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**PREPAREDNESS AND SAFE HOSPITAL:
MEDICAL RESPONSE TO DISASTERS**

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***To the people killed or affected
by disasters around the world,
especially the people of the Bam
city in Iran***

ABSTRACT

Background: A disaster is a serious disruption of the functioning of a community. The number of disasters and affected people has increased during the past decades. “Hospitals safe from disasters” is emphasized by the Hyogo Framework Actions for 2005-2015. Collapsed or damaged hospitals, resource shortcomings, absence of a command system and problems with triage, treatment and transportation have been challenges during previous disasters. The current study was conducted to evaluate various aspects of the medical disaster management system.

Objective: To systematically analyze the level of preparedness and safety of hospitals with respect to the medical response.

Methods: This thesis is based on four studies. *Study I* was an educational based intervention. A reliable questionnaire was used to evaluate the efficacy of the intervention. *Study II* was a qualitative content-analysis study. *Study III* was conducted in twenty-three Iranian hospitals. A tabletop exercise was developed for each hospital. The evaluators compared the compatibility of the participants’ decisions with the job action sheets. The performance was classified into three categories: Fair, Intermediate, and High. *Study IV* was a cross-sectional study. The preparedness, as measured by the Functional Capacity, was evaluated using the Hospital Safety Index, and categorized as safe, at risk or inadequate, respectively.

Results: In *Study I*, there was lack of knowledge among medical personnel in terms of medical disaster management. The mean score on the pre-test and post-test was 67.1 ± 11.6 and 88.1 ± 6.2 , respectively ($p < 0.0001$). In *Study II*, the lack of a disaster plan in the pre-hospital medical system affected triage, treatment and transport of casualties to hospitals. Lack of resources and medical assistance teams were other barriers to pre-hospital medical services, while army and medical volunteers were the main facilitators. In *Study III*, the decision-making performance according to the HICS was at an intermediate or low level. The mean of the performance score was 85 ± 15 . The non-university hospitals had a higher performance rate than university hospitals ($P=0.04$). In *Study IV*, the mean functional capacity score was 0.77 ± 0.03 for Swedish hospitals and 0.45 ± 0.05 for Iranian hospitals ($p=0.016$). All Swedish hospitals qualified as safe and all Iranian hospitals were at risk. The national socioeconomic level was associated with the level of hospital preparedness.

Conclusion: This thesis showed that there is a lack of preparedness in some key elements of medical response to disasters in Iran. Using a national model is an effective and practical model for capacity building and increasing the participants’ knowledge of disaster medicine. To implement a comprehensive plan would not only save lives but enable an effective use of the available resources. Skilled medical volunteers and the military’s medical teams must also be included in this kind of plan. The HICS job action sheets can be used as a template for measuring the hospital response performance. The preparedness, as measured by functional capacity, is related to the socioeconomic level of a country. The challenge is therefore to enhance hospital preparedness in vulnerable countries despite a weaker economic situation. All hospitals must be prepared for a disaster.

Key words: Disaster, Hospital, Safety, Preparedness, Response, Incident Command System, Training, Functional Capacity, Pre-hospital, Triage, Treatment, Transportation, Qualitative, Exercise, Performance

LIST OF PUBLICATIONS

- I. Djalali A, Hosseinijenab V, Hasani A, Shirmardi K, Castrén M, Öhlén G, Panahi F. A fundamental, national, medical disaster management plan: an education-based model. *Prehosp Disaster Med.* 2009 Nov-Dec;24(6):565-9.
- II. Djalali A, Khankeh H, Öhlén G, Castrén M, Kurland L. Facilitators and obstacles in pre-hospital medical response to earthquakes: a qualitative study. *Scand J Trauma Resusc Emerg Med.* 2011 May 16;19:30.
- III. Djalali A, Castren M, Hosseinijenab V, Khatib M, Ohlen G, Kurland L. Hospital incident command system (HICS) performance in Iran; decision making during disasters. *Scand J Trauma Resusc Emerg Med.* 2012 Feb 6;20:14.
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LIST OF ABBREVIATIONS

ADDIE	Analysis, Design, Development, Implement, and Evaluate
DMATs	Disaster Medical Assistance Teams
ED	Emergency Department
EMS	Emergency Medical Services
EMP	Emergency Management Plan
EOC	Emergency Operation Center
EOP	Emergency Operations Plan
GDP	Gross Domestic Product
HCC	Hospital Command Center
HDP	Hospital Disaster Plan
HEICS	Hospital Emergency Incident Command System
HICS	Hospital Incident Command System
HSI	Hospital Safety Index
HVAC	Heat, Ventilation, and Air Conditioning
IAP	Incident Action Plan
ICS	Incident Command System
ICU	Intensive Care Unite
IRCS	Iranian Red Crescent Society
ISD	Instructional System Design
MSB	Myndigheten för Samhällsskydd och Beredskap (Civil Contingency Agency)
SMART	Simple, Measurable, Achievable, Realistic and Task-oriented
UNISDR	United Nations International Strategy for Disaster Reduction
WADEM	World Association for Disaster and Emergency Medicine
WHO	World Health Organization

1. BACKGROUND

1.1. DISASTERS

1.1.1. Definitions and concept

Disasters have always been a part of life. Historically, they have been considered as punishment from the gods. Today the attitude towards disasters is changing, as are our capabilities to mitigate the impact of the events responsible for them (WADEM 2003).

There are various definitions regarding disasters. However, the United Nations/ International Strategy for Disaster Reduction has produced a terminology for disaster risk reduction that is used as a worldwide standardized source of definitions (UN/ISDR 2009). A disaster is defined as a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceed the ability of the affected community or society to cope using its own resources (UN/ISDR 2009).

Disasters are often described as a result of/ or the combination of: the exposure to a hazard; the conditions of vulnerability that are present and the insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease but also other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation (UN/ISDR 2009).

The most common medical definition of a disaster is an event that results in the number casualties that overwhelm the healthcare system in which the event occurs. A health disaster often is considered a medical disaster (WADEM 2003).

Although the number of people killed because of disasters has decreased during the last century, the number of disasters and affected people has increased (Figure 1) (EM-DAT 2012). As a result, there are considerable human and economic impacts of disasters; e.g., within the time period of 2000-2011, disasters have produced around 1.3 trillion dollars (USD) in economic damage, caused 1.1 million deaths and affected 2.7 billion people (Figure 2) (PreventionWeb 2012).

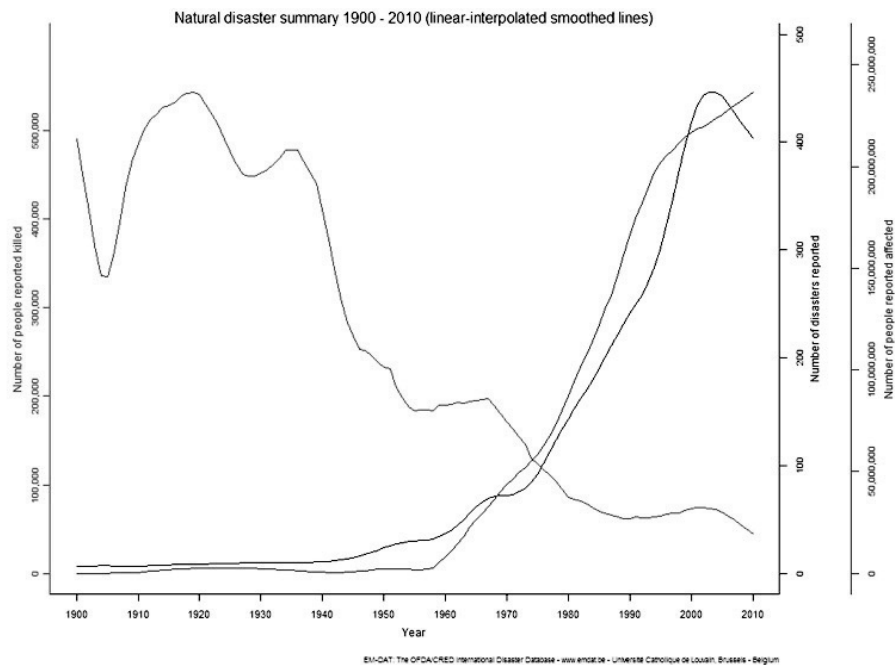


Figure 1- Trend of natural disaster and their human impact from 1900 to 2010
Source: (EM-DAT 2012)

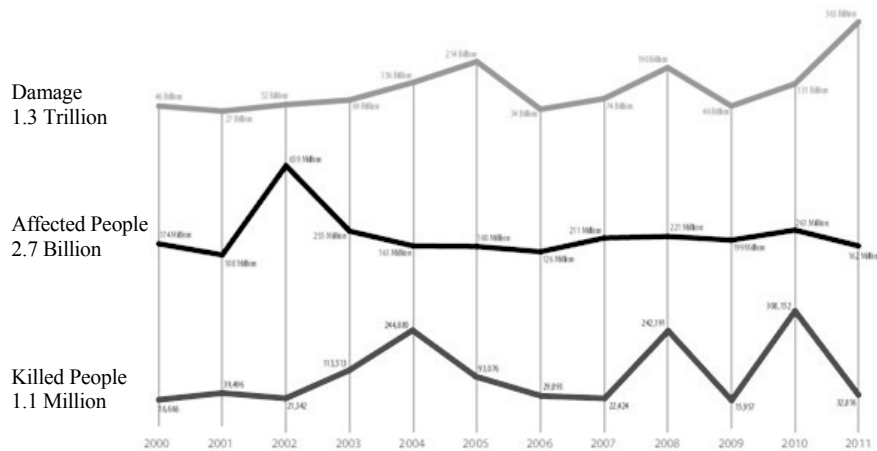


Figure 2- The economic and human impact of disasters from 2000 to 2011
Source: (PreventionWeb 2012)

There are two generic categories for disasters - natural and technological, although, the categorization is somewhat arbitrary since they cannot truly be separated. The natural disaster category is divided into five sub-groups: geophysical, meteorological, hydrological, climatological and biological (Table 1) (EM-DAT 2012).

Category	Sub-group	Definition	Example
Natural	Geophysical	Events originating from solid earth	Earthquake
	Meteorological	Events caused by short-lived/small to meso scale atmospheric processes (in the spectrum from minutes to days)	Storm
	Hydrological	Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up	Flood
	Climatological	Events caused by long-lived/meso to macro scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability)	Drought
	Biological	Disaster caused by the exposure of living organisms to germs and toxic substances	Epidemic

Table 1- General classification of natural disasters

Source: (EM-DAT 2012)

All disasters are related to events of a specific hazard or a combination of hazards that result in damages to a society. A hazard is anything that may pose a danger and has the potential to adversely affect human health, property, activity and/or the environment. Often, a hazard can be described as contained energy (WADEM 2003), or it can induce a reaction.

An event occurs when the hazard is realized or becomes manifest and has the potential to negatively affect living beings and/or their environment. Such occurrences have a characteristic type of onset, intensity, duration, scale and magnitude. The probability of an event for each hazard is called (WADEM 2003).

Impact is defined as the actual process of contact between an event and a society with both positive and negative influences on the society and environment. Damage is the negative result of an impact. A damage containing sufficient magnitude results in a disaster (WADEM 2003). The process from hazard to disaster is shown in figure 3.

There are factors that can affect this process, of which vulnerability and resilience are critical. Vulnerability includes the characteristics and circumstances of a community or system that make it susceptible to the damaging effects of a hazard. It depends on various physical, social, economic and environmental factors of the involved community. The degree of vulnerability depends also upon the resilience of the society at the time of the event (Figure 4). Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions (UN/ISDR 2009).

Resilience is comprised of three elements: (1) the absorbing capacity, (2) the buffering capacity and (3) response to the event and recovery from the damage sustained.

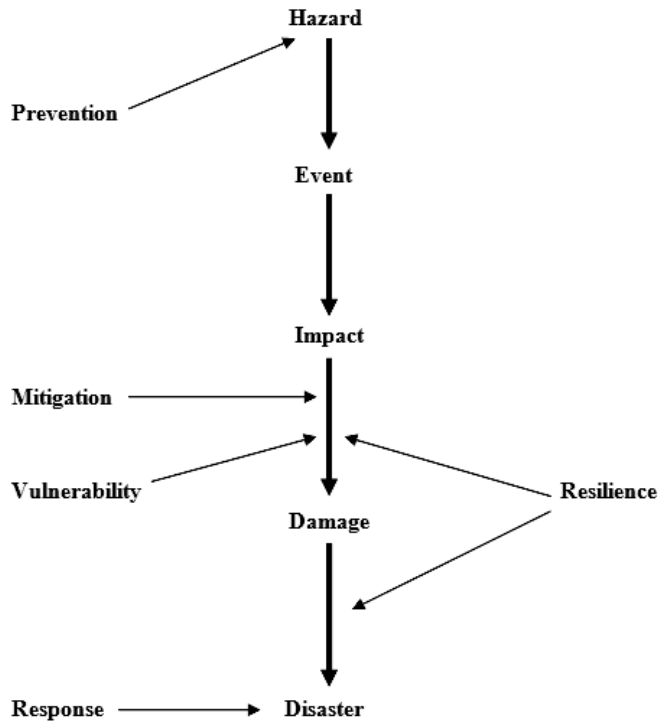


Figure 3- Process from hazard to disaster
Source: (Adapted from the Diagrammatic Process from Hazard to Disaster)
(WADEM 2003)

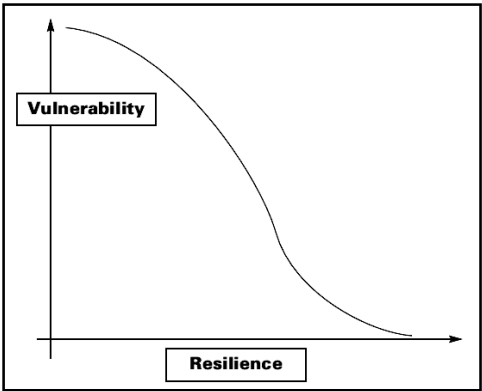


Figure 4- Relationship between vulnerability and resilience
Source: (WADEM 2003)

1.1.2. Disaster risk reduction: Hyogo framework for action 2005-2015

High vulnerability of affected communities during previous disasters has underscored the importance of reducing disaster risk wherever people are exposed to hazards. The effect of disasters also reminds the world of the need for countries to work together before a disaster strikes. This section explains the worldwide strategy regarding disaster risk and is a roadmap in terms of disaster risk reduction and management. The aim of the Hyogo framework for action 2005-2015 is to make the world safer by working on the reduction of risks and the consequences of natural disasters. The strategy for disaster risk reduction, including safe hospital, training, capacity building and cooperation between countries with respect to disaster risk management, is the basis of this current thesis.

The World Conference on Disaster Reduction was held in January 2005 in Kobe, Hyogo, Japan, in the wake of disasters such as the Bam earthquake (December 2003) and the tsunami in the Indian Ocean (December 2004), where it adopted a worldwide Framework for Action 2005-2015. Hence, the Hyogo Framework for Action 2005-2015. It focuses on building the resilience of nations and communities to disasters. The Conference provided a unique opportunity to promote a strategic and systematic approach for reducing vulnerabilities and risks to hazards (Nation 2005).

The strategic goals of the Hyogo framework with respect to disaster risk reduction at national and local levels include integration of disaster risk reduction into sustainable developmental policies and planning, strengthening of capacities to build resilience to hazards, the implementation of emergency preparedness, response and recovery programs (Nation 2005). It emphasizes an all-hazards approach, capacity building and community participation in disaster risk reduction programs.

To provide strategic goals, the Hyogo framework offers five priorities for action. A general consideration which is emphasized is to enhance international and regional cooperation and assistance in the field of disaster risk reduction through the transfer of knowledge, technology and expertise to enhance capacity building for disaster risk reduction, and also to strengthen disaster preparedness for an effective response at all levels (Nation 2005). The Hyogo framework emphasizes “hospitals safe from disaster” as a goal of integrated disaster risk reduction planning in the health sector, a topic also highlighted in this thesis.

1.2. DISASTER MANAGEMENT

Disaster management is an ongoing process to prevent, mitigate, prepare for, respond to, maintain continuity during, and recovery from an incident that threatens life, property, operations and or the environment (NFPA1600 2010). The process is best presented as the disaster management cycle (Figure 5).

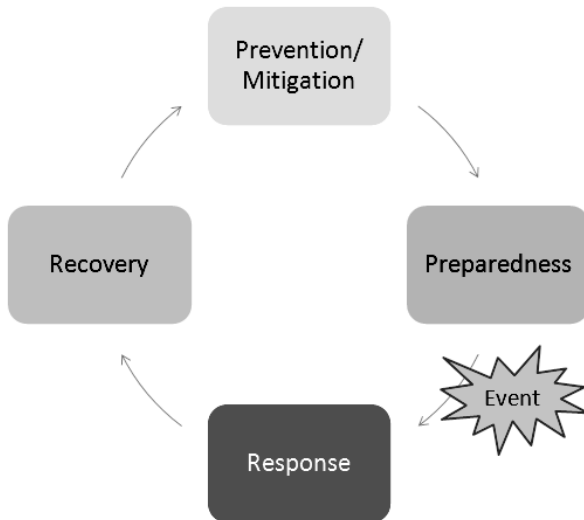


Figure 5- Disaster management cycle

Risk assessment is the basis of disaster management. It is the process of hazard identification, probability analysis, vulnerability analysis and impact analysis (NFPA1600 2010). Based on the results of risk assessment, activities are conducted to prevent and/or mitigate the potential hazards.

