



Earthquake Response Timeliness: Disaster Managers Experience in Responding to Earthquakes in Iran

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Abstract. This paper explores the timeliness of main response activities in the Bam earthquake in order to shed light in disaster response effectiveness in the aftermath of the earthquake. Disaster managers who were involved in disaster response activities in the Bam earthquake were selected using snowball sampling method and 30 participants were interviewed. The interviews data were analyzed applying thematic analysis method. The results showed that the extensive damage and large number of casualties challenged the local emergency response services. The problem was compounded by the lack of personnel in the first few hours after the earthquake. Iran's disaster management system was not prepared to cope with a disaster of this scale. According to the interview data, a response timeline to the earthquake was developed for 48 hours after the earthquake that can assist disaster manager in designing a proper action plan (strategic response plan) prior to an earthquake in the region. This is an efficient way of dealing with disaster response challenges in the aftermath of earthquakes.

5 **Keywords:** Response timeliness, Semi-structured interviews, Thematic method, Disaster managers, and the Bam earthquake.

6 **1. Introduction: Timeliness as a factor in measuring disaster response effectivness**

7 This paper explores the timeliness of main activities that have been operated in response to the Bam earthquake in order to shed
8 light in disaster response effectiveness in the aftermath of the earthquake. The focus is primarily on timeliness in relation to the
9 first 48 hours of response and more on national and local responders.

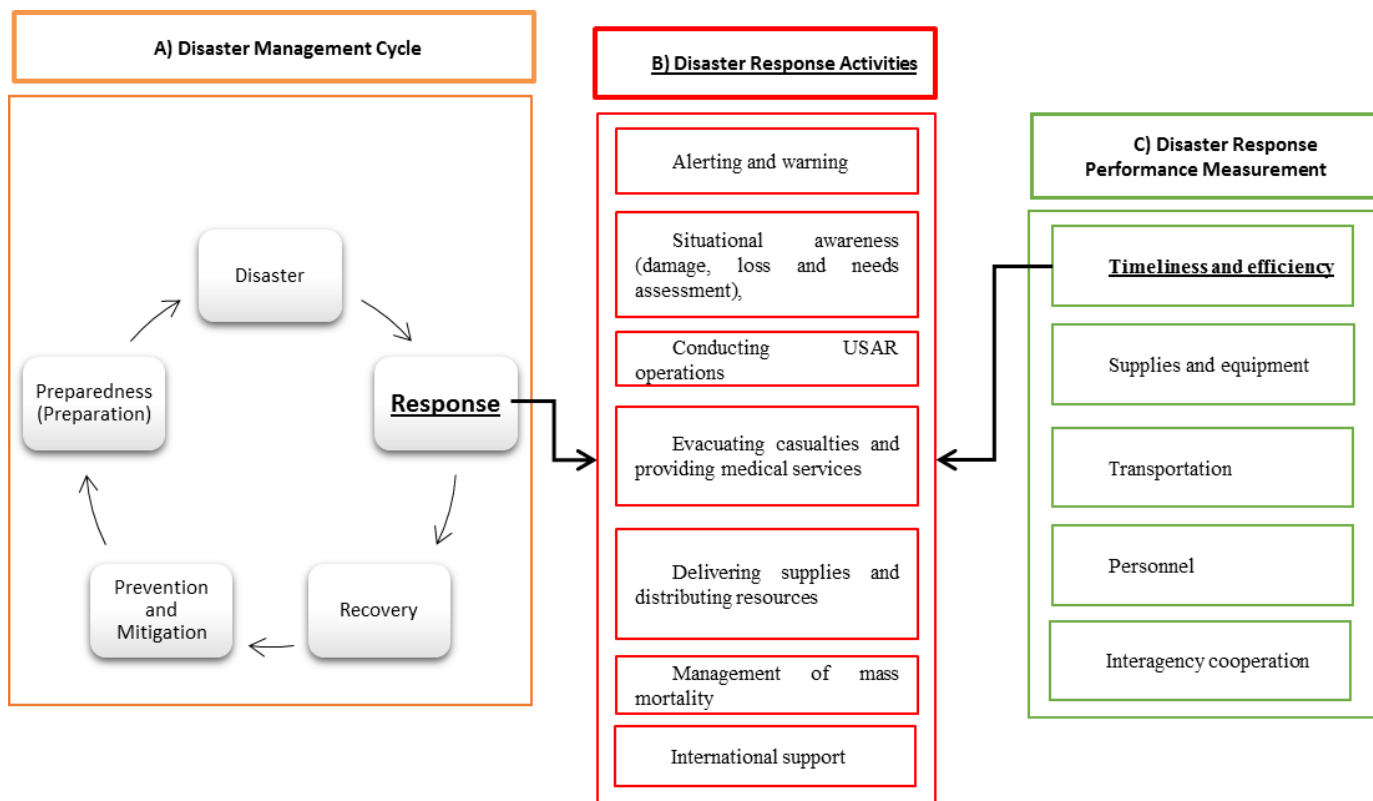
10 The disaster management cycle is a complex process that should be addressed clearly to facilitate all phases of disaster management
11 including prevention and mitigation, preparation (preparedness), response, and recovery (Alexander, 1993; Clary, 1985; Cutter,
12 2003).The disaster-response phase focuses on conducting operations to assist the affected community during a disaster and in its
13 aftermath (Alexander, 1993; Clary, 1985; Cutter, 2003). In this stage, responders provide emergency assistance to victims and act
14 to reduce the likelihood of secondary damage in the area. In the first few hours of a disaster, a proper assessment of the situation
15 is particularly important. Many questions need to be answered: Where is the emergency? How can responders get to the damaged
16 area? How many casualties are there? (Diehl et al., 2006; Quarantelli, 1997). However, the critical component of any disaster
17 response is an early and accurate assessment to detect damage, to identify urgent needs, and to determine relief priorities for the
18 affected population (Lillibridge et al., 1993; Gunawan et al., 2011) wich they need accuracte and high quality information for



19 decision making during disaster responses (Jayawardene et al., 2021). Abir et al. (2017) developed 5 main factors in measuring
20 disaster response performance in the aftermath of a disaster. These include “(1) timeliness and efficiency, (2) supplies and
21 equipment, (3) transportation, (4) personnel, and (5) interagency cooperation” (Abir et al., 2017). Moreover, effective decision-
22 making and timely response operations are important in facilitating rapid responses to a disaster (Borkulo et al., 2006; Ouyang et
23 al., 2008; Smilowitz and Dolinskaya, 2011). For example Zhang et al. (2002) found that accessible, up-to-date, accurate data, and
24 speedy data analysis by disaster managers could facilitate the decision-making process and lead to rapid responses to emergencies
25 (Leidner et al., 2009; Mansourian et al., 2005). Another major factor in the response phase is collaboration among the emergency
26 services involved in disaster response (Scotta et al., 2007). As seen in previous disasters such as the 1995 Kobe earthquake, rapid
27 fire-fighting operations help to save lives and protect property (Namba et al., 1997). In addition, police presence play an important
28 role in controlling and monitoring public security (Varano et al., 2010; Sullum et al., 2010). Another aspect that can lead to an
29 effective disaster response is community involvement in responding to a disaster (Colina et al., 2004; Zhang et al., 2013). Therefore,
30 response operations can be challenging due to lack of information, absence of required resources, and limited access to damaged
31 areas, violation of security and disruption of communication systems, outbreaks of fire, and massive numbers of fatalities (Auf
32 Der Heide, 1989; Chen et al., 2011; National Disaster Management Organization (Ndm), 2011; Nekoei-Moghadam et al., 2016).
33 All of the challenges described above show the complexity of the response phase.

