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EARTHQUAKE MITIGATION IN HEALTH FACILITIES IN MEGA CITY OF TEHRAN

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SUMMARY

Health facilities such as hospitals are among the facilities that can suffer severe damage in the time of natural disasters especially earthquakes. In this paper, first the obtained research results in regard to the type of structure, and the structural and non-structural problems of 110 hospitals in the mega city of Tehran is discussed. Earthquake safety procedures for health facilities, the standards for their appropriate performance and the required structural design and strengthening methods is also considered. Finally, the necessity for equipping these centres with an appropriate earthquake disaster management programme is proposed. With regard to the structural type of most hospitals in Tehran and the structural and non-structural problems in these centers, a schematic of a comprehensive organisation is proposed to the Ministry of Health.

INRODUCTION

Located in the Alpine-Himalayan seismic belt, Iran is one of the most active tectonic regions of the world [1]. Also, due to the impossibility of predicting earthquakes, the necessity for the development of a comprehensive disaster management programme in the urban public centres and critical facilities of the country is of great importance.

Heath facilities especially hospitals are exposed to risk, serious damage and loss of life during earthquakes, if not adequately constructed [2]. In times of disasters, hospitals must continue to provide medical service to those that were hospitalized before the disaster as well as those that require medical attention as a result of the event [3]. It is worth mentioning that the necessity of providing services in these centers during disasters requires hospital preparedness and their structural strengthening. During a disaster, a dangerous situation is caused in public places like hospitals when unorganised and impatient people rush to the exit doors, making the situation much worse. On the other hand, many injured people

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rush in to get medical attention which in turn causes a disastrous situation. They may also create problems for the patients and the hospital personnel [4]. Also mobilisation of the staff, equipment and supplies to a safe place is essential for an effective response [5]. Hospitals do require special attention due to the vital function they perform in the time of disasters and the aftermath. Therefore, planning for a comprehensive disaster management in these centers seems very crucial.

Existing situation of health facilities in mega city of Tehran

Hospitals and health facilities in general play a vital role in the recovery of a community after an earthquake, therefore many factors must be taken into consideration when designing the building, maintaining and operating them [4]. In research done on 110 hospitals in the capital city of Tehran, Figure (1), it was observed that most of the hospitals were of brick or steel, concrete or masonry materials and therefore vulnerable to earthquakes. Figure (2) shows the construction types and Figures (3) and (4) clearly indicate the quality of materials and structural vulnerability of existing hospitals. Figures (5) and (6) summarise the structural and non-structural problems of hospitals which necessitates the analysis and identification of their vulnerability assessments and resistance requirements.

