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Developing a Model for Hospitals' Emergency Department Preparedness in Radiation and Nuclear Incidents and Nuclear Terrorism in Iran

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ABSTRACT

Objective: To develop a national model for hospitals' Emergency Department (ED) preparedness when facing radiation and nuclear incidents as well as nuclear terrorism in Iran.
Methods: This analytical study was carried out in 2019 via Delphi technique in two rounds and prioritization using a pairwise questionnaire. Using classic Delphi technique and pairwise comparison, the components were given to 32 specialists in emergency medicine, nuclear medicine, medical physics, nuclear physics, radiobiology and radiation protection, health in disaster and emergency, and passive defense. Finally, the national model was developed by holding two focus group sessions.
Results: The results from the two rounds of Delphi technique showed that 31 factors of preparedness were classified into three main classes, namely staff, stuff, and structure (system). Only three factors were excluded and the rest were agreed upon by the specialists. Given the weight of each class, it was found that staff preparedness and stuff preparedness had the highest and lowest priorities, respectively.
Conclusion: Comprehensive preparedness requires enhancing and promoting cultural, social, economic, and political levels. Indeed, all preparedness levels should be promoted in alignment with each other. Hence, governments should align their policies to manage such incidents.

Keywords: Preparedness; Emergency department; Hospital; Radiation incidents; Nuclear incidents; Terrorism.

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Introduction

Human being has always been looking for infinite sources of energy. Nuclear power is a very logical way to achieve this sustainability. More than 420 nuclear and radiation incidents have taken place since 1944 and the preparedness to respond to these incidents has ever increased [1]. When a nuclear weapons is detonated or a damage to a nuclear power plants occurs, massive number of people will immediately become anxious and rush to hospitals [2]. Radiation emergencies can transpire not only through incidents, but also as a result of nuclear terrorisms. Controlling these challenges requires taking necessary measures to protect the installations against damaging and unlawful acts and also to protect people's health against these incidents. Safety and security measures have common goals and systems should complement each other in achieving these goals. Hence, a coordinated approach is vital in nuclear safety and security [3].

Preparedness is a major part of disaster management cycle; hence, prior planning is essential. Hospitals can appropriately respond to nuclear incidents with trained staff and stuff. Given the high importance of preparedness for nuclear incidents, its management codes should be used in hospitals and health centers. Disaster exercises have a great impact on increasing the preparedness of hospitals in these incidents [4]. Decontamination is the most important part in managing radiation-exposed people, especially those who require surgery. The operating room should be completely prepared for these patients and the things that can get contaminated in the surrounding area should be minimized [5]. Individuals who respond to these incidents are faced with highly stressful situations influencing their physical and mental health. However, prior planning can minimize these impacts and facilitate decision-making [6]. Emergency department staff should prevent from their own contamination, using personal protective equipment's(PPE). Training medical staff on radiation risk allows them to provide the required cares for patients [7].

As Iran is a disaster-prone country and is situated in a sensitive geopolitical region, planning for nuclear and radiation incidents is of utmost importance. As emergency department of hospitals is the gateway to the hospital and many radiation-exposed people refer to hospitals themselves or are brought to hospitals by relief staff, a national model is of a great importance to promote preparedness during these incidents. This study aimed to develop a national model for hospitals' emergency department preparedness during nuclear and radiation incidents and nuclear terrorism in Iran, 2019.

Materials and Methods

Study Participants

This analytical study was conducted in five separate steps, which include 1. systematic review, 2. qualitative study, 3. Delphi technique, 4. analytical hierarchy analysis technique, and 5. designing a model. After systematic review and interviews with Iranian specialists, 34 factors involved in hospitals' emergency department preparedness in nuclear and radiation incidents and nuclear terrorism were extracted. A classic Delphi technique was used to make decision on the criteria [8, 9]. The components were given to 32 specialists in emergency medicine, nuclear medicine, medical physics, nuclear physics, radiobiology and radiation protection, health in disaster and emergency, and passive defense during the first round of classic Delphi technique. The inclusion criteria for specialists were having at least a master or general practitioner degree, experience working in hospital emergency department, disaster management, or relevant executive background, and willing to participate in the research. Specifically, emergency medicine and health in disasters and emergencies specialists were required to have the experience of working in radiation incidents and other specialists had to possess relevant papers and acceptable knowledge.

