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Educational Needs of Chemical Accident Crisis Teams: A Qualitative Content Analysis Study

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Background & Aims of the Study: Although industrial development has raised living standards, it has increased the rate of incidents. To cope with the adverse effects of these incidents, multiple infrastructures are needed, such as the training of professionals. The present study aimed to formulate training topics needed by chemical accident teams.
Materials and Methods: This qualitative applied research was conducted based on the content analysis method in 2020. In this research, the needed competencies were determined based on the human resource competency model and using the opinion of experts and standards. Thereafter, the training topics of were designed with an emphasis on the health of the operational teams. The needed data were collected through library studies and semi-structured interviews. The validity of the training courses was also assessed using the Content validity index.
Results: The required training topics which were identified in three groups were as follows: familiarity with hazardous chemicals, effects of hazardous chemicals on the body, detoxification, safety principles in hazardous chemical accidents, advanced personal equipment, behavior of hazardous chemicals, determining the health status of operational forces, familiarity with the needs of the body during operations, as well as the assessment of scene and casualties of hazardous chemical accidents.
Conclusion: It is expected that team members will acquire the necessary skills to protect themselves and others after attending the training courses. Moreover, based on the findings, some constructive suggestions were put forward to boost the chemical defense system which can be of great help for future researchers and management policymakers.

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Background

Industrial development and technological advances have raised living standards; nonetheless, despite the substantial benefits of chemical compounds in industry, they present humans with dangerous potentials, such as disasters and chemical crises. Nowadays, more than 15 million hazardous chemical substances are commercially available, 70,000 of which are used on a daily basis, and about 200-1,000 new chemicals are annually added to the list (1). Chemical substances are the source of chemical threats, chemical warfare, chemical contaminators in the environment, as well as

accidental and unintentional industrial chemical accidents and leaks. The Sanchi oil tanker collision is one of these incidents (2). Some toxic industrial chemicals, such as chlorine and ammonia, can also be used as weapons of mass destruction (3).

Unfortunately, agricultural pesticides use is 13 times greater in Iran, compared to the world, which is indicative of the high capacity for the occurrence of disasters. In the International Conference on Chemicals Management in February 2006, Iran, along with 120 other countries, has committed to establishing a comprehensive chemicals management (4). Although our country is prone to disasters, the responsible organizations have not devoted sufficient attention to this critical issue. Based on a related study, none of the teaching hospitals in Isfahan is prepared to cope with these incidents, except for one hospital that has a special emergency department to deal with one of Chemical, Biological, Radiological, Nuclear (CBRN) agents (5).

In addition to everyday chemical incidents, chemical weapons are a serious danger. These weapons not only affect individuals in military organizations but also directly influence the public sector. Therefore, the interaction between military and civilian sectors has significantly expanded, and training methods in various fields, especially health and treatment in the hospital sector, should be continuously practiced. The comparison which was made between the common OPCW (Organisation for the Prohibition of Chemical Weapons) and NATO (North Atlantic Treaty Organization) chemical maneuvers held in Ukraine and chemical maneuvers in the country pointed out the strengths and weaknesses of theses maneuvers and highlighted the necessity of team cooperation at the international level, using the experiences of other countries, and having unified protocols in dealing with chemical accidents (6).

The important issues in passive defense include accident management techniques, reducing the destructive effects of chemical accidents, and especially minimizing civilian casualties. Since chemical accidents can occur in every environment, those in authority should take the needed measures to cope with the raised issues. It is noteworthy that the implementation of preventive measures, as well as the anticipation and community preparedness in crisis management, are necessary before chemical crises and can reduce the damages. One of the most effective measures in this regard is the provision of specialized personnel to perform chemical operations in times of crisis and anticipation of trained facilities, equipment, and relief workers (7), as well as such training as familiarity with chemical weapons, the effects of these substances on the body, detoxification materials, and the detoxification of chemical warfare agents.

