0.63	-	-	-	-
Number of laboratory personnel	0.01	-0.1	0.16	0.64	-	-	-	-
The number of pharmaceutical technicians	0.05	-0.7	0.95	0.82	-	-	-	-
The number of warehouse personnel/storekeepers	-0.2	-3.5	1.2	0.32	-	-	-	-
Number of facility personnel	-0.12	-0.5	0.27	0.55	0.35	-0.24	2.1	0.11
Biological								
Education per capita in the field of biology	-0.43	-1.39	-0.08	0.03	-0.7	-2.14	-0.25	0.02
Number of facility personnel	-0.4	-1.3	-0.15	0.04	-0.3	-1.78	0.75	0.4
The number of infectious disease specialists	0.71	0.33	1.9	0.02	0.3	-3.01	9.32	0.29
The number of laboratory equipment with optimal capabilities	0.41	0.03	1.14	0.04	0.04	-0.55	0.67	0.83
Number of laboratory personnel	-0.12	-0.31	0.17	0.56	-	-	-	-
The number of pharmaceutical technicians	-0.24	-2.12	0.56	0.24	0.44	-1.66	4.53	0.34
The number of warehouse personnel/storekeepers	-0.24	-6.86	1.77	0.23	-0.2	-6.01	1.4	0.2
The number of treatment staff	-0.004	-0.02	0.02	0.86	-	-	-	-
The number of morgues of the deceased	2.53	0.82	4.32	0.006	4.71	1.73	6.01	0.06
The number of PCR-positive deaths in the hospital	0.02	-0.01	0.06	0.19	0.05	-0.08	0.09	0.91
The number of PCR-positive hospital admissions	0.0032	-0.001	0.01	0.11	0.0081	-0.02	0.07	0.27
The total number of respiratory syndrome (positive PCR and negative PCR but with CT and positive clinical symptoms of hospitalization)	0.0035	0.00	0.009	0.08	-.0021	-0.06	0.02	0.22
Radiological and Nuclear								
Nuclear education per capita	-1.03	-2.4	-0.33	0.01	-0.41	-2.16	-0.12	0.3
Dosimeter	0.042	0.01	0.31	0.03	0.032	-0.02	0.26	0.08
The total number of treatment staff	0.0018	-0.006	0.01	0.39	-	-	-	-
The number of pharmaceutical technicians	0.2	-0.42	1.3	0.33	-	-	-	-
Number of warehouse personnel	0.11	-1.8	3.14	0.58	-	-	-	-
Number of facility personnel	0.13	-0.27	0.51	0.52	-	-	-	-
The number of morgues of the deceased	0.22	-0.51	1.7	0.27	-	-	-	-
laboratory equipment	0.11	-0.25	0.42	0.6	-	-	-	-
Number of internal specialists	0.19	-0.5	1.35	0.35	-	-	-	-
General								
CBRN training per capita	-0.15	-0.22	-0.05	0.004	-0.06	-0.26	-0.04	0.009
Number of facility personnel	-0.047	-0.24	-0.03	0.015	0.03	0.018	0.2	0.92
Laboratory equipment	0.052	0.04	0.21	0.006	0.048	0.03	0.2	0.01
The total number of treatment staff	0.0009	-0.004	0.002	0.64	-	-	-	-
Isolated room	-0.31	-3.38	0.41	0.12	-0.14	-2.43	1.1	0.44
The number of morgues of the deceased	0.3	-0.08	0.58	0.13	0.29	0.18	0.5	0.34
Number of warehouse personnel	0.02	-0.37	1.09	0.32	-	-	-	-
The number of pharmaceutical technicians	-0.33	-0.4	0.04	0.1	0.12	-0.32	0.45	0.72

on the evidence, it is recommended that to maintain competence, effectiveness, and appropriateness, technical training and exercises related to CBRN incidents should be repeated periodically and preferably every 6 to 9 months. These training and exercises help the correct, effective, and safe use of protective equipment (25). Other studies have also emphasized that hospitals should strengthen their diagnostic laboratory capabilities during biohazards, such as blood culture bottles and continuous monitoring of blood culture tools, for rapid detection and identification of biological agents. It is also necessary to allocate additional space to the diagnostic laboratories and improve the airflow in the rooms during the occurrence of biological agents. Additionally, because laboratory experts and technicians are among the first responders to detect the presence of an unusual biological agent or disease process, they must be trained in bioterrorism with guidelines and standard procedures (26).

