



Hospital Preparedness Challenges in Chemical Incidents: A Qualitative Study

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ABSTRACT

Aims A significant number of chemical events happen every year in Iran, which may require admission and management of victims in the hospital. The results of studies have shown that Iranian hospitals, like many developing countries, are not sufficiently prepared for these events. The aim of this study was to explain the challenges of hospital preparedness in chemical events in Iran.

Participants & Methods This qualitative research was conducted with the content analysis approach in Tehran. Ten participants were enrolled using purposive sampling. Data collection was through in-depth and semi-structured interviews and continued until reaching data saturation. The selected interviewees consisted of physicians, nurses, members of the Hospital Risk Management Committee, and experts of Health in Emergencies and Disasters, who had experience in responding to and treating chemical casualties. All interviews were recorded, transcribed, imported into the MAXQDA 10 software, and analyzed using the Graneheim and Lundman method.

Findings The main theme was "Lack of priority of chemical events for policy makers". Five categories and eleven sub-categories were extracted. Categories relating to challenges of hospital preparedness in the management of chemical casualties included "Lack of updated plans and protocols", "Ineffective training", "Organizational challenges", "Lack of legal and financial support", and "Lack of infrastructure and decontamination equipment".

Conclusion Iranian hospitals are facing challenges to acquire and maintain preparedness in response to chemical events. Therefore, national standards for hospital response to chemical events should be agreed upon by policy makers, and their implementation should be evaluated in hospital accreditation.

Keywords Chemical Incidents; Emergency Preparedness; Hospital; Qualitative Research

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Introduction

Iran, as a developing country, has experienced the industrialization process very quickly over the past decades. Technological advances, discovery, and use of thousands of chemical substances are an integral part of the industrialization process of this country [1, 2]. Intensive industrialization without providing adequate infrastructure to prevent industrial incidents has brought problems to countries [3, 4]. There have been 40 cases of chemical incidents caused by hazardous materials in the country during 2018 to 2020 [5]. The last decade has seen an increasing trend in the occurrence of chemical events in Iran, so more than 230 people were admitted to hospitals in Zahedan city due to the release of toxic gases in 2014 [6]. The worst chemical incident in Iran was the explosion of a train at Neyshabouri station in 2004, which resulted in more than 300 deaths and more than 450 injuries so that all humans and animals in the scene up to a radius of 500 meters perished [7].

In addition to industrial incidents, the intentional release of chemical agents (industrial agents and those specifically made to harm human health) also happens around the world [8], and there is enough evidence of the danger of terrorist activities, especially in the last decade in the country. Whether intentional or unintentional, chemical incidents are important from different aspects, including economic, political, social, security, and medical. Injuries arising from chemical incidents require special medical care, including triage, decontamination, antidote administration, trauma care, proper use of Personal Protective Equipment (PPE), and prevention of secondary contamination of healthcare personnel [9, 10].

Until recent years, chemical accidents were considered rare cases, so any planning, training, and allocating equipment for treatment of chemical injuries were left only to certain hospitals [8]. Since it is not clear where and when these incidents will occur, it is obvious that all hospitals should be prepared to deal with chemical incidents. The results of a study aimed to evaluate the level of preparedness, capacity, and ability to respond to Chemical, Biological, Radiological, and Nuclear (CBRN) incidents in Teaching Hospitals of Isfahan showed that only one of the hospitals, which had a specialized emergency department to deal with CBRN incidents, had the necessary preparedness to deal with the mentioned incidents [11]. Also, the results of another study showed that medical centers do not have the preparedness necessary to manage chemical incidents. In addition, they reported a lack of planning for the prevention, preparedness, and rehabilitation of chemical incidents in the study areas and at the national level [6].

