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Original Article

Preparedness of a Military Hospital against Chemical Incidents: Based on the Organization for the Prohibition of Chemical Weapons Scenario

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Abstract

Background: Evaluating preparedness in the health sector, particularly within hospitals, is crucial for mitigating the impact of uncontrollable disasters like chemical incidents.

Objectives: This study aims to evaluate the readiness of a military hospital in Tehran to respond effectively to such emergencies.

Methods: In this study, data were collected using a standardized and validated questionnaire, specifically the Hospital Preparedness Tool for Chemical Crises, developed to assess the readiness of the selected military hospital in Tehran.

Results: According to the study's results, the overall level of preparedness at the hospital was assessed as "very good," with a total score of 119. Among the six areas examined in the selected hospital, the highest score was for the planning and guidelines area, with points (73.94%), and in the "very good" category. In contrast, the lowest score was for the risk assessment and early warning area with 7 points (70%), and in the "good" category.

Conclusion: Based on the study findings, the performance of the selected hospital in various dimensions of preparedness and response is assessed at a very favorable level. Also, the hospital has significant capabilities in improving preparedness for various events, including chemical incidents.

Keywords: Preparedness, Military Hospital, Disasters, Chemical Weapons, Organization for the Prohibition of Chemical Weapons

1. Background

Since the creation of humanity until now, human life has faced crises and disasters, and these events have always been intertwined with human existence. Today, avoiding the negative effects, damages, and costs of these events on the lifestyle and health of humans is essential. Disasters and calamities can be classified into three categories: natural, man-made, and combined.[1] Over 90 percent of deaths in developing and less-developed countries are due to accidents and disasters, including chemical accidents as part of these man-made disasters.[2] In the last four decades, the intensity and frequency of natural and man-made disasters have increased at an unprecedented rate, nearly tripling globally. Close to 700,000 people have lost their lives, and over 1.2 million people have suffered from short-term and long-term disabilities as a result of natural disasters, with economic losses exceeding one trillion dollars.[3] It is one of the essential and primary needs of humans in emergency situations, encompassing health and medical needs. During incidents and disasters, the role of hospitals and healthcare centers becomes critical. They are among the first units whose rapid, optimal, and timely provision of health and medical services can significantly reduce mortality and increase the number of survivors. Hospitals are also exposed to complications, damages, and shortages resulting from the occurrence of crises and disasters. Therefore, they need to develop a coherent plan to deal with such events.[4]

In recent decades, the world has faced numerous industrial chemical incidents. Our country has also not been immune to these occurrences and has experienced

several chemical incidents and threats. Four major industrial accidents occurred in the cities of Shazand, Astara, Gachsaran, and Aghajari between 1917 and 2011. Among the high-casualty chemical incidents in the country, one can refer to the explosion of a train carrying flammable and explosive materials in the village of Dehnow, Hashemabad, Neyshabur (2003), the catastrophic explosion of the Bazna industrial unit in Shazand (2008), and the chlorine gas leak due to the deterioration of the cylinder in Dezful (2017). Chemical hazards are among the common hazards in industrial countries. With the growth of industry and the increasing development of factories, we are witnessing an increase in industrial accidents, including chemical accidents. Currently, there are over 300,000 factories and consumer units of chemical materials in the country operating in three sectors: industry, services, and agriculture. This situation is a precursor to chemical incidents. Depending on the nature or extent of a chemical incident, hospitals will face an increased demand for healthcare services, which can lead to disruptions in hospital operations. Chemical incident injuries require specific medical care, including triage, decontamination, medication prescription, proper use of personal protective equipment (PPE), and prevention of secondary contamination of healthcare personnel.[5] Until recent years, chemical incidents were considered rare occurrences, so planning, training, and allocating equipment for treating chemical injuries were limited to specific hospitals. Since it is unclear where and when these incidents may occur, it is evident that all hospitals must be prepared to handle chemical incidents.[6] Therefore, adopting an effective preparedness plan for hospital readiness is both crucial and essential.[3]

