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Earthquake preparedness: the case of Eastern UAE

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Abstract During the last 30 years, UAE witnessed earthquakes that ranged from minor to moderate, with maximum magnitude of 5.1 that occurred in the Masafi area (eastern UAE, on March 11, 2002). Recent earthquakes that hit Iran such as on May 11, 2013, caused tremors and mild shaking of buildings in some UAE cities. Although the tremors are small in magnitude, their sequences apparently become an important research topic and deserve more assessment from different perspectives such as geographical, geological, engineering, and social. This is because low risk does not equal no risk. This study is concerned with public perceptions of earthquake preparedness (reduction of disaster impact) that can be measured by various variables such as developing an emergency plan, preparation of disaster supply kits, and training. The methodology consists of a survey of 470 people who live around the Masafi area, near Fujairah city, UAE. GIS and GPS were used for site selection in conducting the survey, and remote sensing was used as an aid in identification of buildings' ages. Results show that around 90% of the people surveyed have water tanks that can support them up to 3 days, and 60% of them normally buy food that can support them up to 2 days. Thirty percent of the respondents were familiar with storing first-aid kits and tools such as flashlights. The findings point to a need for more research regarding public awareness about earthquakes. The findings of this study may be useful for people who are involved in the four cornerstones of disaster risk reduction: community participation, public policy actions, safer construction and urban development, and development of a culture of prevention.

Keywords Earthquake · UAE · Public awareness

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Introduction

Earthquakes are natural hazards which require attention and preparedness, as can be confirmed by a number of incidences worldwide, including ones in Haiti, Japan, and USA. We all need awareness of life-saving preparedness and response actions which are useful for both small-scale and catastrophic earthquakes. The approach for identifying, assessing, and reducing disaster risk will further help to minimize community vulnerability (Maxwell and Buchanan-Smith 1994; Bendimerad 2003; Kameda 2007; Onstad et al. 2012). Preparedness consists of those activities that have the potential to save lives, lessen property damage, and increase individual and community control over the subsequent disaster response (Edwards 1993).

UAE has treated disasters as an important issue, and it has taken many concrete steps toward emergency preparedness. This is reflected in the densification of the National Seismic Networks, establishment of the National Emergency and Crisis Management Authority (NCEMA) in 2007, and revision of building codes with respect to earthquakes (The National 2013). The move by the government and the public in UAE toward dealing with disasters is a clear indication of growing awareness of the significance of the problem. This study is in line with this move, going down to the roots to assess how the public is prepared. A survey was used to assess communities near earthquake zones in terms of public awareness and training.

Objective of the study

The main objective of this study is to assess the perception of the public in the Masafi area (in eastern UAE) about involvement in earthquake preparedness drills. This includes whether the people have experienced an earthquake event, views of the public on the media as a source of disaster information, to what degree they are prepared for an earthquake, and the status of buildings' ages.

Previous studies

Numerous studies had been conducted around the world on disaster and earthquake preparedness (Becker 2011; Bendimerad 2003; Dixit 2007; Dyer et al. 1999). In UAE, there is some relevant research on tectonic aspects of earthquakes (Al-Homoud 2003; Rodgers et al. 2006); however, the author was unable to find a UAE study directly related to disaster preparedness. In one example of relevant research in the USA, the Federal Emergency Management Agency (FEMA) conducted a survey related to awareness about earthquakes, protective actions, perceptions of risk, and preparedness (FEMA 2011). The results showed that people residing in the Central USA, including those in and outside of the New Madrid Seismic Zone (NMSZ), had read, seen, or heard something related to earthquake preparedness in the last 6 months. The most frequently cited sources of information were media (particularly, television, newspaper, the Internet, and radio) and school. Work and community organizations were also cited by about one third of the respondents.