The human resources should receive both theoretical training and practical courses which are held in training centers and simultaneous detoxification sites. There are such centers in most countries, and they are needed in our country. Canada is one of the countries with a comprehensive defense training program. The Seafield Center in Canada is a training and research center for chemical weapons for military and civilian rapid reaction forces. The anticipated training programs are as follows: familiarity with warfare agents and quasi-agents, familiarity with the concept of contamination and detoxification, familiarity with detoxification materials and equipment, as well as familiarity with personal protection equipment, familiarity with the development of testing methods for chemical warfare agents, chemical crisis management (detoxification), familiarity with drugs and antidotes for chemical agents, familiarity with the methods of examination and analysis of samples suspected of chemical contamination, such as gas, chromatography, mass spectrometry, maintenance methods of chemical detoxification equipment, training in the use of radio-communication equipment to communicate in

contaminated fields, and conducting field military exercises (8).

In addition to training, it is required to create a training field for testing chemical detoxification materials and equipment in chemical accidents. There is a center for the development and testing of detoxification in the majority of countries in the world, some of which are more than 50-60 years old, including Judo Center, the USA (1917), and Port Down, England (1916). Based on the technical specifications of detoxification products, materials, and equipment provided by various companies, there exist such centers in Russia, China, India, Germany, England, France, Poland, Czech Republic, Romania, Brazil, Argentina, South Korea, and Turkey (9).

The unpreparedness of the most sensitive regions of the country to these incidents has highlighted the need for setting up such centers and providing the related training. The quick response of rescue teams requires the development of accident scene management skills and provision of immediate care to disaster-affected people observing safety principles to save their own lives and those of others. Various studies have demonstrated that the readiness of operational teams, including hospital nurses, for the recognition of chemical attack, personal protection of oneself and others, and the ability to teach personal protection to other military personnel, the medical staff of other organizations, and community members contribute greatly to crisis management (10).

Moreover, the chemical accident management maneuver that was held for the relevant experts at the EU level in Italy in 2019 indicated that the academic knowledge of the members of the teams present at the chemical accident scene and the hospital emergency staff is not sufficient, rather skill training programs should be developed as well. Nonetheless, some stages of this maneuver were successfully performed due to the experiences and abilities of the members (11). It is noteworthy that the model and structure of the crisis management system depends on such components as the impact of hazards, medical needs of the affected area, population distribution, activity level of teams, and the timing of the presence of teams after the incident (12).

Nowadays, in addition to the strategic plan for the chemical defense of the country, the comprehensive emergency management plan of Pars Special Economic Energy Zone has practical instructions that can be of great help to other organizations as well. Due to the confidentiality of the program developed by the relevant organization, the details cannot be presented in the current study; nonetheless, those interested can refer to the relevant authorities and benefit from their knowledge, skills, and experiences (13). The Deputy Minister of Health of the Islamic Revolutionary Guard Corps has prepared a comprehensive and complete instruction on medical measures for new wars, such as chemical attacks. Although the name of the training course is not specified, based on the proposed treatments for each problem, training courses can be extracted according to the raised issues (14).

Apart from domestic resources, there are international guidelines and laws that can be used to extract the training required by rescue teams in the event of chemical disasters. For instance, the Sphere movement was a universal set of minimum standards in core areas of humanitarian services. This project does not specifically deal with hazardous material incident management; however, some of its principles are applicable, especially in the field of skill training in this area (15). The North Atlantic Treaty Organization (NATO) has also developed training programs for its operational forces. Since NATO forces are involved in warfare, they are always at risk of dealing with hazardous material incidents.

Therefore, the training department has prepared a protocol for training and educating the required personnel who have the necessary knowledge and skills, including CBRN

identification and monitoring operations, sampling and identification of biological, chemical, and radiological agents, biological identification and control operations, CBRN assessment and recommendations to NATO commanders, CBRN risk management operations, such as detoxification (16). The Occupational Safety and Health Administration (OSHA) have pointed to the necessity of training programs to increase occupational safety and health, save lives, prevent injuries, and protect workers' health by developing safety and health standards and inspecting work environments (17).

In addition to the aforementioned issues, the International Search and Rescue Advisory Group (INSARAG) has established an intergovernmental humanitarian network of disaster managers, government officials, and non-governmental organizations operating under the UN's umbrella. This network is responsible for cooperating in the implementation of international strategies for disaster reduction. Given the type of task envisaged for this organization, it is always possible for urban rescue teams to deal with hazardous materials. Therefore, they receive training on hazardous substances (18).