Preparedness is defined as activities aimed at establishing a mechanism for rapid responses designed to limit risks and effects. One of the vital components of enhancing disaster preparedness is assessing hospital readiness and subsequently ranking them. Hospitals must prepare their physical infrastructure and resource planning, as they are the primary facilities providing care during incidents and disasters.[7] Improving disaster and disaster risk management in hospitals is one of the most important factors in increasing their readiness to deal with disasters. Therefore, enhancing disaster and disaster risk management in military hospitals and consequently improving their readiness is more critical compared to other hospitals.[8] Military hospitals in Iran play a vital role as one of the most significant health and treatment centers in the country during crises. This is particularly important due to the critical role of border hospitals in aiding potential victims and injured individuals during incidents and crises on one hand, and the likelihood of such incidents occurring in the future on the other. The need for preparedness to respond effectively is felt even more strongly, ensuring that through appropriate and coherent measures and programs in all dimensions, they can help mitigate the impacts of crises. Therefore, the comprehensive and proper equipping of military hospitals across the country should be prioritized by health organizations within the armed forces.[9] Increasing the preparedness of military healthcare personnel for disaster response can enhance performance in future global health missions. The strategic document on health, relief, and treatment of the armed forces in Iran states that the mission of military hospitals is to provide aid, transfer, and treat the injured during emergencies. Therefore, the preparedness of military hospitals during emergencies and disasters is more critical than that of other hospitals. Hospitals must be able to respond to the large volume of patients and casualties caused by disasters while continuing their ongoing duties during crisis situations. In this context, military health and treatment centers, given their specialized missions and critical role in the health system's response during crises, must have plans for crisis management and mitigation of its effects (in case of occurrence) and be adequately prepared to handle incidents and disasters. Hospitals will not have adequate preparedness and response capacity without effective training. The necessity of educating and orienting managers, increasing their risk perception, and changing their attitude towards the importance of prevention; long-term planning for holding training classes and retraining courses for managers and staff; training in preparedness against chemical, microbial, radiation, and nuclear (CBRN) incidents; and training the incident command system to employees are among the strategies for improving disaster risk management in military hospitals. The use of diverse educational approaches such as community-based education, interactive education, evidence-based education, and e-learning is also a solution to increase preparedness.[8] When responding to chemical incidents and threats, several components must be considered, including hospital capacities, hospital preparedness levels, up-to-date knowledge, personal protective equipment, and decontamination. Avoiding the securitization of chemical incidents and increasing the risk perception of managers, officials, and the public will provide the necessary basis for hospital preparedness. Consequently, we will witness a reduction in various consequences of chemical incidents, including physical, psychosocial, and economic damages.[5] For this purpose, the Organization for the Prohibition of Chemical Weapons (OPCW) scenario, the Chemical Weapons Convention, an international disarmament and non-proliferation treaty, entered into force in 1997. The convention prohibits the development, stockpiling, transfer, and use of chemical weapons. Today, 193 countries are parties to it. The OPCW, based in The Hague, is the implementing body of the convention and was used for this study.[10] Therefore, the need to establish and enhance preparedness in hospitals,

particularly military hospitals, against chemical incidents is crucial and must be addressed across various functional areas, including: personal safety and equipment, security, control and management, human resources and training, planning and decontamination guidelines, operations and risk assessment, and early warning. Furthermore, conducting various types of exercises, especially functional and full-scale drills, can significantly improve this preparedness.

2. Objectives

This study aims to evaluate the level of preparedness of the selected military hospital in Tehran based on the Organization for the Prohibition of Chemical Weapons scenario for responding to medical emergencies related to chemical incidents.