Ethical Considerations

Written informed consent were obtained from all the specialists. In addition, the specialists had the liberty to reject or accept participation in the research. They were also reassured about the confidentiality and anonymity of all their forms.

Data Collection and Data Analysis

A questionnaire was developed according to systematic review and qualitative research for performing the Delphi technique. It was delivered either hand-delivered or emailed to the specialists. They were asked to determine the importance of factors based on a 5-point Likert scale (very low: 1, low: 2, moderate: 3, high: 4, very high: 5). The specialists were also asked to add other factors (if needed based on their views), which had not been considered in the questionnaire. Components with a mean score <2.5 were excluded [10], and other components were entered into the second round. In the first round, components with a mean score of 3 and above were approved, and the rest were excluded. In other words, if an agreement above 75% was achieved for each criterion, that criterion would be acceptable (75% of the score 5 was calculated to be 3.75)12 ,11]]. The cases in which 50-75% agreement was achieved were entered into the second round of Delphi technique. The second round was given to the same specialists one month later; however, there was disagreement on the threshold of agreement among various studies variables, but the majority of specialists considered 70-80% agreement as a sign of consensus. Thus, the criterion for agreement among the specialists was considered to be higher than 75% in the first round [11, 12].

Ultimately, the identified components of hospitals' emergency department preparedness in radiation incidents in Iran were finalized, and the required information extracted from each Delphi round was obtained through statistical methods. For this, Excel 2016 software was used.

After identifying the national model criteria and finalizing them through the Delphi technique, they were prioritized based on prioritization technique and those with high priority were included in the model. In this step, the identified components of preparedness were prioritized and scored. Analytical Hierarchy Process (AHP) and Expert Choice 11 software were used to prioritize the preparedness components. In order to score and determine the priority and importance of each class and sub-class of preparedness, they were compared in a pair and pairwise questionnaire through a scale of -9 to +9.

AHP is one of the most comprehensive systems designed for decision-making with multiple criteria. AHP was first presented by Saati [13]. In this method, pairwise comparisons are performed to see to what extent element A is more important than element B [14]. In this study, the mean of sum of scores obtained from the 32 specialists' views was calculated and analyzed.

Considering AHP, the elements of each level were compared with their respective element at the higher level in pairs and their weights were calculated, called relative weights. Then, by integrating the relative weights, the final weight was specified. The final weight was obtained by multiplying the importance of the criteria by the weight of the options [15]. After pairwise comparisons, EC software was used. The acceptable range of inconsistency in each system depended on the number of decision makers, but Saati suggested that if the decision inconsistency was higher than 0.1, the decision maker would be suggested to reconsider his judgments. For example, if there were 10 decision makers, the acceptable level of inconsistency was at least 1.45. However, if the inconsistency coefficient was less than or equal to 0.1, the system consistency would be acceptable [13]. In addition, the combined weight was obtained by multiplication of the weight of each criterion by the weight of the sub-criteria.

Based on the previous steps, by holding two-hour group focus sessions with the presence of specialists, the researchers of this study discussed the initial national model for hospitals' emergency department preparedness in radiation incidents. Ultimately, the final model was developed and its schematic Figure 1 was plotted. The sample required to hold a panel of 10 specialists.

Results

The mean age of specialists who participated in this research was 43.96 years, and 23 participants were male. The demographic and job characteristics of the