In the nuclear and radiological dimensions, the study's results showed that the average scores of the studied hospitals were 11.8 (± 5.14) out of 39. In other words, according to these results, the studied hospitals scored 30.26 percent, and therefore, their level of preparedness against nuclear and radiological incidents was assessed as weak. Based on the results, 46.2% of hospitals were evaluated as poor, 50% as average, and only one hospital (3.8%) was evaluated as good in the nuclear and radiological aspects. The results showed that in 30 out of 39 cases (77 percent), the hospitals of West Azerbaijan had an average or poor condition in dealing with nuclear and radiological incidents. Also, the results showed that per capita factors of nuclear training and dosimeter had a significant relationship with the radiological and nuclear dimensions of hospitals' preparedness against general, chemical, biological, radiological, and nuclear incidents ($P < 0.05$). Ahmadi Marzaleh et al. also designed a model for the preparedness of the emergency department of hospitals against radiation and nuclear incidents, which included 31 factors in the three main dimensions of employees, materials and goods, and structure. In the model presented in that study, the preparation of employees had the highest priority, and the preparation of materials had the lowest priority (27). Hsu et al.'s study also showed that 73% of the participants reported that their centers lacked the necessary preparation for the treatment of victims of radiation incidents (28).

In the general dimension, the study's results showed that the average scores of the studied hospitals were 11.19 (± 6.59) out of 58. In other words, according to these results, the studied hospitals scored 19.3 percent, and therefore, their level of preparation in the public sector was evaluated as weak. Based on the results, 80.8% of hospitals were evaluated as poor, 15.4% as average, and only one hospital (3.8%) was evaluated as good in the general dimension. Also, the results showed that CBRN education per capita factors, the number of facility personnel, and laboratory equipment had a significant relationship with the general dimension of hospitals' preparedness against public, chemical, biological, radiological, and nuclear incidents ($P < 0.05$).

Overall, the results of this study showed that the studied hospitals did not have the necessary preparation, capacities, and abilities to deal with CBRN incidents. In line with the results of the present study, the study of Mackie et al. showed that the condition of Queensland hospitals in responding to CBRN disasters was very bad, and compared to international preparedness standards, they have points for improvement in their preparedness and increasing their capacity. They identified CBRN-focused education and training using evidence-based educational approaches as a top priority to prepare hospitals better to respond after a disaster event (29). The study of Mortelmans et al. also examined the level of preparedness of 138 hospitals in Belgium to deal with CBRN incidents. It showed gaps and deficiencies in the hospitals' preparedness for these incidents (30). The reasons for the difference in the level of preparedness of hospitals in front of incidents can be attributed to the difference in research environments, research tools, data collection method, data collection time, and the level of expertise and training of data collectors.

5.1. Conclusions

According to the results of the present study and its comparison with domestic and foreign research, it can be said that most hospitals were not prepared to deal with CBRN incidents. Therefore, it is recommended to adopt necessary and appropriate planning and policies to improve hospitals' preparedness level to deal with CBRN incidents. Because of the country's geopolitical situation, past experiences, and existing international conflicts, its hospitals must have the necessary preparation and ability to deal with CBRN incidents. Researchers suggest that similar studies on the preparedness of hospitals against CBRN incidents in other cities and provinces of Iran should be conducted in the future. Also, they are advised to use other checklists to evaluate hospitals' preparedness levels against CBRN incidents. Different frameworks are designed in hospitals, which are useful in improving the preparedness of hospitals against CBRN incidents. Therefore, health managers should use these models to prepare their hospitals for the future.

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Footnotes

Authors' Contribution: All authors contributed to all study phases, including research idealization, data collection and analysis, and writing and approving the article.

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Data Reproducibility: The dataset presented in the study is available on request from the corresponding author during submission or after publication. The data are not publicly available due to confidentiality.