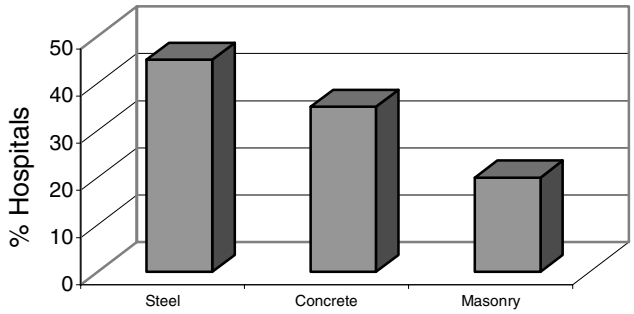

Figure 1: Material used in hospitals under study

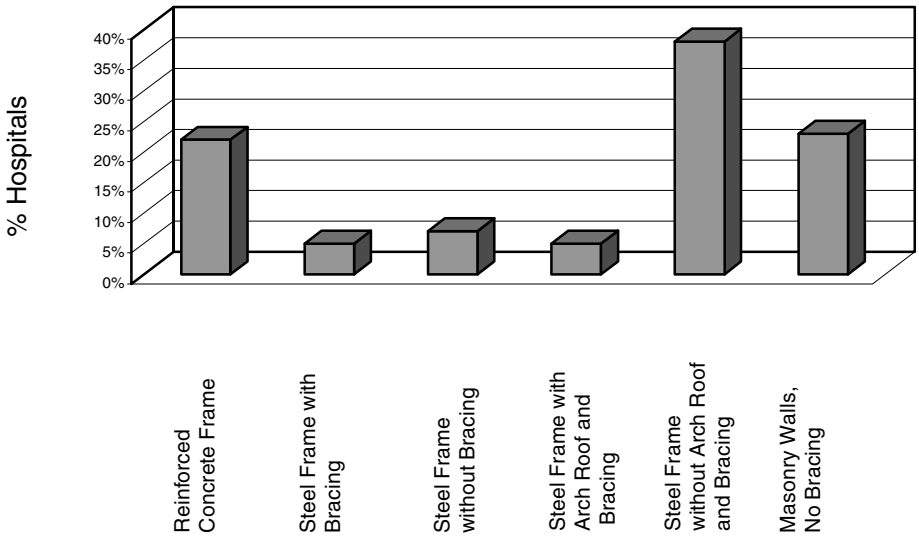

Figure 2: Construction type of hospitals in Tehran

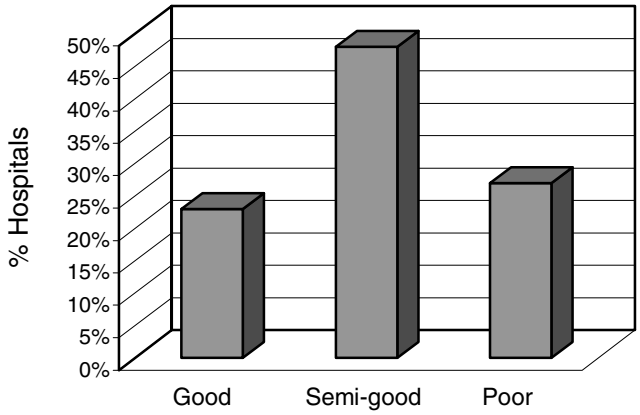

Figure 3: Quality of the materials used

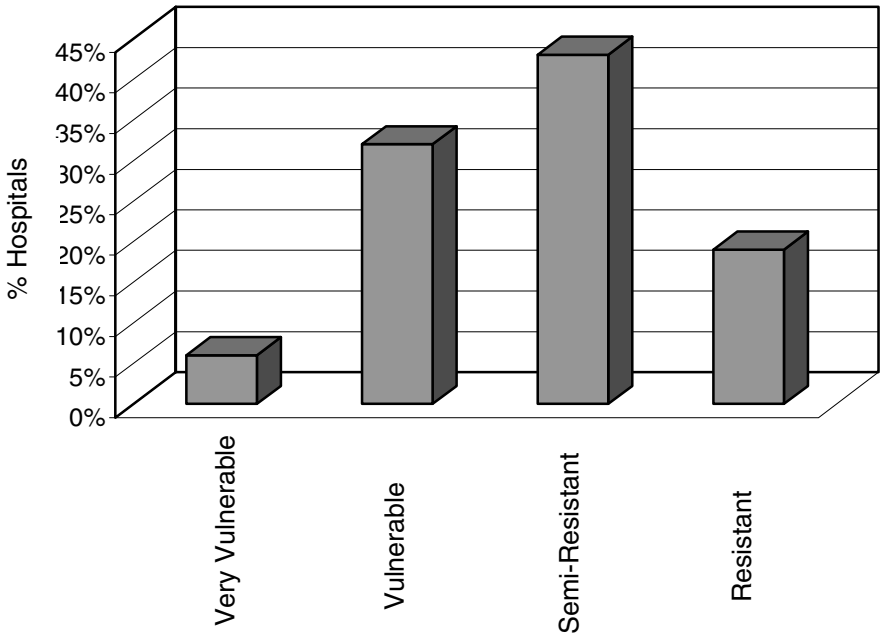

Figure 4: Seismic vulnerability of hospitals

A = Plan Irregularity

B = Vertical Irregularity

C = Soft story

D = Pounding

E = Short column

F = Torsion

G = Poor materials

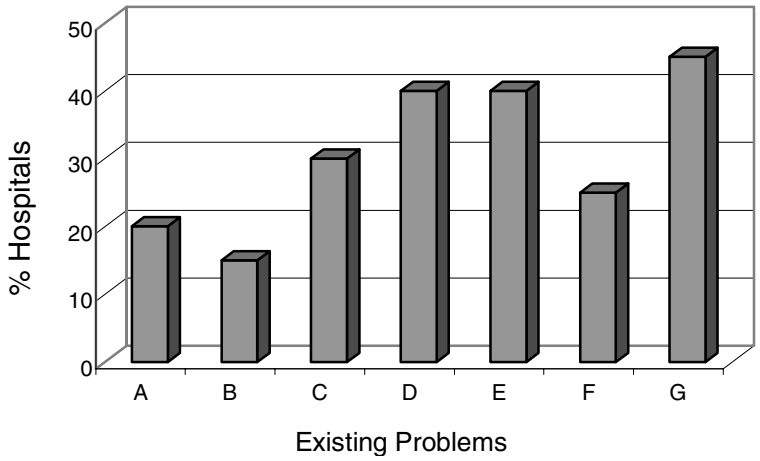

Figure 5: Distribution of existing structural problems- 110 hospitals in mega city of Tehran

H = Lack of structural planes

I = Lack of emergency exit

J = Lack of emergency access

K= Lack of safe shelters

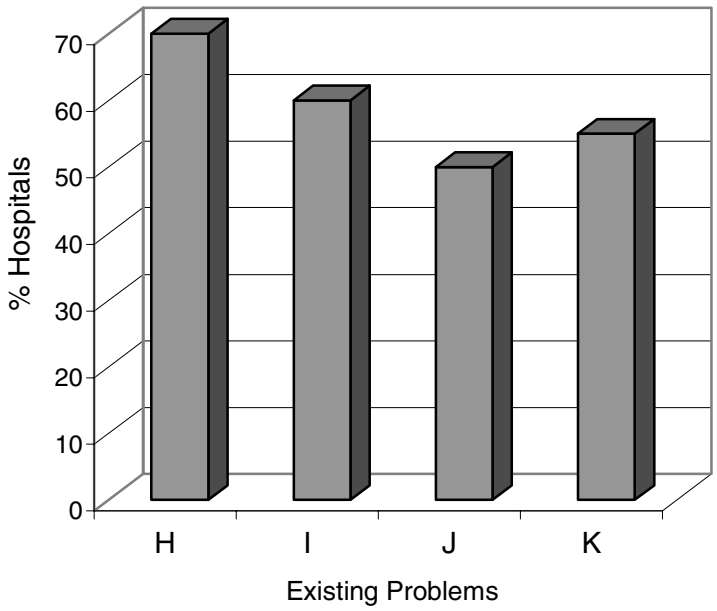

Figure 6: Distribution of non-structural problems- 110 hospitals in mega city of Tehran

Importance of considering the earthquake safety measures for health facilities

The consideration of safety measures for the health facilities against earthquakes should be based on a comprehensive and overall management. Although the type of the construction is the same as other buildings, but due to the way they perform in the time of a disaster and afterwards, more attention and care is required. Three main reasons for giving special attention to health facilities are:

1. The people in these centres: Including medical team, such as doctors and nurses, technical team such as technical staff and support and others such as patients, elderly, children and the visitors,
2. The important and costly medical equipment: Heart Scan, MRI, and other equipment,
3. Their services in emergency and after the disaster: Search, rescue, relief and recovery.

Part of the health facilities' problems in the time of disasters can be addressed in Table (1).