3. Methods

The present study is a descriptive cross-sectional study conducted in 2023 at a selected military hospital in Tehran. This study aimed to investigate the operational capacity of the selected hospital in the event of chemical incidents, so that in the event of incidents such as chemical accidents, explosion of chemical tanks, terrorist attacks, and chemical leaks, it would have the necessary readiness to respond to the incident, prevent casualties, and provide appropriate services to the injured. This study was based on the preparedness tool of selected hospitals in Tehran against chemical crises by Ali Ahmadi et al. (2017), which consists of a 70-question checklist. The scoring method is based on available documents using the Likert scale from 0 to 2 (no, somewhat, and yes). The evaluation method categorized the hospital as very weak, weak, moderate, good, or very good based on the scores. The hospital was evaluated in six areas: 1. Safety and personal equipment (13 questions), 2. Risk assessment and initial warning (5 questions), 3. Security, control, and management (7 questions), 4. Human resources and training (14 questions), 5. Planning and instructions (19 questions), and 6. Decontamination and operations (12 questions). The validation of the questionnaire includes face validity, content validity, construct validity, internal consistency, and stability, measured in 15 hospitals in the country. The Cronbach's alpha coefficient of the questionnaire indicated good reliability ($\alpha = 0.70$). After the exercise, the hospital's level of preparedness was assessed based on the tool's questions and total score. The preparedness level of the selected hospital was determined using descriptive statistical indicators in data analysis. The score was calculated based on the sum of the scores obtained from a total of 140. If the score of the treatment center was between 0-28, the hospital was considered very weak; between 29-56, weak; 57-84, average; 85-112, good; and 113-140, very good.[11]

Table 1. Method of Scoring Hospital Preparedness

Hospital Operational Preparedness Level	Very weak	Weake	Average	Good	Very Good
The score of the selected hospital	0-28	29-56	57-84	85-112	113-140
The percentage of preparedness at the selected hospital	0-20	21-40	41-60	61-80	81-100

4. Results

The results indicate that the selected hospital demonstrates a very good level of preparedness against chemical incidents. The overall preparedness score of the hospital is 119 (82.82%), reflecting strong performance in most of the assessed dimensions. Among the six areas examined, planning and guidelines, with a score of 28 (94.73%), exhibited the highest level of preparedness, highlighting the presence of documented and effective procedures for crisis management. Staff and training, with a score of 22 (78.57%), were also at a significant level, indicating the importance of continuous training and preparation of personnel in dealing with chemical incidents. Nevertheless, risk assessment and early warning,

Table 2. The Level of Preparedness of Different Departments in the Selected Hospital

ROW		1	2	3	4	5	6	*
Checklist variable		Personal Safety and Equipment	Risk Assessment and Early Warning System	Security, Control and Management	Staff and Training	Planning and Instructions	Decontamination and Operations	collection and average
Maximum score		26	10	14	28	38	24	140
Selected Hospital	Hospital score obtained	22	7	12	22	36	20	119
	Score as a percentage	84.61	70	85.71	78.57	94.73	83.33	82.82
	Level of preparation	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good

warning, with a score of 7 (70%), were recognized as the lowest score, and improvement in this area is essential for timely identification of risks and rapid notification.

The conducted assessments showed that the hospital has performed well in areas such as safety and personal protective equipment (85.71%) and operations and decontamination (82.82%). These results indicate a high level of planning and performance by the hospital in the crisis domain; however, the lack of decontamination equipment and the need to enhance early warning capabilities remain significant challenges.

5. Discussion

Identification of chemical substances and their differential diagnosis from other biological and radiological diseases require expertise and access to laboratories capable of providing accurate diagnoses to medical staff in the shortest possible time, thereby guiding them towards timely and effective treatment. The results of this assessment revealed that selected military hospitals in the country are well-prepared in this regard. Hosnian Moghadam and colleagues conducted a 2019 study aimed at developing and experimentally implementing a response to a hypothetical chemical incident at Lqman Hospital in Tehran. The study demonstrated that the hospital's preparedness was at a moderate level, highlighted a significant lack of decontamination equipment, and concluded that the hospital's overall readiness for a chemical incident was insufficient.[12] The results of this exercise showed that the selected military hospital in the country demonstrated very good readiness in terms of human resources and training. Human resources and training are among the issues that have been less addressed and will require better planning to reduce human errors. Training personnel for crises is one of the areas that has been underemphasized and will necessitate improved planning to minimize human errors. Our therapeutic capacity to manage such large-scale incidents has been limited, highlighting the importance of effectively managing resources in such scenarios. A point worth noting is that part of the lack of full team cooperation and adherence to the commander's orders stems from some employees not taking the exercise seriously. It is possible that the actual performance of these employees might exceed their performance during the exercise. On the other hand, this area is extensive and requires the allocation of resources, which must be sought from the relevant factories and industries at risk.[6,8]