Prevention is the aggregate of approaches and measures taken to ensure that human actions or natural phenomena do not cause or result in the occurrence of an event related to an identified or unidentified hazard. Prevention can, in principle, occur only by eliminating the hazard, but it would be difficult and probably impossible to prevent some hazards from occurring (WADEM 2003). Therefore, mitigation should always be considered.

The lessening or limitation of the adverse impacts of hazards and related disasters is called mitigation (UN/ISDR 2009). It is vital that measures for mitigation be implemented by health and medical facilities before disasters.

Preparedness is defined as the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or

current hazard events or conditions (UN/ISDR 2009). It includes warning systems, evacuation, reserve packs of medical supplies, temporary shelter, energy, response strategies, disaster drills and exercises, and training (WADEM 2003).

The response phase refers to the immediate and ongoing activities, tasks, programs, and systems to manage the effects of an incident that threatens life, property, operations, or the environment, i.e. the negative effects of a disaster (NFPA1600 2010).

Recovery is the restoration and improvement of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors. It begins soon after the emergency phase has ended, and should be based on pre-existing strategies and policies that facilitate clear institutional responsibilities for recovery action and enable public participation (UN/ISDR 2009).

The general response to disasters is a combination of various supportive functions, e.g. coordination, communication, energy, transportation, and public health and medical services, which are called emergency supportive functions. A most important function is public health services and medical management of disasters (FEMA 2008).

1.3. MEDICAL DISASTER MANAGEMENT

All disasters, regardless of aetiology, have similar medical and public health consequences, i.e. an immediate overwhelming of the capacity for emergency medical care. Disasters differ in the degree to which these consequences occur and the degree to which they disrupt the medical and public health infrastructure of the disaster scene (Susan M. Briggs 2006).

The general health response to disasters covers multiple services such as assessment of public health/medical needs, health surveillance, potable water/wastewater and solid waste disposal, etc (FEMA 2008).

The most immediate area of health response to disasters is the acute medical care of victims, which includes search and rescue, triage and initial stabilization, evacuation, and definitive medical care. Its' primary acute objective is to reduce the morbidity and mortality associated with the disaster (Susan M. Briggs 2006).

The key principle of disaster medical care is to do the greatest good for the greatest number of patients (Susan M. Briggs 2006; Jenkins, McCarthy et al. 2008). This principle is one of the ethical challenges in disaster medicine. Disasters change the medical ethical rules (Koeing and Schultz 2010). During regular care we focus on identifying the sickest patients and put all efforts and resources into these persons. The change is to leave the individual and do what is best for the group of individuals.

The acute medical care system of disaster casualties is described as a chain consisting of medical rescue, medical transport and hospital treatment (De Boer 1999). As a result, these three medical response functions can be categorized in two levels: pre-hospital and in-hospital. The medical rescue and transport relate to the pre-hospital level.

1.4. HOSPITAL DISASTER MANAGEMENT

Hospitals are powerful symbols of social progress. They are a prerequisite for stability and economic development and have symbolic social and political values which contribute to a community's sense of security and well-being (UN/ISDR 2008).

Hospitals are expected to be ready to play an essential role in reducing deaths and injuries. Hospital readiness may be defined as the ability to effectively maintain hospital operations, sustain a medically safe environment and adequately address the increased and potentially unexpected medical needs of the affected population (Barbera, Yeatts et al. 2009).

Hospital readiness requires a comprehensive disaster plan, which begins with a comprehensive risk assessment and hazard vulnerability assessment to identify the most likely threats to a particular hospital. Readiness continues to mitigation, preparedness, response and recovery phases (Kaji and Lewis 2006; Kaji, Koenig et al. 2007; ASTM 2009).

The goals of a comprehensive hospital disaster plan (HDP) are to enable the hospital to effectively manage an disaster, provide continuity of basic societal functions and minimize the following: physical damage to a hospital, loss of life, injury or illness of hospital personnel and human suffering of the persons affected (ASTM 2009).

A comprehensive hospital disaster plan includes all hazards, all disciplines/phases, and all levels/related organizations in the disaster management process (Koeing and Schultz 2010). Nevertheless, one must not regard the plan as the entire essence of emergency preparedness, but rather as one essential element in a spectrum of activities (Adini, Goldberg et al. 2006). Having a disaster plan does not equal preparedness (Kaji and Lewis 2006), however a comprehensive disaster plan is considered as the back bone of hospital preparedness.

One important aspect of a comprehensive disaster plan is an all-hazards approach, which refers to the consideration of any incident or event that could pose a threat to human life, property or the environment (ASTM 2009). An all-hazards approach does not literally mean being prepared for any and all hazards that might manifest themselves in a particular community including the hospital. It means that there are common needs and responses required in disasters, such as the need for treatment and triage of victims that can be addressed in a general plan and that plan can provide the basis for responders to prepare for unexpected events. It provides a basic framework for responding to various disasters, but planners typically address the kinds of disasters that might be expected to occur (William L. Waugh 2004).

Another aspect of a comprehensive disaster plan is to consider all phases of the disaster management cycle. An effective hospital disaster management plan must be constructed for four stages of emergency management: (1) mitigation, (2) preparedness, (3) response, and (4) recovery (Cyganik 2003; Adini, Goldberg et al. 2006; ASTM 2009).

The mitigation phase should establish interim and long term actions to eliminate hazards that impact the entity or reduce the impact of those hazards that cannot be eliminated. The hospital should develop and implement a strategy to eliminate hazards or mitigate the effects of hazards that cannot be eliminated by actions, e.g. the use of applicable building construction standards; relocation, retrofitting, or removal of structures at risk; reduction or limitation of the amount or size of the hazard; establishment of hazard warning and communication procedures; redundancy or duplication of essential personnel, critical systems, equipment, supplies, pharmaceuticals, information systems, operations, or materials (ASTM 2009).

Also, a necessary part of the mitigation plan is to monitor and assess the hazards and unsafe situations which may arise and develop measures to ensure personnel safety. Plans and procedures must ensure the safety of personnel, facilities and resources so that the system can operate effectively (ASTM 2009).

The preparedness phase includes those actions taken before an incident to improve the capability and capacity of the hospital to respond to a major incident within or outside the hospital. Preparedness efforts include, but are not limited to, providing elements of surge capacity, developing and maintaining training programs for hospital employees, drill and exercise activities, maintaining mutual cooperation with regional hospitals as well as community organizations regarding emergency preparedness activities (Cyganik 2003; ASTM 2009).

The response phase is the most critical and important part of the disaster management cycle; it includes those actions necessary to minimize negative effects of an incident on the hospitals and lead to recovery and restoration of essential hospital services. However, its success is an effect of the mitigation and preparedness plans.

The response contains all processes that should be directed at reducing morbidity and mortality, which is the main objective of the medical part of a disaster plan. It includes but is not limited to command, control, communication, coordination, triage, treatment, surge capacity actions, etc. (Cyganik 2003; Hick, Koenig et al. 2008; ASTM 2009). The Incident Command System (ICS) is the core of the response phase, which is not only the command-control system during hospital emergency responses. But is also the organizing structure for hospital emergency management throughout the entire emergency management cycle, including the mitigation, preparedness, response, and recovery phases (Arnold, Dembry et al. 2005; Hick, Koenig et al. 2008).

The recovery phase is the last phase of disaster management and refers to all activities aimed at bringing infrastructure and individuals back to pre-disaster conditions, including the implementation of mitigation measures to facilitate short- and long-term recovery and rehabilitation. Also, it includes the elements of planning, finance and administration, documentation, and business continuity (Cyganik 2003; ASTM 2009).

The recovery plan should be developed using strategies based on the short- and long-term priorities, processes, vital resources, and acceptable time frames for restoration of services, facilities, programs, and infrastructure (ASTM 2009).

The third important aspect of a comprehensive hospital disaster plan is to be a part of the community disaster plan. Hospitals constitute only one part of the community. They

do not function in isolation during a disaster, it is essential for hospital disaster plans to be integrated into the community disaster plan at all levels (Kaji and Lewis 2006).

Mutual aid agreements with relevant community organizations and other health care facilities should be included as part of hospital disaster plans. These agreements should include, but not be limited to, personnel, supplies, equipment, transportation and whatever else is determined to be needed in the event that a disaster occurs. In fact, a remarkable benefit of hospital cooperation with other hospitals and regional health centres is to address surge capacity and capabilities (Richter 1997; ASTM 2009).

Communications with these organizations should be established on a regular basis to ensure an effective emergency response. This can be based on common terminology, codes, and processes to facilitate effective communication and coordination during an emergency. Some key organizations that a hospital should effectively interact with are (ASTM 2009):

- Other hospitals, healthcare organizations, clinics, poison control centers, and other specialty care centers,
- Emergency medical services (EMS) agencies,
- Emergency management agencies,
- Law enforcement agencies,
- Fire services,
- Media.

The link between the hospital and the community disaster plan needs to be based on a common language and agreed upon between the hospital and all responsible organizations (Braun, Wineman et al. 2006).

1.4.1. Vulnerability of hospitals

The very nature and purpose of a hospital, as the initial source of medical care, demands that it remain fully operational in the aftermath of any major disaster (Schultz, Koenig et al. 2003). To consider the priorities for hospital disaster management activities, it is important to know which of the services provided by a health facility will be of greater or lesser importance in the management of a disaster. , the importance of medical services can be rated as (1) dispensable, (2) preferable, (3) necessary, (4) very necessary and (5) indispensable in the event of a disaster (Table 2) (WHO/PAHO 2000).

Clinical and support services	Importance rating
Trauma and orthopedic	5
Intensive care unit	5
Urology	5
Emergency care	5
Sterilization	5
Diagnostic imaging	5
Pharmacy	5
Nutrition	5
Transport	5
Recovery	5
Blood bank	5
Outpatient consultation/admission	4
Pediatric surgery	4
Pediatrics	4
Laboratory	4
Haemodialysis	4
Laundry services	4
Internal medicine	3
Gynecology and obstetrics	3
Administration	3
Neonatology	3
Respiratory medicine	2
Ophthalmology	2
Filing and case management	2
Dermatology	1
Psychiatry	1
Oncology	1
Otorhinolaryngology	1
Dental services	1
Therapy and rehabilitation	1

Table 2- Importance of typical hospital services in an emergency

Source: Pan American Health Organization (PAHO/WHO)

Adverse natural phenomena affect health systems' operations both directly and indirectly (WHO/PAHO 2004). An unexpected number of deaths and injuries, migrations from the affected area towards other areas where the health system capacity may be overwhelmed by the new arrivals, an increase in the potential risk of a critical outbreak of communicable diseases, etc., are indirect effects of disasters on health systems (WHO/PAHO 2004).

Experience shows that hospital damage from natural disasters often occurs in the event of a disaster and this not limited to developing countries (Schultz, Koenig et al. 2003;

WHO 2005; Edelman 2006; Gray and Hebert 2007; Bagaria, Heggie et al. 2009; Chapin, Daniels et al. 2009; Miyamoto 2009). The most likely impact of an event on a hospital is damage leading to a functional collapse (WHO/PAHO 2004), which results in a complete or partial evacuation of the damaged hospital (Schultz, Koenig et al. 2003; Sternberg, Lee et al. 2004; Bagaria, Heggie et al. 2009).

There is a consensus that knowledge of the potential impact to facilities on hospital operations is of major importance for the following reasons (WHO/PAHO 2000; Paul and Lin 2009):

1. Hospital facilities must maintain their normal functions and attend to the sudden surge of demand for medical treatment following a disaster,
2. Hospitals accommodate a large number of patients, who, due to their disabilities, are unable to evacuate a building in the event of a disaster,
3. Hospitals have a complex network of electrical, mechanical and sanitary facilities, as well as expensive equipment, all of which are essential for the routine operation of the hospital,
4. The ratio of the cost of non-structural elements to the total cost of the building is much higher for hospitals than other buildings (WHO/PAHO 2000; Paul and Lin 2009).

In summary, the complexity, occupancy level, installations and specific equipment of hospitals make them vulnerable (WHO/EURO 2006).

It is the duty of authorities to assess a hospital's vulnerability to disaster damage and to obtain estimates of existing risk levels in order to ensure a proper response to emergency needs. A reliable and comprehensive hospital vulnerability assessment should be carried out by taking into account three elements of vulnerability: Structural, non-structural and administrative/organizational (WHO/EURO 2006).

➤ Structural elements

The structural elements include foundations, columns, bearing walls, beams, staircases and floors. Evaluation of the structural vulnerability and relevant issues are specific to the type of hazard. Generally, the impact of disasters on structural elements differ from slight damage to complete destruction (WHO/EURO 2006).

➤ Non-structural elements

The non-structural vulnerability evaluation considers architectural elements, equipment and furnishings and basic installations and services (Table 3) (WHO/PAHO 2000).

The consequence of damage to non-structural elements is categorized as (WHO/EURO 2006) low, moderate and high. Low; will probably not cause injury to the occupants or interfere with the performance of the facility. Moderate; represents a moderate probability of causing injury to the occupants or of interfering with the performance of the facility, and high; will probably cause injury (and even death) of the occupants or seriously compromise the performance of the facility.

Architectural Elements	Installations	Equipment and furnishings
<ul style="list-style-type: none"> • Divisions and partitions • Interiors • Facades • False ceilings • Covering elements • Cornices • Terraces • Chimneys • Glass • Attachments • Ceilings • Antennas 	<ul style="list-style-type: none"> • Drinking water • Industrial water • Steam • Medical gasses • Industrial fuel • Vacuum network • Air conditioning • Piping • Waste disposal 	<ul style="list-style-type: none"> • Medical equipment • Industrial equipment • Office equipment • Furnishings • Supplies • Clinical files • Pharmacy shelving • Laboratory shelving

Table 3- Nonstructural elements in a hospital

Source: Pan American Health Organization (PAHO/WHO)

The non-structural elements' impact on hospital conditions can produce different types of problems for hospital function and the safety of patients and personnel; these are defined as life safety risk, property loss risk and loss of function risk (WHO/EURO 2006).

➤ The administrative/ organizational elements

Of all the elements that interact in the day-to-day operations of a health facility the administrative and organizational aspects are among the most important ones. They include all physical and administrative measures that are required for organizing the ability of hospital personnel to respond to disaster situations and to optimize the hospital's capacity to function during and after a disaster (WHO/PAHO 2000).

Administrative aspects: Some important issues that must be evaluated in the context of administrative vulnerability are contracting, acquisitions and routine maintenance, as well as the physical and functional interdependence of the different areas of the facility (WHO/EURO 2006).

Organizational aspects: A continuous and smooth day-to-day operation of a hospital depends on an optimized organization of personnel, equipment, material, resources, and spatial organization (WHO/EURO 2006).

The method for evaluation of the administrative/organizational vulnerability is subjective and qualitative and based on the knowledge and experience of the medical staff that are faced with all the problems that may arise during the operation of the health facility. Based on the vulnerability evaluation, the hospital functionality can be classified as (WHO/PAHO 2000):

- Good: the parameter under review satisfactorily meets current local standards in disaster reduction and there is no need to modify it;
- Average: the parameter under review satisfies local standards only moderately and a minor modification could improve performance significantly;

- Poor: the parameter under review does not meet local standards and must be modified substantially to resolve this deficiency.

Addressing the Hyogo framework's priorities for actions and due to the importance of hospitals in disaster management, the global campaign "Hospitals Safe from Disasters: Reduce Risk, Protect Health Facilities, Save Lives" was developed the Secretariat of the United Nations International Strategy for Disaster Reduction (UNISDR) in partnership with the World Health Organization (WHO) in 2008-2009 (UN/ISDR 2008). This topic will be addressed in the following section.

1.4.2. Hospital Safety Index (HIS)

The aim of the Hospitals Safe from Disasters strategy is to ensure that hospitals will not only remain standing in case of a disaster, but that they will function effectively and without interruption (WHO 2008). There are three objectives, with respect to hospital safety:

- Protect the life of patients, visitors and hospital staff,
- Protect the investment in equipment and furnishings, and
- Protect the performance of the health facility.

Addressing the described objectives, and as part of risk reduction strategy in the health sector, it is important to identify the safety level of hospitals should a disaster occur.

Hospital evaluations aim to identify elements that need improvement in a specific hospital, and to prioritize interventions in hospitals that, because of their type or location, are essential during and after a disaster. To facilitate this process and diminish technical and financial demands, the hospital safety index has been offered (WHO 2008). It is a rapid and low-cost diagnostic tool, which has been developed by Pan American Health Organization (PAHO/WHO) to assess the probability of a hospital or health facility remaining operational in emergency situations (WHO 2008). There are other methods for vulnerability evaluation of health facilities (McLaughlin 2001; WHO/EURO 2006), however, WHO recognizes that it is the best system of rapid evaluation that exists (WHO 2008).

The hospital safety index is not only a tool for making technical assessments, but it provides a new approach to disaster prevention and mitigation for the health sector. It is not an "all or nothing" approach to hospital safety, but allows for improvement in a facility over time (WHO 2008). The hospital safety index is assessed in two main forms:

Form 1 includes general information about the health facility, e.g. number of beds, hospital occupancy rate, etc.