The fact is that there are hidden aspects of the challenges related to hospital preparedness in response to chemical events in the country, which are unknown and have not been studied. In developing countries and Iran, studies were conducted to determine the degree of hospital preparedness in response to chemical events, the results of which indicate the inadequacy of hospital preparedness in dealing with these events [6, 11, 12]. On the other hand, the literature review revealed that no study has been conducted with a qualitative approach to explain the challenges of hospital preparedness in dealing with chemical events in Iran. Considering the cultural, social, and economic differences of societies, the present study aimed to explain the challenges of hospital preparedness in chemical events.

Participants and Methods

Study design and sampling

The present qualitative research was conducted with the content analysis approach to identify the challenges of hospital preparedness in chemical events from March to August 2021 in Tehran. A purposive sampling technique was used for 10 key informants in the field of incidents and disasters. The participants were selected with the maximum variation in age, gender, and educational level. The selected interviewees consisted of physicians, nurses, members of the Hospital risk management committee, and experts of Health in Emergencies and Disasters, who had at least one experience in the medical response to chemical events. Most of them had managerial and policy-making roles in hospitals, some of them had experience in treating chemical victims in the Iraq war against Iran, and some of them volunteered to treat chemical victims in Syria. The exclusion criterion was withdrawing from the study at any time during the study.

Data collection

Face-to-face, semi-structured and in-depth interviews were held with total privacy for participants. The time and place of the interview was determined with the coordination of the participants. All the interviews were conducted by the same trained member of the research team. The duration of the interviews lasted between 50-80 minutes. The interview questions and guide were compiled based on reviewing the literature and the opinions of experts and were pilot tested in two interviews. The interview guide included open-ended questions such as "what challenges did you have in response to chemical events?", "What are the management problems that you have experienced or may experience during a chemical event?", "What are the weaknesses in assessing a hospital's performance of chemical events?" If necessary, the probing question was used, "Can you explain more about what you mean?" Interviews continued until

data saturation. After eight interviews, no new data was added, but two additional interviews were conducted to ensure data saturation. All interviews were recorded, transcribed, imported into the MAXQDA 10 Software. Finally, data were analyzed using Graneheim and Lundman's method [13]. The recorded audio file was transcribed immediately after each interview. The interviewer listened to the recorded statements and reread several times to understand better the feelings and experiences of the participants. Then the interviews were analyzed and coded line by line and the initial codes were extracted. 326 initial codes were merged with each other based on their similarities, and in the next step, the merged codes were placed in categories and subcategories. The most homogeneity was observed within the categories and the most heterogeneity between the categories.

Rigor

The trustworthiness of this research was confirmed through credibility, dependability, conformability, and transferability. To enhance the research's credibility, the researcher tried to collect data by establishing proper communication, allocating enough time, and gaining the trust of the participants, and deeply examined the interviews by repeatedly reading them and immersing in the data. The researcher also tried to increase research credibility with data triangulation and peer checks. To enhance the research transferability, the maximum variation of participants was considered based on age, gender, and educational level. To respect the research's dependability, the researcher provided the interviews and codes to two of the participants, and the clarification of issues was done via member checks. Providing examples of participants' statements also increased the research's dependability. To enhance the research conformability, the researcher made some parts of the interviews available to the experts of qualitative research and the supervising professors and applied their comments.

Findings

The participants (n=10) consisted of physicians (n=5), nurses (n=2), experts of Health in Emergencies and Disasters (n=2), and incident managers (n= 1). The majority of participants were men, and the age range was 38-63 years (Table 1).

Table 1) Characteristics of participants

Participant	Sex	Educational level	Workplace
P1	Male	PhD in the Health in Emergencies and Disasters	Crisis management organization, and hospital
P2	Male	Emergency medicine doctor	Hospital
P3	Male	Emergency medicine doctor	Hospital
P4	Male	General practitioner	Red Crescent Organization and Hospital

P5	Male	Pulmonologist	Chemical Injuries Research Center
P6	Male	PhD in nursing	Faculty member of the University of Medical Sciences Hospital, and
P7	Male	Ophthalmologist	Faculty member of the University of Medical Sciences
P8	Female	PhD in the Health in Emergencies and Disasters	Faculty member of the University of Medical Sciences
P9	Female	Master's degree in disaster management	Chemical Injuries Research Center
P10	Male	Master's degree in nursing	Hospital

The study findings included 11 sub-categories and 5 main categories under one theme, as depicted in Table 2.