The results of this exercise showed that the selected military hospitals in the country demonstrated excellent readiness in terms of security, control, and management. Since hospitals are critical for transferring the injured for further treatment, it is essential to address their needs beyond medical measures and take all possible actions to ensure the safety of the injured and provide them with comfort during their hospital stay. Edbert et al. also highlighted in their study that healthcare workers must be adept at communicating with victims and managing the movement of individuals when responding to disasters.[13]

Furthermore, the results of this exercise showed that the selected military hospitals in the country had good planning and preparedness guidelines, as having an organization aligned with high efficiency is an essential requirement in hospitals. Organization must be carried out in such a way that, during normal times, it serves as a foundation for times of crisis and war, enabling the hospital to perform appropriately under different and difficult conditions. The obtained score indicates that the situation in this study is better compared to others, which may be due to the position of the hospitals, their military nature, and their exposure to various crises. Amerioun et al examined the readiness status of selected military hospitals in Iran, and their results showed that the level of hospital readiness was generally good in most aspects. However, in the aspects of responding to the needs of the injured, conducting drills, accepting and transferring, and discharging the injured, it was at an average level.[14]

In the study by Yarmohammadi et al. conducted in 12 educational hospitals in 2013, it was shown that none of the hospitals under review had the necessary capacities and capabilities to deal with chemical, microbial, radiological, and nuclear accidents. Only the emergency department of one hospital was evaluated as relatively good in terms of both preparedness and response.[15] Mohabbati et al.'s study also showed that this readiness is below average, based on the checklists published by the Ministry of Health.[16] A study in Germany showed that only about half of hospital doctors are aware of their disaster control program, and only 33 percent of hospitals have participated in disaster training scenarios.[17]

The evaluation by Majid Shahrati et al. of the second joint chemical exercise, conducted in Ukraine by the OPCW, 16 European countries, and Iran, held in Ukraine in 2005, highlighted several weaknesses: lack of scientific knowledge among the medical teams from participating countries regarding triage methods and handling chemical casualties; incompatibility of hospital facilities brought by different countries' medical teams with the chemical exercise; absence of appropriate educational and briefing programs at the start of the exercise; reliance on trauma patient records for chemical casualty triage, leading to errors by triage officers; unavailability of essential antidotes for chemical incidents; insufficient knowledge among medical teams about treating casualties and the types of antidotes used; and absence of specialized color-coded cards (red, blue, green, black) for triaging chemical casualties, which indicate treatment priorities.[18]

Hassanian Moghadam et al. mentioned the following as weaknesses of the specialized chemical exercise held in the country: failure to observe the appropriate distance

between the car decontamination area and the casualty triage area, the use of ordinary stretchers instead of wire stretchers for decontamination of the injured, lack of proper control and direction of sewage from the decontamination of tools and injured people into special containers, and lack of proper notification of weather and wind conditions.[12]

Studies in Canada have shown that, despite all the progress, there is no preparedness, especially for the decontamination of patients.[19,20] A report indicates that the situation in the United States has improved somewhat. Nearly all hospitals have programs to address natural disasters, with most focusing on chemical, biological, nuclear, and explosive incidents. Approximately three-quarters of hospitals have been integrated into comprehensive disaster programs.[21] has specifically announced a report on a trend of collaborative planning with other local healthcare centers; however, only 46 percent of them have reported memorandums of understanding with these facilities for admission during the declared disaster.[22] Definitely has problems everywhere, and hospitals that have not conducted drills for preparedness remain unaware of the magnitude of the problem.