Table 1: Part of the problems health facilities face in the time of earthquakes

1	The countless gathering of people in these centres during the day and night
2	The toxic and potentially hazardous gases in these centers
3	The impossibility to predict the personal behavior or the patients during earthquakes
4	The complexity in design and the structural framing system of these centres and the lack of familiarity of people and especially the patients with the existing structures
5	The possibility of fire and losing the medical information record cabinets of the patients
6	The possibility of leaking of the hazardous chemical and radioactive materials
7	The great dependence of these centres to electricity, water supply, gas, communication lines and equipment and facilities like elevators
8	The possibility of stealing the medicines in case of no provisions for security
9	The destruction of the whole building and impossibility of finding medicines or the personnel
10	The blockage in the exit/passages and lack of communication services with the outside world

Disaster Management Planning

Strengthening structures of important critical facilities such as hospitals for confronting earthquakes is one of the most crucial issues that should be emphasised as a top priority in the disaster management planning [6,7,8,9]. The proposed guideline for planning in the health facilities is classified into two phases as shown in Table (2).

Table 2: Summary of Guidelines for planning in the health facilities against earthquakes

	Phase 1: **Planning for the needs**	Phase 2: **Conducting the plans**
1	Mitigating structural risks	Structural vulnerability investigation and evaluation
2	Mitigating non-structural risks	Establishment of the emergency information
3	Educating and training of personnel	Evacuation procedures
4	Creating emergency shelters	Taking the safety measures into account
5	Establishing the disaster management system in each centre	Establishment of the rescue and relief operation procedures
6	Protecting the medical equipment and patient's documents	Protecting the patients and personnel
7	Providing preparedness measures	Structural and engineering cases

Immediate programmes and planning

Vulnerability assessment of the health facilities

The analysis of the structural conditions of each health facility, the seismic potentiality identification of the area and the evaluation of the degree of their vulnerability against earthquakes are among the most important cases that should be considered urgently.

The establishment of the disaster management system inside each of these centres

In each of these centres, it is necessary to establish a disaster management team with the operational sub-groups. In Figure (8), the chart for different operational headquarters in hospitals is proposed.

Structural and non-structural recommendations and measures

With regard to the responsibilities of hospitals in offering services in the time of a disaster, these centres need to be strengthened against earthquakes.

Some of the necessary structural recommendations for the design and performance of these centres are proposed as follows:

- Choosing the right earthquake characteristics for design
- Application of appropriate loading and analysis
- Conducting structural analysis for dynamic forces due to earthquakes
- Identification of the soil-structural interactions
- Application of detailed design in foundations
- Design of strengthened connections for non-structural components
- Use of appropriate materials for construction
- Appropriate construction and overall control on their implementation.

Also required structural measures for appropriate seismic performance of the health facilities are:

- Avoiding building form irregularities of the health facilities in vertical and horizontal planes
- Avoiding design and construction of inadequate diaphragms
- Refusing the use of different structural systems in the construction of the health facilities
- Providing special attention for not creating deficiencies in the connections
- Avoiding the use of limited number of columns in vast spaces
- Considering the effects of non-structural elements on the structural system
- Considering interaction caused by damage to non-structural components on structures
- Avoiding attachment of non-structural components without adequate connections.

Non-structural recommendations are also proposed for the establishment and the development of the disaster management plan in health facilities. Required non-structural measures for appropriate performance of the health facilities against earthquakes are:

- Protecting the life of the medical, technical and support personnel, patients and the visitors inside and outside the hospitals and health facilities
- Evacuating personnel and the people in the hospital area in an emergency, if required
- Using the emergency equipment and facilities after an earthquake
- Acquiring help from the search and rescue personnel after an earthquake without any serious disturbance
- Reducing the damage to the performance of the health facilities
- Using the appropriate building maps for the use of rescue and relief staff
- Using disaster management system in the centre
- Using special first aid teams
- Using emergency power systems

- Using appropriate spaces for emergency shelters
- Allocating the responsibilities to the administrative structure and body of the centre during the time of a disaster and its aftermath.

The classification of the necessary activities is shown in Figure (7) in four steps: Before, start, during and after the earthquake.