One way to gain a better understanding about residents' disaster preparedness levels is to use a self-administered questionnaire to collect primary data. Roca and Beckman (2006) carried out a survey that focused on disaster preparedness for all hazards, and it was designed in the wake of heightened public awareness of vulnerabilities at the Herbert Hoover Dike. Around 6.4% of the total population (38,026) in the glade area participated in the survey, and results in awareness spread across them. However, a large segment of the area's citizens, around 42% of the people, still continues to lack the necessary understanding of the hazards within the community (Roca and Beckman 2006).

A study conducted by Becker (2011) for understanding disaster preparedness and resilience in Canterbury, New Zealand, resulted in 229 survey returns, representing a return rate of 15.3%. Most participants (97%) had seen information about preparing for hazards or emergencies. The highest cited source of hazards/preparedness information was television (82%), followed by the yellow pages in the telephone book (78%), newspapers/magazines (72%), and other written information (e.g., brochures) (69%). However, respondents in another survey conducted by Johnson (2007) indicated that the most effective way to receive information was from local newspaper (56%), followed by television news (53%), fact sheets/brochures (51%), and mail (51%). Other sources included radio (39%), magazine (23%), and the Internet 21%.

Morgan (2012) surveyed 5195 people in greater Christchurch on the impacts of the earthquake, confidence in decision making, and satisfaction with communications and information. The response rate for this survey was 52%. The results showed that over half (54%) of greater Christchurch residents have had to make decisions about house damage, repairs, and relocation. While 35% expressed satisfaction with the overall communications and information received, 32% express dissatisfaction, and the remaining 33% did not have a firm view. For three in ten (29%), making these decisions has had a moderate or major negative impact on their everyday lives.

Disaster risk reduction includes not only community participation and public policy actions but also safer construction and urban development. Issues related to the severity of hazards to human life, the required response following an earthquake, the loss in value of real estate and household effects, structural damages by the results of hazards to human life, and structural damages by the results of loss of property value need to be addressed in the evaluation of buildings (Fujitani et al. 2000). Generally, building users, owners, and experts want to suppress hazard severity to a small level.

Dixit (2007) conducted a research in Nepal on the demographic features, housing details, perceptions on different disasters, perceptions on responsibility to make the house safer, and citizen priorities regarding making the community earthquake safe. The results highlighted the respondents' concerns, as they feel that their lives would be severely affected by earthquake disasters, and their primary concern in the event of an earthquake disaster was on free technical assistance and loans with lowered interest rates as the most appropriate support.

Dyer et al. (1999) conducted a study for earthquake preparedness in southern California. The total number of respondents in the survey was 267. In this group, 92.7% had experienced an earthquake before, 83.4% had received preparedness information, and 82.9% felt prepared for any earthquake emergency. Earthquake preparedness is not just stocking up food and keeping a flashlight near the bed, as has been suggested by earlier literature reviews and previous question assessments. In case of an earthquake, emergency response agencies are overburdened with the number of reactions to be addressed and may not be able to reach every neighborhood immediately (OES 1995). Neighbors or co-workers need to be trained for initial response actions to be taken at the time of need and be prepared to take care of others also for at least 72 h. Forming a neighborhood response team or joining the

existing one can greatly improve a person's chance of surviving an earthquake and achieving self-sufficiency of the neighborhood.

Methodology

In this study, a self-administrated questionnaire with 28 questions was prepared. The questionnaire included five parts: demographic details, previous earthquake experience, engagement in preparedness activities, status of objects inside buildings, and buildings' ages.

The first part of the questionnaire included four questions about the demographic details of the respondents (such as gender, age), educational level, and the name of area where they live. Dyer et al. (1999) and Fujitani et al. (2000) used similar questions to show the importance of demographics in any survey and how they are interconnected.

The second part of the questionnaire included six questions to capture the earthquake experience, preparedness information received, and the general level of concern over earthquake risk (Becker 2011; FEMA 2011; Johnson 2007; Kano 2009; Roca and Beckman 2006).

The third part included eight questions relating to the extent to which people engaged or planned to engage in preparedness activities such as training, creating a family evacuation plan, which evacuation means available, what the preferred notification means, degree of preparation, and whether the family had an emergency kit (Dyer et al. 1999; FEMA 2011).