34 This research aim is to measure timeliness in disaster response activities, as seen in figure 1. A response timeline that is created
35 according to the activities that have been performed in the aftermath of an earthquake can assist disaster manager in evaluating
36 their response to the earthquake. For example, a response timeline that was developed for Hyogo prefecture in Japan based on the
37 records of the 1995 Great Hanshin-Awaji Earthquake, the 2011 Great East Japan earthquake, and the Awaji Island earthquake in
38 2013 that it provided useful idea for disaster manager regarding what to do and how to do it after a disaster (Kikakuka, 2015). In
39 another example, a response timeline was presented regarding government's response in the aftermath of the Nepal (Gorkha)
40 earthquakes in 2015 (Gama, 2015; United Nations Development Programme (Undp), 2016; Earthquakes and Megacities Initiative
41 (Emi), 2015) and also a timeline that was reported on the parliament's response to the Canterbury earthquake in New Zealand
42 (New Zealand Parliament, 2010). These response timelines can help disaster managers in designing or revising the strategic
43 response plans in case of any future earthquakes occurrence. However, in case of the Bam earthquake, there was lack of studies on
44 producing a response timeline for this earthquake, and this is the motive behind conducting this research. Therefore, this study
45 investigates the timeliness of response activities to the affected area by conducting semi-structured interviews with disaster
46 managers who were involved in the Bam earthquake.

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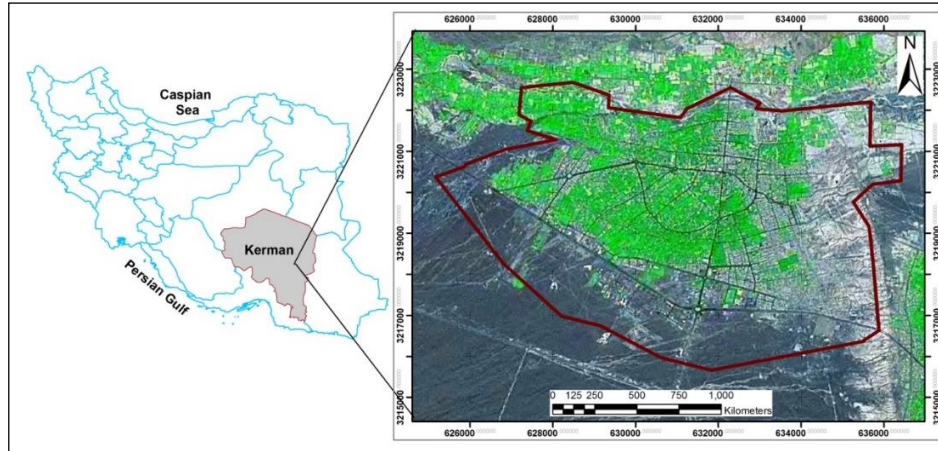
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49 Figure 1. A. Disaster management cycle (Alexander, 1993), B. Disaster response activities and C) Performance measurement
50 (Abir et al., 2017)

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52 **2. Material and methods**

53 This study was based on a qualitative research approach, and data were collected through reviewing literature and interviewing
54 disaster managers to clarify the timeliness of main activities in disaster response. This study has been conducted through several
55 stages as explained in the following: Selecting the Bam earthquake as a case study, collecting data by interviewing disaster
56 responders including managers and experts who were involved in disaster response activities during the Bam earthquake,
57 conducting thematic analysis method, and interpreting the results by considering other studies.

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59 **2.1. Case study**

60 Bam city that was struck by a devastating earthquake in 2003 (Ahmadizadeh and Shakib, 2004) has been selected as a case
61 study. It is located in the southeast of Iran (Figure 2). This city was selected because of the existence of an adequate data and
62 literatures regarding the impact of earthquake on buildings, population and infrastructure, and availability of disaster managers
63 who were involved in disaster-response in the earthquake for conducting interview surveys.



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Figure 2. Geographical location of Bam city

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The Bam earthquake occurred on 26 December 2003, at 05:56:56 local time (01:56:56 Greenwich mean-time) when many people were sleeping in their homes. The magnitude was reported at 6.3 mb (body wave magnitude) by the Geophysical Institute of Tehran University (Geophysical Institute of Tehran University (Gitu), 2003). Surface wave magnitude measured 6.7 Ms and moment magnitude was determined as 6.6 Mw by the US Geological Survey (U.S. Geological Survey (Usgs), 2003; Ahmadzadeh and Shakib, 2004). Moreover, two foreshocks occurred the night before the earthquake, at approximately 15:00 and 22:00 local time, and another foreshock was felt 35 minutes before the main shock, with a magnitude of less than 4 Richter (Berberian, 2009). Zare (2004) mentioned 5 foreshocks greater than 5 Mb just seconds before the main earthquake.

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The earthquake inflicted considerable impact on the population and buildings. The infrastructures and also historical places were badly affected (Ghafory-Ashtiany and Hosseini, 2008). The Statistical Centre of Iran (Statistical Centre of Iran (Sci), 2004) collected the post-earthquake data on the impacts of the earthquake on the population and buildings of Bam city via a street survey in 2004. According to this information, 19,087 families (89,145 people), were living in Bam city at the time of the earthquake. As a result of the earthquake, 22,391 people were killed, 8,136 were injured and hospitalized, 55,167 were not injured, and 422 people were missing (Statistical Centre of Iran (Sci), 2004).

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The total number of buildings in the affected region was 45,395, of which 34,093 collapsed, while the remaining 10,827 were partially damaged. These included 131 school and healthcare buildings in the Bam region (Statistical Centre of Iran (Sci), 2004). In Bam city, there were a total of 28,625 buildings and gardens in Bam city, of which 26,111 collapsed and 2,381 were partially damaged (Statistical Centre of Iran (Sci), 2004). From the total number of buildings and gardens, 22,585 units were individual buildings and the remaining were included in the gardens (The level of destruction of a garden mostly related to its surrounding walls which can cause road blockages). According to the building damage map produced by the National Cartographic Center of

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86 Iran (National Cartographic Center (Ncc), 2003) via image processing of the aerial photos (taken 3 days after the earthquake),
87 about 80% of all buildings were destroyed (Earthquake Engineering Research Institute (Eeri), 2004).

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89 **2.2. Disaster management system in Iran**

90 Management of natural disasters in Iran was under the responsibility of a special disaster task force in the Office of the President
91 before 1991. Since 1991, several changes were made in the disaster management structure, especially after the Manjil Earthquake
92 in 1990. On a national level, disaster risk management came under the Ministry of Interior (MOI). The responsibilities and
93 functions related to natural and human-made disasters were formally assigned to this Ministry by virtue of the Budget Act in 1991
94 (National Disaster Management Organization (Ndm), 2011). Two specialized bodies were created to provide support and to
95 operationalize the disaster management activities: A) the Bureau for Research and Coordination of Safety and Reconstruction
96 Affairs (BRCRS), which was tasked with mandates including research; formulation of preparedness and mitigation plans;
97 collection, analysis and dissemination of related information; coordination of relief, reconstruction and rehabilitation activities. B)
98 The National Disaster Task Force (NDTF), which was established as an inter-organizational coordinating body, particularly for
99 emergency relief operations in the national territory. Emergency response across sectors was under the responsibility of the
100 ministries that were coordinated by the NDTF. The manager of the NDTF was also the director of BRCRS. Based on the enactments
101 of the National Committee for Reduction of Natural Disaster act in 1991, the role of the Ministry of Interior and this committee
102 was established as a policy and decision-making body, with the mandate to research and explore practical ways to mitigate natural
103 disasters (National Disaster Management Organization (Ndm), 2011).

