

# TWO YEARS ON, WHAT HAS BEEN ACCOMPLISHED IN BAM HEALTHCARE FACILITIES

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On December 26<sup>th</sup>, 2003 the historical city of Bam experienced one of its strongest earthquakes. It measured 6.6 on the Richter scale. The largest part of the city, which was classified as a world heritage site by the United Nation, was totally destroyed. The disaster caused death to 26,500 people and wounded more than 25,000 people. Health care facilities were very much in demand; however 120 facilities were severely damaged and made treatment impossible. The authors visited some facilities and conducted interviews with the personnel of the two main hospitals in the city; the Imam Khomeini Hospital and the Aflatoonian Hospital. The damage to health care facilities affected the victims directly. Some of them could not be treated which lead to their subsequent death. There are many reasons for the malfunctioning of hospitals; however, structural and non-structural damage were still very significant there. The present paper presents the situation of the afore mentioned hospitals two years from the earthquake. It focuses on the circumstances of non-structural elements including medical equipment and lifelines. Some of the equipment were found to be placed without attachment to their supports. Others were mounted on wheels or freely standing, which caused their damage. The outcome of this research is some suggestions to avoid what was experienced in 2003 in the future.

## 1. Introduction

The earthquake occurred on the 26<sup>th</sup> of December 2003 measuring 6.6 on the Richter Scale (Ramezani, 2004). It caused the total collapse of 85% of Bam City, the epicentre is shown in Fig.1; death to more than 26,500 (Ghafory-Ashitany, 2004) and injury to more than 25,000 people (Kishore et al., 2004). As a result of its location, Iran has a long history of earthquakes; between 1948 and 1998 the country has experienced at least 14 earthquakes measuring  $M=5$  and over (Beverly et al., 2004). Among those 14, at least two of them measured over magnitude 7.3 and caused the death of 13,500-21,500 people (Ramezani, 2004). Furthermore, according to the International Federation of Red Cross and Red Crescent Societies (IFRCS, 2004) since 1909 between 143,000 and 178,000 people were killed because of 19 earthquakes. In 2003, Iran had the highest number of deaths due to earthquakes; 29,617 people were killed which means 90.48% of the total number all over the world (CRED homepage, 2005), see Fig.2. Likewise, a study done by the UN showed that between 1980 and 2003 Iran had the highest number of death related to earthquakes (UN homepage).

It is obvious to say that the large number of victims confirms the vital role of hospitals; the USAID (2005) reported that the IFRCS hospital received 550 patients per day. On the other hand, the local hospitals were not able to function because of the damage that they experienced while they were needed the most. The World Health Organization (WHO, 2004) described the damage caused, by the earthquake, to health care facilities as "significant"; 120 health care facilities were severely damaged or completely collapsed (Beverly et al., 2004);

two of them were main hospitals: the Aflatoonian Hospital and the Imam Khomeini Hospital. Some of the authors, who were members of the Japanese investigation team, visited those two facilities to assess the smoothness of the rescue activities. The authors visited the facilities twice; the first time was in February 2004 and the second was in September 2005.



Fig.1 – Location of the epicentre (Ref. [www.farsinet.com/bam/](http://www.farsinet.com/bam/))

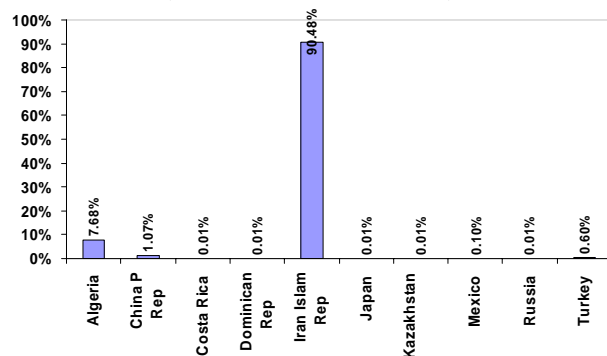


Fig.2- Percentage of earthquake-related death in 2003

During both visits, interviews were made to collect information and to understand the situation during and after the earthquake. Some interviews were held with some members of the staff who were present during the event. The present report shows the result of those interviews and discusses the weaknesses that were found in healthcare facilities and aims to propose some solutions. It is hoped that the suggestions will help decision makers to make the situation better for any future earthquake.