Table 2) Categories and subcategories

Main theme	Main categories	Subcategories
Lack of priority of chemical events for policy makers	Lack of updated plans and protocols	- Failure to perform a risk assessment of hazardous materials - Lack of standard operating procedures and protocols
	Ineffective training	- Lack of holding chemical education courses - Failure to evaluate the training course
	Organizational challenges	- Lack of decontamination team - Lack of hospital leveling
	Lack of legal and financial support	- Lack of chemical standards in hospital accreditation - Failure to allocate budget for hospitals to get preparedness
	Lack of infrastructure and decontamination equipment	- Lack of hospital decontamination infrastructure - Lack of personal protective equipment - Lack of antidote and medical supplies

A) Lack of updated plans and protocols

The first category extracted from the data was related to the “Lack of updated plans and protocols”, consisting of two subcategories, “Failure to perform a risk assessment of hazardous materials” and “Lack of standard operating procedures and protocols”.

•Failure to perform risk assessment of hazardous materials

To deal with chemical incidents, the hospital must have plans and protocols, and they must be up-to-date and aimed at assessing the risk of chemical hazards. Lack of risk assessment and lack of knowledge of the consequences of a chemical incident is among the most important reasons for the lack of hospital preparedness. In this regard, one of the participants said:

“The things we forget is that we don't do a risk assessment at all. Risk assessment is very important.

How can I prepare my hospital if I don't know what the sources of chemical incidents threatening my hospital?" (P2)

Another participant stated that, in addition to identifying out-of-hospital chemical hazards, in-hospital chemical substances should also be identified:

"In one of the hospitals in Tehran, where fires happen several times a year, if a fire occurs, for example, in the operating room, laboratory, or radiology ward of the same hospital, a chemical incident may occur because inside the hospital there are many chemicals that are not considered in the risk assessment." (P3)

• **Lack of standard operating procedures and protocols**

Most of the participants stated that the protocols of the hospital in response to chemical incidents do not have the necessary comprehensiveness and integrity and that each hospital operates independently, and there is no standard and uniform protocol and instruction in this field for all hospitals. One of the participants said:

"According to the request of one of the referral hospitals in the chemical research center, we developed 24 operating procedures and protocols, which remained at the level of the same hospital and were not nationalized." (P1)

Another participant stated that we must have standard and up-to-date operating procedures to effectively respond to chemical incidents.

"We must have standard operating procedures for decontamination of the victims, treatment of lung, eye and skin injuries, burial and disposal of contaminated clothes, a plan for how to discharge sewage contaminated with chemicals that do not enter the municipal wastewater, but unfortunately, the lack of such standard operating procedures is evident." (P9)

B) Ineffective training

The second category resulting from the study data was "Ineffective training", consisting of two subcategories, "Lack of holding chemical education courses" and "Failure to evaluate the training course".

• **Lack of holding chemical education courses**

The participants considered training as one of the most important effective factors in hospital preparedness in response to chemical incidents, but they stated that these trainings are held in very few hospitals. One of them stated:

"I teach topics related to crisis management in many hospitals, but apart from military hospitals, only one or two hospitals across the country requested to teach chemical topics." (P8)

• **Failure to evaluate the training course**

Another challenge in this field is that the employees do not take the training seriously, and the training is more of a show and not effective. One of the participants said:

"Hospital managers these courses only to get points in accreditation and some employees also participate to get certificates, and the effectiveness of such training is not evaluated." (P10)

C) Organizational challenges

The third extracted category was related to "Organizational challenges", consisting of two sub-categories, "Lack of decontamination team" and "Lack of hospital leveling".