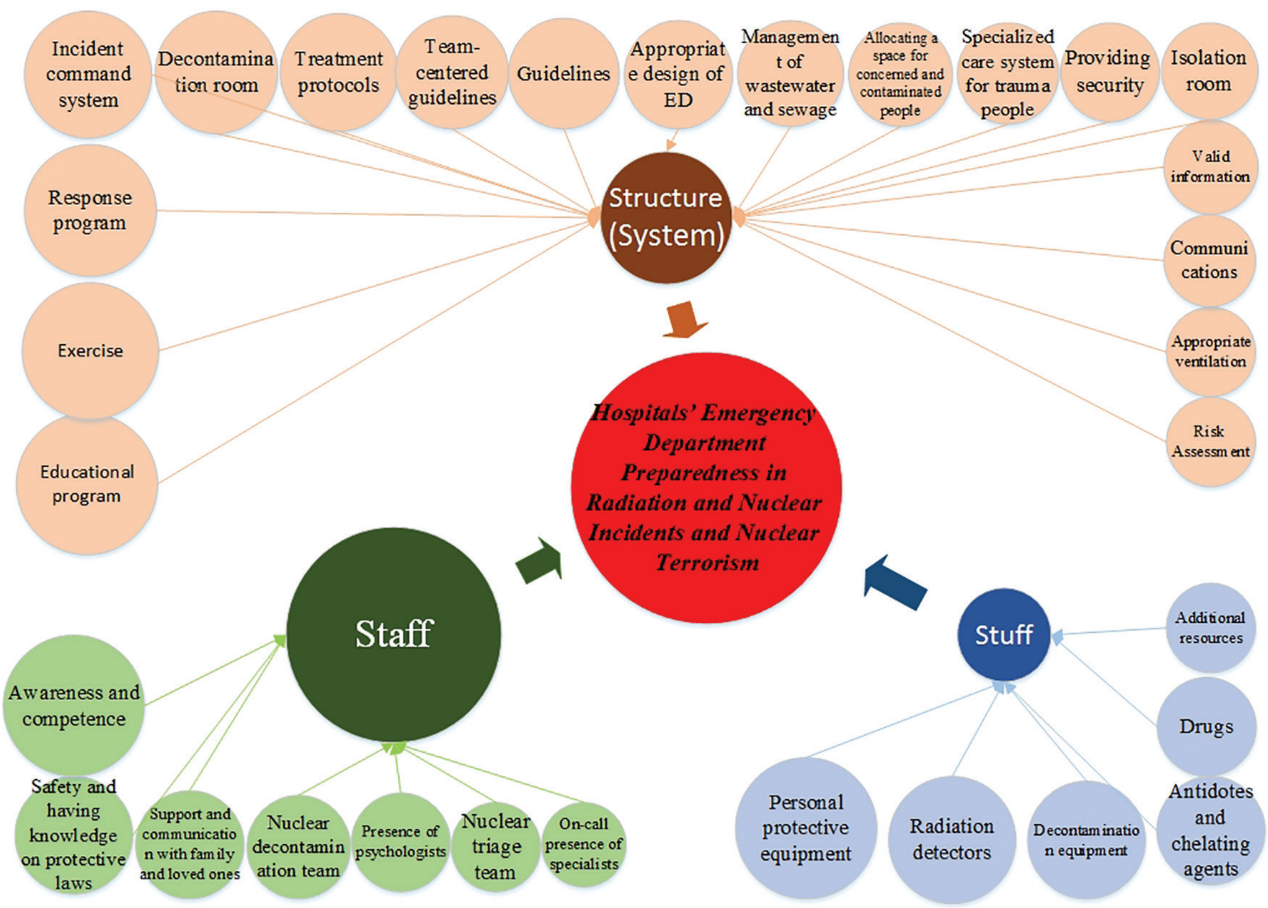

Fig. 1. Hospitals' emergency department preparedness in radiation and nuclear incidents and nuclear terrorism in Iran.

participants is presented in Table 1. The results of the two rounds of Delphi technique showed that 31 preparedness factors were classified into three main classes, namely staff, stuff, and structure (system). Only three factors were excluded and the rest were agreed upon by the specialists.