It seems that training healthcare staff and conducting annual exercises in selected centers are necessary actions to maintain readiness and respond to chemical agents. Establishing such preparedness is not limited to responding to chemical agents and can keep healthcare infrastructures ready to deal with other unforeseen incidents, including biological and radiological events. Given the limited resources of our country and the significant depth of the problem, which is evident in mass incidents, fundamental planning must be undertaken to address these threats. Skilled human resources may be the most crucial factor in identifying and mitigating these challenges; therefore, educational planning to better prepare medical and healthcare staff is considered a priority, and specialized educational hubs in this field could provide substantial support. On the other hand, reviewing the events and crises of the country and their fair criticism will create lessons for the future, as addressing their weaknesses is considered a threat identification strategy. The country's strategic antidote reserves have been in short supply during various epidemics and need to be managed.[9]

The most essential needs after the crisis are transfer, diagnosis, and treatment services, especially in hospitals. All hospital staff in general, and hospital crisis staff in particular, have a significant responsibility, especially in the initial hours of unintended incidents. To play an effective and efficient role after the crisis, ensuring the readiness of the hospital in terms of facilities, equipment, and staff preparedness is essential. Due to insufficient resources for providing facilities, equipment, and medical consumables, hospital managers often prioritize daily tasks over conducting emergency response exercises, such as those for fires, rescue operations, and plane crashes. Furthermore, hospital staff turnover occurs over time, making periodic drills essential to ensure readiness for service response during unforeseen incidents.[12]

6. Conclusion

This study revealed that the selected military hospital demonstrates a commendable level of preparedness for handling chemical incidents, though improvements are still required in certain areas, particularly in risk assessment and early warning. The scores achieved in areas such as planning and guidelines, human resources, and training underscore the hospital's strengths in developing processes and preparing personnel. However, challenges like inadequate decontamination equipment and the need to enhance risk assessment capabilities remain areas for improvement.

To enhance preparedness, it is recommended that hospitals conduct specialized training programs and practical exercises, focusing on decontamination and risk assessment. Additionally, leveraging modern technologies for early warning and assessment of chemical hazards can play a crucial role in boosting preparedness levels. Furthermore, developing and implementing comprehensive programs in collaboration with other healthcare and industrial centers related to chemicals can significantly help reduce the damage caused by chemical incidents.

Ultimately, the results of this study can serve as a model for assessing and improving the preparedness of other hospitals, particularly military hospitals in the country. By implementing the proposed strategies, it is anticipated that hospitals can operate more effectively during similar crises and mitigate their adverse impacts.

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Author Contributions

Authors contributed equally to this work.

Ethical Approval

This article is extracted from a research project with the ID 402000349 at Baqiyatallah University of Medical Sciences, which is being conducted under the ethics code number IR.BMSU.BAQ.REC.1402.116 from the Ethics Committee of Baqiyatallah University of Medical Sciences.

Declaration of Generative AI and AI-assisted technologies

During the preparation of this work, the authors used the Monica AI tool to assist with grammar and fluency. The authors then reviewed and edited the content and are responsible for the evolution of the content for publication.

Conflict of Interest Disclosures

All authors declared that they have no conflict of interest.

Research Highlights

What Is Already Known?

- Chemical hazards have been considered as one of the major threats in industrial societies, as well as in Iran, with a history of numerous accidents with human casualties and economic losses.
- As the first line of medical response to incidents, hospitals play a vital role in reducing mortality and managing chemical casualties.
- Due to their specific mission and geographical location, military hospitals require a higher level of preparedness in dealing with crises, including chemical incidents.

What Does This Study Add?

- Identifying specific strengths: The overall level of preparedness of this military hospital is “very good” (score 119 out of 140).
- Highlighting the top strength: it was found that the area of "planning and guidelines" was the strongest area of preparedness in this hospital, with a score of 94.73%.
- Emphasis on operational solutions: the study suggests specific improvement solutions, such as conducting specialized and periodic exercises, improving early warning systems, and developing interdisciplinary collaborations with industrial and medical centers, which can provide a framework for action.

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