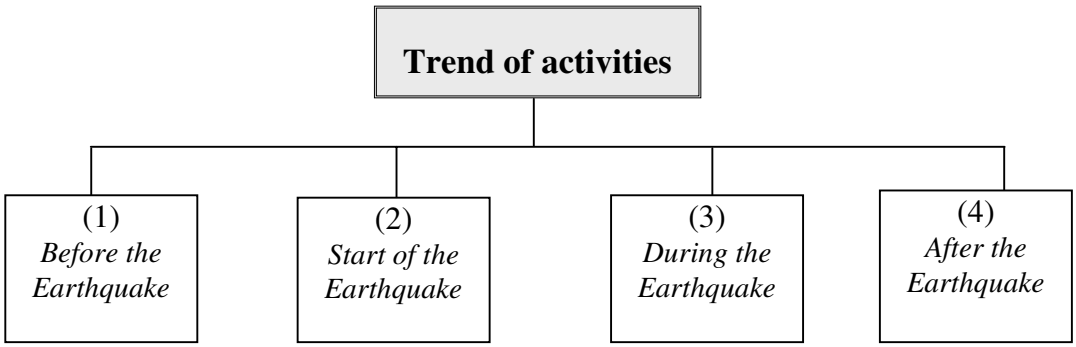

Figure 7: Different operational phases

Different operational teams in health facilities and hospitals are also presented in Figure (8) and their responsibilities are then discussed with regarding to the four phases mentioned.

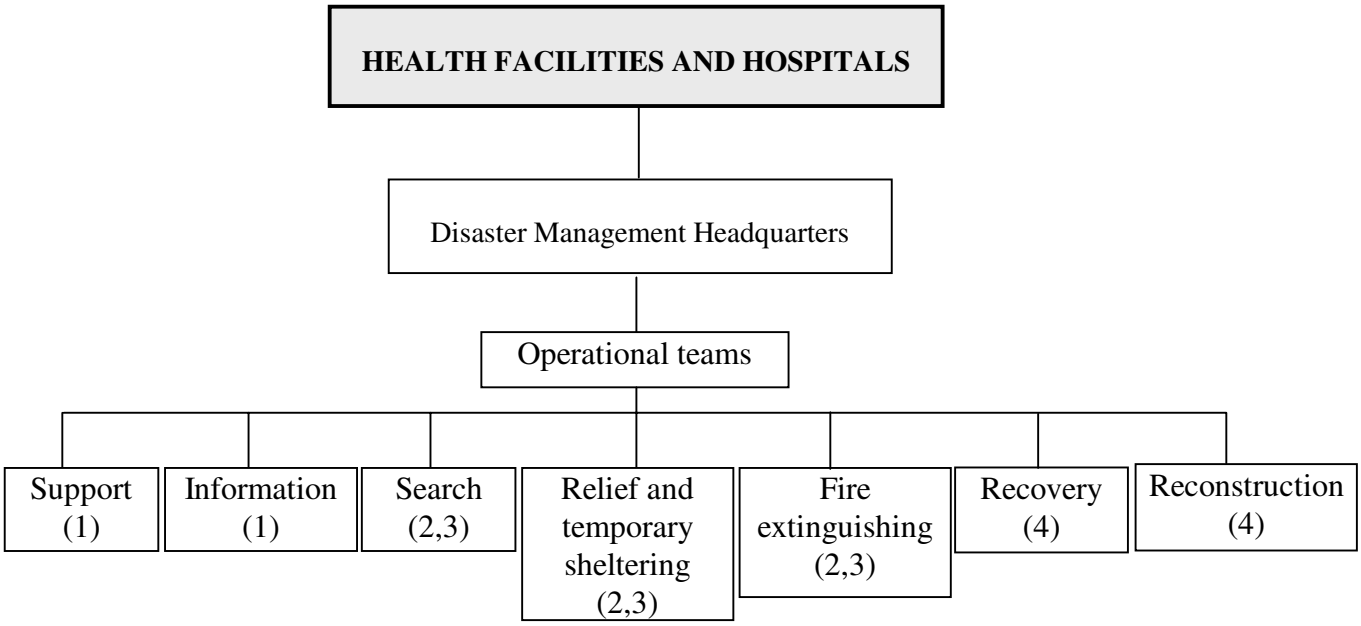

Figure 8: Different operational teams in health facilities and hospitals

Support team

This group considers the analysis of the probable risks in hospitals due to earthquakes, some of their responsibilities are as follows:

- Ensuring the safety of the hospital equipment

- Preparing necessary kits after the earthquake including water, food and necessary medicines
- Drawing up an overall map of the hospital location and identification of the dangerous and safe places
- Considering the hospital water, electricity and gas systems
- Checking the emergency exit doors in the hospital
- Activising the disaster management systems in hospital.

Information management team

Part of the information management group activities is during the disaster which are as follows:
- Awareness of the existing conditions
- Providing information and guidance to patients and other hospital personnel
- Controlling the information and notifying to the search, relief, fire extinguishing and support teams
- Conducting an updated inventory of all chemicals on site
- Awareness of the emergency exit doors and connection ways
- Public awareness through mass media
- Conducting a list of the emergency telephone numbers of patients relatives
- Evaluating and estimating the operation
- Reporting the consequences of the disaster.

Search team

This group addresses the search and rescue (SAR) at the time and during the disaster. Their main activities are:
- Building inspection for finding the victims and captives
- Observing the damaged areas and preventing people to enter those areas
- Evacuating and transferring the injured from dangerous areas to safe places
- Implement emergency procedures as dictated by the situation.

Relief and temporary shelter team

This group consists of the relief, temporary and emergency shelters team for the post earthquake time. Some of their activities are as follows:
- Listing the physical conditions of each patient for identifying those who need especial and emergency care
- Identifying a list of patients who do not need emergency help
- Providing assistance to the injured, especially those who need medical provisions
- Emergency provisions such as hygienic provisions, medical services and mobile medical teams
- Emergency welfare including water supply and distribution of food and medicines among patients and injured
- Providing on-site shelter in high occupancy assemble areas
- Establishing shelters (emergency tents, immediate buildings repair) and temporary settlement for the patients in safe and appropriate places.

Fire extinguishing team

The probability of a fire after an earthquake is very high. The trained fire group operates as follows:
- Inspecting the hospital building for probable fire
- Preparing guidelines for fire safety
- Establishing the prevention system and confronting fire after earthquakes in the hospital
- Preparing extinguisher fire capsules for extinguishing fire after any possible earthquake
- Educating individual members of the fire team and inviting them to relaxation in the time of a fire
- Evacuating the hospital in case of fire.

Recovery team

Part of the recovery team activities are:

- Long-term recovery and normalising the situation in the hospital
- Re-offering the emergency services at the hospital
- Providing physical and psychological assistance to patients, injured and those who have lost their close relatives.

Reconstruction team

Some of the responsibilities of the reconstruction group are as follows:

- Considering the damaged areas in the hospital
- Reconstructing the damaged structures in the hospital
- Long-term buildings repair.

CONCLUSION

The impossibility of predicting the occurrence of earthquakes and locating of Iran in the Alpine-Himalayan seismic belt as one of the most active tectonic regions of the world necessitate a comprehensive disaster management plan in the urban and rural areas of the country. Planning for earthquakes in health facilities especially hospitals is of great importance, in order for the infrastructure and equipment to remain functional after the disaster impact. Risk reduction and disaster planning in hospitals need the cooperation of various sectors of architects, engineers and administrators.

With regard to the structural type of most hospitals in the capital city of Tehran and the structural and non-structural problems in these centers, an organizational chart as shown in Figure (9) is proposed to the government. It is hoped that this planning can reduce the consequences of the earthquakes to an acceptable degree.