## 2. Rescue activities

As it has been mentioned previously the disaster was massive, which made the Iranian rescue teams incapable of rescuing all the victims; at least 44 countries sent 1,800 rescuers to help the relief activities. During the first hours there was no treatment. A doctor stated that they had to “lie” to patients by informing them that the help was coming to make them wait and resist the pain that they were feeling. The doctor stated that they did not have even Intravenous (*known as IV*) lines which are vital in an emergency. Moreover he declared that during the first 5 hours there was no treatment at all, later the help started coming from the neighbouring cities and the serious cases, which was the case of the majority of victims, were transferred to their hospitals. The hospitals of Kerman (about 200 km), Shiraz (about 120km) and Jeroft (120km) cities received the victims mainly by helicopter and some others by other means including private cars. The personnel of the Aflatoonian hospital stated that during the first days, before the arrival of the international teams, all victims were transferred to the above mentioned cities. The personnel used the equipment, which they received from other cities, to treat the victims they used until the arrival of the international teams who setup their mobile hospitals, near the local facilities and helped them to operate, see photos 1 and 2. Some Iranian rescue teams were sent to be trained by the German Red Cross for two years.

It is not unusual to find problems during rescue activities, however the need to be analysed closely to prepare for future disasters. The IRFCS reported that there was miss-communication and bad co-ordination between the 13 sectors, which they created in Bam for the rescue, and the 28 provinces. The same trouble caused unequal distribution of aid between the different sections. The local government estimated the number of people who needed long-term psychological support to be in the range of 25,000 patients.

## 3. Hospitals overview

### 3.1 Aflatoonian Hospital

The Aflatoonian hospital is a private hospital; the 2-story building was built about six years before the earthquake 5km from the centre of Bam. The facility has a capacity of 70 beds which can be extended to 120 beds in the event of an emergency. Between 25 and 30 patients are being treated every day in the hospital in addition to 70 inpatients which makes the facility full without being in an emergency situation. The medical service is composed

of 57 people; 17 of them are doctors, 40 nurses.

A problem with the facility’s insurance caused its closure on January 5<sup>th</sup> 2005; after that the facility partially opened to provide treatment in its garden and parking lot, where the international teams setup their tents, the personnel reported. The actual building was totally closed until July 2004, then opened again and started serving the patients. The government of Kerman helped in repairing the facility, which was exempted from paying the water supply fees until October 2005. Photos 3 and 4 show the front of the facility before and after being repaired, respectively.

### 3.2 Imam Khomeini Hospital

The facility is a public hospital located in the centre city of Bam. Its capacity is 100 beds, and it hosts 290 staff members; 24 doctors, 146 nurses and 120 administrative personnel. The facility had many problems that hampered its normal functioning; mainly the severe structural damage that it experienced, see Photo 5. The international aid teams installed their prefabricated hospitals beside the actual building, as photos 1 and 2 show. They lend Iranian personnel some of their equipment, which were used in the treatment. Later the rubble was cleared and the rest of actual building was demolished. Some prefabricated buildings were installed by international companies and societies are being used as small clinics, photos 6, 7 and 8. According to the staff of the hospital the facility is still providing patient with emergency care; however, we believe that it is impossible to grant an emergency service for serious cases or to respond to a disaster like that of 2003.



Photo 1- Mobile hospitals, German team, February 2004



Photo 2- Tent, Spanish team, February 2004





Photo 3- Aflatoonian Hospital, February 2004

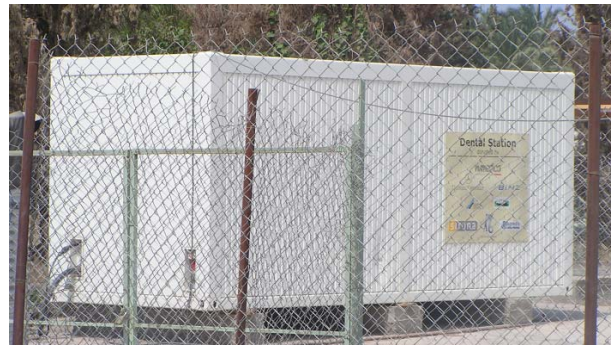


Photo 7- Dental Station donated by some companies



Photo 4- Aflatoonian Hospital, September 2005



Photo 8- Building donated by Save the Children Society Japan



Photo 5 – Total collapse of Imam Khomeini Hospital, 2004

#### 4. Interviews

The interview dealt with the *structural damage, injury to staff, lifeline damage, damage to medical equipment, relief after the earthquake, management problems and general data about the facilities*. Interviews were made in two different periods; the first was in February 2004, during our first visit to the affected area, and the second set was done during our second visit to the same area in September 2005. We chose the interviewees to be from all types of personnel that can be found in any hospital; doctors, administrative and nurses.