The fourth part included three questions about hanging objects, heavy furniture, and electronics.

The fifth part included seven questions focusing on buildings such as height of the building, whether the house experienced earthquake damage, type of earthquake insurance, and degree to which the house was earthquake-resistant (Fujitani et al. 2000; Johnson 2007). Hardcopies of the survey were distributed face to face to people from villages near the Masafi area (in eastern UAE; Figs. 1 and 2) between November 2014 and January 2015. The selection of the villages was based on their proximity to earthquake zones (Al-Homoud 2003; Rodgers et al. 2006). GPS was used to identify the geographic locations (latitude, longitude) of the villages. The target houses were chosen through a cluster sampling method in which the gridded fishnet was created using GIS and random sample areas were

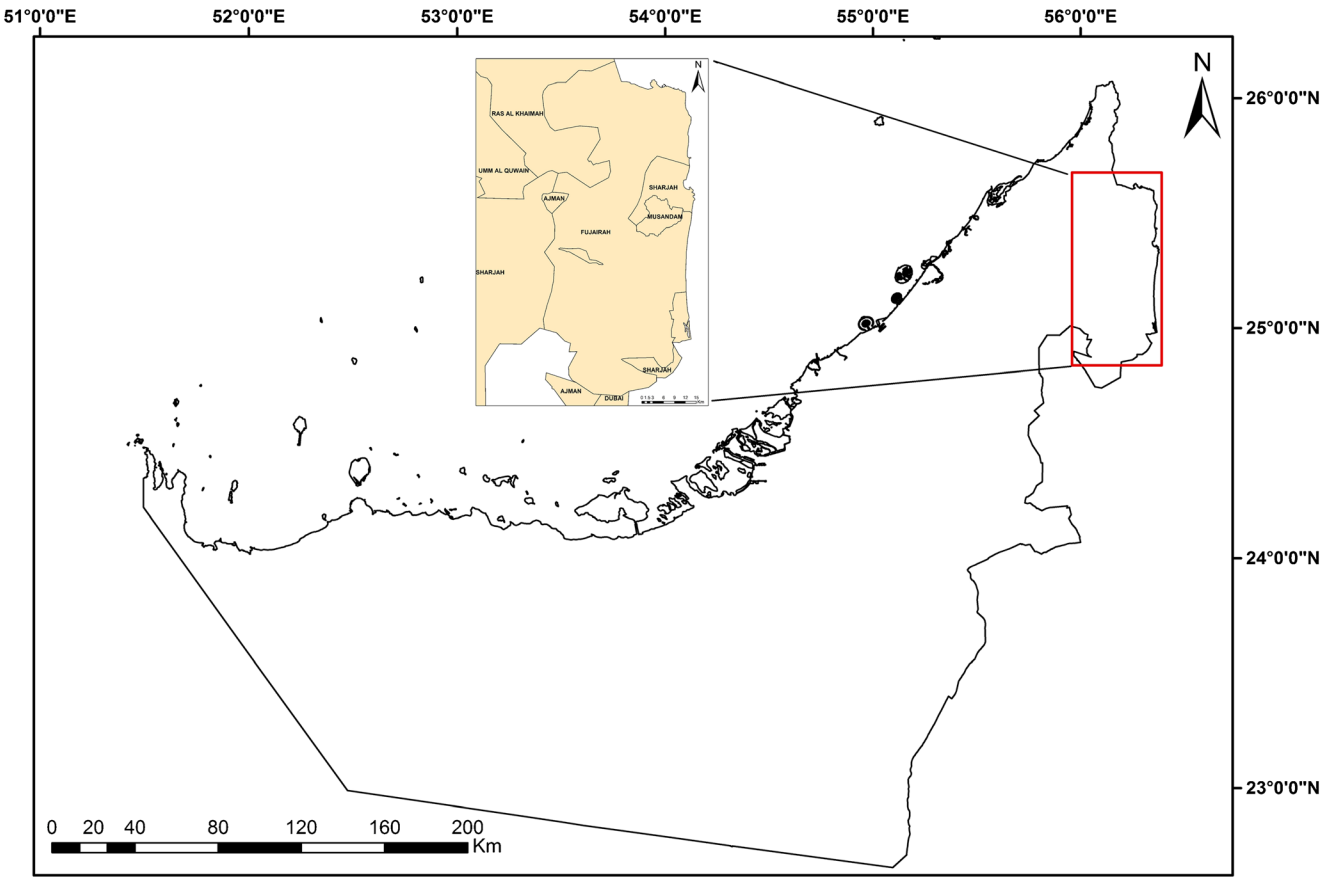

Fig. 1. Study area

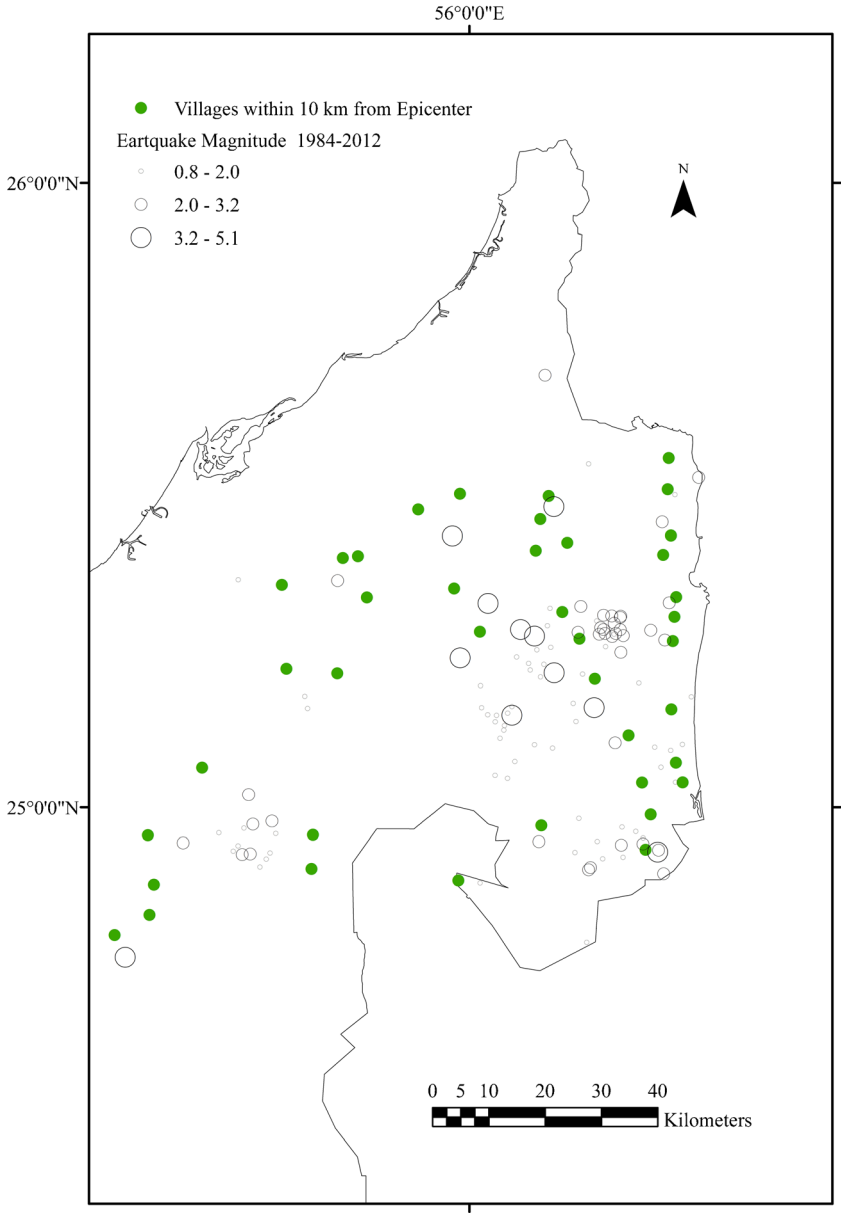

Fig. 2. Villages within proximity of earthquakes (1984–2012)

selected for household studies (Grais et al. 2007). The area was divided into grids, and the center point of each grid was taken for sample representation. Coordinates of these points was used for ground survey, and the questionnaires were distributed accordingly, thus highlighting the useful role that GIS can play in disaster surveys. Samples were taken from respondents' houses or nearby houses in case the center points of the grid fell in a vacant area.