Form 2 is the Safe Hospitals Checklist, which contains 145 variables, each of which has three safety levels: low, medium, and high. It is divided into four sections or modules:

1. Geographic location of the health facility
2. Structural safety
3. Non-structural safety
4. Functional capacity

The Safety Index has a maximum value of 1 (one) and a minimum of 0 (zero) and corresponds to the sum of the individual scores from the Safe Hospital Checklist (WHO 2008). The total score is further classified as A, B or C (WHO 2008) (Table 4).

Safety index	Classification	What should be done?
0 – 0.35	C	Urgent intervention measures are needed. The hospital's current safety levels are inadequate to protect the lives of patients and hospital staff during and after a disaster.
0.36 – 0.65	B	Intervention measures are needed in the short-term. The hospital's current safety levels are such that patients, hospital staff, and its ability to function during and after a disaster are potentially at risk.
0.66 – 1	A	It is likely that the hospital will function in case of a disaster. It is recommended, however, to continue with measures to improve response capacity and to carry out preventive measures in the medium- and long-term to improve the safety level in case of disaster.

Table 4- Classification of Hospital Safety Index and its explanation based on the total score

Source: (WHO 2008)

Module 1: The first module is for the determination of the hazards that exist in the area; it is not included in the calculation of the safety index.

Module 2: Module 2 evaluates the structural safety of the facility and involves the assessment of its type of structure, materials, and previous exposure to natural and other hazards.

Module 3: This module evaluates non-structural safety which includes the safety of critical networks like electrical and telecommunication systems, heat, ventilation, and air conditioning (HVAC) systems in critical areas, office and storeroom furnishings and equipment such as computers, medical diagnostic and treatment equipment and architectural elements.

Module 4: Module 4 considers safety based on functional capacity. The organization of hospital in response to a disaster is central to evaluating a hospital's capacity to function during and after a disaster.

Functional capacity is defined as the level of preparedness of the hospital staff for major emergencies and disasters as well as the level of implementation of the hospital disaster plan (WHO 2008). It consists of five sub-modules that are compatible with the preparedness cycle, which consists of planning, organizing, training, equipping, exercising, evaluating and taking corrective action for improvement (Figure 6) (FEMA 2010). In fact, the functional capacity module considers an ongoing process for disaster preparedness.

The functional capacity module of the Safe Hospital Index considers the following positions (WHO 2008):

- a) Organization of the Hospital Disaster Committee and the Emergency Operations Centre,
- b) Operational plan for internal and/or external disasters,
- c) Contingency plans for medical treatment in disasters,
- d) Plans for the operation, preventive maintenance, and restoration of critical services,
- e) Availability of medicines, supplies, instruments, and other equipment for use in emergencies.



Figure 6- The preparedness cycle
Source:(FEMA 2010)

a) Organization of the Hospital Disaster Committee and the Emergency Operations Centre

A hospital disaster committee is a multi-disciplinary team, from inside and outside a hospital, which coordinates the preparation, development, implementation, evaluation, and maintenance of a hospital disaster plan (NFPA1600 2010). The hospital emergency operation center, EOC, (also called Hospital Command Center, HCC) is a pre-defined location for hospital incident management team to convene and coordinate response activities, resources and information (EMSA 2006). This area can be used for relevant activities during other phases of the disaster management cycle, e.g. preparedness

activities. A standard EOC/HCC has some features such as security, safety, accessibility, etc that should be considered in designing and establishing the location (EMSA 2006).

This sub-module of the HSI consists of following parameters according to WHO (WHO 2008):

- The committee is formally established to respond to major emergencies or disasters
- Committee membership is multi-disciplinary
- Each member is aware of his/her specific responsibilities
- Space is designated for the hospital EOC
- The EOC is in a protected and safe location
- The EOC has a computer system and computers
- Both internal and external communications systems in the EOC function properly
- The EOC has an alternative communications system
- The EOC has adequate equipment and furnishings
- An up-to-date telephone directory is available in the EOC
- “Action Cards” available for all personnel

b) Operational plan for internal or external disasters

The emergency operations plan provides the structure and processes that the organization utilizes to respond to and initially recover from an event (Preparedness 2012). It assigns responsibilities to organizations and individuals for carrying out specific actions that exceed routine responsibility at projected times and places during an emergency. It is flexible enough for use in all disasters (FEMA 2010).

This sub-module consists of following parameters (WHO 2008):

- Strengthen essential hospital services
- Procedures to activate and deactivate the plan
- Special administrative procedures for disasters
- Financial resources for emergencies are budgeted and guaranteed
- Procedures for expanding usable space, including the availability of extra beds
- Procedures for admission to the emergency department
- Procedures to expand emergency department and other critical services
- Procedures to protect patients’ medical records
- Regular safety inspections are conducted by appropriate authority

- Procedures for hospital epidemiological surveillance
- Procedures for preparing sites for temporary placement of dead bodies and for forensic medicine
- Procedures for triage, resuscitation, stabilization, and treatment
- Transport and logistics support
- Food rations for hospital staff during the emergency
- Duties assigned for additional personnel mobilized during the emergency
- Measures to ensure the well-being of additional personnel mobilized during the emergency
- Cooperative arrangements with local emergency plan
- Mechanism to prepare a census of admitted patients and those referred to other hospitals
- System for referral and counter-referral of patients
- Procedures for communicating with the public and media
- Procedures for response during evening, weekend, and holidays
- Procedures for the evacuation of the facility
- Emergency and other exit routes are accessible
- Simulation exercises and drills

c) Contingency plans for medical treatment in disasters

Contingency planning is a management process that analyses specific potential events or emerging situations that might threaten the organization and establishes arrangements in advance to enable timely, effective and appropriate responses to such events and situations. It consists of organized and coordinated courses of action with clearly identified institutional roles and resources, information processes and operational arrangements for specific actors at times of need. Based on scenarios of possible emergency conditions or disaster events, it allows key actors to envision, anticipate and solve problems that can arise during crises (UN/ISDR 2009). It undertakes activities to ensure that proper and immediate response will be taken by management and employees in the case of a specific disaster.

This sub-module considers the contingency plans for following disasters (WHO 2008):

- Earthquakes, tsunamis, volcanoes, and landslides
- Social conflict and terrorism
- Floods and hurricanes
- Fires and explosions

- Chemical accidents OR exposure to ionizing radiation
- Pathogens with epidemic potential
- Psycho-social treatment for patients, families, and health workers
- Control of hospital-acquired infections

d) Plans for the operation, preventive maintenance, and restoration of critical services

Critical services such as the communication system, water supply, medical gases, etc., are important elements of hospital operations. Mitigation of disaster impacts on these critical services is a subject in the area of the non-structural module, however to provide and restore back-up systems is a responsibility of the organizational module. The function of a hospital, especially indispensable services like the Intensive Care Unit (ICU) and Emergency Department (ED), is dependent on these critical services (WHO/EURO 2006).

This sub-module consists of following parameters (WHO 2008):

- Electric power supply and back-up generators
- Drinking water supply
- Fuel reserves
- Medical gases
- Standard and back-up communications systems
- Wastewater systems
- Solid waste management
- Maintenance of the fire protection system

e) Availability of medicines, supplies, instruments, and other equipment for use in an emergency

Sufficient amounts of medical supplies including essential medicines are vital elements of hospital preparedness (Adini, Goldberg et al. 2006; Bukhari, Qureshi et al. 2010). Anticipation of needs on the basis of experiential data and disaster assessment can provide enhanced medical care during disasters (Bukhari, Qureshi et al. 2010).

This sub-module considers the contingency plans for the following disasters (WHO 2008):

- Medicines
- Items for treatment and other supplies
- Instruments
- Medical gases
- Mechanical volume ventilators

- Electro-medical equipment
- Life-support equipment
- Personal protection equipment for epidemics (disposable)
- Crash cart for cardiopulmonary arrest
- Triage tags and other supplies for managing mass casualties

The functional capacity module of the HSI is a standardized module (WHO 2008); however it does overlap with other standardized models and systems in the field of hospital disaster management such as surge capacity and the hospital incident command system (EMSA 2006; Kelen and McCarthy 2006; Hick, Koenig et al. 2008). For example, surge capacity is said to include staff, stuff, structure and services and is not considered a sub-module in the HSI, but its elements are seen in different sub-modules of the functional capacity module.

1.4.3. Surge capacity

Medical capacity is a term that is used to describe the number of persons that can be evaluated or treated within the health care system at any given time. Medical surge capacity is the maximum number of persons that the health care system can evaluate or treat on sudden demand (Stratton and Tyler 2006). In other words, surge capacity is the maximum potential delivery of required resources, either through augmentation or modification of resource management and allocation (Kelen and McCarthy 2006). Surge capacity is a critical component of hospital preparedness.

Conceptually, an optimized sustainable system for surge has the following components: comprehensive supplies and equipment, trained personnel, physical space, and management infrastructure, policies and procedures for escalation, which can respectively be referenced as “stuff, staff, structure, and systems” (Barbisch and Koenig 2006; Kaji, Koenig et al. 2006; Hick, Koenig et al. 2008).

There is another concept related to surge capacity that is called surge capability which refers to the ability to manage patients requiring unusual or very specialized medical evaluation and care. Surge requirements span the range of specialized medical services (expertise, information, procedures, equipment or personnel) that are not normally available at the location where they are needed. Surge capability also includes patient problems that require special intervention to protect medical providers, other patients and the integrity of the health care organization (Barbera and Macintyre 2007).

Hospitals are expected to manage surge capacity issues without external aid for up to 96 hours (Hick, Barbera et al. 2009; Kelen, McCarthy et al. 2009). However, other health care agencies and community emergency management organizations help the hospitals with respect to surge capacity and capability (Schultz and Stratton 2007). Community infrastructure including emergency medical services, communications

infrastructure, government institutions (e.g. public safety agencies), and private infrastructure (supply chains, utilities, transportation assets) may have significant impact on the ability of a hospital to maximize its surge capacity (Hick, Barbera et al. 2009).

1.4.4. Hospital Incident Command System

A hospital disaster plan should describe an incident command structure for medical operations that coordinates medical care and the use of medical personnel and resources. It should be designed to be an extension of day-to-day service, facilities and resources. The Incident Command System (ICS) defines fundamental practices of hospital management and control of personnel and resources (ASTM 2009)

Origin of the Incident Command System

The ICS was developed in the 1970s by an interagency task force working as a cooperative local, state and federal effort called FIRESCOPE (Fire fighting Resources of California Organized for Potential Emergencies) to combat forest fires. Research on the response to major incidents revealed weaknesses in a number of areas, prior to the development of ICS, as follows (EMSA 2006):

- Inadequate communication because of conflicting terminology or inefficient or improper use of technology;
- Lack of a standardized management structure that would allow integration, command and control, and workload efficiency;
- Lack of personnel accountability;
- Lack of a systematic planning process.

Incidents of all sizes and types were often mismanaged, resulting in health and safety risks, unnecessary damage, ineffective resource management and economic losses as a result of the above listed shortcomings. To meet those challenges, ICS is designed to:

- Be useable for managing all routine or planned events, of any size or type,
- Allow personnel from different agencies or departments to be integrated into a common structure that can effectively address issues and delegate responsibilities,
- Provide needed logistical and administrative support to operational personnel,
- Ensure their key functions are covered and eliminate duplication.

A modification of the ICS, the Hospital Emergency Incident Command System (HEICS) was developed by the Orange County, California Emergency Medical Services (EMS) in 1991 and tested at six hospitals in 1992 (Arnold, Demby et al. 2005). Then, it was revised in 1996 and 1998; the last edition is called Hospital Incident Command System (HICS) which was revised in 2006 to improve capabilities

of the system and establish closer alignment with community disaster management plans (EMSA 2006).

The HICS is currently the most commonly used model for hospital disaster response in the United States; is also used in Taiwan and Turkey (Arnold J, O'Brien D et al. 2001; Arnold, Dembry et al. 2005; Tsai, Arnold et al. 2005; Autrey and Moss 2006).

HICS is composed of a Command group and four sections including Operations, Planning, Logistics and Finance/Administration, as illustrated in the figure 7 (EMSA 2006).

For each position there is a job action sheet that explains the main mission and the expected tasks within immediate, intermediate and extended operational time periods, 0-2 hours, 2-12 hours and beyond 12 hours, respectively. It also explains the demobilization/system recovery (EMSA 2006). As an example, the job action sheet of the incident commander is shown as appendix 1.

- Command group

The activities at the Hospital Command Center (HCC) are directed by the Incident Commander, who has overall responsibility for all activities within the HCC and may appoint other Command Staff personnel to assist (EMSA 2006):

- The Public Information Officer,
- The Safety Officer,
- The Liaison Officer,
- Medical/Technical Specialists.

- Operations section

Many incidents usually involve injured or ill patients. The Operations Section is responsible for managing the tactical objectives outlined by the Incident Commander. This section is typically the largest in terms of resources to marshal and coordinate, therefore, Branches, Divisions and Units are implemented as needed. The operations sections consists of one department level management part and five branches (EMSA 2006); staging management, medical care operations, infrastructure operations, security operations, business continuity operations and hazardous material branch.

- Planning section

The Planning Section will “collect, evaluate, and disseminate incident situation information and intelligence to Incident Command.” They will also be responsible for preparing status reports, displaying various types of information, and developing the Incident Action Plan (IAP). The planning section consists of four units: resource, situation, documentation and demobilization (EMSA 2006).

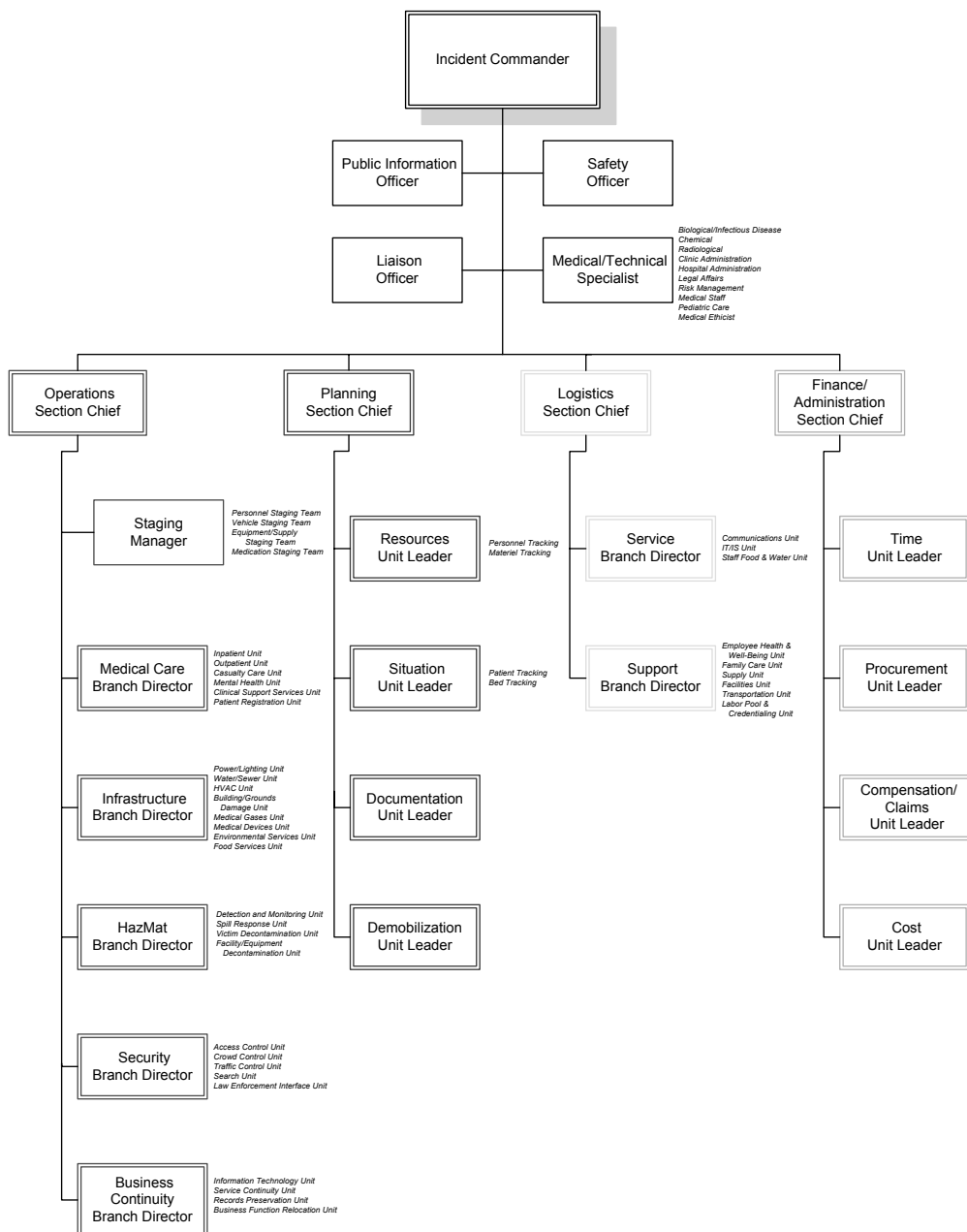


Figure 7- Organization of the hospital incident command system
Source: (EMSA 2006)

- Logistics section

For the hospital to respond effectively to the demands associated with a disaster, support requirements are coordinated by the Logistics Section. These responsibilities include acquiring resources from internal and external sources using standard and emergency acquisition procedures and requests to the local EOC. The logistics section is subdivided into two branches: service and support branch (EMSA 2006).