#### 5. Interview result

##### 5.1 Aflatoonian Hospital

The hospital suffered severe structural damage; some columns tilted, some others cracked and some parts collapsed, see Photo 3. According to one member of the hospital, the structural damage cost 5 billion IRR, *Iranian Rials* (65 Million JPY, *Japanese Yen*) of the cost of the entire building which is about 12 billion IRR (155.6 Million JPY). It should be noted that recently the cost of construction has become more expensive than a few years ago, in other words the damage to the facility is less than 41.6% (=cost of repair/cost of entire building). The facility suffered malfunction to its lifelines; electric power was cut for about two days, there was no landline telecommunication until the day of the first visit, there was no mobile telecommunication for at least 12 days following the quake, concerning the water supply the facility was provided with two reservoirs that were used as alternative sources. The tanks are able to store 13m<sup>3</sup> of water which can be used for about two days, photos 9 and 10. The damage to lifeline caused malfunction of medical equipment which caused delay of



Photo 6- Prefabricated buildings installed instead of the Imam Khomeini Hospital, September 2005



the treatment. International aid teams provided the facility with some equipment which helped it to re-open and provided the necessary care. Nevertheless, some medical equipment were not used since their fall and/or their displacement caused their damage, see photos 11 and 12. At the time of the earthquake the facility did not have any alternative source except the water tanks shown in photos 9 and 10. Later, a 32KW electric power generator was brought to be used in emergencies, as Photo 13 illustrates. The interviewee stated that in an emergency the generator will be used only for the operation room. However, the engine is able to make the majority of the equipment function; it can produce 768KWh/day, thus 23,808KWh in 31 days which is 80% of the consumption of August 2005.

Fortunately, none of the hospital staff members were injured in the hospital; however some of the personnel could not reach the hospital during the emergency. The personnel who were not available in hospitals were directly or indirectly affected by the quake; one doctor was killed and the others had injured/dead members in their families which obliged them to stay with them and take care of them. The facility had to manage with the personnel who were present in the time; however with more than 600 patients, shortage of lifelines and damaged medical equipment the situation becomes very difficult and made the personnel obliged to transfer the majority of injuries to other facilities. The interviewee stated that the large amount of medicine that the facility had could not save all the patients since many patients died given that they did not receive the necessary care because of the insufficient number of personnel. One of the questions asked was about the most needed item during the salvage operations; the answer was "doctors" then "nurses".

The facility was provided with an emergency manual that was made two years before the occurrence of the earthquake. Regrettably, that manual considers only fire and traffic accidents. On the other hand the hospital provides its personnel with disaster prevention lectures, 5 times per year, and 24 disaster trainings per year; such preparedness helped the personnel to find solutions and to share the stress of the work together during the emergency phase. Also, during the emergency the hospital groups with four other hospitals in the vicinity to pool their resources.



Photo 9- Water Tank 1, Aflatoonian Hospital



Photo 10, Water Tank 2, Aflatoonian hospital



Photo 11- Topple of equipment, Aflatoonian Hospital



Photo 12- Displacement of a sterilizer, Aflatoonian Hospital



Photo 13- Electric power generator, Aflatoonian Hospital

## 5.2 Imam Khomeini Hospital

The facility suffered heavy damage to its structure; some parts totally collapsed, Photo 5. The lifelines malfunction was widespread since electricity was cut for two days in some areas and seven days in others. There was no water supply until the day of our first visit, there was no telecommunication; landline phones were cut for about 14 days and mobile phones were cut for at least one day, the heating system was inoperable until our visit. The damage caused the facility to close. However, after receiving some equipment from the international aid teams, such as a water tank and an electric power generator, the hospital re-opened partially and started receiving patients. Later it had to be closed again after transferring all the patients to other facilities. Personnel stated that the damage had an awful impact on the patients. The facility was not provided with any alternative sources for water supply and electric power. During our visit on September 2005 we knew that a 20KW electric power engine was brought to be used in an emergency. The engine is provided with a fan for its cooling system which makes it independent from the water supply. Nevertheless, the facility is still in need of an alternative source for its water supply.