104 In 2003, the Rescue and Relief Comprehensive Plan (as an Integrated National Disaster Management Plan (INDMP)) was
105 approved by the Council of Minister's Decree. According to this plan, three major components were introduced: 1) A National
106 Disaster Task Force (NDTF), chaired by the Minister of the Interior. The main functions of the NDTF were policy-making,
107 decision-making and coordination of different organizations' activities in the mitigation, preparedness, response, and recovery
108 phases of disaster management. 2) The National Committee for Preparedness against Natural Disaster (NCPND) was responsible
109 for training, research, planning, and exercises for disaster management. There were three specialized working groups under this
110 committee, including operation, education, and prevention and management of disasters. 3) Specialized affairs that were
111 responsible for the other issues related to disaster management of the natural and human-made disasters. These components were
112 suggested at national, provincial, and township levels (National Disaster Management Organization (Ndm), 2011).

113 Since the Bam earthquake disaster in 2003, the Headquarter Council of Disaster Management and Prevention was established
114 by the Council of Minister's Decree in 2004 under the Presidential office. This decision allowed for effective and comprehensive
115 disaster management and coordination among all the organizations involved in disaster management (National Disaster Management
116 Organization (Ndm), 2011).



117 In 2008, under a new National Disaster Management Law passed by the Parliament, the National Disaster Management
118 Organization (NDMO) was formed. NDMO aimed to utilize the national, regional and local capacities to cope with all forms of
119 disasters. Moreover, it was to create an integrated management system for planning and coordinating executive activities in a
120 cohesive manner over different phases of disaster management in affected areas (as it was discussed in the Rescue and Relief
121 Comprehensive Plan in 2003). The objectives of NDMO were to utilize the full potential and resources available from government
122 ministries, public institutions, and private sectors. These involved banks, insurance companies, military forces, non-governmental
123 institutes, Islamic councils, municipalities, public associations, and organizations under the auspices of the Supreme Leader of the
124 country. In order to coordinate the activities of the involved organizations (organization which were primarily responsible to
125 manage a disaster) and institutions affiliated to the legislative, executive and judiciary organs, and the Armed Forces, and enacting
126 of regulations and standards governing the four phases of disaster management (prevention and mitigation, preparedness, response
127 and recovery), the Supreme Council of the National Disaster Management Organization was formed.

128 The Disaster Management Coordination Council has also been formed under the chairmanship of the Head of National Disaster
129 Management Organization. Membership of the representatives deputizing the related organizations and agencies coordinated the
130 activities regarding the four phases of disaster management. Disaster Management Coordination Council at provincial and city
131 levels were formed under the chairmanship of the Governor Generals and Governors, respectively. The membership included all
132 relevant organizations involved and twenty-two specialized groups from relevant ministries and organizations to cooperate with
133 the Disaster Management Organization (Seyedin, 2005) (National Disaster Management Organization (Ndm), 2011) (Ali Ahamadi,
134 2012; Ardalan et al., 2012). Therefore, an integrated structure for disaster management was formed in 2008 in different
135 administration levels, including national, provincial, township, and city levels (National Disaster Management Organization
136 (Ndm), 2011) and the law was passed in the parliament in 2019 (Parliament, 2019). The main changes were at the city level, where
137 many organizations involved in disaster management should be prepared to cope with a probable disaster. All this happened as a
138 results of disaster management challenges in responding to the Bam earthquake.

139 140 **2.3. Study Design**

141 Qualitative research methods were used to explore perceptions of disaster response timeliness among a group of disaster managers
142 (people who made the decision on how to react) and experts that were involved in responding to the Bam earthquake in 2003 in
143 order to generate more detailed insights into timeliness of the numerous response activities in the aftermath of the earthquake (the
144 focus was primarily on Iranian actors). In doing so, in this research in-depth interview approach was selected. Although, focus
145 groups can allow for the maximisation of data collection, particularly if time is limited (Acocella, 2012), but participants can hide
146 the truth in presence of other colleagues (Sim, 1998). However, interviews can provide in-depth information and insight that cannot
147 be discussed in a group of people coming from different organizations (Sim, 1998). Therefore, based on individual interview
148 approach, the researcher ensure a comprehensive data gathering in all aspects of disaster response regarding what response
149 activities were conducted, how and when they were operated in the aftermath of the Bam earthquake in 2003.



150 To ensure all aspects of disaster response are considered a questionnaire was designed based on extracted themes by reviewing
151 extensive literature in Persian and English languages regarding the response phase of the Bam earthquake (Figure 3). Then, semi-
152 structured interviews were conducted with disaster managers and experts from different governmental and non-governmental
153 sections in different hierarchical levels. They were selected based on the snowball sampling or chain-referral sampling method
154 (Biernacki and Waldorf, 1981). In This method after observing the initial subject, the researcher asks for assistance from the subject
155 to help identify people with a similar trait of interest. The researcher then observes the nominated subjects and continues in the
156 same way until a sufficient number of subjects are obtained.
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Disaster Response Timeliness Questionnaire

1. Basic information: Sex: Age:..... Education Level:.....
2. What organization you were working in at the time of earthquake? What was your duty in the organization? Organization:..... Job/ Occupation:.....
3. What was your responsibility in responding to the Bam earthquake?
4. When did you make aware of the earthquake occurrence? What did you do?
5. When first disaster management committee of your organization was held?
6. When did your organization send help to the damaged area?
7. When did you (your colleagues) reach the damaged area?
8. Alerting and warning theme:
 - When and how did you find out the exact location that earthquake happened?
9. Situational awareness (damage, loss and needs assessment) theme:
 - When did you get the first situational awareness report on the damaged area?
 - When did you find out regarding the extent of damage and losses caused by the earthquake?
 - When did you get the first report on required resources?
10. Conducting USAR operations theme:
 - When and how were first USAR teams dispatched toward the damaged area and get there?
11. Evacuating casualties and providing medical services theme:
 - When were injured people evacuated from the damaged area? How this happened?
 - When were medical services and supplies got to the damaged area?
12. Delivering supplies and distributing resources such as food and shelters (tents) theme:
 - When and how were required resources (food, water and tents) got to the damaged areas?
 - When and how were resources distributed among people?
13. Burying corpses theme:
 - When was burying corpses started? How was it done?



14. International support theme:

- When was the first international help alert issued?
- When and how were first international SAR teams arrived at the damaged area?

Explanation by the researcher:.....