The Federal Emergency Management Agency (FEMA) is an agency of the United States Department of Homeland Security. The main mission of this organization is to deal with the destructive effects of natural and man-made disasters to reduce damages and casualties in the United States. The organization has developed a protocol for the management of hazardous materials which refers most of the expert and operational discussions to the standards of the National Fire Protection Association (NFPA) (19). The NFPA is a leading accredited private organization in the technical field of fire protection, troubleshooting, and prevention. The standards of this organization include 400 guidelines that are compiled and regularly reviewed by various committees of prominent scientific and operational members. Some of these standards can be used to respond to hazardous material incidents (20).

Working with chemical substances and the resultant crises raise the following concerns: the effect of training on maintaining the health of teams present at the scene of chemical accidents and injuries, paying attention to the specific characteristics of chemical accidents, describing the duties of teams at the scene of chemical accidents, and achieving training topics that empower operational forces to take care of themselves and others. Based on the aforementioned issues and considering the absence of any training package to empower operational forces to manage chemical accidents and crises in the country, the present study aimed to provide an educational package with an emphasis on the educational needs that help maintain the health of service providers and affected people using international and domestic guidelines and regulations, as well as experts' opinions.

Materials & Methods

This qualitative applied research was conducted based on the content analysis method in 2020. To achieve an accurate result, firstly, the process of chemical incident scene management was determined, followed by the specification of the duties of each of the active teams in this scene. Subsequently, the abilities, knowledge, and skills which are required for the optimal performance of assigned duties were extracted using the model of human resource competencies, and empowerment courses were designed in accordance with the competencies of each operational team. Finally, based on the obtained cases, empowerment training courses were defined.

Based on each stage of the human resource competency model, a different research method is presented (Table 1).

Table 1) Research method at each stage of the study

Research stages	Data collection	Data analysis	Output
Determining the management process of crises involving chemical accidents	-Library studies and open interviews with chemical defense and crisis management experts	-Consensus and agreement on a single standard model of crisis management using the Delphi method	-Teams present at the scene of chemical accidents and the relationship among them
Job description of teams at the scene of the chemical accident	-Creating databases with library studies, such as the book of team member description and international standards and a semi-structured interview with Hazardous Material Team -Experienced personnel in crisis management and experienced personnel from each team in chemical accidents	-Selection of duties and responsibilities with Delphi method screening and meetings with experts and agreement on specific tasks	-Describing the tasks assigned to the teams(on the maintenance of the health of the relief workers and people)
Determining the competencies required to perform the tasks	-Database formation through semi-structured interviews with experts in previous stages and assessment of NFPA standards -Modification of competency topics and their needs assessment through closed interview and questionnaire for experts	-Holding a meeting with the presence of 82 experts experienced in crisis management and with a history of attending various incidents, especially chemical ones, by the Director-General of Passive Defense of Qom Province for Delphi screening and agreement on competencies	-Knowledge, skills, and ability required to perform tasks
Designing the training topics of competency promotion training courses	-Establishment of a database through an open interview with the educational supervisor of Qom Fire and Emergency Service Organization - Department of Health Education, Qom University of Medical Sciences - Experts of the first stage of the research process	-Training topics: Experts in the field of medical education, and the field of development and empowerment of human resource management	- Training topics
Assessing the validity of training courses	-Completion of CVI questionnaires by experts related to each of the chemical accident teams	-Content validity index analysis	-Definitive and valid training courses

Table 2) Teams present at the scene of chemical disaster management

Operational teams	Zero stage of the accident	Crisis management stage		
		Hot zone	Warm zone	Cold zone
Firefighting	✓	✓	✓	✓
Relief workers	✓	×	×	✓
Police	✓	×	×	✓

The study population included the teams present at the scene of chemical accidents, such as firefighting hospital emergency, Red Crescent, law enforcement force, traffic police, and armed delta force teams forces rapid response teams, and occupational safety and health teams. Emergency departments of medical centers were not included in the current

study. On the other hand, the current study addressed the duties of these teams which are related to maintaining the health of the relief workers and the affected people.