- Finance and Administration

The Finance/Administrative section is for financial and expense/payment accountability and coordinating reports and records of the response. This section is intended to develop financial and administrative procedures to support the program before, during and after an emergency or a disaster. The Finance/Administration Section coordinates personnel time (Time Unit), orders items and initiates contracts (Procurement Unit), arranges personnel-related payments and Workers' Compensation (Compensation/Claims Unit), tracking of response and recovery costs and payment of invoices (Cost Unit) (EMSA 2006).

1.4.5. Education and training programs

Education and training are key elements of disaster readiness. All medical staff should understand the nature and consequences of possible hazards and how they can contribute to disaster management activities. They should be familiar with all internationally used scientific terms (Ammar 2008).

It is recognized that the science of disaster medicine is evolving and currently lacks not only recognized mature theories, but also rarely accessible and up-to-date evidence-based epidemiological studies. Both are considered essential to be developed in parallel with the educational programs (Archer and Seynaeve 2007). There have been, however, international and national attempts to develop standard educational curricula and materials for medical workers with respect to disaster medicine (WADEM 2003; Archer and Seynaeve 2007; Collander, Green et al. 2008; Subbarao, Lyznicki et al. 2008; Schultz, Koenig et al. 2012).

In 2004, the World Association for Disaster and Emergency Medicine (WADEM) developed the International Standards and Guidelines on Education and Training in the field of health and disaster medicine (Seynaeve G 2004). The guidelines emphasize that education and training programs should be multi-disciplinary and have vocational focus, case or scenario-based, themed approach, core and electives, modular approach, supervised practical experience and a competency-based approach (Seynaeve G 2004).

Developing a disaster education and training program

Terminology is the foundation for education and training efforts. Because disaster medicine is interdisciplinary by nature, the establishment of an integrated compendium of terms, acronyms and definitions is an important first step. The basic theory that supports the development of education and training programs is called Instructional

System Design (ISD) (Clark 2010). It is also known as ADDIE (Analysis, Design, Development, Implement, and Evaluate) (Clark 2010) that involves five phases (Figure 8) (Koeing and Schultz 2010):

- Analysis of training needs and identification of requirements for each target audience, including regulations, standards and accepted practices
- Design of the education and training program and schedule, individual activities, and delivery methods
- Development of content and instructional resources
- Implementation of the education and training program
- Evaluation and improvement activities

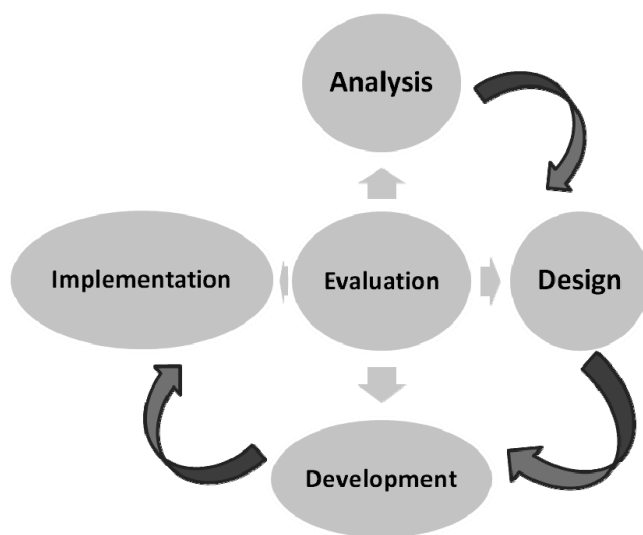


Figure 8- The phases of Instructional System Design

Levels of proficiency

The use of “levels of proficiency” (awareness, operations and expert) is common in education and training courses. Awareness-level proficiency involves having the basic knowledge or understanding of the topics. Operations-level proficiency entails the knowledge, skills, and abilities of a topic to safely perform any tasks involved. Expert-level proficiency is the operations-level, plus the knowledge, skills and abilities to apply expert judgment necessary to solve complex problems (Koeing and Schultz 2010).

Education programs for hospitals

The frequency and scope of training should be sufficient to maintain knowledge levels in the various types of hospital personnel. This can be validated through a competency-based approach that allows healthcare workers to be evaluated during a scheduled drill/exercise (ASTM 2009; Schultz, Koenig et al. 2012). There are some important subjects that need to be addressed in a disaster training program for healthcare systems, including hospitals, such as individual and family preparedness, safety, incident command system, organizational resiliency, surge capacity and capability, and mutual cooperation with external systems (Koeing and Schultz 2010).

The minimum hours of hospital personnel training of emergency operations preparedness may be established by a regulatory or certifying body, but hospital employees are recommended to train two to ten hours per year per employee, based on the employee's function and the hazard vulnerability assessment for his/her department (ASTM 2009). Training adequacy should also be measured by achievement of educational objectives and demonstration of competency in the content (ASTM 2009).

Training program in disaster medicine was considered by current thesis as study I.

1.4.6. Disaster drills and exercises

An exercise is the generic term for a range of activities that test emergency response readiness, evaluate an emergency response plan and assess the success of training and development programs, all of which are for improving a hospital disaster plan (School of Nursing 2006; ASTM 2009; Melissa Cheung 2010). In addition, drills and exercises can identify areas of the plan that have not been addressed, provide experience in the use of the plan, can be used to identify training that is required or has been conducted, evaluate personnel performance, meet requirements for community preparedness and maintain continuous learning on all-hazards preparedness (ASTM 2009).

In general terms of hospital context, a hospital preparedness exercise is the means for a hospital to test and evaluate its capacity and capabilities for preventing, preparing for, protecting from, responding to, and/or recovering from an event that may overwhelm a hospital's patient care or operating systems. Exercises are an essential component of an emergency management program and one of the most effective ways a hospital can test, evaluate and ultimately improve this program (Lynn, Gurr et al. 2006; Melissa Cheung 2010).

There are five basic categories of drills and exercises: orientation exercises, tabletop exercises, drills, functional exercises and full-scale exercises. The first two categories are primarily discussion based, whereas the other three are action oriented (School of Nursing 2006).

- Discussion-based Exercises

- Orientation exercises that familiarize the personnel with the emergency response plan and/or with new or changing information/procedures.
- Tabletop exercises that are used to stimulate in- depth discussions of a simulated situation and make decisions about it. In these exercises, the problem-solving methods will take longer than compared to the actual emergency conditions where the decision making must be faster. Problem solving is the main purpose of this kind of exercises (School of Nursing 2006).

- Operations-based Exercises

- Drills that are used to test personnel training, response time, interagency cooperation and resources, and equipment capabilities.
- Functional exercises that test and evaluate the capabilities of an emergency response system.
- Full-scale exercises that are used to test and evaluate a major portion of the emergency operations plan in an interactive manner over an extended period. These exercises typically involve more than one agency (School of Nursing 2006).

Before developing and conducting an exercise and to maximize the efficacy and efficiency of these exercises some key areas should be considered such as training of personnel, defining clear objectives and providing requirements (Dausey, Buehler et al. 2007; Melissa Cheung 2010).

Participants must be trained in the emergency operations plan and their roles during an emergency situation; an exercise can only effectively test the knowledge of the participants. An exercise should be small-scale which requires less time and resources. It will result in effectively focusing on the deficiencies of previous exercises and improve response practice. Also, the exercise needs clear and SMART (simple, measurable, achievable, realistic and task-oriented) objectives so that they can be specifically tested. Finally, it is important to use exercises that involve the entire community, including the EMS, police, fire and public health departments because very few incidents affect a single entity (Dausey, Buehler et al. 2007; Melissa Cheung 2010).

Generally, developing an exercise consists of five steps (Melissa Cheung 2010): foundation, design and development, conduct, evaluation, and improvement planning.

These phases are meant to be a cycle, with the next exercise based on lessons learned and improvements made from previous exercises. Also, it is necessary that before a hospital can enter the exercise cycle, it must have established an emergency management program (ASTM 2009; Melissa Cheung 2010).

The purpose of the evaluation of an exercise is to assess the performance of participants and the emergency operations plan in order to determine the proficiency with which the

hospital staff was able to carry out the tasks and demonstrate the desired capabilities and competencies, as well as the extent to which objectives were met. Evaluation of exercises is essential for identifying weaknesses and gaps, which is critical in improving and strengthening a health care organization's emergency management program. For each type of exercise the evaluation criteria should be developed by the exercise design and control team (Lynn, Gurr et al. 2006; ASTM 2009).

Performance measures

Performance is a measure of how well an activity is executed and measured in terms of structure, process or outcome (Moore 1999; Sobo, Andriese et al. 2001). Performance measurement analyzes the success of a work group, program or organization's efforts by comparing data on what actually happened to what was planned or intended (Lichiello and Bernard J. Turnock 2011).

Performance measurement is the selection and use of quantitative or qualitative measures of capacities, processes and outcomes to develop information about critical aspects of activities during education and training, exercise and real incidents (Gryth, Radestad et al. 2010; Lichiello and Bernard J. Turnock 2011). Results of management groups' performance such as command, control and coordination activities by the hospital incident command system is one way of testing and evaluating disaster preparedness (Arnold, Paturas et al. 2005; Ruter, Nilsson et al. 2006).

In this thesis decision making performance of the hospital incident command system was measured, during table top exercises, using the job action sheets of the HICS as performance indicators (EMSA 2006).

1.5. PRE-HOSPITAL MEDICAL RESPONSE TO DISASTERS

Community-based planning, including collaboration between hospitals and other organizations, is critical for effective community resilience and response to disasters (Sauer, McCarthy et al. 2009). Experience from major disaster has demonstrated that the greatest success in disaster management and response is achieved through a coordinated effort of multiple types of agencies, e.g. search and rescue, EMS and hospitals (Catlett, Jenkins et al. 2011).

Preparedness planning should concern community disaster planning rather than planning specifically for the preparedness and survival of individual hospitals (Ginter, Duncan et al. 2007). It is essential for emergency medical services (EMS) and hospital disaster plans to be integrated with each other and the community disaster plan (Kaji and Lewis 2006).

A coordinated cooperation between EMS and hospitals affects hospital function and the capacity in managing casualties; the performance of EMS in the correct triage of victims and transportation of mildly injured victims to appropriate alternative care sites helps unburden acute care facilities allowing them to manage greater numbers of higher acuity victims (De Boer 1999; Gautschi, Cadosch et al. 2008; Koeing and Schultz 2010).

The first priority of the pre-hospital medical response to disasters is the rescue and provision of emergency care for victims who have life threatening injuries (Gautschi, Cadosch et al. 2008).

Pre-hospital medical management of disasters is usually a combination of mutual efforts of several medical and logistic organizations such as EMS, Army, Red Cross, etc. Therefore, triage, primary medical care and transportation of casualties are often overlapping missions among EMS and other organizations with or without sufficient experience or overriding control (Koeing and Schultz 2010).

Emergency medical services are vital during all phases of disaster response, with key roles including mass-casualty triage, on scene treatment, communication, evacuation, coordination of patient transport and patient tracking. In some jurisdictions, EMS personnel may also take leadership roles during disaster response and be a part of the command staff or an integral part of regional or national assets (Catlett, Jenkins et al. 2011).

An effective strategy for EMS can be to use Incident Command System to provide on-scene medical services (Koeing and Schultz 2010; Catlett, Jenkins et al. 2011).

Since EMS providers are typically involved in the immediate period following the onset of a disaster, it is well positioned to perform initial and ongoing triage of patients who will need acute medical care (Catlett, Jenkins et al. 2011).

Triage in a disaster management setting starts with a clearly established operational disaster plan that defines the roles and automated algorithms of the multidisciplinary rescue teams and medical squads involved. The medical efforts are largely in vain when conducting triage without a functioning evacuation process. In fact, the establishment of a medical transport corridor is a high-priority task, especially during the first 2–6 hours after the onset of a disaster (Gautschi, Cadosch et al. 2008).

The establishment of a medical transport corridor incorporates the coordination of community transportation systems along highway corridors or other transportation routes working together to create enhanced services for passengers and patients. The subsequent goal of a medical transport corridor is to provide an avenue for the safe and fast transport of patients to a predefined target, e.g. receiving hospitals. Victims with severe trauma only have a chance of survival if treatment in a trauma center is rapidly available (Gautschi, Cadosch et al. 2008).

Specific treatment rendered during and subsequent to the triage process must be goal directed and will depend on the capabilities and capacity of the responding resources. Because the triage process is dynamic, an important function is interval victim reassessment if necessary. Treatment strategies likely to reduce morbidity and mortality among victims staged in the treatment unit include maintaining an airway, needle thoracostomy, controlling haemorrhaging and spinal stabilization (Koeing and Schultz 2010).

In this thesis pre-hospital medical response to the Bam earthquake was evaluated as an important part of a comprehensive integrated medical disaster management system.

1.6. DISASTERS IN IRAN

Iran is a disaster prone and vulnerable country and has a high number of deaths resulting from disasters (Iran 2005). Among the 40 different types of natural disasters, 31 have been identified in Iran. Major disasters include frequent earthquakes, floods and droughts (Iran 2005). Earthquakes have been the main disaster in terms of causing deaths between 1980-2010 (Figure 9) (PreventionWeb 2012).

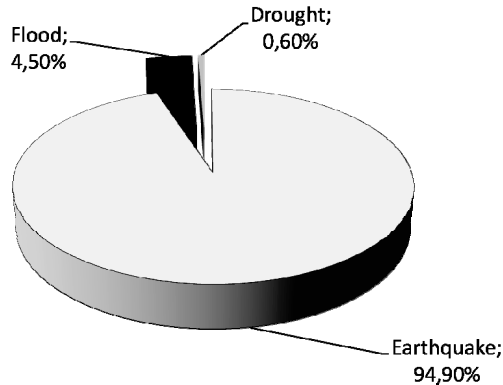


Figure 9- Percentage of reported deaths due to three main disasters (Earthquake, Flood, and Drought) in Iran from 1980 to 2010.

Iran, a middle income country (Bank 2008), also suffers severe economic damage and human impact resulting from natural disasters. Millions of affected people and economic impacts of billions US dollars have been reported between 1900 and 2012. The main disasters during this period have been earthquake, flood and drought (EM-DAT 2012).

Previous disasters in Iran have presented different challenges for the medical response to disasters. Collapsed or damaged hospitals and health care facilities, shortages of resources, absence of a command system and problems with triage, treatment and transportation were some of the challenges. We have chosen the Bam earthquake as a model to analyse and better understand the problem with the medical response to disasters in Iran.

1.6.1. The Bam earthquake

The Bam earthquake was the most severe disaster in Iran in this century. It affected approximately 200,000 people including a 30,000 death toll and 23,000 injured (WHO 2005).

On December 26th 2003, at 5:26 am an earthquake measuring 6.5 on the Richter scale struck the city of Bam and surrounding villages in Kerman province in south-eastern

Iran. The earthquake, with a shallow focal depth (8 km), appears to have had its epicenter very close to Bam city. Most buildings in the affected area were sun-dried brick masonry constructions with extremely poor earthquake resistance. Although the impact of the earthquake was limited to a relatively small area of about 16 km in radius, the 2500 year old city of Bam, an internationally renowned heritage site, was almost completely destroyed. Some key impacts of this earthquake on the health facilities is shown in table 5 (WHO 2005).

Health Facility	Number	% of Damage
Health house	95	100
Rural Health Center	14	100
Urban Health Center	10	100
Health posts	5	100
Maternity facilities	5	100
Emam district hospital (public)	136 beds	50
Mahdieh maternity hospital (public)	54 beds	40
Aflatoonyan hospital (private)	65 beds	100
Emergency station (115)	1	100
Behvarz training center	1	100
District health network expansion center	1	100
District health care management center	1	100
Faculty of nursing and paramedics	(2000 sq.m.)	100
Dormitory of the faculty of nursing	(1500 sq.m.)	100

Table 5- Damage of health care infrastructures due to the Bam earthquake
Source: World Health Organization (WHO 2005)

Local health care facilities were rendered almost completely unusable because of irreparable damage to buildings. Overall, no health care facility was functional, owing to extensive damage and the unavailability of local health workers. Initially, around 50% of the local health care workforce could not be accounted for. None of three hospitals in the affected area were functional; therefore, many hospitals in other areas of the country received, by air, more than 12,000 injured patients as a result of the disaster (WHO 2005).

An immediate response by the Government of Iran and the Iranian Red Crescent Society (IRCS) launched a massive rescue and relief operation. With support from the army, the ministries of Interior and Health and the collaboration of IRCS, a large scale evacuation operation was conducted to move the injured out of the city (WHO 2005).

Disaster Severity Scale of the Bam earthquake

Disaster severity scale (DSS) is a score based mathematical approach that was developed by de Boer, in 1990, to assess and compare disasters with respect to their severity (de Boer 1990; De Boer 1999; Ferro 2005).

The DSS uses seven parameters: (1) the disaster's effect on the infrastructure in the affected area; (2) disasters related to man-made vs. natural hazards; (3) the impact time; (4) the geographical radius of impact; (5) the number of casualties; (6) the average severity of the injuries sustained by living victims; and (7) the rescue time (de Boer 1990; De Boer 1999).

The score varies from 1–13 and is calculated by the attribution of a score (0, 1, or 2) to each grade of the included classification. The sum of these scores is the DSS score, an estimation of the severity, duration, scale, and magnitude of the disaster. The higher score, the greater severity of the disaster (de Boer 1990; De Boer 1999; Ferro 2005).