Figure 3. Disaster response questionnaire

2.4. Participant recruitment

Disaster responders (managers and experts) in main organizations who were involved in the response activities to the Bam earthquake, and they were experienced in a variety of response activities to the other earthquake with varying degrees of education and age were selected by the researcher using snow ball sampling method. Kerman Disaster Management Centre (KDMC) invited the selected managers or experts for an interview. It was intended that at least thirty interviews would be necessary because of the variety of response activities to the Bam earthquake. A tailored form of information was given to the involved interviewee outlining the following: study objectives; the use of data; the protection of participant privacy; and the results dissemination. Individual interviews were conducted between August to December 2011. As noted by Brod et al. (Brod et al., 2009) data collection should continue until no new insights are produced (i.e. data saturation). In total, thirty individuals participated in the interviews to ensure that all aspects of the response activities were covered. All interviewees were highly experienced and had been involved in organising responses for different earthquakes, such as Zarand (-Mansourian), Bam (2003), Sirch (1981) and Golbaft (1981). Eight of them had participated in responding to three earthquakes, and all had more than four years of experience in disaster management and search and rescue operations, with a broad range of experiences covering many aspects of disaster-response. The average age of the sampled individuals was 46 years, and with 83% having a university degree. A breakdown of the interviews in terms of participants' organization, participant numbers, and their experience of earthquake response activities are documented in Table 1.

Table 1. Demographic characteristics of the study participants in the interviews

Participants organizations	No of Participants	Average Age	level of Education	Employment status	Participants experiences
Paramedics and Health Services of Kerman and Bam cities	5	49	University Level	Full Time	In Zarand (2005) [48][48][48][48][48] [45][45][45][45] 45(45)(45)(45), Bam (2003) earthquakes



Iranian Red Crescent Society of Kerman and Bam cities	5	43	University Level	Full Time	In Zarand [48][48][48][48][45][45][45]
Local and provincial government authorities of Kerman and Bam cities	8	44	One Diploma and Seven University Level	Full Time and Two Part Time	45(45)(45)(45), Bam (2003), Sirch (1981) and Golbaft (1981) earthquakes
Municipalities of Kerman and Bam cities	5	49	Two Diploma and Three University Level	Full Time	
Fire-fighting organizations of Kerman	7	45	Two Diploma and Five University Level	Full Time	In Zarand (2005) [48][48][48][48][45][45][45]45(45)(45)(45)(45), Bam (2003) earthquakes

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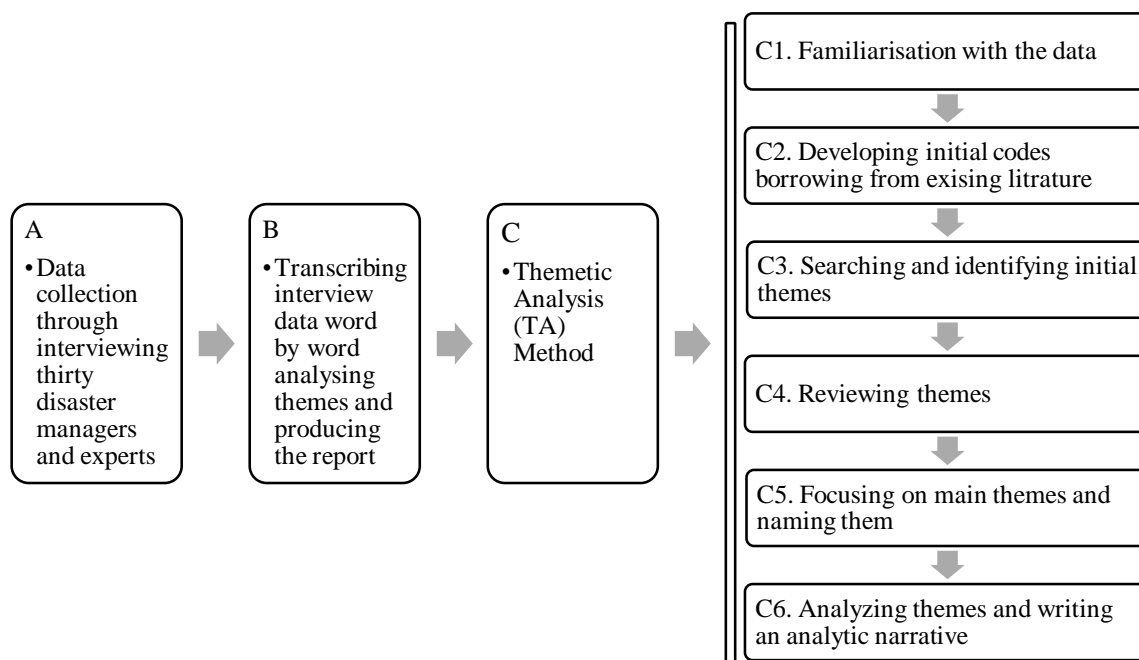
2.5. Data collection

A review of existing literature on earthquake disaster response and disaster response metrics helped inform the development of a topic guide for the purpose of data collection. The topic guide covered a number of thematic areas, which sought to elicit the perceptions of participants in relation to: earthquake risk; previous earthquake experiences; levels of preparedness to response; disaster response activities and disaster response timeliness: time when responders reached the damaged area. In data collection process, the interview was conducted in a meeting room around a table facilitating face-to-face interaction with the participant. Interviews took between 30 to 60 minutes, and they were recorded digitally with the verbal consent of participants. Kitlinger (1995) stated that participants might express a response bias, sharing opinions and viewpoints in favour of their organizations. In order to address such challenge, the interviewer tried to seek for verification and validation from participants throughout the data collection phase by asking them the same questions and repeating viewpoints back to the other relevant participants to see if answers of all interviewees in the same theme are similar. This process would assist researcher to make sure regarding “interpretive validity and research rigor” (Morse et al., 2002).



192 **2.6. Analysis**

193 Transcribing the recording by the researcher helped an initial familiarisation with the data (Braun and Clarke, 2006). Through
194 transcribing process, all identifiable information were removed from the transcripts and the researcher have called them interview
195 1 (Int1) to interview 30 (Int30). The unit of analysis formed by individual lines of transcript, and each individual spoken passage
196 contains a section in the transcripts. The coding was done manually using Excel software to be able to conduct the study using
197 well-known Thematic Analysis (TA) method (Boyatzis, 1998; Braun and Clarke, 2006). Thematic analysis is a method for
198 identifying, analysing, and reporting main themes in data that consists of following stages, as seen in Figure 4.
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200

201 Figure 4. Thematic analysis flowchart

202 In order to facilitate analysing data deductively, in the early steps of analysis, “borrowing” concepts and codes from existing
203 literature was utilized (Benaquisto and Given, 2008). Thus, the initial codes and concepts were identified by a review of existing
204 literature documenting disaster response activities, timeliness and effectiveness in the aftermath of earthquakes, concepts
205 associated with disaster response metrics (Abir et al., 2017). These were mainly useful in terms of organizing the data relevant to
206 borrowed themes (e.g. ‘response activities’, ‘warning and alerting’, ‘response timeliness’, ‘response effectiveness’, ‘resources
207 distribution’ etc.), specifically ‘timeliness and efficacy’ (Abir et al., 2017). A number of criteria were determined in order to assign
208 data to different themes including which response activity participants was referred to, the time of reaching to the damaged area
209 by responders of that specific response activity, describing how that activity was done in the damaged area. Thus, participant must
210 referred to a specific response activity in their comments in order to be assigned to the specific code such as “alerting and warning,



211 situational awareness (damage, loss and needs assessment), conducting USAR¹ operations, evacuating casualties and providing
212 medical services, delivering supplies and distributing resources, burying corpses, and international support”. In certain
213 circumstances, it was difficult to clearly assign some comments solely to one particular component of cognitive process (theme).
214 In such cases, the comments were attributed to relevant themes for completeness of data and then were analysed within the broader
215 context of the results.