In the first round, 22 factors were agreed upon (75%), and 11 factors obtained agreement levels between 50% and 75%, and one factor obtained an agreement level less than 50%. The factors that obtained agreement below 75% were given to the specialists in the second round of Delphi. Finally, 31 factors with agreement levels above 75% were identified and three factors were excluded. The three main classes are shown in Table 2. The extracted classes and subclasses were given to 32 specialists to determine the priority of each factor via pairwise comparisons. The results of pairwise comparisons and prioritization of the preparedness factors are presented in Table 3. Based on the weight of each class, it was found that staff and stuff preparedness had the highest and lowest priorities, respectively. In the staff preparedness class, knowledge and competence sub-class had the highest priority and the on-call presence of nuclear medicine or medical physics specialists 24/7 had the lowest priority. At the level of structure (system) preparedness, holding specialized, general, and research educational programs had the highest priority and incidents risk assessment in the emergency department had the lowest priority. Finally, in the class of stuff preparedness, availability of different types of Personal Protective Equipment (PPE) had the highest priority and the availability of additional resources (beds and so on) had the lowest priority. The consistency rate of all examined cases was less than or equal to 0.1, which was acceptable.

Two focus group sessions were held for two hours and the initial model was emailed to 10 specialists. Based on the information obtained from the previous steps, the final model of hospitals' emergency department preparedness in radiation and nuclear incidents was obtained. The size of each classes and sub-class was based on their priority.

Discussion

This research was conducted to develop a national model of hospitals' emergency department preparedness during radiation and nuclear incidents in Iran. The preparedness factors were classified into three classes. The main components included staff, stuff, and structure (system), and each contained sub-classes. After performing the investigation, no model was found on hospitals' emergency department preparedness in radiation and nuclear incidents in Iran as well as in other countries. Various studies have only focused on analyzing each factor affecting preparedness separately and independently.

The present study results revealed staff to be the most critical and vital part of the response to nuclear and radiation incidents. Thus, increasing the staff's capacity by promoting their knowledge could reduce vulnerability. Moreover, protecting the staff would reduce harm to themselves and patients. Hence, medical physics or nuclear medicine specialists should be present in the emergency department 24/7. They should provide medical and specialized consultations to the emergency department staff when an incident occur. In the event of radiation and nuclear disasters, and even nuclear terrorism, the health and safety of emergency department staff should be prioritized. In fact, the emergency department staff should take all the necessary measures to treat patients unless their lives are at risk.

Table 1. Demographic and job characteristics of the research participants

		Number	Percentage (%)
Gender	Male	23	71.87
	Female	9	28.12
Level of education	Doctor of Philosophy	17	53.12
	Specialist Physician	12	37.5
	Master of science	3	9.37
Field	Emergency Medicine	8	25
	Medical Physics	7	21.87
	Health in Disasters and Emergencies	6	18.75
	Nuclear Medicine	4	12.5
	Nuclear Engineering	3	9.37
	Passive Defense	3	9.37
	Radiobiology and Radiation Protection	1	3.12

Table 2. Three classes extracted from Delphi along with the number of subclasses

N	Class	Number of sub-classes
1	Staff	7
2	Stuff	6
3	Structure(System)	18

Table 3. Prioritization of classes and sub-classes of hospitals' emergency department preparedness in radiation and nuclear incidents and nuclear terrorism

Main class	Class weight	Priority	Sub-class	Sub-class weight	Combined weight	Priority
Staff	0.772	1	Staff's knowledge and competence	0.366	0.2825	1
			Staff's safety and their knowledge on protective laws	0.363	0.2802	2
			Staff support and communication with their family and loved ones	0.125	0.0965	3
			Availability of the nuclear decontamination team specifically	0.062	0.0478	4
			The presence of psychologists to meet the staff's mental health needs	0.034	0.0262	5
			Availability of the nuclear triage team specifically	0.028	0.0216	6
			On-call presence of nuclear medicine or medical physics specialists 24 hours per day and 7 days per week	0.021	0.0162	7
Structure (System)	0.175	2	Holding specialized, general, and research educational programs	0.2002	0.0350	1
			Holding computerized, real, and operational exercises	0.1901	0.0332	2
			Development of plan to response to disasters	0.0763	0.0133	3
			Development of the Incident Command System (ICS)	0.0650	0.0113	4
			Availability of decontamination rooms	0.0501	0.00876	5
			Availability of treatment protocols	0.0500	0.00875	6
			Availability of team-centered guidelines in responding to contaminated patients	0.0451	0.0078	7
			Availability of specialized guidelines	0.0431	0.0075	8
			Appropriate design of the emergency department	0.0409	0.0071	9
			Management of wastewater and treatment of radiation sewage	0.0312	0.00546	10
			Allocating spaces and locations for concerned, contaminated, and non-contaminated people	0.0310	0.00542	11
			Availability of specialized care system for trauma and radiated people	0.0298	0.00521	12
			Providing security	0.0271	0.00474	13
			Availability of isolation rooms	0.0269	0.0047	14
			Access to valid information resources	0.0258	0.0045	15
			Intra-organization and inter-organization communications	0.0241	0.0042	16
			Appropriate ventilation	0.0227	0.0039	17
			Incidents risk assessment in the emergency department	0.0206	0.0036	18
Stuff	0.053	3	Availability of different types of Personal Protective Equipment (PPE)	0.475	0.0251	1
			Availability of radiation detectors	0.256	0.0135	2
			Availability of decontamination equipment	0.149	0.0078	3
			Availability of antidotes and chelating agents	0.067	0.0035	4
			Availability of drugs	0.030	0.0015	5
			Availability of additional resources (beds and so on)	0.022	0.0011	6