Disaster Severity Scale of the Bam earthquake can be calculated based on the defined parameters (de Boer 1990; De Boer 1999). The Bam earthquake scored the highest possible score according to the DSS, which is shown in table 6.

No	Parameter	Definition and Score	Bam earthquake
1	The effect on the surrounding community	Simple (1): The integrity of surrounding community is intact; Compound (2): The involvement of national and international organizations is required.	2
2	Origin of the disaster	Man-made (0) Natural (1)	1
3	The duration of cause	Short (0): Less than 1 hour Relatively long (1): Between 1-24 hours Long (2): More than 24 hours	2
4	The radius of the disaster area	Small (0): Less than 1 km Relatively large (1): Between 1-10 km Large (2): More than 10 km	2
5	The number of casualties dead and wounded requiring medical treatment	Minor (0): 25-100 casualties Moderate (1): 100-1000 casualties Major (2): More than 1000 casualties	2
	The average severity of injuries	$(T1 + T2) < T3$ (0) $(T1 + T2) = T3$ (1)	2

		(T1 + T2) > T3 (2) T1: Severe injury (Red); T2: Moderate injury (Yellow); T3: Light/ Mild injury (Green). T1 and T2 need hospitalization.	
	Medical rescue time (rescue, treatment, transportation)	< 6 hours (0) 6-24 hours (1) > 24 hours (2)	2
Total		Range of scores: 1-13	13

Table 6- The Bam earthquake as stratified in accordance with the Disaster Severity Scale

In spite of an unprecedented medical response, the search and rescue teams, the emergency medical teams and other concerned health and medical teams showed that further planning, training and exercises were necessary to respond to disasters (WHO 2005).

1.6.2. Improvement of medical disaster management in Iran

In 2003, a few months before the Bam earthquake, the first national disaster management plan was approved by the government. It was composed of three main sections: prevention and risk management, education and operation. Health and medical function was classified as a workgroup of the operation section.

After the Bam earthquake, there was still a remaining lack of key elements of the medical disaster management system, such as a comprehensive hospital disaster plan, a pre-hospital disaster plan, structured training programs for medical personnel and a standardized system for command and control during response phase.

In 2007, the Iranian Ministry Health recommended all hospitals to establish the HICS. However, there was at the time, no evaluation regarding the readiness capability of hospitals, educational based capacity increase in risk reduction and standardized guidelines regarding a hospital disaster management plan.

1.7. DISASTER MANAGEMENT IN SWEDEN

Sweden is a high income country (Bank 2008) with a low human impact of disasters (EM-DAT 2012). The annual average impact of disasters in Sweden has been one death, eleven people affected by disasters, and an estimated cost of 95 million dollars, within 1980-2010 (PreventionWeb 2012). Storm, flood and epidemics are the reasons for disasters in Sweden (EM-DAT 2012). The most severe recent disaster in Sweden was a storm in 2005 that killed seven people and resulted in a cost of 2.8 billion US dollars (PreventionWeb 2012).

In Sweden there is a National Platform for Disaster Risk Reduction, in which 18 authorities and organisations cooperate; the purpose of which is to increase societal capabilities for preventing and dealing with the negative consequences of natural events, known in everyday speech as natural disasters (MSB 2011).

The National Platform for Disaster Risk Reduction was established in 2007 by the government, with the Swedish Civil Contingencies Agency (MSB) responsible for the collaboration with other competent authorities and organisations for the running of a national platform for natural disasters (MSB 2011).

Sweden's national platform consists of a steering committee from the authorities and organisations, which is responsible for the overall direction of the work; an authority network made up of the contributing authorities and organisations, which carries out the day-to-day platform work; a secretariat at the MSB, which is responsible for the coordination, communication and administration of platform work; working groups on limited specific tasks; and reference groups when there is a specific need (MSB 2011).

In Sweden, similar to other Scandinavian countries, the organisation of disaster preparedness is a shared responsibility for all of the emergency services (police, fire and rescue, health care) to plan and prepare for disasters. The Military plays only a small role in disaster response but can sometimes be used for support, especially in natural disasters. The health disaster management system, including hospitals, is organised on a regional level (Ortenwall 2005).

1.8. SOCIOECONOMIC FACTORS AND DISASTER MANAGEMENT

The socioeconomic situation of a community is correlated with the vulnerability of its inhabitants and their medical requirements in the event of a disaster (Stephenson and DuFrane 2002; Brouwer, Akter et al. 2007; Milch K, Gorokhovich Y et al. 2010). In fact, high income countries do not experience fewer disasters than low income countries. However, in the face of an equal quantity and quality of disaster, richer nations suffer fewer deaths from natural disasters (Kahn 2003).

Although the cause and effect relationship between disasters and social and economic development has been ignored (Stephenson and DuFrane 2002), the development, disasters and vulnerability of the countries can be correlated (Stephenson and DuFrane 2002). Addressing the Hyogo framework (Nation 2005), the evaluation and comparison of the countries with respect to disaster epidemiology, vulnerability condition, disaster management elements and socioeconomic factors may enhance disaster preparedness condition in low, middle and high income countries.

In the field of medical disaster management, some of the socioeconomic factors such as funding, legal strategies, standards and rules for the health care are correlated to hospital disaster planning and preparedness to response (Barbera, Yeatts et al. 2009; Sauer, McCarthy et al. 2009). As a result, socioeconomic factors might be the crucial determinant for hospital preparedness against disasters in a community.

2. OBJECTIVES

The main objective of this thesis was to systematically analyze the level of preparedness and safety of hospitals with respect to medical response to disasters.

Each study had a specific objective, as follows:

Study I

- To enhance the knowledge of the personnel of the Medical Sciences Universities of Iran with respect to medical disaster planning
- Capacity building at the Medical Sciences Universities of Iran with respect to medical disaster planning

Study II

- To explore the pre-hospital medical response to a disaster in Iran

Study III

- To measure the decision making performance of the Hospital Incident Command System in Iran

Study IV

- To compare the relationship of the hospital preparedness and socioeconomic levels between a middle with a high income country

3. MATERIALS AND METHODS

The thesis is based on four studies. The first study was an educational based capacity building study conducted in Iran, nationwide. The second study utilized a qualitative method to evaluate pre-hospital medical response to one of the world's most destructive earthquakes in the last decade, the Bam earthquake. Study III and IV evaluated the preparedness and response phases of a comprehensive hospital disaster plan. The third study measured the performance of hospital response to simulated disasters. In fourth study an internationally standardized evaluation tool was used to compare two different countries with respect to hospital preparedness.

3.1. STUDY SETTING

The main part of this thesis was conducted in Iran; however study IV was done both in Iran and Sweden.

Iran is the fourth largest country in Asia with a population approximately 75 million in 2009 (WHO 2011). It consists of 31 provinces (Figure 10). Iran is a middle income country and the second largest economy in the Middle East and North Africa in terms of Gross Domestic Product (GDP) (Bank 2008).

Iran is a disaster prone country. Drought is the most extensive disaster but earthquakes are the most destructive with respect to both the number of deaths and economic damage (Iran 2005; PreventionWeb 2011).



Figure 10- Map of Iran

Sweden is a Nordic country on the Scandinavian Peninsula in Northern Europe. It is the third largest country in the European Union by area, with a total population of about 9.4 million in 2009. Sweden consists of 25 provinces (Figure 11). It is a high income country and ranks as the 21st country in the world in terms of GDP.

Sweden is not a disaster prone country. There have been 9 disasters in this country in 1980-2010, and 22 people were killed as a consequence of these disasters. Storm is the most common, also most important disaster with respect to economic damage, but flood is the most serious with respect to the number of deaths.



Figure 11- Map of Sweden

3.1.1. The disaster management collaborating centers in Iran

There are currently 46 University of Medical Sciences in Iran. Each university is responsible for providing and monitoring health services in its given area, including medical preparedness and response to disasters by hospitals and emergency medical services.

The universities are grouped in 9 disaster management collaborating centers which are responsible to plan and make policy in the given region, for health and medical disaster management.

The collaborating centers follow national policies and plans that are developed and ordered by Iran's Ministry of Health and Medical Education which is the organization responsible for health and medical issues in accordance with the National Disaster Management Act. The structure of Iran's medical disaster management system is shown in figure 12.

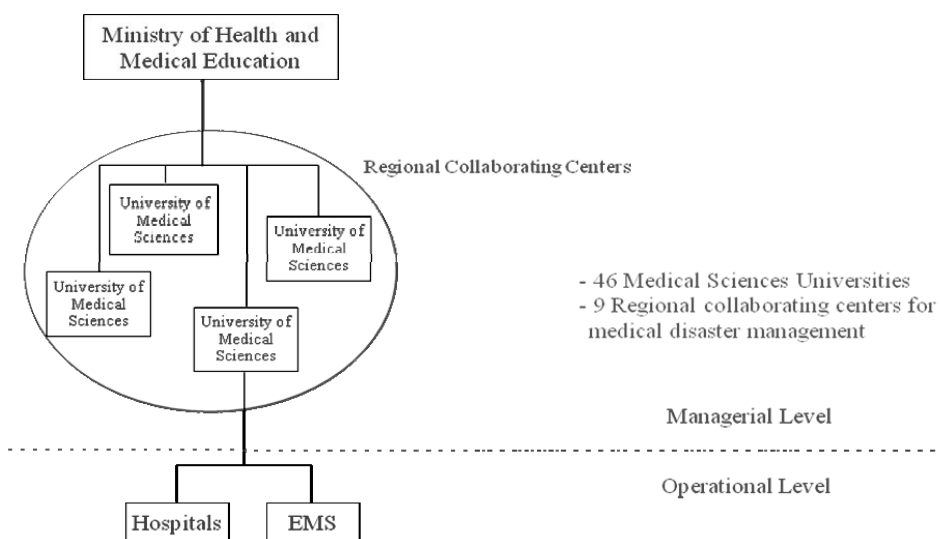


Figure 12- Iran's Medical Disaster Management System

3.2. OVERVIEW OF THE STUDIES

This thesis is composed of four studies. The concept of hospital preparedness was evaluated from different aspects by conducting these studies (Figure 13):

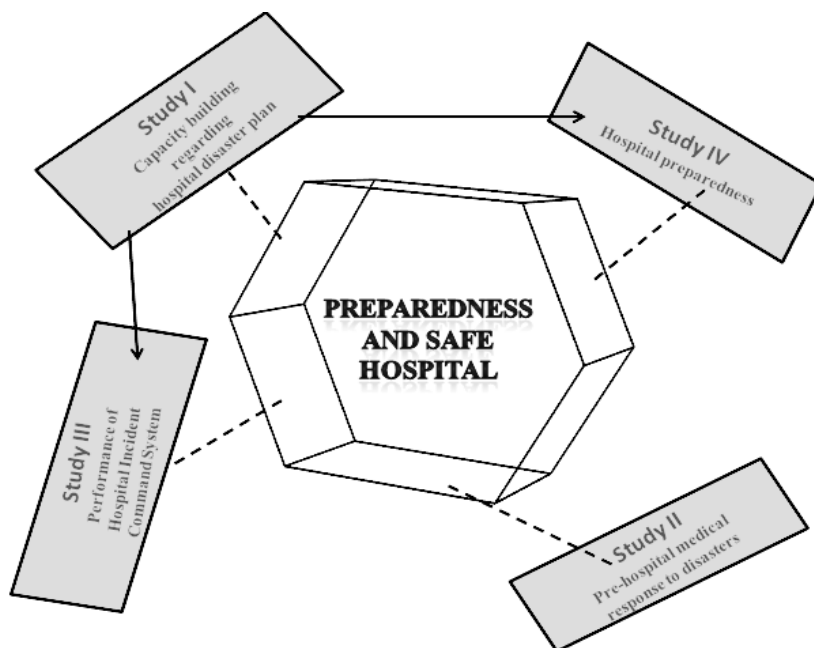


Figure 13- An overview of the connection between the study I-IV

The studies were conducted from November 2007 to November 2011. Different methods were used for study design and data collection of each individual study. An overview of the research questions, study design and source of data is shown in figure 14.

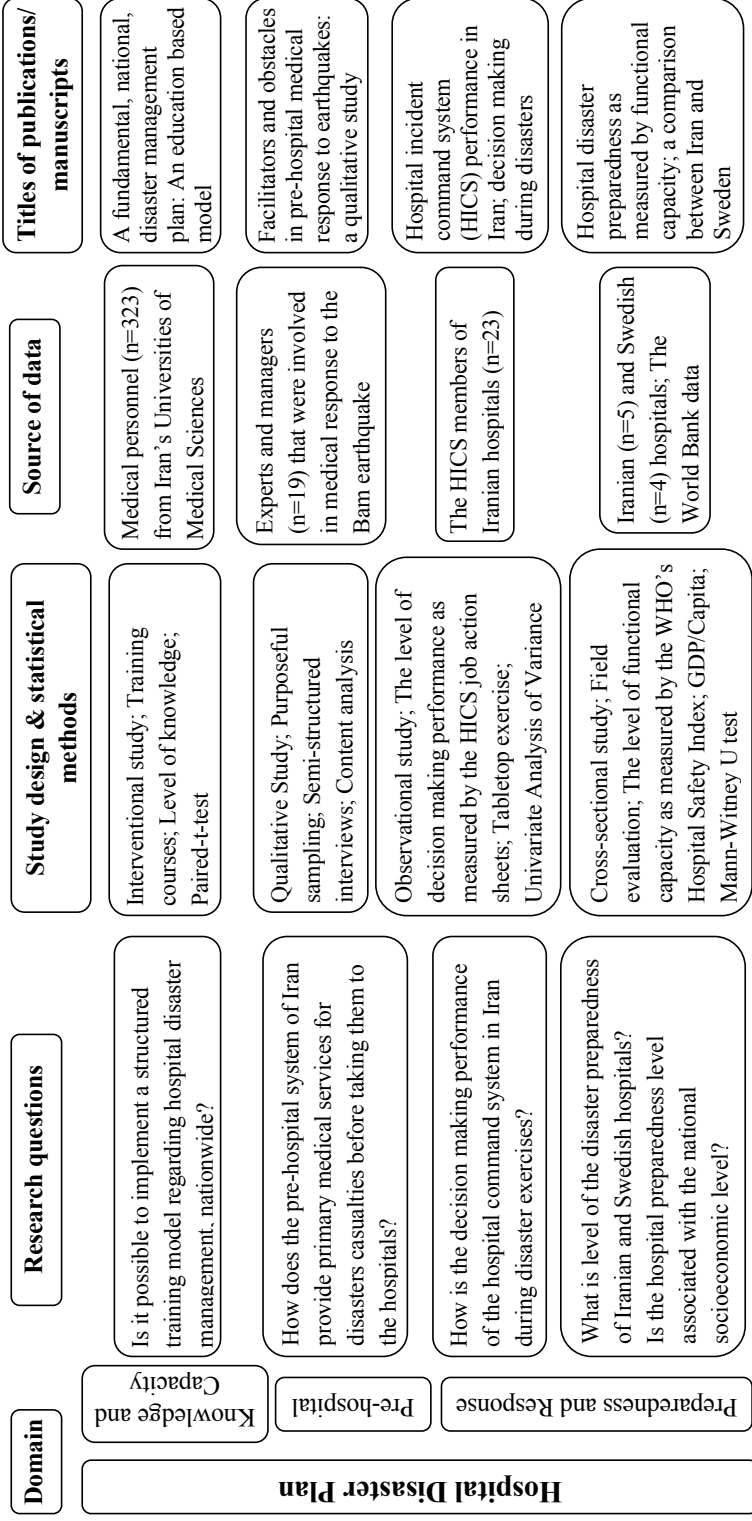


Figure 14- An overview of research questions, study design and source of data

3.3. MATERIALS AND METHODS OF STUDY I-IV

3.3.1. Study I

A fundamental, national, disaster management plan: An education based model

Study I was conducted at the Universities of Medical Sciences in Iran as the first step in a comprehensive evaluation of hospital disaster management conditions.

To follow a structured approach, the Instructional System Design (ISD) model (Koeing and Schultz 2010) was considered, including the following steps:

- Analysis of training needs and identification of requirements for the target group
- Design of the education and training program and schedule
- Development of content and instructional resources
- Implementation of the education and training program
- Evaluation and improvement activities

We found an absence of disaster management training courses for hospitals and emergency medical services in Iran. Then, the Secretariat of Health for Risk Management in Disasters formed a national group consisting of medical disaster planning experts. This group, including the current study researcher, designed a training program to address medical disaster management subjects for all Medical Sciences Universities.

A qualified training team, including the current study researcher, was designated to develop the syllabus and learning objectives, and then introduce this program into each collaborating center. The course content was approved by the national group, including important concepts, e.g. risk management, disaster planning, incident command system, hazardous materials, etc. The courses included classroom lectures, group work activities, and a tabletop exercise.

The courses were scheduled for three days and conducted by the researcher and two other lecturers in the collaborating centers with the participation of five to seven experts from each University of Medical Sciences.

A questionnaire was developed to evaluate the efficacy of this educational intervention. Its validity was measured by a group of experts and the reliability was confirmed by Cronbach's Alpha test using a half-split method. Pre- and post- tests were conducted for each course and the students' t-tests were used to compare their scores.