216

217 3. Findings

218 By reviewing existing literature and analysing interview data, eight main themes were developed regarding disaster response
219 timeliness in each activity in the aftermath of the Bam earthquake. These themes are described and contextualized in the following
220 sections:

221 3.1. Timeliness in alerting and warning

222 Alerting and warning is all about making aware disaster responders exactly what happened and where it happened. They should
223 be prepared always to act accordingly as fast as possible. The first alert on the epicenter of the earthquake was wrong that made
224 responders confused on the place of being hit by the earthquake, as Jazmoorian was not populated, and there was not any dense
225 urban areas. This may make them to think of not being quick in first hours after the earthquake. Although, disaster responders
226 reached the Bam city around 2 hours after the earthquake:

227 *“... We start riding toward Jazmoorian around 6:30 am in the morning, but on the way we saw several cars was moving*
228 *toward Kerman city and one of drivers pointed at us with bloody hands and we got the point that the damage level was*
229 *heavy. We reported back to Kerman center and asking for more help. We traveled around 150 km and later in the security*
230 *point; they told us the earthquake center was Bam city. We reached the Bam city around 7:50 a.m....” (Int8)*

231 The Bam earthquake happened early morning on Friday, a weekend in Iran, therefore, many of disaster managers were not at
232 work, they were at their home. As many interviewees report on this situation:

233 *“... I was at home, and then I have woke up by the shaking, then 5 minutes after the earthquake my colleagues reported*
234 *that the earthquake epicenter was in Jazmoorian. But in the meantime another colleague who was from Bam range me*
235 *and said that I have tried many times to contact my family in Bam city but it seems telephone lines are busy and no one*
236 *answered the phone....” (Int1)*

¹ Urban Search and Rescue



237 Few evidence shows that the earthquake epicenter was not Jazmoorian and they could see cars coming toward Kerman city that
238 carries injuries and also people in south part of Kerman Provinces could answer their phones, but no one in Bam could answer
239 their ones:

240 *“... My relatives were in Bam city and I tried to contact them, but no one answered my calls, still I did not know where*
241 *the earthquake epicenter was. We dispatched three ambulances toward south part of Kerman province with the hope of*
242 *finding the exact place. Around 80 kilometer far from Kerman city, we witnessed damaged cars moving toward Kerman*
243 *city asking one of them, then we found out the earthquake epicenter was in the Bam city. It was around 6:30 am We*
244 *got to Bam around 7:30 a.m.... ” (Int4)*

245 Making aware the involved organizations regarding the real situation in the affected area should be done quickly. It was one
246 and half-hour later that first disaster management meeting was held in Kerman city:

247 *“... The first Disaster Management meeting was held at 7:00 a.m. in Kerman city.... having all involved organizations in*
248 *the meeting, here we found out the damage level in Bam city, then asked for help from other cities, it was 7:30 a.m....”*
249 *(Int5)*

250
251 **3.2. Timeliness in situational awareness (damage, loss and needs assessment)**

252 Situational awareness means to be aware of the extent of damage and loss, and also what and how much required resources is
253 needed to cope with the disaster. As outlined by some of the participants, it was a slow process of assessing the damaged area and
254 reporting to top disaster managers on the real situation in Bam city. First reports were ambiguous that reported light destructions
255 of buildings in the area that seems there was lack of conducting proper field observation before this report:

256 *“ ... I got to my office around 6 a.m., the first official call was from police brigade in Bam city at 6:30 reporting on the*
257 *situation in Bam city as light damage level in the area. There was no news about the governor of Bam at that time...”*
258 *(Int6)*

259 Being able to report on the situation in the affected area needs dedicated personnel who in Bam city, they were injured or killed or
260 their relative were effected severely by the earthquake:

261 *“...We could not find anyone, no mayor, no governor; everybody was missing...there were no facilities on the scene to*
262 *assess the extent of damage... Many organizational personnel were killed or injured...no one was at work at 5:27 a.m. on*
263 *Friday morning at the weekend...” (Int20)*

264 In first disaster management meeting in Kerman city, still there was not clear information on what happened in Bam. We had real
265 observations around 8:30 a.m, and the second report on the situation of Bam city at 11:00 a.m. declaring massive destruction to
266 buildings that caused many casualties:



267 *“...We flied to Bam city by a helicopter. Above Bam, we witnessed a destroyed city. It was around 9:30 a.m. ...” (Int9)*
268 *“...The second report on the situation in Bam city announced at 11:00 a.m. reporting extensive building damage and*
269 *population loss...” (Int14)*

271 **3.3. Timeliness in conducting Search and Rescue (SAR) operations**

272 Conducting SAR is the most important activity in disaster response operation that can save many lives if it starts quickly.
273 People are the first ones on scene, then they can save many others who need help, either tapped people under debris or got injured,
274 as mentioned by interviewees:

275 *“... In the first hours, people saved themselves. There was no management system in place at the beginning... ” (Int13)*

276 *“...We got to the scene around 11:00 a.m., but by that time many people were saved by their relatives or their*
277 *neighbours...” (Int23)*

278 Professional SAR teams got to the damaged area by delay, lack of professional rescuers was a big challenge in first day of the
279 earthquake:

280 *“...Many people were trapped under debris. The speed of SAR operation was slow and rescuer got to the damage area*
281 *very late. Required equipment was not available. Entrapped people were dragged out of debris by force, and because of*
282 *this action their spinal cord was cut that caused many people to be paralyzed (crash syndrome) forever...” (Int3)*

283 *“...SAR teams of Iranian IFRC and their rescue dogs came to Bam city on Saturday noon. They could find 670 people*
284 *who were buried under debris... ” (Int12)*

286 **3.4. Timeliness in evacuating casualties and providing medical services**

287 Evacuating injuries and providing medical services should be done quickly to ensure saving more lives. Ordinary people
288 assisted trapped and injured people, but their help in some cases was not done in an appropriate way, as they sometimes dragged
289 injuries out of debris by force and they carried them on a blanket or a soft bed:

290 *“...Many people were injured. Ordinary people carried some of injuries on a blanket to cars or ambulances and then got*
291 *to the first medical centre in Bam... Sometimes injuries were dragged out of debris by force that could cause some of*
292 *them crash syndrome (their spinal cord could be cut ... these people could be paralyzed for the rest of their life... (Int27)*
293

294 Many cars rushing toward Bam city that caused traffic jam and road blockage in the entrance of the city, then no one could get
295 out of city. In this situation, air transportation could be the only option:



296 “...Around 4 p.m. main road toward Bam city was blocked by many cars wanted to get into the city. No one could get out,
297 therefore, many injuries were stuck in the traffic jams. This situation made rescue operation very slow. It was around 17
298 hours of road blockage at the Bam entrance road...” (Int6)

299 “...We asked people to bring their injuries to the Bam airport around 4 p.m. ... Air transportation was the only way to
300 evacuate injuries from Bam and transport them to other hospitals. It started around 10 p.m., by this time many injuries
301 were died in the airport saloon....” (Int17)