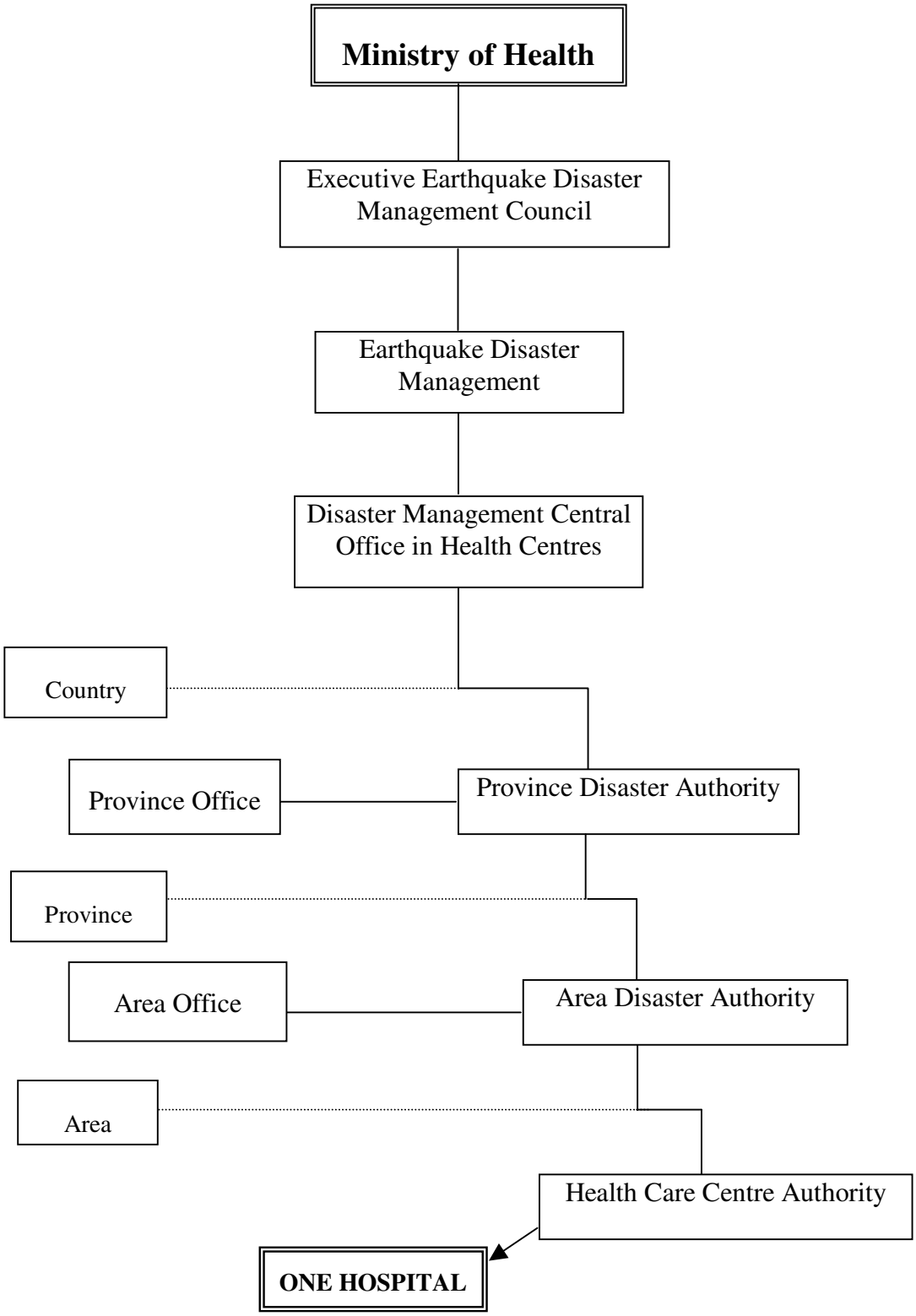

Figure 9: Proposed chart for a comprehensive earthquake disaster management plan in health facilities

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