Results

Considering that the duties of operational teams are the basis for determining training needs and they are defined based on the location of teams in different zones, the appropriate crisis management model was determined to deal with and manage the scene of chemical accidents. Thereafter, the duties of each team in the relevant zones were extracted as the basis for designing the required training.

A) Stage zero (the beginning of the incident and the presence of different people on the scene): There are people who may encounter hazardous substance incidents and weapons of mass destruction during the performance of their normal tasks. Each person from any organization who is present at the scene of a chemical accident at this stage has the following duties:

- Detecting hazardous materials/weapons of mass destruction in the environment
- Protecting yourself and others
- Keeping in touch with professional forces
- Keeping the region secure

The correct performance of the afore-mentioned tasks requires the following competencies: the recognition of hazardous material incidents and weapons of mass destruction, knowledge of scene zoning, hazardous substances and chemical compounds, the major routes a chemical may enter the body, first aid, use of personal protective equipment, zoning and establishment in a safe area.

Based on the tasks and the associate competencies, the following training courses (based on priority) are as follows:

1. Oreintation with hazardous chemicals
2. Oreintation with personal protective equipment (introductory)
3. Effects of hazardous chemicals (introductory)
4. Reporting (in hazardous chemical accidents)
5. First aid in chemical accidents (Preliminary)
6. Detoxification (the environment, equipment, and individuals)
7. Oreintation with Incident command system (ICS)-Basic
8 Oreintation with the job descriptions of all teams present at the scene of chemical accidents
9. Realizing the environment and gathering information
10. Oreintation with various methods of informing professional teams in accidents
11. Oreintation with hazardous materials incidents (different scenarios) and weapons of mass destruction
12. Zoning the scene of hazardous chemical accidents
13. Oreintation with Safety Data Sheet (SDS) and its applications
14. Recognizing your limitations (in dealing with hazardous chemical accidents)
15. Principles of preserving and recording evidence at the scene of chemical accidents

B) Hot zone (main center of the incident): Respondents at the operation level are those who respond to accidents and crises in order to protect people, the environment, or properties in the face of chemical release or weapons of mass destruction. There are more competencies at this level, compared to the awareness level. In the hot zone, there are technicians who are specialized in specific operations and are more knowledgeable and skillful, compared to the operational forces. Nonetheless, in the current research, there was no difference between operational forces and technicians, and the training needed to maintain their health and that of others was the same for both levels.

Some of the health-related tasks assigned to these teams are as follows: determining the physical and chemical properties and hazards of substances, the symptoms of exposure and

determining the major routes a chemical may enter the body, determining the permissible range of exposure, carrying out safety measures (protective measures, cleaning, and leakage control), determining the dimensions of the area at risk according to environmental conditions, prioritizing emergency medical services, and determining how to evacuate victims according to the type and level of exposure, rescuing victims, determining the detoxification methods for contaminated people, equipment, devices, and the environment, zoning the scene, and determining the synergistic effects.

To perform the abovementioned tasks correctly, the following competencies are needed: knowledge of chemicals, anatomy and physiology of the body, the effects of substances on body systems, the symptoms and effects of acute and chronic exposure, the major routes a chemical may enter the body, the permissible levels of different substances and safety principles, the detoxification principles and methods, methods of exposure and control of substances, the synergistic effects of substances on the body, immediate therapies (pharmaceutical and non-pharmacological), triage methods, detoxification methods (individuals, equipment, and the environment), determining the effects and symptoms of acute physiological and psychological pressure on personnel, determining the exact type and number of required equipment according to the type and severity of the accident and the number of victims, as well as the accurate recording of evidence and symptoms of personnel and victims.