The number of victims was significant, the number of personnel was not satisfactory; large numbers of staff could not reach the hospital to aid in treatment because they had to help their own injured families, or they were themselves injured and in some cases they were themselves the victims. The Imam Khomeini hospital suffered also from the quantity of medicine that was not sufficient. All the stated factors added to the malfunction of the hospital and the torment of the victims who did not receive the necessary treatment before the arrival of the international aid teams. The staff reported that medicine, water, food and sheets were the most needed items in the facility.

The interviewee claimed that the facility does not have any type of activities to tutor the personnel about actions that should be taken in an emergency situation. Moreover, there was no emergency manual; lectures were very limited and restricted to a certain category of personnel.

## 6. Equipment stability and lifeline

### 6.1 Equipment stability

As a result of the shaking many equipment got damaged which may be the result of displacement, rocking or displacement-rocking. The personnel of the Aflatoonian Hospital stated that almost all the equipment were damaged with various severity; the cost of repairing the damage was between 10-100% of the price of the equipment itself. For instance, Table 1 shows some of the equipment and the severity of their damage. Some of them were fixed and some others were disposed, of such as the Radiology unit shown in Photo 14. As result of the displacement the pipelines of the water supply which attach to the CSR, shown in Photo 15, were damaged rending the whole equipment useless.

Some services are still operating in prefabricated

buildings, such as the operation room and the women's ward. The prefabs are posed on small masonry walls without being attached to any support which may make them unstable in the case of strong shaking, see photos 16 and 17. The masonry is not capable of resisting to horizontal loads, which is the case of earthquakes; this may result in their damage during an earthquake. The damage to walls leads to the total malfunction of the service provided in the prefab.

Using mobile units is helpful in hospitals but this solution is still very vulnerable and easy to be displaced during an earthquake. During the visit we found that some equipment were placed on wheels, as photos 18 and 19 show. In general the equipment that are subjected to frequent movement are placed on the wheeled systems, this cannot be the case for a blood bank, Photo 18 or infant incubator, Photo 19. The use of wheels in these cases may put the life of the infant in danger and the lack of blood given the occurrence of an earthquake. It is highly recommended to avoid the use of wheels whenever it is possible to use other safer means.

Table 1- Medical equipment damage

Unit	Severity of damage	Remarks
X-Ray	10%	
Sterilizer (CSR)	10%	Damage to the water pipes because of the displacement, Photo 12 and Photo 15
Radiology	100%	Photo 14



Photo 14- Radiology unit



Photo 15- Central Sterilization Room (CSR)





Photo 16- Operation room, Women ward



Photo 17- Operation room, bottom view



Photo 18- Blood bank



Photo 19- Equipments mounted on wheels

## 6.2 Lifeline

Both hospitals were provided with electric power generators; however, only the Aflatoonian Hospital was provided with water tanks which can be used during an emergency. The Imam Khomeini facility is not fitted with any water tanks, which makes its emergency service incapable to function in case of emergency.

As a result of the shaking one of the water tanks of the Aflatoonian Hospital bulged as photos 20 and 21 show. The buckling was found all the 4 feet with various severities; however, two of them had serious impact and they affected the tank itself as it is shown in Photo 21. The feet should be replaced and the damaged area of the tank should be repaired to avoid any failure in case of another earthquake.

## **7. Synopsis of the problems and strengths**

What can be learned from the previous sections is that there are some problems which need to be treated and some strengths that need to be made common in hospitals. The two hospitals considered have some common problems; both facilities suffered severe structural damage, lack of personnel, lifeline and medical equipment problems. It is clear that the Aflatoonian Hospital was more prepared than the Imam Khomeini Hospital. The latter facility was not providing its personnel with any type of activities that could make the situation better, the quantity of medicine was very limited that was ended directly after the patients started coming and there was no emergency manuals that could help personnel in understanding the situation that they faced. The Aflatoonian hospital was a member in a group of hospitals that work together during emergencies, which gives more possibilities to save more people and protect human life.

Iran has a very long history of earthquakes and has the highest number of victims which shows the lack of preparedness or the non-sufficient preparedness; in other words there was no plan for emergencies even planning and managing the emergencies.