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References

1. Munasinghe NL, O'Reilly G, Cameron P. Establishing the Domains of a Hospital Disaster Preparedness Evaluation Tool: A Systematic Review. *Prehosp Disaster Med*. 2022;**37**(5):674–86. [PubMed ID: 36052843]. [PubMed Central ID: PMC9470528]. https://doi.org/10.1017/S1049023X22001212.
2. Fallah-Aliabadi S, Ostadtaghizadeh A, Ardalan A, Fatemi F, Khazai B, Mirjalili MR. Towards developing a model for the evaluation of hospital disaster resilience: a systematic review. *BMC Health Serv Res*. 2020;**20**(1):64. [PubMed ID: 31996213]. [PubMed Central ID: PMC6988294]. https://doi.org/10.1186/s12913-020-4915-2.
3. Abbasabadi Arab M, Khankeh HR, Mosadeghrad AM, Farrokhi M. Developing a Hospital Disaster Risk Management Evaluation Model. *Risk Manag Healthc Policy*. 2019;**12**:287–96. [PubMed ID: 31849545]. [PubMed Central ID: PMC6911334]. https://doi.org/10.2147/RMHP.S215444.
4. ÖRÜN S, TÜRkerİ B, DoĞTaŞ Z, AkÖZ A. CBRN Incident Awareness of Healthcare Professionals Working in Public and University Hospitals. *Eurasian J Tox*. 2022;**4**(1):3–10. https://doi.org/10.51262/ejtox.1073410.
5. Randhawa AS. *Chemical, biological, radiological and nuclear disaster management: Indian perspective*. New Delhi, India: Indian Institute of Public Administration; 2019. Doctoral Dissertation.
6. Yarmohammadian MH, Nasr-Isfahani M, Anbari E. Assessment of preparedness and response of teaching hospitals of Isfahan, Iran, to chemical, biological, radiological, and nuclear incidents. *Health Inf Manag*. 2016;**12**(6):777–84.
7. Emergency Management Australia. *Australian emergency manuals series*. Emergency Management Australia; 1998.
8. Malkari B, Karimian N. [Psychological- social consequences chemical bombardment of the Sardasht victims (a qualitative study)]. *Iran J Public Health*. 2013;**5**(3):7–13. Persian.
9. Yamaguchi M, Kitamura A, Oda Y, Onishi Y. Predicting the long-term (137)Cs distribution in Fukushima after the Fukushima Dai-ichi nuclear power plant accident: a parameter sensitivity analysis. *J Environ Radioact*. 2014;**135**:135–46. [PubMed ID: 24836353]. https://doi.org/10.1016/j.jenvrad.2014.04.011.
10. Delshad H, Azizi F. [Health risk of nuclear-power-plant accidents on thyroid gland and human health]. *Iran J Endocrinol Metab*. 2012;**14**(6):586–96. Persian.
11. Aminizadeh M, Farrokhi M, Ebadi A, Masoumi GR, Kolivand P, Khankeh HR. Hospital management preparedness tools in biological events: A scoping review. *J Educ Health Promot*. 2019;**8**:234. [PubMed ID: 31867398]. [PubMed Central ID: PMC6905292]. https://doi.org/10.4103/jehp.jehp_473_19.
12. Khankeh HR. *[Hospital preparedness in accidents and disasters]*. Tehran, Iran: University of Social Welfare and Rehabilitation Sciences; 2012. Persian.
13. Ardalan A, Kandi M, Talebian MT, Khankeh H, Masoumi G, Mohammadi R, et al. Hospitals safety from disasters in I.R.iran: the results from assessment of 224 hospitals. *PLoS Curr*. 2014;**6**. [PubMed ID: 24596661]. [PubMed Central ID: PMC3938570]. https://doi.org/10.1371/currents.dis.8297b528bd45975bc6291804747ee5db.
14. Heidaranlu E, Ebadi A, Khankeh HR, Ardalan A. Hospital Disaster Preparedness Tools: A Systematic Review. *PLoS Curr*. 2015;**7**. [PubMed ID: 26425401]. [PubMed Central ID: PMC4575155]. https://doi.org/10.1371/currents.dis.7a1ab3c89e4b433292851e349533fd77.
15. Ortiz-Barrios M, Gul M, Lopez-Meza P, Yucesan M, Navarro-Jimenez E. Evaluation of hospital disaster preparedness by a multi-criteria decision making approach: The case of Turkish hospitals. *Int J Disaster Risk Reduct*. 2020;**49**:101748. [PubMed ID: 32834973]. [PubMed Central ID: PMC7335495]. https://doi.org/10.1016/j.ijdrr.2020.101748.
16. *CBRNE Plan Checklist: A Template for Healthcare Facilities*. The Center for Excellence in Emergency Preparedness; 2022, [cited 2022 Aug 21]. Available from: https://pdf4pro.com/view/cbrne-plan-checklist-the-centre-for-excellence-in-3fe75.html.
17. Alahmari AA, Khan AA. Chemical, Biological, Radiological, and Nuclear Preparedness of Public Hospitals in Riyadh. *Disaster Med Public Health Prep*. 2023;**17**. e401. [PubMed ID: 37264827]. https://doi.org/10.1017/dmp.2023.66.
18. Seyedin H, Moradimajd P, Bagheri H, Abbasi Dolatabadi Z, Nasiri A. Providing a Chemical Events and Threat's Preparedness Model for Hospitals in the Country: A Qualitative Study. *J Mil Med*. 2022;**23**(3):220–7.
19. Crawford IW, Mackway-Jones K, Russell DR, Carley SD. Delphi based consensus study into planning for chemical incidents. *Emerg Med J*. 2004;**21**(1):24–8. [PubMed ID: 14734369]. [PubMed Central ID: PMC1756368]. https://doi.org/10.1136/emj.2003.003087.
20. Heidaranlu E, Tavan A, Aminizadeh M. Investigating the level of functional preparedness of selected Tehran hospitals in the face of biological events: a focus on COVID-19. *Int J Disaster Resil Built Env*. 2022;**13**(2):150–62. https://doi.org/10.1108/ijdrbe-08-2021-0088.
21. Irannejad B, Safarabadi M, Jadidi A. [Survey of biological incidents preparedness of hospitals in Markazi Province in 2016]. *J Mil Med*. 2017;**19**(2):169–75. Persian.
22. Sharififar S, Jahangiri K, Zareiyan A, Khoshvaghti A. Factors affecting hospital response in biological disasters: A qualitative study. *Med J Islam Repub Iran*. 2020;**34**:21. [PubMed ID: 32551310]. [PubMed Central ID: PMC7293813]. https://doi.org/10.34171/mjiri.34.21.
23. Djalali A, Della Corte F, Segond F, Metzger MH, Gabilly L, Grieger F, et al. TIER competency-based training course for the first receivers of CBRN casualties: a European perspective. *Eur J Emerg Med*. 2017;**24**(5):371–6. [PubMed ID: 26928294]. https://doi.org/10.1097/MEJ.0000000000000383.