The following training courses can instill the aforementioned competencies in fire team members:

1. Oreintation with hazardous chemicals (advanced)
2. Safety Principles for hazardous chemical accidents (operational staff)
3 Oreintation with the methods of exposure and control of hazardous chemicals
4. Detxofication the scene of dangerous chemical accidents (advanced)
5. Personal protective equipment (advanced)
6. Behavior of hazardous chemicals (advanced
7. Principles of preserving and recording the symptoms of exposure of employees and people at the scene of hazardous chemical accidents
8. Mental health in the management of hazardous chemical accidents
9. Preparation of specialized reports at the scene of hazardous chemical accidents
10 Oreintation with the Incident Command System (ICS) (advanced)

C) Cold zone of the incident (peripheral and marginal area): In this area, there exist various personnel, including support forces and command systems. Injured people transferred from a hot area should be treated in this area before being transferred to a hospital if they need immediate treatment and care. Therefore, the main operational forces in this area are relief workers, including medical emergencies and the Red Crescent. Relief workers are assigned to three levels: basic, operational, and the staff with specific competencies and missions.

The duties of the operational teams present in the cold zone are as follows: determining the potential mechanism of injury prevention and possible treatment methods according to the type of materials and tanks, determining the health risks of affected people, collecting and interpreting information, identifying new high-risk areas, identifying the capacity of local hospitals and detoxification centers, identifying formal and informal assistance sources, identifying communications at the scene of the accident, extracting patient information before the transfer, providing necessary medical care based on the nature of the accident, emergency detoxification, determining the need for advanced equipment, preserving evidence, supporting personnel in hazardous materials incidents, reporting and documenting the incident.

The performance of these tasks requires the

following skills and knowledge: understanding the clinical effects of chemicals on the body, understanding personal protection techniques and personal protective clothing, gathering information using databases clinical protocols of ERG-SDS, recognizing coordination methods of communication with respondents and people, recognizing the factors present at the scene (teams and equipment), identifying the required therapies and the effects of medicines on the victims of chemical accidents and treatment responses, understanding the effects of environmental factors on the behavior of chemicals, understanding treatment protocols and evaluation methods and tests, prevention of secondary contamination and evaluation of detoxification performed, familiarity with the characteristics of the scene and methods of preserving evidence, assessing the health of operational forces after the operation, determining injury prevention procedures, determining the required treatments and expected clinical symptoms, safe transfer of patients, evaluation of the implemented measures (interpretation of clinical and paraclinical symptoms and results), and confirmation or rejection of contamination.

Training courses related to the aforementioned competencies are:

1. Behavior of chemicals (from a medical perspective)
2. Identifying detoxification hospitals and centers
3. Documenting and preparing reports
4. Oreintation with the methods of preserving and recording clinical evidence of victims of hazardous chemical accidents
5. Oreintation with methods of communicating with people and coordination with operational teams
6. Determining the health status of operational forces (before and after entering the scene)
7. Oreintation with the needs of the body during the operation (all operational teams)
8. Oreintation with the medical records of the injured in the scene of managing hazardous chemical accidents
9. Treatment of casualties caused by hazardous chemical accidents
10. Personal protection (relief workers)
11. Assessing the scene and casualties of hazardous chemical accidents
12. Transfer and dispatch of the injured
13. Detoxification (environment, equipment, and people)

Discussion

Due to the importance of training and empowering human resources in reducing casualties and damage caused by chemical accidents and crises, the present study strived to design the educational headlines required by teams present in accident scene management and chemical crises according to the local conditions of the country and with an emphasis on maintaining the health of operational teams and the affected people using scientific texts and interviews with experts. The main assumption of the current research was based on assigning chemical incidents to cold, warm, and hot zones. In other words, if the pattern of crisis management of chemical incidents changes, the principle of the courses will remain intact; nonetheless, the classification of the courses will need to be modified.

In order to achieve these educational headlines, firstly, the process of crisis management and zoning of the accident scene was examined; thereafter, the teams needed to manage the scene were selected, and their job descriptions were extracted. Subsequently, the competencies (the needed knowledge, skills, and enablers) were extracted by considering ISO training standards. Compared to the NFPA protocols, which are the most complete international codes, these training topics have the added advantage of being native and conformity to the job descriptions defined for teams in the disaster management structure of

the country.