• **Lack of decontamination team**

The participants emphasized that the formation of decontamination teams and their training can play an important role in managing these incidents. One of the current challenges is the lack of decontamination teams at the university and hospital levels. In this regard, one of the participants said:

"All chemical plants are located in the south of Tehran, which has a population of about two million and has had numerous chemical incidents, and so, at least one special HAZMAT team is needed only in the south of Tehran." (P4)

• **Lack of hospital leveling**

According to most of the participants, one of the important challenges in organizing is the lack of hospital leveling, as they believed that all hospitals in the country can't be prepared at the same level and in the same way, and it will result in a huge cost; therefore, the hospitals should be classified into different levels based on equipment, staff training, and other preparedness requirements.

"Hospitals should be classified into three levels, one, two, and three, so that the level three should have the least preparedness, for example, Personal Protective Equipment (PPE) only one or two series and basic training of emergency personnel, the level two should have higher preparedness, for example, PPE with more number, more specialized training and team formation, and the level one, which is a specialized hospital, must have the highest level of preparedness, for example, a large number of PPE, decontamination infrastructure, separate waste, and sewage disposal system, chemical emergency department and skilled specialized team." (P7)

D) Lack of legal and financial support

The fifth category extracted from the study data is "Lack of financial and legal support", consisting of two subcategories, "Lack of chemical standards in hospital accreditation" and "Failure to allocate budget for hospitals to get preparedness".

• **Lack of chemical standards in hospital accreditation**

Developing standards is one of the factors that can increase the level of hospital preparedness in responding to incidents. In 2009, the Joint Commission for Accreditation of Health and Medical Centers developed accreditation standards related to hospital crisis management. This framework has specified the minimum level of preparedness versus

disasters with the approach of all hazards. Since accreditation is an important factor in paying the costs of providing services, it is one of the strongest motivations for hospital managers to obtain preparedness in responding to disasters. In this regard, one of the participants said:

“The Ministry of Health, Medical Education should include the standards of chemical incidents in the accreditation criteria that rank hospitals. Based on that, if the hospital was not ready, it should not provide its needs and budget, because the hospital's expenses are financed through accreditation.” (P6)

• Failure to allocate budget for hospitals to get preparedness

According to the findings from the study, budget allocation was the start of providing equipment and infrastructure and even conducting training courses. There is still no budget for hospitals for such Incidents, and this can be considered an important reason for the hospital not being ready. One of the participants stated:

“One of the problems is that when the equipment is not used and the time goes by, there must be a budget to buy again, and no one provides the budget to replace it.” (P8)

E) Lack of infrastructure and decontamination equipment

The fourth category was related to “Lack of infrastructure and decontamination equipment”, consisting of subcategories, “Lack of hospital decontamination infrastructure”, “Lack of personal protective equipment”, and “Lack of antidote and medical supplies”.

• Lack of hospital decontamination infrastructure

The participants stated that the infrastructure of our hospitals has not been designed for response to chemical incidents.

“Hospitals' emergency department should be designed in such a way that it can quickly become a chemical emergency department in case of chemical incidents, that it must have a decontamination infrastructure and that the wastewater from washing the victims must be collected in a container, the ventilation system must be suitable, and the entrance and exit doors must be separate.” (P5)

• Lack of personal protective equipment

Many participants complained about the lack of standard PPE, and one of them said:

“Decontamination of a chemical victim who enters the hospital is very important. The person who visits the patient should not be contaminated himself, so we need some protective equipment; for example, PPE for chemical incidents must be up to date. Therefore, we must use type A or finally type B clothes, but now in the hospital where I am the vice president of treatment, and it is a referral hospital, we use type C.” (P1)

• Lack of antidote and medical supplies

Several participants stated that although a low cost is needed to provide antidotes, there are not enough antidotes available in the hospital. One of the participants said:

“A few simple antidotes, including amyl nitrite, sodium thiosulfate, and sodium nitrite should be available as a kit inside the hospital, which is not. For example, after contamination with cyanide compounds, you don't have much time, and the patient dies during the time you want to get the antidote from another hospital. During the Syrian chemical war, when I volunteered in one of the Syrian hospitals, these kits were available to doctors.” (P4)

Discussion

This study aimed to explain the challenges of hospital preparedness in chemical events. Preparedness is one of the basic stages of the crisis management cycle in the time before the crisis and covers all programs and activities that enable any organization to respond quickly and effectively to crises [14-19]. Obtaining and maintaining a suitable level of preparedness are considered challenges for most hospitals in the world [12, 17, 18]. There is a need for more effort to develop and maintain such preparedness for incidents that do not happen predominantly [19].

The first category extracted from this qualitative study was “Lack of updated plans and protocols”. Our findings showed that hospitals lack a coherent plan to deal with chemical events and do not assess the risk of hazardous substances. Barbara *et al.* reported that one of the challenges of hospital preparedness is the traditional planning assumptions that are based on conventional wisdom rather than evidence- and experience-based [17]. Planning is the foundation of hospital preparedness and has a great impact on the hospital's response to incidents [20, 21]. To respond to chemical incidents, hospitals must observe certain considerations in the planning process [22], and the planning process must be carried out according to the evaluation and identification of hazardous substances and risk assessment [23, 24]. The results of a study on the development of a risk management program showed that monitoring the hospital's performance in disasters and making the necessary reforms with the aim of developing and updating risk management programs will improve resilience in dealing with risk [25]. Threat identification and risk assessment are essential components of hospital preparedness to deal with disasters and emergencies. Medical personnel should be aware of chemical incidents that are likely to occur in their geographical area, and they should be aware of the characteristics of possible incidents [20]. The results of a study showed that in the largest non-nuclear explosion in modern history took place on August 4, 2020, in Beirut,

Lebanon, at the preparedness level, government agencies failed to adequately identify the hazard risk associated with the storage of large volumes of explosive chemicals in an urban site [26]. The results of another study showed that knowing the origin of chemical events (hospital and outside the hospital), estimating the vulnerability of hospitals against these incidents, and information about the consequences of chemical events can be a wide view for managers and policymakers in this field [27].

The second category was "Ineffective training". The training of medical personnel is an important part of the preparation of hospitals in disasters, since chemical events happen suddenly and their incidence rate is relatively low compared to other events, it causes that most of the medical personnel do not have the necessary experience and preparation in this field. In the present study, most of the interviews focused on the importance of training and practice for healthcare providers, pointing out that training programs were implemented for a limited number of hospitals and had little impact on hospital preparedness. The results of a study conducted in the last two years is consistent with the results of the present study, stating that the biggest challenge facing hospital preparedness in dealing with chemical incidents is low scores in training and practice. The results of a study showed that the barriers to achieving proper training were lack of suitable training locations, lack of relevant and accessible training courses, and lack of funds to train a large number of employees [28]. It should be noted that improving knowledge serves as a basis for performance, but it is not enough to ensure proper performance, so it is necessary to evaluate the knowledge and actual performance of healthcare workers [25]. In this regard, a study with the Delphi technique related to the management of chemical incidents suggests a national training standard that should be implemented for all medical and nursing personnel in the emergency department [22]. A survey had reported that medical staff needs to be trained in the safe use of personal protective equipment to treat CBRN casualties. They also need to learn the procedures for decontaminating patients who have been exposed to chemical agents [24].

The third category obtained in this study was "Organizational challenges", which takes account of the sub-categories of "Lack of decontamination team" and "Lack of hospital leveling". Hospitals should train ready and skilled teams to carry out decontamination, treatment and care of chemical victims and the design of these teams should be such that there are trained people in the composition of these teams in all shifts. The lack of decontamination team in the country's hospitals is another challenge raised by the participants. The results of the studies considered the existence of these teams as a necessity in hospital preparedness in dealing with chemical incidents [19, 26].