24. Kollek D, Wanger K, Welsford M. Chemical, biological, radiological and nuclear preparedness training for emergency medical services provider. *CJEM*. 2009;**11**(4):337–42. [PubMed ID: 19594972]. https://doi.org/10.1017/s1481803500011386.
25. Moradi Majd P, Seyedin H, Bagheri H, Tavakoli N. Hospital Preparedness Plans for Chemical Incidents and Threats: A Systematic Review. *Disaster Med Public Health Prep*. 2020;**14**(4):477–85. [PubMed ID: 31610820]. https://doi.org/10.1017/dmp.2019.91.
26. Dowlati M, Seyedin H, Moslehi S. Hospital Preparedness Measures for Biological Hazards: A Systematic Review and Meta-Synthesis. *Disaster Med Public Health Prep*. 2021;**15**(6):790–803. [PubMed ID: 32713417]. https://doi.org/10.1017/dmp.2020.132.
27. Ahmadi Marzaleh M, Rezaee R, Rezaianzadeh A, Rakhshan M, Haddadi G, Peyravi M. Developing a Model for Hospitals' Emergency Department Preparedness in Radiation and Nuclear Incidents and Nuclear Terrorism in Iran. *Bull Emerg Trauma*. 2019;**7**(3):300–6. [PubMed ID: 31392231]. [PubMed Central ID: PMC6681888]. https://doi.org/10.29252/beat-0703014.
28. Hsu EB, Jenckes MW, Catlett CL, Robinson KA, Feuerstein CJ, Cosgrove SE, et al. Training to hospital staff to respond to a mass casualty incident. *Evid Rep Technol Assess (Summ)*. 2004;(95):1–3. [PubMed ID: 15526398]. [PubMed Central ID: PMC4781264].
29. Mackie BR, Weber S, Mitchell ML, Crilly J, Wilson B, Handy M, et al. Chemical, Biological, Radiological, or Nuclear Response in Queensland Emergency Services: A Multisite Study. *Health Secur*. 2022;**20**(3):222–9. [PubMed ID: 35612425]. https://doi.org/10.1089/hs.2021.0214.
30. Mortelmans LJ, Van Boxstael S, De Cauwer HG, Sabbe MB, Belgian Society of E, Disaster Medicine S. Preparedness of Belgian civil hospitals for chemical, biological, radiation, and nuclear incidents: are we there yet? *Eur J Emerg Med*. 2014;**21**(4):296–300. [PubMed ID: 23978957]. https://doi.org/10.1097/MEJ.0000000000000072.