Separate teams, called nuclear triage and decontamination teams, must be present in the emergency departments before an incident [16-18]. Triage and decontamination in nuclear and radiation incidents are different than those in normal conditions. The emergency department system (structure) refers to system and structure required in the emergency department. People who have been exposed to radiation should be kept in special rooms in the emergency department and treated immediately. Developing protocols and guides can organize and accelerate the treatment of the exposed individuals. Furthermore, the emergency department must continuously receive information on incidents from the Emergency Operations Center and the Hospital Crisis Committee. Risk communication and timely use of available and valid information in order to respond to these incidents are of utmost importance. Valid information can also be obtained from local police, fire department, and Emergency Medical Services(EMS). Launching hotlines between individuals and specialized organizations could also be very helpful.

The most important factor of preparedness in nuclear and radiation incidents is to hold training courses and exercises. Training courses should be held for all emergency department staff regularly and continuously. Exercises should also be held at least twice year to increase the staff's preparedness. In this context, all types of exercises (table top, real, and simulation) should be performed [18, 19]. When these exercises are performed continuously, they would be more effective [20]. Holding these exercises and additional trainings regularly and periodically can be helpful in improving the attitude, knowledge, and skills of emergency department physicians and nurses. Training courses should be held at specified intervals for emergency department staff [21, 22]. By providing the staff with such appropriate trainings, they can provide appropriate responses to these incidents [23, 24].

Incident Command System (ICS) is a structure for managing disasters and incidents. ICS should be formed in the emergency department and the people in charge as well as their successors should be identified in each unit [17]. After the occurrence of nuclear incidents, ICS should be activated as soon as possible in order to provide quick response. The third most important factor of preparedness was stuff. Accordingly, adequate number of radiation detectors and personal protective equipment should be available in the emergency department. Moreover, all the emergency department staff, including specialists, physicians, and nurses, and even the health staff should be trained on the correct use of PPE [23, 25]. The level of radiation received by individuals should be measured quickly by detectors and the therapeutic measures have to be taken based on the level of radiation received. The medicines and chelating agents required in the emergency department should be considered, as well. Furthermore, injured patients should be treated as soon as possible [16, 19, 23]. When radiation-exposed patients are brought to a hospital, it is acceptable that a hospital is not decontaminated; hence, decontamination should begin as soon as possible. During these times, all staff should use PPE properly to prevent from any contamination.

One of the limitations of the present research was lack of access to all specialists to enter the Delphi and AHP techniques. Therefore, the researchers tried to enroll the available people who had relevant knowledge needed for this research. The model of hospitals' emergency department preparedness during radiation incidents is recommended to be designed and validated in different communities, so that international organizations can use them.

In conclusion, preparedness is the most important component during disaster management cycle. In fact, increasing the preparedness leads to more appropriate responses to disasters. As occurrence of nuclear and radiation incidents are possible at any given time, staff, stuff, and systems should be prepared. Comprehensive preparation requires cultural, social, economic, and political. In addition, all levels of preparedness should be enhanced in alignment with each other. Thus, governments must align their policies to manage such incidents.

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