## **8. Discussion and suggestions**

Damage to health care facilities varies from country to country i.e. level of preparedness in each country. Usually it starts with the structural and it ends with lifelines and management; for that Iran should take into consideration the experience of other countries such as Algeria, following the Boumerdes earthquake of May 21, 2003. Additionally, the preparedness should be done according to trustful systems, such as the case of Japan. Japan could reduce greatly the number of victims even if some problems are still being found during emergencies. The preparedness should be made in all the categories; structure, lifeline and planning.

### 8.1 Lifeline issues

The difference between any commercial/living building and health care building is the lifeline/equipment that exists in both of them (PAHO, 1993 and 2000). Health

care facilities are equipped in very particular equipment that are used to treat patients. Hospitals' equipment are related to each other with very complicated ways. The main problems that were found in Iran and in many other facilities in the world can be classified into three categories; *alternative sources, damage and malfunction of equipment.*

As their name indicates “alternative sources” have to be always in hospitals; an alternative source is a source that could be used in case of loss of the main source therefore it has to be always with that source. A health care facility cannot function if it doesn't have electricity or water or any other lifeline. The Khomeini hospital did not have any emergency electric generators, did not have any water supply and therefore it had to be closed. This situation was found in many cases in the world; in Algeria, for example, following the Boumerdes earthquake the Thenia Hospital did not have any alternative source for water, later a reservoir was brought and used as an “alternative source”; there was no electric power generators which made the personnel use candles to treat the patients during the first hours (Hamada et al., 2003). Achour et al. have shown that the most important lifeline in healthcare facilities after the earthquakes that occurred in Miyagi and Hokkaido in 2003 was electric power.

The damage to equipment can be caused mainly by *a)* its toppling over or being displaced as shown in photos 11, 12, 22, 23 and 24, or *b)* being under other elements such as structural elements given a structural damage. Only the first case will be discussed since the second leads to the case of structural preparedness; the anchorage of elements to their support is one way to protect those elements. There are many types of anchorage; the type of anchorage depends on the equipment. Some equipments need flexible anchorage, others need stiff, etc. Pipelines represent one of the most vulnerable elements in healthcare facilities; since they can be damaged easily because of their geometry that cannot resist strong shaking; Myrtle et al. (2005) showed that the piping system is the most important system in healthcare facilities. To protect them, it is recommended to divide the pipes into parts joined with flexible joints to allow movement during the shaking.

Malfunction can be caused by two main reasons; the first is the physical damage to the lifelines such as what happened in Kobe Medical College of Kobe University, Japan, when the electric power generators had to shut down because of the lack of cooling water (Shinozuka et al., 1995). The second reason is the malfunction or the physical damage to the external systems providing the internal systems with the necessary type of lifelines such as what happened in both facilities, Imam Khomeini and Aflatoonian Hospitals, with the mobile telecommunication. To protect the facilities from such vulnerability it is recommended to have different sources (providers) and also it recommended having equipment that does not depend on any other equipment or at least depends on the smallest number.

### 8.2 Important issue

Iran has a very good opportunity to re-build new facilities. Given that healthcare facilities are composed of very complex systems related to each other with very difficult relations; it is highly recommended that engineers, doctors and architects discuss the situation of the new facilities; drawings, the location of the equipments etc. The Imam Khomeini is no longer able to function in earthquake related emergencies, simply because there is no proper building and there is no alternative source for water supply. Therefore only the Aflatoonian hospital is the one that has to deal with all the patients given an earthquake. Taking into account that the Aflatoonian has 70 beds and they are all full in non-emergency time, the facility is not capable to respond with a situation like such in 2003.



Photo 20- Buckling of feet of the water tank



Photo 21- Buckling of feet of the water tank



Photo 22- Falling over of a gas cylinder





Photo 23- Displacement of equipment



Photo 24- Topple of medical equipment

## 9. Conclusion

Iran has a high risk of having earthquakes, yet it still has not prepared for them. Many problems were faced during the emergencies and it should be noted that they are not particular only to Iran because many countries are suffering from the same problems. However, the situation in Iran can be made much better using the resources that the country has. The preparedness of personnel is very necessary since they are the most important people to treat injuries and therefore save lives.

The excessive use of wheels may not be a good idea given that it may cause instability of the equipment. Furthermore the majority of equipment were standing freely without being attached to their supports. This may cause added instability, which remains one of the most serious problems for the malfunction of hospitals. This issue is being seriously investigated in our laboratory.

If preparedness was done the situation would be much better and the numbers would be less than they are as well as the economic losses would not be high as they are.

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