Although most industrial incidents cause a few people to be injured, the likelihood of contamination of emergency workers and hospital facilities is always raised as a concern. Accordingly, most medical centers prefer to have a team to respond to internal disasters and injured people who either refer to the hospital themselves or are referred to the hospital after decontamination [27]. Based on the experiences of the participants, hospitals should be divided into different levels based on their capacity and specialized field of activity. Leveling is a suitable way to reduce the cost of hospital preparedness, because the preparedness of all hospitals in the country will not be at the same practical level, and the authorities refuse to accept the allocation of huge budgets for these incidents; therefore, there will be no progress in hospital preparedness. In this regard, the results of Siman-Tov *et al.*'s study showed that the preparedness level of hospitals is promoted according to the geographical location, being in an urban or suburban area and proximity to another hospital [29].

The fourth category was "Lack of legal and financial support". Participants believed that the standards of medical response to chemical incidents should be part of the accreditation criteria of hospitals and the Ministry of Health should approve a budget for the hospital preparedness for unconventional incidents. According to the results of Barbara *et al.*'s study, the Ministry of Health in the leading countries is obliged to provide equipment and infrastructure suitable for these incidents to all hospitals in the field of dealing with CBRN incidents [17]. In this regard, results of Bennett study showed that the majority of hospitals was not part of a larger health system and had not received any federal funding for preparedness efforts. It is conceivable that these factors may indicate that hospitals are constrained by the availability and capacity of existing resources required for the preparedness of hospitals for managing victims exposed to chemical or biological warfare agents [30].

The fifth category in this study was "Lack of infrastructure and decontamination equipment", encompassing the subcategories of "Lack of decontamination infrastructure" and "Lack of antidote and PPE". Considering that the chemical victims themselves are the cause of the spread of harmful agents, therefore, special places should be provided for the infected victims until they are transferred to the normal department for continued care after decontamination. Williams *et al.* cited the important role of the hospital physical space in preparedness to deal with chemical incidents, and argued that the researches have emphasized the necessity of physical preparedness in the response to chemical incidents so that if the hospital lacks a permanent and specified site for decontamination, it should be able to establish a temporary decontamination location within 15 minutes [31]. The

results of past studies show that the lack of primary decontamination on the incident scene has led to secondary contact and contamination of hospital staff. To this end, it is important to establish the decontamination infrastructure in the emergency department of the hospital [19].

One of the other important factors in preparedness for chemical incidents is adequate, accessible and up-to-date storage of antidotes and PPE. In this regard, studies have shown that high costs were imposed on the hospital to provide antidotes and PPE for incidents with low probability of occurrence, so this is the challenge of most hospitals around the world, especially in developing countries [32, 33]. However, the results of studies in leading countries in the management of CBRN incidents are inconsistent with ours, stating that antidotes for chemical agents are available in all hospitals, but their challenges are storing antidotes and equipment in a place close to the emergency department, preventing their expiration date and ensuring the appropriate amount of stock over time [29].

According to the characteristics of qualitative Research, the generalization of the results of this study is limited only to the study environment.

Similar studies are suggested to determine the causes of forgetting the experiences of Iraq's imposed war against Iran and not prioritizing chemical events and terrorism from the perspective of policymakers with the use of other methods, such as quantitative studies and interviews with informants.

Conclusion

Iranian hospitals are not sufficiently prepared to respond to chemical incidents like many hospitals in the world. Preparedness strategies should be designed according to the capacity and level of the hospital. National protocols and standards for preparedness to respond to chemical incidents should be developed and kept up to date. On the other hand, providing appropriate strategies such as effective training, increasing the risk understanding of policymakers and managers, and most importantly, including the standards of responding to chemical incidents in the accreditation criteria of hospitals can provide the necessary conditions for hospital preparedness in dealing with these incidents. Therefore, there is a need to design and implement incentive mechanisms for both medical facilities and authorities to create preparedness before such incidents occur and maintain it over time.

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