3.3.2. Study II

Facilitators and obstacles in pre-hospital medical response to earthquakes: a qualitative study

Study II was an interview-based qualitative study. Content analysis was used for the subjective interpretation of the interviews' content. Content analysis is a method of analyzing written, verbal or visual communication messages. It is a research method of making replicable and valid inferences from data to their context, with the purpose of providing knowledge, new insights, a representation of facts and a practical guide to action. There are two methods of content analysis (Elo and Kyngas 2008):

1. Inductive method: It consists of open coding, creating categories and abstraction of data, from which themes and categories emerge.
2. Deductive method: This method is often used when the researcher wishes to retest existing data and categories in the new context (Elo and Kyngas 2008).

Deductive content analysis was chosen in this study since the category of pre-hospital medical response to disasters was already defined as triage, emergency care and transport to medical centers.

The current study aimed to explore and retest the process of the medical response to disasters in Iran with respect to the Bam earthquake.

Nineteen interviews were conducted. The participants were experts and managers of Iran's emergency and disaster medical system and were involved in the medical response to the Bam earthquake.

Purposeful sampling was used to select participants who were included until saturation of each concept was reached and further data collection failed to contribute additional information. Sample size was given by data saturation.

An interview guide was used. Each interview started with general questions regarding the medical management of the Bam earthquake, and then continued with specific questions regarding different aspects of the pre-hospital response.

The interviews and their content were conducted in Persian, transcribed verbatim and then translated into English. The transcribed data was read several times and primary codes were extracted, compared for similarities and differences and then categorized. The categories were extracted from review literature with respect to the pre-hospital medical response to disasters. The transcripts and primary results were checked by the participants. The same investigators conducted all interviews and data analysis.

Data validation and reliability were considered by different methods such as in-depth prolonged engagement with the data and the availability of transcribed data and notes from the analysis process.

Ethical permission of the study was obtained from the Natural Disaster Research Institute in Iran. Before including the participants in the study, informed consent was obtained and all participants were informed that they could withdraw their participation at any time.

3.3.3. Study III

Hospital Incident Command System (HICS) performance in Iran; decision making during disasters

This observational study was conducted in twenty-three Iranian hospitals, both non-university and university hospitals, that had implemented the Hospital Incident Command System and were able to conduct a tabletop exercise.

Affiliation, size, use of an HICS advanced training course, the presence of a hospital command centre and a hospital disaster plan were assessed for each participating hospital.

A tabletop exercise was developed for each hospital, and the chosen disaster scenario was based on the most likely hazard for each given hospital. The exercises took place in a large area, each group, reflecting a HICS section, worked separately at different tables and could communicate between and within groups.

The expected activities and the participants' roles were explained by the facilitator. Each of the participants was assigned a role that was based on his or her position in the HICS and the duties which were planned for in a real disaster. Each scenario took place in a given time interval.

All positions of the HICS were assessed in accordance with the HICS template (EMSA 2006) including the five main sections (command, operations, planning, logistics and finance/administration) using job action sheets, during both the exercise and the evaluation process (EMSA 2006).

The participants were asked to document all decisions made during the exercise.

The scoring of the HICS job action sheets, as well as the performance indicators for decision making, was done by three evaluators who were medical doctors with experience of working in the field of HICS and HDP. The tentative scoring of the HICS performance was completed in consensus after a team discussion for each exercise. I suggest separating the evaluators and how the scenario was scored.

The evaluators compared the compatibility of the participants' documented decisions with the content according to the job action sheets as a measure of the decision making performance. Based on the compatibility of the participants' decisions with the relevant job action sheet, the performance for each HICS position was scored as 1, 2 or 3,

leading to the maximum total score of 192. The total HICS score was a sum of the five main sections scores.

The total HICS score was divided into three categories: Fair (1-76), Intermediate (77-134) and High (135-192). These cut-off values are based on expert consensus.

The t-test and Univariate Analysis of Variance were used to compare scores between hospitals. A p-value of less than 0.05, two tailed, was considered to be significant.

3.3.4. Study IV

Hospital disaster preparedness as measured by functional capacity, a comparison between Iran and Sweden

This cross-sectional study was conducted in Iran and Sweden. The selection of hospitals represents a convenience sample.

Background variables including affiliation, size and the most common hazards were measured for each participating hospital. The gross domestic product (GDP) per capita and life expectancy were also used as proxies for the socioeconomic standard of each country.

The state of preparedness, was evaluated and calculated as measured by using the Functional Capacity module of the Hospital Safety Index , HSI, from the World Health Organization (Pan American Health Organization/WHO).

The functional capacity consists of five sub-modules according to the HSI, as follows:

- 1- Organization of the Hospital Disaster Committee and the Emergency Operations Center,
- 2- Operational plan for internal or/and external disasters,
- 3- Contingency plans for medical treatment in disasters,
- 4- Plans for the operation, preventive maintenance and restoration of critical services,
- 5- Availability of medicines, supplies, instruments and other equipment for use in an emergency.

A coordination board was established in Iran and Sweden, separately, to arrange the evaluation process of the participating hospitals. The assessment was conducted by a group of three evaluators in Iran and five evaluators in Sweden. The team coordinator was the same in both countries.

The level and value of each variable was determined by the evaluators in consensus. Scoring was performed in accordance with the template (WHO 2008). All five sub-modules, as described above, 1-5, have equal weighting with a maximum score of 0.2 for each sub-module. Hence, the maximum sum of the five sub-modules was 1 (100%).

The functional capacity was categorized, according to the HSI evaluation guideline as descending levels: A (0.66-1), B (0.36-0.65) or C (0-0.35), which relate to safe, at risk or inadequate, respectively.

A Mann-Witney U test was used to compare means of the functional capacity score between hospitals with respect to their country, affiliation and size.

As part of the evaluation group's responsibilities, the preparedness condition, comments and recommendations were suggested to the coordination board and the hospital authorities.

The hospital's names and places were not disclosed in accordance with the recommendation by WHO (WHO 2008).

4. RESULTS

4.1. STUDY I

A training course was conducted in each disaster management collaborating center. There were 30–35 people participating in each course and 323 participants in total. The mean score on the pre-test was 67.1 ± 11.6 , while the mean score for the post-test was 88.1 ± 6.2 . The maximum score was 100. A comparison of average scores of the pre- and post-test for participants using the Student's t-test, demonstrated that the courses had a significant effect on improving the knowledge of the participants ($p < 0.0001$).

4.2. STUDY II

Nineteen experts and managers participated in this study. They were working in the field of medical science, emergency medicine or health management.

The pre-hospital medical services were divided into three categories: triage, treatment and transportation. Facilitators and obstacles were identified for each category.

• Obstacles and facilitators of Triage

The most important factor which affected the performance and workload of the medical services was the absence of triage. The absence of both a standardized disaster management plan and disaster medical teams together with a lack of resources were the obstacles to triage.

At the airport, groups of medical personnel from the army or the Universities of Medical Sciences were the main facilitators of triage.

• Obstacles and facilitators of Treatment

Emergency medical care was missed at the scene and the casualties were transferred to other cities without receiving initial medical attention. The absence of both a disaster management plan and organized disaster medical teams, along with a shortage of resources were the main obstacles to emergency treatment.

Experienced and trained medical personnel from the army, the Red Crescent and the Universities of Medical Sciences were the facilitators of the emergency medical care.

Obstacles and facilitators of Transportation

The transportation of casualties to medical centers is an essential function in disaster response.

No coordinated transportation plan at any level, a shortage of trained medical personnel and transportation vehicles, and no standard protocols for evacuation were the obstacles to the transportation function.

The air evacuation of thousands of victims from Bam to other cities by the air force was the main facilitator of transportation function.

In summary, the absence of a disaster management plan was the core obstacle that affected the entire process of the pre-hospital medical response to the Bam earthquake (Figure 15).

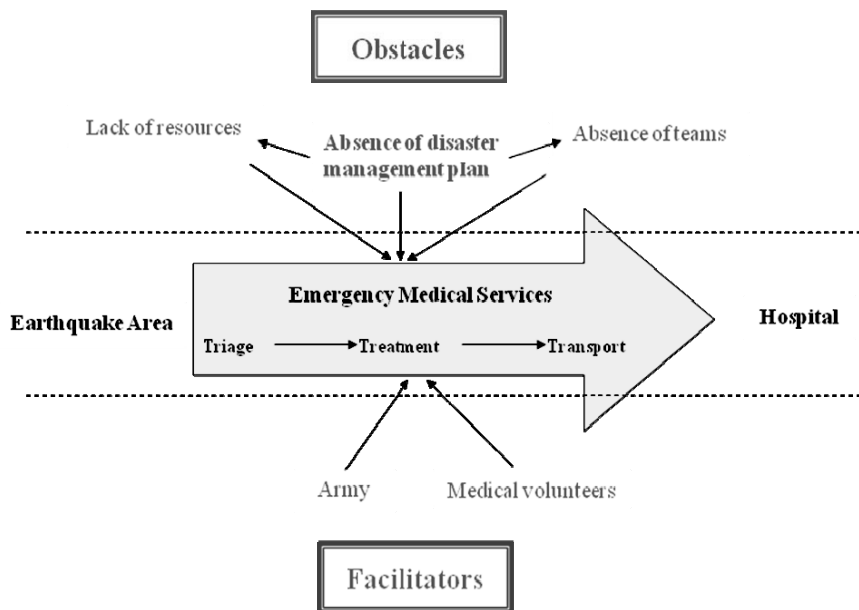


Figure 15- Obstacles and facilitators of the pre-hospital medical response to the Bam earthquake

4.3. STUDY III

Twenty three hospitals were included, 14 public and 9 university hospitals, none of which had a hospital disaster plan; only two hospitals had a designated Hospital Command Centre.

The exercises included one of the following hazards: earthquake (n=15), accident with hazardous materials (n=5) or fire (n=3).

The lowest total HICS score was 56 and the highest was 119, with a mean of 85 (± 15 SD) (Table 7). The score of each section was also included in table 7.

Sections of HICS	Mean \pm SD (Range)
Command	5.2 \pm 1.7 (3-9)
Operations	43.1 \pm 7.8 (26-58)
Planning	8.6 \pm 2.9 (5-17)
Logistics	19.1 \pm 3.7 (12-26)
Financial/Administration	9.0 \pm 1.8 (6-13)
Total HICS	85.0 \pm 15.6 (56-119)

Table 7- HICS scores presented for each section of the 23 participating hospitals.

The HICS performance was intermediate for 19 hospitals (83%); no hospital had a high level of performance.

The performance level of the different individual HICS sections was fair to intermediate, except for the logistics and finance/administration sections which had a high level of performance in three and five hospitals, respectively.

The HICS and its main sections in the non-university hospitals had a higher performance than the university hospitals ($P < 0.05$).

There was no significant difference between hospitals' HICS performance with respect to either using an advanced training course or their size ($P > 0.05$).

Non-university affiliation was the only independent predictor of the HICS performance ($P = 0.04$) in a regression model including medium size, public affiliation, advanced course and earthquake scenario.

4.4. STUDY IV

The most common hazards, which also portray the highest risk for Iranian hospitals, were earthquake, failure of infrastructure and epidemics. For the Swedish hospitals these were chemical accidents, epidemics and terrorism. GDP per capita was 4,678 US\$ and 52,731 US\$ in Iran and Sweden, respectively.

Five hospitals from Iran and four from Sweden were included in this study. The highest functional capacity score was 81% and the lowest was 75% in the Swedish hospitals. The highest functional capacity score was 53% and 40%, of 100%, was the lowest for the Iranian hospitals (Table 8).

Swedish hospitals had the lowest score in sub-modules related to contingency plans and availability of resources, while the lowest score for the Iranian hospitals was in the sub-module of contingency plans (Table 8).

Functional capacity Score	Hospitals									p-value (2-tailed)
	Sweden				Iran					
	1	2	3	4	1	2	3	4	5	
Sub-module 1	0.190	0.190	0.190	0.200	0.128	0.110	0.090	0.082	0.082	0.016
Sub-module 2	0.158	0.162	0.154	0.142	0.092	0.080	0.088	0.066	0.080	
Sub-module 3	0.134	0.134	0.116	0.102	0.086	0.050	0.050	0.050	0.038	
Sub-module 4	0.200	0.176	0.176	0.200	0.138	0.138	0.112	0.112	0.112	
Sub-module 5	0.130	0.120	0.120	0.110	0.090	0.080	0.100	0.100	0.090	
Total Score	0.812	0.782	0.756	0.754	0.534	0.458	0.440	0.410	0.402	
Mean ± SD	0.77 ± 0.03				0.45 ± 0.05					

Table 8- Hospitals safety index of hospitals, as measured by functional capacity.

Sub-module 1: Organization of the Hospital Disaster Committee and the Emergency Operations Centre

Sub-module 2: Operational plan for internal or/and external disasters

Sub-module 3: Contingency plans for medical treatment in disasters

Sub-module 4: Plans for the operation, preventive maintenance, and restoration of critical service

Sub-module 5: Availability of medicines, supplies, instruments, and other equipment for use in emergency

The highest value for each sub-module is 0.200

The mean functional capacity score was 0.77 ± 0.03 SD for the Swedish hospitals and 0.45 ± 0.05 SD for the Iranian hospitals ($p=0.016$).

There was no significant difference between hospitals' functional capacity with respect to either their affiliation or size ($P>0.05$).

All Swedish hospitals qualified as level A and all Iranian hospitals were level B, no hospitals in either country were at level C (Figure 16).

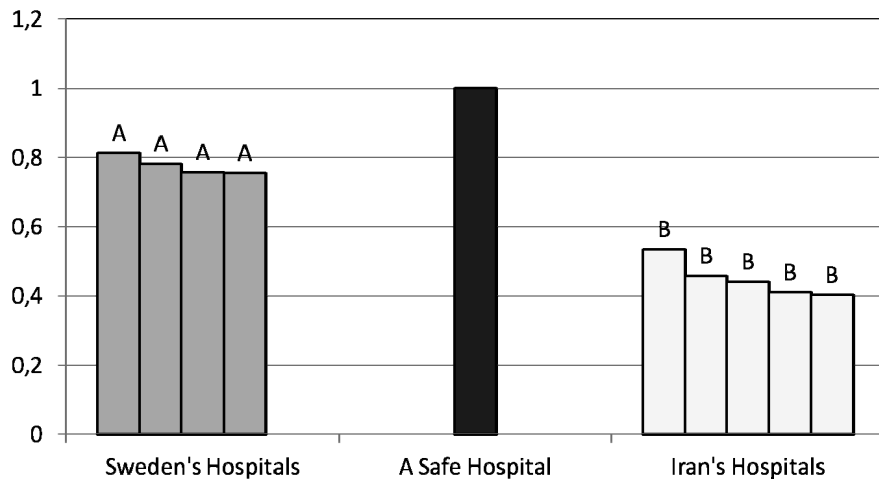


Figure 16- The functional capacity level of Swedish and Iranian hospitals compared to a safe hospital, as suggested by the hospital safety index (PAHO/WHO)

5. DISCUSSION

The main objective of this thesis was to systematically analyze the level of preparedness and safety of hospitals with respect to medical response to disasters. This thesis showed that the preparedness level of the medical system of Iran is at best at an intermediate level with respect to response to disasters.

5.1. TRAINING PROGRAM IN DISASTER MEDICINE

Training programs are an element of hospital preparedness. This study showed that there is an absence of a standardized training program and lack of disaster medicine knowledge for medical personnel and hospital workers. This is also confirmed by previous studies that the training for hospital-based employees is insufficient or unavailable (Hsu, Jenckes et al. 2004; Collander, Green et al. 2008; Bistaraki, Waddington et al. 2011; Stander, Wallis et al. 2011). However, our results show that it is possible to conduct a standardized nationwide training program to enhance the knowledge of a considerable number of medical personnel regarding hospital preparedness and disaster management issues in a short period of time. The effectiveness of disaster management training courses for medical personnel has also been demonstrated in other studies (Hsu, Jenckes et al. 2004; Pryor, Heck et al. 2006; Hoepfner, Olson et al. 2010; Bistaraki, Waddington et al. 2011). However, the available evidence is insufficient to determine whether a given training intervention in disaster preparedness for health care providers is effective in improving the knowledge and skills in disaster response (Williams, Nocera et al. 2008). That there is no defined optimal strategy for the design and quality control of educational programs could be a reason for ineffectiveness (Collander, Green et al. 2008; Williams, Nocera et al. 2008).

This study was the first step in developing and conducting a structured nationwide training course on the subject of disaster medicine for Iran's medical system. Using the current results, the next steps should focus on developing a consensus-based standardized all-hazard disaster core curriculum for medical personnel and also to follow with more precise methods in design, conduct and evaluation of the training courses (Subbarao, Lyszicki et al. 2008; Schultz, Koenig et al. 2012). This may improve disaster preparedness conditions in Iran's hospitals.

5.2. PRE-HOSPITAL MEDICAL RESPONSE TO DISASTERS

Our results showed that the performance of the pre-hospital medical system in response to the Bam earthquake was not standardized and that there was a lack of essential resources and procedures with respect to triage, basic medical care and transportation. Untriaged casualties, without receiving basic medical treatment and after long delay, were transferred to hospitals that were mostly outside of the Bam area. Transportation was not medically standardized and there was no system for coordination and communication between the pre-hospital system and receiving hospitals.