302
303 Being aware of all affected locations should be the aim of comprehensive disaster response plan. Involving every single place
304 in the plan and not forgetting anywhere:

305 “...We focused only on Bam and forgot other villages around the city...” (Int8)

306

307 3.5. Timeliness in delivering supplies and distributing resources

308 Preparing supplies and resource distribution is not a primary issue in the first hours, but disaster managers should pay attention
309 to what are the needs of people in the affected area. Enough amount of resources such as food, shelter, clothing, women needs are
310 very important to be delivered to the area and to be distributed in an organized, and respectable way to people in need. As, it was
311 a challenge in first days in Bam:

312 “... In first day of the earthquake on Friday evening, resource distribution was random and unorganized...” (Int3)

313 “... The first supply container got to Bam around 3 p.m. including food and shelter, but it was not enough at all...” (Int17)

314

315 Knowing where to go and how to get to people in need is a challenge. In Bam city, there were not proper street networks everywhere
316 to service all affected people:

317 “... Main streets remained running, but some of narrow alleys were completely blocked, especially in old part of the city.
318 This caused resource distribution to be hampered. Affected people who were living near main streets could get food and
319 tent quickly, but people who were in those narrow alleys couldn't get any resources in two first days...” (Int14)

320 “...There were many gardens in Bam city and their walls were destroyed and they were blocked the road...these
321 blockages were hampered accessibility to far areas from main streets. People in these areas could not get enough food
322 and shelters in first days...” (Int4)

323

324 3.6. Timeliness in burying corpses



325 Massive destruction can kill many people in the affected area. Existence of many corpses on the affected area can endanger
326 people's health. Therefore, one of the disaster response action should be dealing with this situation quickly. The Bam earthquake
327 caused many fatalities. Many of corpses were buried by their relatives in the Bam cemetery. In the first hours, there was no
328 equipment to excavate the ground and people only used shovel to grave their loves one:

329 *"...Many people were died under debris, and they were dragged out of debris and then buried by their relatives in the*
330 *Bam cemetery... In the first hours, corpses were buried in holes that excavated by hands disorderly everywhere...they*
331 *were not deep enough so that animals could bring them out... around 3000 corpses were buried in this condition..."(Int7)*

332 *"...Saturday morning around 8:00 a.m., we started to excavate canals width of 2 meters and length of 40 meters and*
333 *depth of 2 meters by mechanical excavators. In each canal around 140 to 150 corpses were lined up beside each other*
334 *and then their locations were marked by their relatives and then were covered by soil..." (Int24)*

335 *"... Burring corpses was started from Friday evening and continued till 5 days after the earthquake. Many people were*
336 *buried on the second and third days of the earthquake..." (Int24)*

337

338 **3.7. Timeliness in international support**

339 Fast damage and loss assessment is key to determining the level of needed help and asking for international support. When the
340 extent of disaster and its damage is huge and the national government cannot handle the situation, international help alert will be
341 issued. In case of Bam, it happened ten hours later:

342 *"... First alert on international support was issued around 3:30 p.m..." (int7)*

343

344 SAR operations are the most influential part of any response plan. As, international SAR teams are equipped with advanced
345 technologies that can facilitate determining the location of trapped people under debris and then save more lives:

346 *"... SAR teams from Switzerland reached the Bam a day after the earthquake on Saturday morning at 8:00 a.m., and then*
347 *we had to other SAR teams on Saturday eveningthere were 15 field hospitals of foreign countries that were established*
348 *7 days after the quake..." (Int8)*

349 *"... International teams were completely equipped, but our volunteers did not have even a shovel..." (Int9)*

350

351 International help such as food and clothing should be compatible with the culture of affected people:

352 *"... International helps (food and clothing) were not compatible with the needs of people in the Bam city" (Int9)*

353



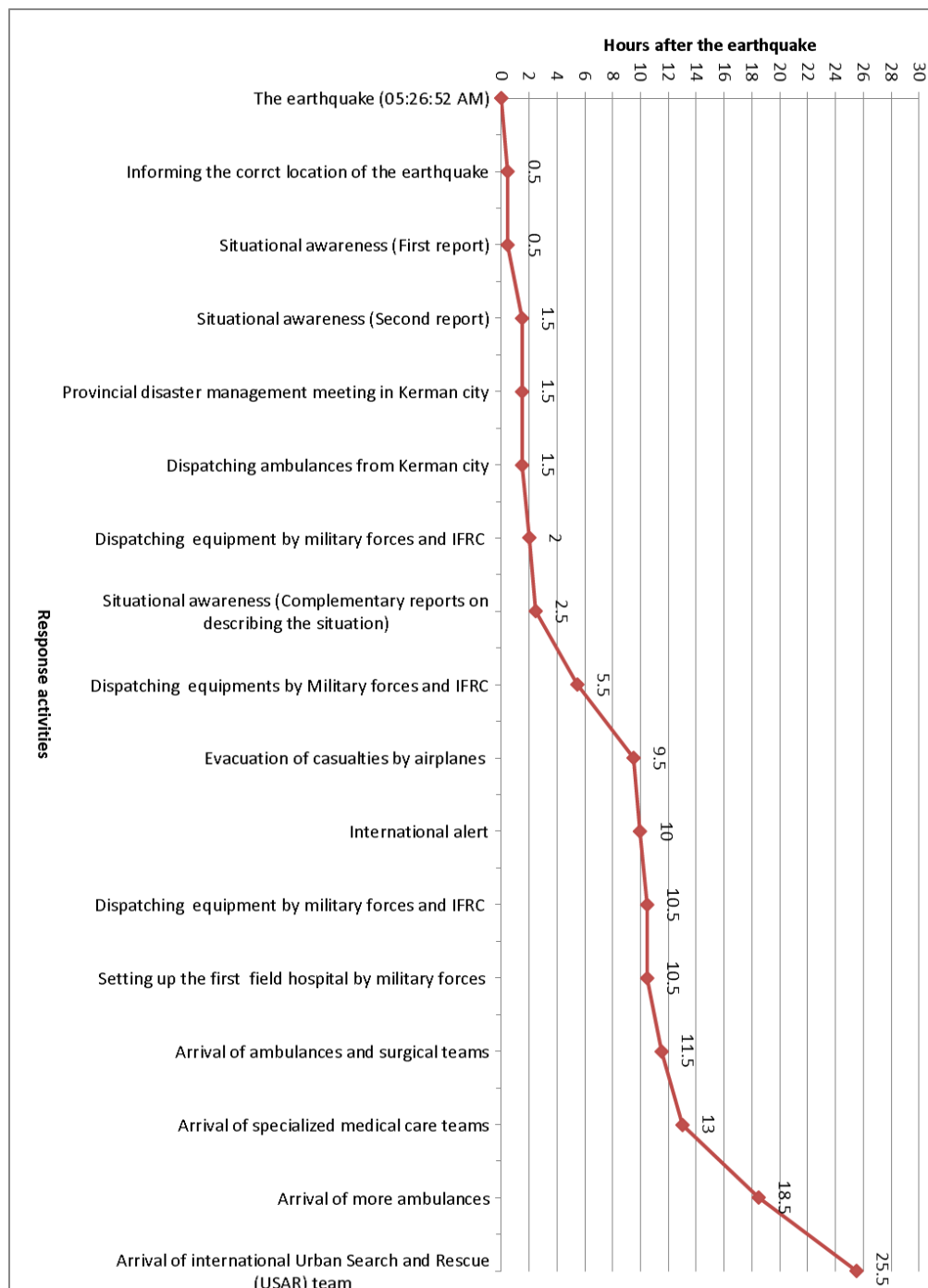
354 Based on in-depth analysis of interview data with disaster manager and reviewing the literature as interpreted above response
 355 activities according to the arrival time at the affected area are listed and described in Table 2 and Figure 5.