The total population in the villages around Masafi (Al Khalu, Beerah, Murbadh, Al Haniya, Thooban, AlKhurais) was around 5191, and based on that, 500 surveys (approximately 10% of the total population) were distributed. A pilot pre-test survey (sample of 50) was conducted prior to the distribution of the main survey, and based on that, some questions/issues were modified and some were deleted to improve the internal validity of the questionnaire. Approval to conduct this research was obtained from the Ethical Committee of the Research Affairs at UAE University on June 29, 2014. Participants were informed that the content of the investigation would be used for research purposes only and that they could withdraw from the survey at any time. It is also explained that their participation would be kept confidential and results would be shown without reference to individuals.

Results

Demographic characteristics of respondents

Out of the 500 surveys distributed, 470 responses were received (94% response rate). The response rate was found to be high in comparison to other studies. For instance, Fujitani et al. (2000) used 815 samples and received 496 responses (60% response rate) while Morgan (2012) obtained a response rate of 52% and Becker (2011) 15.3%. Table 1 shows aggregate household information collected from the survey. The number of males (49%) and females (51%) is almost equal. The majority of the respondents were aged less than 40 (around 83%) and educated (94%) (Table 1). The level of education may play an important role in exposure to media and to awareness about any seismic disaster that have taken in the past and that may happen in the near future. Edwards (1993) found that earthquake preparedness activities were correlated with multiple demographic characteristics like presence of children at home, higher education, higher household income, neighborhood tenure, and home ownership.

Earlier earthquake events and sources of disaster information

The survey results showed that 85% of the respondents had experienced earthquake before (Table 2). The result is consistent with the fact that many researchers had documented seismic activities in the eastern part of UAE (Al-Homoud 2003; Rodgers et al. 2006). The area includes cities such as Fujairah and Masafi. Two active fault lines pass through the region, making it more prone for earthquake events. People who had experienced an earthquake are more likely to prepare for it (Dooley et al. 1992), and in this study, 63% of the respondents showed concern about earthquake. Apart from this, 15% of the people who did not experience earthquakes were also willing to attend meetings, participate in emergency evacuation plans, and receive training in first aid. These statistics show that awareness and information exchange in the region are increasing day by day as the usage of new technology increases, which will be beneficial at the time of actual need.

Turning to the views of public on media as a source of disaster information, around 40% of the respondents have received the information to make their families and homes safer through television, followed by computer-based social network (24%) (Table 2). The dependency on television may be due to the accuracy/reliability of information, official responsibility, and attraction. Mileti and O'Brien (1992) found in their research that after the occurrence of the Loma Prieta earthquake in California, adjustments were significantly related to quality of information (consistency, specificity, and source sureness) and information strengthening through number of warnings. On the other hand, computer-based information is often preferred because of its convenience and accessibility at any time and place. It must be pointed out that mobile telephones (cell phones) are gaining momentum as they are becoming cheaper and are now often supported with cameras, GPS, and Internet. Cell phones are thus a medium where awareness applications could be designed to meet their specifications. The results specify that the awareness program conducted by government and non-government organizations related to disaster knowledge has been conducted at a satisfactory level, and the responses from the residents also have a positive view of the programs.