Our results are consistent with other studies of the Bam earthquake (Mirhashemi, Ghanjal et al. 2007; Saghafinia, Araghizade et al. 2007; Motamedi, Saghafinia et al. 2009; Khankeh, Khorasani-Zavareh et al. 2011) and from similar disasters in other parts of the world (Chan, Alagappan et al. 2006; Schwartz, Goldberg et al. 2006; de Ville de Goyet 2007; Gautschi, Cadosch et al. 2008), however our study has evaluated the function of entire chain of pre-hospital medical response to a disaster, also has explored the barriers and facilitators of this chain of functions.

Due to the extensive human impact and the sudden-onset of disasters, there will always be challenges to provide rapid and sufficient pre-hospital medical service to the casualties. The lack of the three main functions in pre-hospital medical services, i.e., triage, treatment and transport, may result in both increased mortality and morbidity at the scene, as does the low efficacy of hospital response to the disaster. Low efficacy of hospital functions can be a result of imbalance between hospital resources and the number or types of casualties.

Comprehensive preparedness of the medical system including EMS is a necessity with respect to natural disasters and their high frequency and severity in Iran. An integrated disaster management plan, mutual support and the use of a coordination system between hospital and pre-hospital services is a requirement for an effective medical response to disasters. The EMS and other pre-hospital medical services must have an integrated disaster management plan.

5.2.1. Absence of a disaster management plan

The current study showed that the absence of a disaster management plan was the main barrier to an efficient pre-hospital medical response to the Bam earthquake. The absence of a standardized plan was mentioned as the main reason for the lack of triage, basic treatment and medical transport to the hospitals.

Our finding is consistent with previous studies of other disasters. The lack of a disaster plan has been reported after the Asian tsunami in 2004, the Pakistan earthquake in 2005 and the Gujarat earthquake in 2001 (Roy, Shah et al. 2002; Schwartz, Goldberg et al. 2006; de Ville de Goyet 2007; Rajkumar, Mohan et al. 2011). Another study in European countries explains the lack of a disaster plan in response to the large number of affected people during the Asia tsunami (Deebaj, Castren et al. 2011).

A comprehensive disaster management plan is the basis of preparedness for an effective medical response to disasters. Our study analyzed this subject through a qualitative research method. It explores an important failure in medical disaster management system of Iran, also emphasizes on a worldwide problem with respect to medical response to disasters. Iran's medical system should develop an integrated comprehensive disaster management plan for both hospitals and pre-hospital services. It will result in providing medical services to necessary casualties.

A literature review has shown that preparedness of the medical system, at disaster scenes, significantly reduces the number of patients requiring transport to hospitals (Soomaroo and Murray 2012) and therefore reduces false workloads at the hospitals.

5.2.2. Lack of required medical resources

The availability of necessary medical resources, with respect to type and amount, is a key subject of all parts of a disaster management system including response, logistics, planning and the financial sections of a disaster response system (FEMA 2012). Our study showed that there is a lack of essential medical resources in the medical response system of Iran. This is confirmed by other researchers in Iran (Motamedi, Saghafinia et al. 2009; Khankeh, Khorasani-Zavareh et al. 2011). Following the Tsunami, there was a severe shortage of evacuation vehicles, therefore, there were problems with the transportation of the victims to hospitals. (Schwartz, Goldberg et al. 2006); there was also a lack of medical supplies (Zoraster 2006). During the Pakistan earthquake (2005) there was a lack of equipment and supplies (Yasin, Malik et al. 2009), as in the Chi Chi earthquake in Taiwan and the Haiti earthquake (Chan, Alagappan et al. 2006; Missair, Gebhard et al. 2010). In contrary, an excess of resources has also been reported as a challenge in response to a mass casualty incident in Norway (Romundstad, Sundnes et al. 2004).

The availability of sufficient and appropriate resources is a criterion of good disaster management (Peltz, Ashkenazi et al. 2006). A lack of medical resources is one of the problems during the first days of a disaster. As well as logistic problems, the absence of a coordination system is a reason for this condition (Chan, Alagappan et al. 2006; Khankeh, Khorasani-Zavareh et al. 2011). For disaster planning, it is critical that Iran's medical system takes into account the entire aspect of resource management, including a coordination system between pre-hospital services, hospitals and logistics centers, and providing enough medical resources for the pre-hospital medical services at the disaster scene.

5.2.3. Lack of disaster medical teams

Disaster medical assistance teams (DMATs) are defined as "mobile, trained medical teams that can be rapidly deployed during the acute phase of a disaster, provide medical treatment and relief activities and assist in the transfer of casualties from disaster-affected areas to appropriate medical facilities" (Kondo, Koido et al. 2009).

Our study showed that there was no standardized disaster medical assistance team to respond to the Bam earthquake in Iran. The lack of structured medical teams in disasters has been reported from other disasters (Liang, Shih et al. 2001; Kondo, Koido et al. 2009; Missair, Gebhard et al. 2010). The absence of medical teams affects triage, treatment and transportation of disaster casualties. The role of standardized medical teams is critical when the local medical system is completely destroyed (Missair, Gebhard et al. 2010), as seen in the Bam earthquake.

Understanding the importance and advantages of structured medical teams from previous disasters resulted in the development of disaster medical assistance teams, first in the United States in 1985, then in other countries (Lee, Low et al. 2005; Kwak, Shin et al. 2006; Mace, Jones et al. 2007; Kondo, Koido et al. 2009; Fuse and Yokota 2010; Grindlay, Young et al. 2010). It is of great importance to establish DMATs in Iran. The number, location and purpose of these teams should be based on local disaster management plans, including relevant disaster plans of hospitals.

5.2.4. Medical volunteers

Our results showed that, except for the first hours after the earthquake, there was an excess of medical personnel both as organized groups from the medical system and individual volunteers. Their participation was a facilitator of the on-scene medical system to provide various medical services, such as triage.

Our results are consistent with other studies regarding the medical response to the Bam earthquake (Akbari, Farshad et al. 2004; Nia, Nafissi et al. 2008; Motamedi, Saghafeinia et al. 2009). Also, during the Gujarat earthquake (India), the Kashmir earthquake (Pakistan) and the tsunami in Thailand, large numbers of medical personnel from both the host area and abroad came to the disaster area to handle the medical needs of the victims (Roy, Shah et al. 2002; Schwartz, Goldberg et al. 2006; Yasin, Malik et al. 2009).

Volunteers play a crucial role in mass-casualty incidents (Peltz, Ashkenazi et al. 2006). Using different kinds of volunteers like medical students, medical reserves and allied health practitioners who are trained and skilled in medical care can make a large difference in improving the utilization of human resources at an emergency site and thereby potentially improve treatment outcomes (Baldwin and Wilson 2008; Frasca 2010; Sapp, Brice et al. 2010). There is an uncountable number of volunteers in Iran, organizing them is not possible during the response phase of a disaster, however it should be considered during the preparedness phase.

5.2.5. Military services

The constructive role of the military system in the medical response to disasters has previously been reported (Abolghasemi, Poorheidari et al. 2005; Bricknell and MacCormack 2005; Zoraster 2006; Amundson, Lane et al. 2008; Stuart and Johnson 2011).

The current study illustrated the broad role of military teams, especially when participating in the airlifting of casualties and the provision of necessary resources. They also established field hospitals, transported medical and health care personnel to the disaster area and provided medical service to casualties. These results are supported by other studies demonstrating the role of the military during the early phase of response (Abolghasemi, Poorheidari et al. 2005; de Ville de Goyet 2007; Nia, Nafissi et al. 2008; Motamedi, Saghafinia et al. 2009).

Similar experiences are reported in other disasters, e.g. the Haiti earthquake (Stuart and Johnson 2011), hurricane Katrina in the USA (Lezama, Riddles et al. 2011), the Tsunami in Thailand and Indonesia (Schwartz, Goldberg et al. 2006; Zoraster 2006) and the Chi-Chi earthquake in Taiwan (Hsu, Ma et al. 2002; Chan, Alagappan et al. 2006).

As demonstrated, the army plays an important part in the early response to disasters. The army can be used in all parts of the medical response to disasters and should be considered when developing a comprehensive disaster management plan. Integration between a medical disaster plan and military disaster programs is a necessity.

5.3. PERFORMANCE OF HOSPITAL INCIDENT COMMAND SYSTEM

The Incident Command System is both the organizational element of disaster preparedness and the core of a disaster management system in the response phase (Arnold, Dembry et al. 2005; ASTM 2009; FEMA 2010). The overall objective is to facilitate the hospital response to disasters by superimposing a managerial structure for command and control in addition to a coordination of organizational missions, e.g. administrative, logistical, informational, financial and operational tasks (Arnold, Paturas et al. 2005; Born, Briggs et al. 2007).

The current study showed that the decision making performance of the hospital incident command system in Iran is at a fair or intermediate level.

There is no prior publication, to our knowledge, using the same organizational structure, to evaluate the performance of hospital response to disasters. Previous researchers mainly evaluated command and control functions of a disaster response (Ruter, Nilsson et al. 2006; Kaji, Langford et al. 2008; Ruter and Vikstrom 2009; Gryth, Radestad et al. 2010), but our study covered all functions of a structured response organization.

However, our results are consistent with other studies (Ruter, Nilsson et al. 2006; Kaji, Langford et al. 2008; Ruter and Vikstrom 2009; Gryth, Radestad et al. 2010). It is necessary to evaluate all components of the hospital disaster response in order to assess the efficacy of a hospital response to a disaster. We suggest HICS, and its job action sheets, be used to measure hospital performance in a standardized way.

The HICS was implemented in Iran in 2007, but without any national strategy or guidance with respect to the hospital disaster plan, Therefore, no hospital was found to have a disaster plan in our study. In fact, the hospitals were not organized with respect to comprehensive disaster management. The absence of a hospital command center in all evaluated hospitals, except two, confirms that the hospitals had not provided the essential elements of response to disasters. We believe that the authorities of medical disaster management in Iran must establish comprehensive strategies, guidance and procedures with respect to a hospital disaster plan, including implementing the HICS. There are no current studies on the effect of implementing a disaster plan on HICS performance.

5.4. HOSPITAL PREPAREDNESS AS MEASURED BY THE FUNCTIONAL CAPACITY

In the evaluation of a hospital disaster plan, the most important elements to consider are: organization of disaster planning, emergency coordination, communication, training, expansion of hospital surge capacity, personnel, availability of equipment, stockpiles of medical supplies and expansion of laboratory capacities (Adini, Goldberg et al. 2006). The functional capacity module covers all these elements but in different categories (WHO 2008). The current study evaluated all elements of hospital preparedness, as measured by the functional capacity, including a disaster committee and EOC, an operational plan for internal and external disasters, contingency plans, plans for critical services and the availability of resources.

There is, to our knowledge, no previous publication that has comprehensively evaluated the multiple elements of a hospital preparedness framework. Previous publications have limited their study to some of the mentioned elements (Higgins, Wainright et al. 2004; Kaji and Lewis 2006; Adini, Goldberg et al. 2007).

Another important aspect of this part of the thesis is that the study IV is the only published study using an internationally standardized tool (HSI from WHO) to compare two countries with respect to all-hazards hospital preparedness. Previous studies were conducted in only one country, using a national evaluation tool, and most assessed the preparedness level with respect to only one type of disaster (Higgins, Wainright et al. 2004; Kaji and Lewis 2006; Leiba, Ashkenasi et al. 2006; Ferrier 2008; Kaji, Langford et al. 2008; Li, Huang et al. 2008; Top 2010; Niska and Shimizu 2011).

5.4.1. Impact of socioeconomic condition on hospital disaster preparedness

This study showed that the level of disaster preparedness, as measured by functional capacity, in Iran's hospitals was at risk. Iran is a middle income country (Bank 2008). This finding is consistent with other studies from countries with similar disaster vulnerability and economic conditions (Bank. 2008; Li, Huang et al. 2008; Top 2010; EM-DAT 2012). Shortage of financial resources and a lack of governmental consideration in developing programs can be barriers for a desirable hospital preparedness level (Ginter, Duncan et al. 2007; Barbera, Yeatts et al. 2009; Sauer, McCarthy et al. 2009).

Furthermore, in this study, the hospital preparedness level is explored as safe for the Swedish hospitals. Sweden is a high income and socioeconomically rich country (Bank 2008). Previous studies from the United State and Canada support our results that countries with a higher socioeconomic status also have a higher level of preparedness (Higgins, Wainright et al. 2004; Kaji and Lewis 2006; Ferrier 2008; Kaji, Langford et al. 2008; Niska and Shimizu 2011).

We believe that the higher level of preparedness in Swedish hospitals compared to Iranian hospitals is an effect of the higher socioeconomic standard in Sweden. Previous studies in middle and high income countries confirm our results (Higgins, Wainright et al. 2004; Kaji and Lewis 2006; Leiba, Ashkenasi et al. 2006; Ferrier 2008; Kaji, Langford et al. 2008; Li, Huang et al. 2008; Top 2010; Niska and Shimizu 2011). Two studies from middle income countries, Turkey and China, have both shown shortcomings with respect to hospital preparedness (Li, Huang et al. 2008; Top 2010). Conversely, the level of hospital preparedness in high income countries was similar to those of the hospitals evaluated in Sweden (Ferrier 2008; Niska and Shimizu 2011). Furthermore, it has been shown that socioeconomic factors, e.g. funding, legal strategies, standards and rules for health care influence the hospital disaster preparedness condition and response capability such as planning, training, and developing of resources (Ginter, Duncan et al. 2007; Maldin, Lam et al. 2007; Ransom, Goodman et al. 2008; Barbera, Yeatts et al. 2009; Sauer, McCarthy et al. 2009; Milch, Gorokhovich et al. 2010).

This indicates that countries with a high socioeconomic standard also have prioritized sufficient investments in their hospital preparedness plans in order to create safe and functional hospitals. The challenge is to enhance hospital preparedness despite a weak economic situation. Hospital disaster planning must be considered in vulnerable countries as a strategy for development.

5.4.2. The Hospital Disaster Committee and the Emergency Operations Centre

We could identify that there is an absence of an organized disaster committee in Iranian hospitals. Conflicting results are reported from the United State and China. Conversely, there is a survey from South Africa also demonstrating the absence of an organized disaster committee (Higgins, Wainright et al. 2004; Li, Huang et al. 2008; Stander, Wallis et al. 2011).

All Swedish hospitals had established a disaster committee. This condition is confirmed by the mentioned studies from the United State and China (Higgins, Wainright et al. 2004; Li, Huang et al. 2008).

Also, the absence of a prepared EOC in Iranian hospitals was obvious in the current study, which is contrary to other studies that most hospitals had an EOC (Li, Huang et al. 2008; Top 2010; Stander, Wallis et al. 2011). However, these studies confirm our results regarding Swedish hospitals that all had an organized EOC.

A hospital disaster committee is a multi-disciplinary team, from inside and outside a hospital (NFPA1600 2010) responsible for developing a qualified comprehensive hospital disaster plan. The lack of organized disaster committees may be the main reason for the absence of preparedness elements and the risky level of Iran's hospitals. An active multi-disciplinary disaster management committee is a necessity for Iranian hospitals. The committee members must be nominated based on their qualifications.

The hospital emergency operation center is a location for the hospital incident management system to conduct their managerial duties (EMSA 2006). The functionality of an EOC/HCC can affect the entire performance of the hospital disaster management system (Kaji, Langford et al. 2008); either its absence or failure may result in a low level of preparedness and a weakness of relevant elements (EMSA 2006). One of the first priorities necessary in the disaster planning process for Iranian hospitals is to establish an effective EOC/HCC as an element of preparedness and core of response activities.

Swedish hospitals should keep and enhance quality and capability of hospital preparedness with respect to EOC and disaster committee.

5.4.3. Operational plan for internal and external disasters

Hospitals are required to have an emergency operations plan which describes how a facility should respond to and recover from possible disasters (Association 2012; Preparedness 2012). It includes various activities such as triage, expanding usable space and extra beds, activate and deactivate the plan, cooperative arrangements with community emergency organizations, etc (WHO 2008).

The current study showed that the preparedness levels of Iranian hospitals are at risk with respect to operational plans for internal and external disasters. The preparedness condition of Swedish hospitals is at safe level. These results are controversial when considering reports from other researchers (Kaji and Lewis 2006; Adini, Goldberg et al. 2007; Li, Huang et al. 2008; Top 2010; Kollek and Cwinn 2011; Stander, Wallis et al. 2011). Different strengths and weaknesses, with respect to various elements of operational plans, have been reported in previous studies. However, no study has reported that all operational activities and procedures are at an acceptable level (Kaji and Lewis 2006; Adini, Goldberg et al. 2007; Li, Huang et al. 2008; Top 2010; Kollek and Cwinn 2011; Stander, Wallis et al. 2011).

The emergency operations plan (EOP) provides the structure and processes that the organization utilizes to respond to and initially recover from an event. The EOP is therefore the response and recovery component of the hospital emergency management plan (EMP) (Association 2012; Preparedness 2012). A low level of preparedness in this area may predict low performance of hospitals in response to possible disasters. The aim of medical response to disasters is to save lives of affected and injured people, and the failure thereof will result in increasing mortality and morbidity. Development of a standardized and extensive operational plan must be a priority for a well organized disaster committee in Iranian hospitals. Swedish hospitals should have a control program to maintain and enhance quality of the existent operations plans.

5.4.4. Contingency plans

Based on the current study, the preparedness of Iranian hospitals was not at a safe level with respect to contingency plans for different disasters. There was a lack or absence of contingency plans, e.g. earthquake and hazardous materials, respectively. Also, level of

preparedness in Swedish hospitals was at risk or lower limit of the safe condition with respect to contingency plans.