356 Table 2. Response time in 26 hours after the Bam earthquake

Time	Hours after the earthquake	Explanation
05:26:52 AM (Local time)	0	Event: Earthquake alert: Friday, December 26, 2003 at 01:56:52 (Lam et al.) Magnitude: 6.6 Ms
5:59 AM	35 min	Informing the correct location of the earthquake
5:59 AM	35 min	Provincial awareness: The first report was sent 35 minutes after the earthquake by the commander of the 1st Brigade of Bam
7:00 AM	1.5h	Situational awareness: Reports on describing the situation and requesting help were sent by the commander of the 1st Brigade of Bam city
7:00 AM	1.5h	Provincial disaster management meeting in Kerman city
7:00 AM	1.5h	Dispatching two ambulances from Kerman: They were in Bam city
7:30 AM	2h	Military equipment and facilities: Military forces dispatched to Bam city; they were in the damaged areas by 8:00 AM (Arrival of the first team in the damaged area)
8:00 AM	2.5h	Situational awareness: Complementary reports on describing the situation and requesting help were sent by the commander of the 1st Brigade of Bam city



11:00 AM	5.5h	Military equipment and facilities: Transport of 150 medical personnel to the damaged area
15:00 PM	9.5h	Evacuation of casualties by airplanes: The evacuation was done via Bam airport.
15:30 PM	10h	International alert: The Iranian authorities launched a request for international assistance.
16:00 PM	10.5h	Military equipment and facilities: On the day of the disaster, 937 medical assistance personnel were transferred to the damaged area. The first Iranian field hospital was set up by Iranian military forces in the area on the first day.
17:00 PM	11.5h	Arrival of ambulances and surgical teams: 102 ambulances, 8 field emergency stations, and 4 surgical teams arrived in the damaged area.
19:00 PM	13h	Arrival of specialized medical care teams: They arrived in the city almost 14 hours after the earthquake.
12:00 PM (Midnight)	18.5h	Arrival of ambulances: 24 self-sufficient ambulances and vans arrived in the damaged area.
7:00 AM on 27 December 2003	25.5h	Arrival of international Urban Search and Rescue (USAR) team: Switzerland provided the first Urban Search and Rescue team, who arrived at Bam airport on the morning of 27 December. USAR teams from 10 countries arrived in Bam on 27 December late evening.



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Figure 5. The earthquake disaster-response time line (in 26 hours after the earthquake)



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4. Discussions

According to interviews data, only main themes regarding response activities, during the 26 hours after the Bam earthquake are described. These include: alerting and warning, situational awareness (damage, loss and needs assessment), conducting USAR operations, evacuating casualties and providing medical services, delivering supplies and distributing resources such as food and shelters (tents), and burying corpses, and, finally, international support.

4.1. Alerting and warning

The first alert was issued by the Geophysical Institute of Tehran University (Geophysical Institute of Tehran University (Gitu), 2003), reporting an earthquake occurrence in south of Kerman province in Jazmoorian region, an area about 200 km from the real earthquake's location. However, about 35 minutes later, according to the Disaster Management Task Forces of Kerman province, and reports coming from the military commander of Bam city, the earthquake epicenter was precisely identified in Bam city. It caused a delay in informing the involved organizations in dispatching their resources to the damaged areas. Additionally, the delay in responding to the earthquake happened because of the lack of proper information on the extent of damage to buildings and population (the situation) in the affected area (Naserasadi, 2004; Berberian, 2009) because some communication towers located on rooftops of collapsed buildings were damaged (Nadim et al., 2004; Manafpour, 2003; International Federation of Red Cross and Red Crescent Societies (Ifrc), 2004). As a result, the telephone lines, mobile phone networks, and Internet networks were disrupted after the earthquake.

4.2. Situational awareness (assessing damage, loss and needs)

The primary information on the impact of the earthquake on the building damage and population losses were reported by the military commander about 35 minutes after the earthquake. The initial assessments were not of much concern and disaster managers thought that damage was negligible or very light; this was because of the lack of information on the ground. However, complementary reports on the situation, the damage to buildings and infrastructures, and population losses 1 and 2 hours after the disaster, indicated the real critical situation on the ground.

The first official map of the building damage in the city was produced using aerial photography two days after the earthquake on 28th of December (Alavi Rzavi, 2008; Manafpour, 2003). Furthermore, the United Nations Disaster Assessment and Coordination (UNDAC) teams arrived early on the morning of 28 December and performed the first rapid assessments of the disaster zone to estimate the resources required in assisting the victims of the earthquake.

4.3. Conducting USAR operations

The emergency response services of the city (the governor's office, fire services, police stations, and health and medical services) were all severely affected. Many people working in these public sectors were either killed or injured. The Governor's office, which was supposed to be the disaster management centre, was severely damaged. The main firefighting centre and some



391 of the police stations had completely collapsed (Nadim et al., 2004; International Federation of Red Cross and Red Crescent
392 Societies (Ifrc), 2004; Akbari et al., 2004; Manafpour, 2003). The impact of the earthquake on the population, buildings, and
393 infrastructure was extensive. Consequently, hampered the functionality of local emergency management services and postponed
394 the disaster-response activities in Bam city.

395 In the early morning hours, after the Bam earthquake, the survivors desperately tried to help their family members and neighbors
396 who were missing or trapped under the debris of collapsed buildings. Within half an hour of the earthquake, the Iranian Red
397 Crescent Society (IRCS) began to mobilize its emergency response teams and, within two hours, the first IRCS urban search and
398 rescue (USAR) teams had reached Bam city. Moreover, the first assistance teams of Iranian military forces arrived to the damaged
399 area 2 hours after the earthquake. It was followed by the arrival of military forces of different brigades of the Kerman Province in
400 the area at 11 AM. In addition to the official operations, many volunteers from various segments of Iranian society came to the
401 region to help those affected.

402 **4.4. Evacuating casualties and providing medical services**

403 All three main hospitals and 10 urban health centres were destroyed and rendered unusable. Many people working in these
404 public sectors were either killed or injured. Due to the extensive damage and unavailability of local healthcare workers, only one
405 health facility was functional in Bam city after the earthquake (International Federation of Red Cross and Red Crescent Societies
406 (Ifrc), 2004; Earthquake Engineering Research Institute (Eeri), 2004).

407 The majority of the evacuated victims (serious injuries) were transferred to first-line treatment centers by ambulances and other
408 vehicles. They have been admitted to 12 hospitals in the neighbouring cities and big cities in Iran. Many of these treatment centers
409 were located in the cities of Kerman and Jiroft, 185 km and 120 km far from Bam city, respectively.