Earthquake preparedness

Many studies have found an empirical relationship between disaster preparedness actions and characteristics associated with their preparedness behavior and intentions to adopt

Table 1. Demographic characteristics

	Features	Number of respondents[a]	Respondents (%)
What is your gender?	Male	229	48.7
	Female	241	51.3
What is your age?	<30 years	236	50.2
	30–40 years	157	33.4
	41–50 years	50	10.6
	>50 years	27	5.8
Education?	Middle school	50	10.6
	High school	38	8.0
	Vocational	152	32.5
	Higher	193	41.0
	Graduate	8	1.7
	Illiterate	29	6.2

[a] Number of total respondents is 470

Table 2. Source of information

		Respondents (%)[a]
Experienced earthquake before?	Yes	85
	No	15
Source of information about disaster awareness	Television	42.0
	Computer-based social network	24.5
	Mobile	14.6
	Newspaper	11.1
	Radio	7.8

[a] Number of total respondents is 470

mitigation measures (Lindell and Whitney2000; Lizarralde et al. 2015). Awareness and knowledge for disasters can also be raised by disaster education aimed directly at the public, as well as from school-based programs (Faupel and Styles 1993; Tanaka 2005). Therefore, education could enhance awareness and preparedness for disasters.

The survey conducted here showed that around 50% of the respondents attended earthquake training given by the authorities (Table 3). Although they had some initial knowledge of overcoming the problems of earthquakes, there were low levels of developed emergency plans (23%) as well as preparation of disaster supply kits (25%) (Table 3). This poor performance, despite the efforts taken up by the government, may be due to lack of space to store the items of community need, or due to availability of disaster preparedness materials at their door steps, at malls, at supermarkets, and at health facilities. The low attention of population to store disaster kits is noticed in many cities around the world. For example, a study conducted in Memphis, Tennessee, USA, found that despite the higher level of preparedness found among people, they were still lacking some basic safety measures such as family plans (31%) and only 37% of them had stored water/food and first-aid supplies (Edwards 1993). However, people were found to be highly motivated to talk or plan to talk on the matter of disasters with their friends, relatives, family members, and neighbors (66%). This indicates that more awareness campaigns are needed, and such campaigns will certainly have a positive effect in the long run. Mileti and Darlington (1997) found out that after the awareness campaign, emergency equipment storage rose from 50 to 81%, stockpiling of food and water increased from 44 to 75%, and purchasing insurance schemes rose from 27 to 40%.

Building age and objects inside homes

Earthquakes can hit anyone, anywhere, and at any time, and one of the major challenges in emergency preparedness is the vulnerability and protection of the physical infrastructure and the personnel. Damage during an earthquake can result from several factors such as strength of shaking, length of shaking, type of soil, type of building, and resonant frequency of building (Chopra and Goel 2000). Efficacy of protective occupant actions is very much dependent on the seismic performance of buildings, household objects, and age with height of buildings (Lungu et al. 1999). Several important characteristics of buildings affect performance during an earthquake. Buildings of different construction materials or configurations will respond in different ways to the same ground motion; some may collapse while others survive.

As per the survey, 88% of the buildings in the study region were either one or two stories. Generally, small buildings experience more shaking by high-frequency earthquake waves while large structures or high-rise buildings are more affected by low frequency or slow shaking. Fifty percent of the respondents are living in houses that are more than 10 years old, and 35% in houses aged between 6 and 10 years. Seventy percent of the houses are built with stone blocks that may fall during shaking, and 58% are not earthquake-resistant.

The author found difficulty in getting data about the buildings' ages from the municipality. Therefore, it is

Table 3. Degree of earthquake preparedness

	Have done (%)	Plan to do (%)	Not done (%)	Unable to do (%)
Attended meetings	49.3	29.3	18	3.4
Talked with members	33.6	33.1	29.3	4
Developed emergency plans	23.1	30	42.1	4.8
Prepared a disaster supply kit	25.3	34.2	37.8	2.7
Trained in first aid	31.2	33.8	29.3	5.7

recommended to utilize remote sensing. Earlier researchers highlighted the role of remote sensing in getting important parameters about buildings such as perimeter, area, height, material, and age (Weiland et al. 2012; Yagoub 2015).