The extracted training topics are much more comprehensive and complete, in comparison with the training topics of the Seafield Center in Canada which assigns training to four sections. Most of the training topics of this center are compatible with the training topics of the present study, and more specialized topics of operational teams have not been addressed. Some of the identified cases are completely consistent with the training topics of the Seafield center, including training on the dangers and characteristics of chemicals, medical treatment, how to deal with and detect chemical agents, practicing with agents in the outdoor environment, collection of samples and detoxification of contaminated targets, contamination control and possible effects of transmission to other sites (secondary contamination). However, in the current study, more complete and accurate details have been identified, especially in the field of medical treatment, for instance, determining the health status of the operational forces (before and after entering the scene), familiarity with the needs of the body during the operation, treatment of casualties of hazardous chemicals, assessment of scene and casualties of hazardous chemicals.

In comparison with the NATO training program which includes 10 general training topics, the extracted training topics are more complete. The training topics of the NATO training program are mainly consistent with knowledge training in the findings of the current study, and the training of specialized and operational forces has not been addressed. Similar training topics include understanding awareness requirements in responding to CBRN incidents, understanding personal protection requirements, first aid, understanding diagnostic requirements, as well as command and control needs for disaster response. The current study did not address the consequences of cooperating with the military forces in response to the CBRN incidents, which is part of the NATO instructions. It can be ascribed to the difference between the military nature of NATO and the crisis management organizations in our country. In the event of a terrorist incident or chemical crisis, the military forces manage the issue which has a different mechanism and is not the subject of the current study.

The training topics obtained in the current study are more comprehensive, in comparison with 11training topics proposed in the study conducted by Shoushtari (2017) entitled " Establishment of detoxification training centers and skill training in the face of chemical attacks" . At the same time, there is the greatest correspondence between the training topics proposed in these two studies. Among the 11training topics obtained in the stated study, the 7 following training topics are quite similar and consistent with those reported in the current study: 1) familiarity with warfare agents and quasi-agents, 2) familiarity with the concept of contamination and detoxification, 3) familiarity with chemical detoxification materials and equipment and practical training in their use, 4) familiarity with personal equipment and practical training in their use, 5) chemical crisis management (detoxification), 6) familiarity with drugs and antidotes for chemical agents,7) training in the use of radio-communication equipment to communicate in contaminated fields. Nevertheless, four training topics were not in line with the current study, including field military exercises.

Making a comparison between the findings of the current study and the National response framework, it can be argued that the training and conditions envisaged in that program are not specific to chemical accident scene management, although there are common points that can be used. Therefore, the training provided in the present study is of great help to teams to deal with chemical accidents.

Making a comparison between the present study and the training provided in the comprehensive emergency plan for Pars Special Economic Energy Zone, it can be stated that the

aforementioned program is merely intended to respond to the incidents in that zone, and other scenarios are not considered. However, considering the commonalities of chemical accidents, the mentioned program can be used in part for the teams present at the scene of chemical management throughout the country. Comparing the present study with the standards and recommendations of Osha, Ocha, and Sphere, the current study was able to design a more comprehensive training program with a detailed understanding of job description and analysis of the future opportunities and threats in the country. Complete and accurate implementation of this program can significantly help maintain the health of relief workers and the affected people.

It is noteworthy that wherever there is a need to discuss the competencies of operational teams, most American standards, such as Osha and Ocha, refer the issue at hand to NFPA standards. Given that all of these guidelines are country-specific, this reference and citation is completely logical and can prevent parallel work. Most of the guidelines and studies conducted in the country put emphasis on the necessity and importance of education; nonetheless, no title or package has been suggested. Therefore, the current study strived to fill this gap.

Conclusion

The present study aimed to determine the training courses and enablers of the teams present at the scene of chemical accidents, Compilation of job descriptions of each team present at the scene of chemical accidents at each stage of the operation, competencies (knowledge, skills, abilities) required for the accurate performance of the assigned tasks, the enablers and training courses on competencies. Owing to the realization of aforementioned goals in the current study, we can present the training topics needed to empower all operational forces in charge of chemical accidents and crises at different levels. Therefore, it is suggested that the planned courses be implemented for the relevant people, and the results be reviewed upon the completion of the courses according to the future needs, the facilities, and the assigned tasks. In addition to providing training, the implementation of some measures for the retention of trained personnel, knowledge management, career mapping, designing and reviewing courses in accordance with the new responsibilities of organizations, and providing the necessary equipment can be of great help for increasing sustainability and reducing country's vulnerability to chemical threats.

Footnotes

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Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of the current article.

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