410 Many casualties were transported to the airport as the second major settlement center before air evacuation. The injuries were
411 examined by medical professionals at the airport and the level of medical care required was identified and categorized as red
412 (urgent), yellow (delayed or expectant), green (minor), or black (deceased) (Mohebbi et al., 2008). The air evacuation started
413 around 3 PM, about 9.5 hours after the earthquake occurred. In the first 48 hours after the earthquake struck, more than half of the
414 23,000 injured people were evacuated to large hospitals around Iran using civilian and military aircrafts, helicopters (air
415 evacuation), ambulances and private cars (road transport). According to a study by Mirhashemi et al. (2007), 41.7% of the patients
416 were transported to hospitals by air, 15.1% by private vehicles, and 22.7% by ambulance. It took, on average, 25.2 ± 16.3 hours to
417 reach a hospital. For example, the first group of patients reached the Chamran Hospital in Shiraz just 12 hours after the earthquake
418 (Emami et al., 2005).

419 In addition to twelve large hospitals in neighboring provinces, a dozen field hospitals provided by international relief medical
420 groups and the Red Crescent Society were involved in providing medical care to the victims (Abolghasemi et al., 2005). For



421 example, the first Iranian field hospital was set up by Iranian military forces on the first day at 11 PM, and 937 medical assistance
422 personnel were transferred to the area (Abolghasemi et al., 2006).

423 **4.5. Delivering supplies and distributing resources**

424 The infrastructure of Bam city suffered a range of slight to heavy damage. The distributing network of drinking water and
425 electricity distribution system were completely damaged (Alavi Rzavi, 2008). This left people in the damaged area without water
426 and electricity. The main streets in Bam city were still usable immediately after the earthquake; however, the debris of collapsed
427 buildings blocked 70% of the narrow streets close to the center of the city for several days. The airport runway and railroad only
428 suffered slight damage (Nadim et al., 2004), which meant they could be used for dispatching supplies to the city immediately after
429 the earthquake (Alavi Rzavi, 2008).

430 Therefore, resource distribution, spatially providing shelter in the early days was essential for survivors of the earthquake who
431 were suffering from extreme emotional and physical distress, due to the cold weather at night, sometimes below freezing
432 temperatures during the winter (Fallahi, 2007). The Iran Red Crescent Society (IRCS) had provided temporary shelters in the form
433 of tents and food. They began distributing more than 50,000 tents, as emergency shelters, and food (canned foods) among those
434 made homeless by the earthquake as early as the first day of the earthquake (Ghafory-Ashtiany and Hosseini, 2008). Most people
435 preferred to set up their tents next to their destroyed or damaged houses; others were accommodated in existing open areas.

436 In order to manage the relief efforts, the affected region including Bam and Baravat cities, and Spikan, Poshtehrood, Corek and
437 Baghchemak villages were divided into 14 zones and all the humanitarian efforts in each zones were coordinated with authorities
438 in one of the provinces in the country. Later, this was reconsidered, and Bam city was divided into 10 zones, including 49 sub-
439 zones. This appeared to be an effective approach for managing relief efforts in a large disaster zone (Ghafory-Ashtiany and
440 Hosseini, 2008; Alavi Rzavi, 2008). The relief efforts and resources distribution had happened quickly after the earthquake.
441 However, people located beside main streets received most of the resources first, while others, who were further from the main
442 streets, were reached after a period of several days.

443 **4.6. Burying corpses**

444 The main causes of morbidity and mortality were direct injuries, fractures, traumatic injuries, and suffocation as a result of
445 building collapses (Abolghasemi et al., 2006). The deceased people were buried through traditional religious ceremonies in
446 collective graves (Ghafory-Ashtiany and Hosseini, 2008); about 93% of corpses were buried within 48 hours after the earthquake
447 (Akbari et al., 2004).

448 **4.7. International support**

449 The Iranian authorities did not make the first request for international assistance until 03:30PM (Abolghasemi et al., 2006)
450 about 10 hours after the earthquake. The first international notification of the earthquake was posted on the Virtual On-Site
451 Operations Coordination Centre (Virtual OSOCC) at 03:42 AM Universal Time Coordinate (Lam et al.).



452 Within 72 hours of the earthquake, the UN dispatched its Disaster Assessment and Coordination Team (UNDAC) to support
453 the Iranian Government in coordinating this enormous international response. The UN Country Team and UN agencies provided
454 relief items, as well as technical support. The International Federation of Red Cross and Red Crescent Societies (IFRC) and various
455 Non-Governmental Organizations (NGOs) set up field hospitals and distributed food items, blankets, and tents as emergency
456 shelters (United Nation (Un), 2004; Fallahi, 2007). In response to the earthquake, international agencies also were mobilized from
457 many countries and they contributed to the search and rescue operations. Nearly 40 international teams provided USAR operations
458 in Bam, but only five of them arrived within 30 hours after the earthquake. The response and cooperation between Iranian
459 authorities, Iranian Red Crescent Society (IRCS) and the international community was exemplary (United States Agency for
460 International Development (Usaid), 2004). However, the military forces, operational teams and volunteered people did not know
461 where to go first in the damaged area, and they were distributed randomly to different areas.

463 5. Conclusions

464 By interviewing disaster managers and reviewing the literature the timeliness of main response activities to the Bam earthquake
465 was investigated in 26 hours after the earthquake occurrence aiming to understand when each activity was conducted and what
466 was the reasons of having delays, as explained in the following:

467 -Response activities should be conducted quickly and accurately to facilitates assisting people in need. Disaster responders
468 must be prepared always to act accordingly in case of any disaster occurrence.

469 -The results showed in responding to the Bam earthquake, disaster managers were not prepared for such a devastating event,
470 and more importantly, the country's disaster management system was not prepared to cope with a disaster of this scale. The
471 extensive damage to buildings and infrastructure, accompanied by the large number of casualties, challenged the local emergency
472 response services. The problem was compounded by the extensive damage to the utilities (emergency services) and lack of
473 personnel (people who have been working in different sectors in Bam city such as doctors, nurses, rescuers etc.). These caused
474 delays in reporting on the situation of damage and losses in first place.

475 -There was not any disaster management center in Bam city in first day in order to manage disaster response operations or
476 event to store the resources first or assign SAR teams to the highly damaged areas. SAR teams, vehicles carrying resources and
477 volunteers were distributed randomly to the damaged areas in Bam city. Lack of an operation center in the area caused delays in
478 conducting all activities in disaster response.

479 -Defining the level of needed help was a critical act. The first request for international assistance was launched about 10 hours
480 after the earthquake. This delay in issuing the request was due to the lack of information on damage level and required resources,



481 which significantly affected response time. This showed that the situational awareness was reported without conducting any proper
482 field observations in the first hours.

483 -People were the first on the scene to help. However, people who were not prepared to cope with the earthquake. Although,
484 they were helping the others immediately, but they had not enough training on first aid learning, rescuing victims and carrying
485 them. Their response timeliness was quick and extraordinary that had significant effect in saving many lives.

486 -Security issues was another challenge, as there were many traffic jams in the main road toward Bam city that hampered
487 response operation via roads. This needs more investigations to shed light on what was the reason of having this situation in first
488 day of the earthquake

489 -Developing a response strategic plan prior to earthquakes occurrence is an efficient way of dealing with a disaster. Therefore,
490 the results of this study that considered the real situation and deficit in responding to a disaster in Iran; can assist disaster manager
491 in designing a proper action plan (strategic response plan) in responding to a similar earthquake in the region incorporating the
492 Sendai Framework for Disaster Risk Reduction.

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