Making a house completely earthquake-resistant is an impossible task, but to minimize the possibility of serious injuries, some in-home items can be designed/fixed properly (Dixit 2007; Fujitani et al. 2000). For example are bookcases, modular wall units (which are generally tall and heavy, providing damage to life), water heater-carrying pipes full of hot water (which can be ruptured, causing burning and bruises), appliances (which can be a cause to break gas or electrical lines), and heavy picture frames or mirrors near beds. These in-home items are much of the concern in all parts of the world and kept in vision while preparing the survey conducted for UAE. Results showed that 88% of the respondents hung some objects or vases in their houses, and 72% also had installed heavy furniture such as a wardrobe or book shelf in the walls like wardrobe and library (Table 4). It is very clear that there is a need for more public awareness about fixing hanging objects properly on walls, especially at professional institutions such as schools that have many people so that such objects may cause fatal injuries when they fall. An earthquake preparedness study conducted in California showed that only about a third of households have learned how to make their home structure safe (Kano 2009).

Seventy-five percent of the respondents were ready to spend money on remodeling their houses to be earthquake-resistant, making structural modifications in the houses, fixing objects, and selecting a stable site for future dwelling (Table 4). This shows that individuals considered a safe house as their main responsibility. The result is in line with a study conducted by Dixit (2007) regarding people in Nepal. He asked the question "If your house would collapse and kill some of your family due to big earthquake, whom do you blame?" Forty-five said that they would blame themselves, 18% would blame the house builder, 18% did not know, 15% would blame God, 3% would blame the government, and 1% would blame someone or something else.

Governmental departments in UAE, such as municipalities, have recently approved building codes that put into account buildings taller than 10 floors as well as schools and hospitals to withstand quakes between 5.5 and 5.9 on the Richter scale (The National 2013). New laws state that all buildings—not just high-rise structures—must abide by UAE code 2A, a seismic code originally used only for tall structures. The buildings' codes provide enough evidence to verify that in UAE, people are taking the preparative measures seriously.

Conclusion

New laws in UAE state that all buildings must abide by the seismic codes. In addition to this, public awareness could play an important role in reduction of earthquake damage.

This study focused on public perception on earthquake preparedness. Results showed that 85% of the respondents have experienced an earthquake and 63% are concerned about them. Around 40% of the respondents have received information through television about making their family and home safer for earthquakes. Another 24% have received such information through computer-based social networks. It must be pointed out that mobiles are starting to gain momentum as sources of disaster preparedness information, and they are becoming cheaper and supported with many tools. Fifty percent of the respondents had attended earthquake training given by respective authorities. There was low number of respondents who had developed emergency plans (23%) and prepared disaster supply kits (25%). Moreover, 88% of the respondents have hanging objects in their homes, 50% of the people are living in houses which are more than 10 years old, 70% of houses are built with stones that may fall while shaking, and 58% of houses are not earthquake-resistant. Thus, building codes approved by UAE municipalities need to be implemented and followed up with construction companies.

An overall assessment of the respondents about disaster preparedness in UAE and readiness behavior suggests that a large portion of the population is still not well prepared for disaster situation. Experiences from

Table 4. Effects on objects and buildings

	Yes (%)	No (%)	Not answered
Hanging objects in the house	88	9	3
Heavy furniture in the house	72	24	4
Electronic reinforced in the wall	14	84	2
Willing to spend money on remodeling the house to be earthquake-resistant?	75	22	3

around the world have shown that more awareness campaigns that put into account the social context of individual behavior prepare people better and consequently reduce earthquake impact. An example of better preparation can be seen in the resilience policy of the UK, which links the community resilience with notions of community participation in decision making. This includes creation of inclusive and cultural prototypes, a local economy based on sound environmental principles, and supportive inter-community links (Featherstone et al. 2012). Certain policies which guarantee a basic education to the people in reducing the vulnerability and mitigation for any disaster impacts could be adopted. The study provides suggestions for the process by which disaster risk reduction knowledge is disseminated in UAE. The survey itself also functioned as an awareness raising event.

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