A national report showed that nearly all hospitals in the United State had response plans for chemical releases, natural disasters, epidemics and biological incidents, where as preparedness for explosive or incendiary incidents was less frequent (Niska and Shimizu 2011). An extensive survey in South Africa showed similar conditions in their hospitals (Stander, Wallis et al. 2011). Our results are supported by a study in Turkey where the majority of the hospitals also have no contingency plans (Top 2010).

For a hospital to have an effective response to a disaster in a short period of time, relevant contingency plans must be issued in advance (Li, Huang et al. 2008). The absence or lack of contingency plans in Iranian and Swedish hospitals results in delays or incompetency in response to disasters. Following an all-hazards approach as well as using a hazard vulnerability assessment will enhance the preparedness level of Iranian hospitals with respect to contingency plans for future disasters. The Swedish hospitals need to develop the absent contingency response plans, also to work on existent ones.

5.4.5. Plans for critical services

In our study, the preparedness of Iranian hospitals was at the level of risk according to the categorization by the WHO (WHO 2008) with respect to plans for the operation, preventive maintenance and restoration of critical services. However, this sub-module had the highest level of preparedness compared to other sub-modules, e.g. contingency plans, disaster committee, etc. The Swedish hospitals were at safe level with respect to this element, plans for critical services.

Although there is no previously publication studying the problems with critical services in Iranian hospitals, our results are also consistent with other studies regarding impacts of failure of critical services on the functionality of hospitals during external or internal disasters; e.g. hurricane Katrina in the United States, the Chilean earthquake and a power failure in a Swedish hospital are some examples (Gray and Hebert 2007; Angantyr, Haggstrom et al. 2009; Kirsch, Mitrani-Reiser et al. 2010). The capability to restore critical services is a necessity for Iranian hospitals.

Although the Swedish hospitals are at safe level with respect to plans for critical services, the previous experience regarding critical services failure in a Swedish hospital (Angantyr, Haggstrom et al. 2009) emphasizes on necessity of having reliable critical services in Swedish hospitals.

5.4.6. Availability of medicines, supplies and equipment

Our study showed that both Iranian and Swedish hospitals are not prepared with respect to the availability of resources during disasters. Similar results have been reported from other studies (Li, Huang et al. 2008; Top 2010; Stander, Wallis et al. 2011), however both national and local studies showed a high level of resource availability in the US hospitals (Kaji and Lewis 2006; Niska and Shimizu 2011).

The unavailability of resources as well as the lack of mutual agreements with external organizations, which is a part of the operational plan, confirms that Iranian hospitals will not be able to provide medical services for an influx of casualties during disasters. A comprehensive hospital disaster plan and sufficient financial resources may solve this problem.

In Swedish hospitals, the problem was not unavailability or shortage of resources; the problem was the lack of a systematic and reliable method to estimate quantity of necessary medical resources. The Swedish hospitals need to use systematic methods with which to calculate needs to guarantee the provision of necessary resources during disasters.

5.5. IMPACT OF BACKGROUND VARIABLES ON HOSPITALS DISASTER PREPAREDNESS AND RESPONSE

The current thesis (studies III & IV) showed that hospital size, based on the number of beds, does not affect either the decision making performance as measured by HICS or the hospital preparedness, as measured by functional capacity.

There is no previous report regarding hospital size and managerial performance as measured by HICS. In addition, there is no consensus on size in relation to hospital preparedness (Adini, Goldberg et al. 2007; Top 2010). However, a study in Canada showed a low level of preparedness for small hospitals as compared to medium and large hospitals (Ferrier 2008). We believe that hospital performance is an effect of preparedness and not size per se. It is however important through hospital disaster planning to consider hospital size with respect to surge capacity.

Our study found that the HICS performance at non-university hospitals was significantly higher than that of university hospitals; however, there was no difference with respect to the level of preparedness.

There are, to our knowledge, no published studies on performance as measured by HICS and hospital affiliation. Non-university hospitals in Iran have a longer experience of HICS and are also better funded, which may explain our results.

Previous studies support our results that hospital affiliation does not affect hospital preparedness, e.g. plan characteristics, standard operational procedures and surge capacity (Kaji and Lewis 2006; Adini, Goldberg et al. 2007; Top 2010).

Hospital preparedness for responding to disasters is a result of government focus and guidance, national policies and regulations and community standards rather than affiliation; however, funding and experience from disasters are factors which improve hospital disaster preparedness and response capabilities (Barbera, Yeatts et al. 2009). All hospitals must be prepared to deal with disaster victims since it is not possible to predict which hospitals will be involved in the acute medical response to disasters.

5.6. LIMITATIONS

One limitation of this study is that the studies samples were the not the same for all studies. In fact, it was not feasible to evaluate different aspects of the same medical system in terms of disaster management; therefore there was no complete connection between study samples. Although we could not evaluate an entire system in the same time and place, the most important parts of a whole medical system were evaluated with respect to disaster management in Iran. We explored some important gaps in each evaluated part and despite of the dispersion of the study samples, our results can be considered in local and national medical disaster planning.

This thesis was performed mainly in Iran which restricts the ability to generalize our results. However, the Hospital Safety Index and the Hospital Incident Command System with its job action sheets are standardized tools designed to be used worldwide (EMSA 2006; WHO 2008). Furthermore, the hospital preparedness evaluation was also conducted in Sweden.

Another important limitation of this study was that the preparedness (HSI) and response (HICS) evaluation tools have not formally been tested with respect to their validity to predict the capability and performance of the system during real disasters. It is a worldwide subject today, and there is still a need for a valid evaluation tool with respect to hospital preparedness (Adini, Goldberg et al. 2006; Burstein 2008; Kollek and Cwinn 2011). However, the evaluation of hospital disaster management capability using internationally structured tools is important in a vulnerable country. Outcome studies using a valid tool remain to be performed.

The number of participating hospitals in the evaluation of preparedness was small. However, this is the first study comparing two countries (Iran and Sweden) using an internationally standardized method for evaluating hospital preparedness and using an all-hazards approach.

The selection of the participating hospitals in this thesis was a convenience sample. Therefore a selection bias is possible and the generalization of our results may be impaired. However, all hospitals need to be prepared to respond to possible disasters.

An additional limitation is that the evaluators were not the same throughout the study. Only the main researcher assessed all hospitals' preparedness and pre-hospital response to the Bam earthquake. However, this is the first study to consider the most important parts of the medical system, with respect to hospital preparedness and socioeconomic standard and compare a high with a low socioeconomic standard. Furthermore, the structured format of the evaluation tools minimizes the potential variation due to subjective interpretation.

Another limitation is that we have not measured inter-rater reliability of HIS and HICS. We did, however, have a team discussion after each exercise and evaluation and then the evaluators independently came to the same score.

Additional limitation is that the cut-off levels for the categorizing of HICS performance are arbitrary. However, they were based on expert consensus. There is currently no better way to perform this categorization. Standardizing these cut-off levels requires prospective outcome based studies, which still remain to be performed.

Using tabletop exercises may be questioned with respect to the validity of the assessment of HICS operational performance as compared to that of the performance in a real disaster. However, decision making in a hospital command center, performed by the HICS commander and the section chiefs during a disaster, is the core of the HICS performance from a managerial and operational perspective.

6. CONCLUSIONS

This thesis aimed to analyze different aspects of hospital preparedness and the acute medical response to disasters. It assessed the efficacy of an educational intervention in capacity building and enhancing personnel knowledge regarding disaster medicine including hospital disaster management. In addition, the pre-hospital medical response to the Bam earthquake was evaluated in this thesis. Finally, two components of a comprehensive hospital disaster plan, preparedness and response phases, were analyzed. The main conclusions are listed as follows:

- Participants showed a significant increase in their level of knowledge with respect to disaster medicine in the training course. Using a national model can be an effective and practical model for capacity building of national and regional educational programs (Study I).
- Pre-hospital medical response to the Bam earthquake was not at acceptable condition. There was lack of triage, treatment and transport in pre-hospital level. Skilled medical volunteers and the military's medical teams were facilitators in the early phase of the medical response to the Bam earthquake. The main obstacles to the pre-hospital medical response were the lack of a disaster management plan, the absence of disaster medical assistance teams and the overall lack of resources. It is evident that implementing a comprehensive plan would not only save lives but decrease suffering and enable an effective usage of the available resources to provide a standardized pre-hospital medical response to disasters (Study II).
- The decision making performance in the participating hospitals, as measured during tabletop exercises and using the Hospital Incident Command System (HICS) was intermediate to poor. No hospital was at high level. The performance was better in the non-university hospitals as compared to university hospitals and was shown to be independent of the hospital size. We believe that a comprehensive hospital disaster plan should include not only managerial and operational elements of hospital preparedness, but also an appropriate command system suited to the specific hospital organization. The HICS job action sheets can be used as a template for measuring the hospital response capability (Study III).
- Preparedness, as measured by functional capacity was at a safe level in Swedish hospitals as compared to at risk in Iranian hospitals. The level of hospital preparedness is related to the socioeconomic level of the country, in this comparison between Sweden and Iran. The challenge is therefore to enhance hospital preparedness in vulnerable countries despite weaker economic situations (Study IV).
- Hospital preparedness is not related to affiliation and size. All hospitals must be prepared for a disaster (Study III & IV).

Appendix 1- Job Action Sheet of Incident Commander

INCIDENT COMMANDER

Mission: Organize and direct the Hospital Command Center (HCC). Give overall strategic direction for hospital incident management and support activities, including emergency response and recovery. Authorize total facility evacuation if warranted.

Date: _____	Start: _____	End: _____	Position Assigned to: _____
Signature: _____			Initial: _____
Hospital Command Center (HCC) Location: _____		Telephone: _____	
Fax: _____	Other Contact Info: _____	Radio Title: _____	

Immediate (Operational Period 0-2 Hours)	Time	Initial
Assume role of Incident Commander and activate the Hospital Incident Command System (HICS).		
Read this entire Job Action Sheet and put on position identification.		
Notify your usual supervisor and the hospital CEO, or designee, of the incident, activation of HICS and your HICS assignment.		
Initiate the Incident Briefing Form (HICS Form 201) and include the following information: <ul style="list-style-type: none"> • Nature of the problem (incident type, victim count, injury/illness type, etc.) • Safety of staff, patients and visitors • Risks to personnel and need for protective equipment • Risks to the facility • Need for decontamination • Estimated duration of incident • Need for modifying daily operations • HICS team required to manage the incident • Need to open up the HCC • Overall community response actions being taken • Status of local, county, and state Emergency Operations Centers (EOC) 		
Contact hospital operator and initiate hospital's emergency operations plan.		
Determine need for and appropriately appoint Command Staff and Section Chiefs, or Branch/Unit/Team leaders and Medical/Technical Specialists as needed; distribute corresponding Job Action Sheets and position identification. Assign or complete the Branch Assignment List (HICS Form 204), as appropriate.		
Brief all appointed staff of the nature of the problem, immediate critical issues and initial plan of action. Designate time for next briefing.		
Assign one of more clerical personnel from current staffing or make a request for staff to		

Immediate (Operational Period 0-2 Hours)	Time	Initial
the Labor Pool and Credentialing Unit Leader, if activated, to function as the HCC recorder(s).		
Distribute the Section Personnel Time Sheet (HICS Form 252) to Command Staff and Medical/Technical Specialist assigned to Command, and ensure time is recorded appropriately. Submit the Section Personnel Time Sheet to the Finance/Administration Section's Time Unit Leader at the completion of a shift or at the end of each operational period.		
Initiate the Incident Action Plan Safety Analysis (HICS Form 261) to document hazards and define mitigation.		
<p>Receive status reports from and develop an Incident Action Plan with Section Chiefs and Command Staff to determine appropriate response and recovery levels. During initial briefing/status reports, discover the following:</p> <ul style="list-style-type: none"> • If applicable, receive initial facility damage survey report from Logistics Section Chief and evaluate the need for evacuation. • If applicable, obtain patient census and status from Planning Section Chief, and request a hospital-wide projection report for 4, 8, 12, 24 & 48 hours from time of incident onset. Adjust projections as necessary. • Identify the operational period and HCC shift change. • If additional beds are needed, authorize a patient prioritization assessment for the purposes of designating appropriate early discharge. • Ensure that appropriate contact with outside agencies has been established and facility status and resource information provided through the Liaison Officer. • Seek information from Section Chiefs regarding current "on-hand" resources of medical equipment, supplies, medications, food, and water as indicated by the incident. • Review security and facility surge capacity and capability plans as appropriate. 		
Document all key activities, actions, and decisions in an Operational Log (HICS Form 214) on a continual basis.		
Document all communications (internal and external) on an Incident Message Form (HICS Form 213). Provide a copy of the Incident Message Form to the Documentation Unit.		

Intermediate (Operational Period 2-12 Hours)	Time	Initial
Authorize resources as needed or requested by Command Staff.		
<p>Designate regular briefings with Command Staff/Section Chiefs to identify and plan for:</p> <ul style="list-style-type: none"> • Update of current situation/response and status of other area hospitals, emergency management/local emergency operation centers, and public health officials and other community response agencies • Deploying a Liaison Officer to local EOC • Deploying a PIO to the local Joint Information Center • Critical facility and patient care issues • Hospital operational support issues • Risk communication and situation updates to staff • Implementation of hospital surge capacity and capability plans • Ensure patient tracking system established and linked with appropriate outside 		

Intermediate (Operational Period 2-12 Hours)	Time	Initial
agencies and/or local EOC <ul style="list-style-type: none"> • Family Support Center operations • Public information, risk communication and education needs • Appropriate use and activation of safety practices and procedures • Enhanced staff protection measures as appropriate • Public information and education needs • Media relations and briefings • Staff and family support • Development, review, and/or revision of the Incident Action Plan, or elements of the Incident Action Plan 		
Oversee and approve revision of the Incident Action Plan developed by the Planning Section Chief. Ensure that the approved plan is communicated to all Command Staff and Section Chiefs.		
Communicate facility and incident status and the Incident Action Plan to CEO or designee, or to other executives and/or Board of Directors members on a need-to-know basis.		

Extended (Operational Period Beyond 12 Hours)	Time	Initial
Ensure staff, patient, and media briefings are being conducted regularly.		
Review and revise the Incident Action Plan Safety Analysis (HICS Form 261) and implement correction or mitigation strategies.		
Evaluate/re-evaluate need for deploying a Liaison Officer to the local EOC.		
Evaluate/re-evaluate need for deploying a PIO to the local Joint Information Center.		
Ensure incident action planning for each operational period and a reporting of the Incident Action Plan at each shift change and briefing.		
Evaluate overall hospital operational status, and ensure critical issues are addressed.		
Review /revise the Incident Action Plan with the Planning Section Chief for each operational period.		
Ensure continued communications with local, regional, and state response coordination centers and other HCCs through the Liaison Officer and others.		
Ensure your physical readiness, and that of the Command Staff and Section Chiefs, through proper nutrition, water intake, rest periods and relief, and stress management techniques.		
Observe all staff and volunteers for signs of stress and inappropriate behavior. Report concerns to the Employee Health & Well-Being Unit Leader.		
Upon shift change, brief your replacement on the status of all ongoing operations, critical issues, relevant incident information and Incident Action Plan for the next operational period.		

Demobilization/System Recovery	Time	Initial
<p>Assess the plan developed by the Demobilization Unit Leader and approved by the Planning Section Chief for the gradual demobilization of the HCC and emergency operations according to the progression of the incident and facility/hospital status. Demobilize positions in the HCC and return personnel to their normal jobs as appropriate until the incident is resolved and there is a return to normal operations.</p> <ul style="list-style-type: none"> • Briefing staff, administration, and Board of Directors • Approve announcement of “ALL CLEAR” when incident is no longer a critical safety threat or can be managed using normal hospital operations • Ensure outside agencies are aware of status change • Declare hospital/facility safety 		
<p>Ensure demobilization of the HCC and restocking of supplies, as appropriate including:</p> <ul style="list-style-type: none"> • Return of borrowed equipment to appropriate location • Replacement of broken or lost items • Cleaning of HCC and facility • Restock of HCC supplies and equipment; • Environmental clean-up as warranted 		
<p>Ensure that after-action activities are coordinated and completed including:</p> <ul style="list-style-type: none"> • Collection of all HCC documentation by the Planning Section Chief • Coordination and submission of response and recovery costs, and reimbursement documentation by the Finance/Administration and Planning Section Chiefs • Conduct of staff debriefings to identify accomplishments, response and improvement issues • Identify needed revisions to the Emergency Management Plan, Emergency Operations Plan, Job Action Sheets, operational procedures, records, and/or other related items • Writing the facility/hospital After Action Report and Improvement Plan • Participation in external (community and governmental) meetings and other post-incident discussion and after-action activities • Post-incident media briefings and facility/hospital status updates • Post-incident public education and information • Stress management activities and services for staff 		

Documents/Tools
<ul style="list-style-type: none"> • Incident Action Plan • HICS Form 201 – Incident Briefing Form • HICS Form 204 – Branch Assignment List • HICS Form 207 – Incident Management Team Chart • HICS Form 213 – Incident Message Form • HICS Form 214 – Operational Log • HICS Form 252 – Section Personnel Time Sheet • HICS Form 261 – Incident Action Plan Safety Analysis • Hospital emergency operations plan and other plans as cited in the JAS • Hospital organization chart • Hospital telephone directory • Radio/satellite phone

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