Health Promotion Perspectives, 2014, 4(1), 122-131
doi: 10.5681/hpp.2014.016
http://journals.tbzmed.ac.ir/HPP

A Comparative Study on Physical Vulnerability of Urban Area against Natural Hazards: Importance of Health Promoting Approach in Civil Engineering

Mohsen Ahadnezhad Reveshty[1], *Mohammad Javad Kamelifar[1], Behzad Ranjbarnia[2], Alireza Pashaiifar[3]

[1] Department of Geography, Zanjan University, Zanjan, Iran
[2] Department of Geography and Urban Planning, Isfahan University, Isfahan, Iran
[3]Department of Management, Islamic Azad University of Tabriz, Tabriz, Iran

ARTICLE INFO

Article type:
Original Article

Article history:
Received: Mar 02 2014
Accepted: June 20 2014
e-published: July 12 2014

Keywords:
Population health,
Urban tissue,
Physical vulnerability,
MCE,
Fuzzy approach

***Corresponding Author:**
Mohammad Javad Kamelifar
Tel: +98 411 3855088;
e-mail:
M.javad_kamelifar@yahoo.com

ABSTRACT

Background: Estimation of urban vulnerability to earthquakes can be considered as an Ill-structured problem in urban in both unplanned and planned areas. Multi-criteria evaluation (MCE) provides a way to integrate different spatial data layers in a geographic information system to create composite maps representing risk. We utilized MCE in a raster Geographic Information System (GIS) to evaluate risk in vulnerable tissues of Tabriz, Iran zone.
Methods: In this MCE physical risk factors and sub-factors were included and were weighted by experts. Afterward data entered to GIS and then the layers of the criteria were exported. The obtained results were entered to IDRISI and fuzzified. Ultimately the final map of physical vulnerability was outputted by overlaying order.
Results: Vulnerable tissues are highly consistent to non-official areas. However, the planned area which is called Valiasr is in low risky condition and this condition is desirable in crisis times. Here, we observe the preference of physical pre-planning operations.
Conclusion: The links between urban planning and health are many and varied. Environmental, social and economic conditions in cities can have both positive and negative influences on human health and centre. Urban planning and related professions play an important role in shaping those conditions.

Citation: Ahadnezhad Reveshty M, Kamelifar MJ, Ranjbarnia B, Pashaiifar A. A Comparative Study on Physical Vulnerability of Urban Area against Natural Hazards: Importance of Health Promoting Approach in Civil Engineering. Health Promot Perspect 2014; 4(1): 122-131.

Introduction

When a disaster occurs, the interaction of disaster and vulnerabilities leads to remarkable loss of human beings lives and injuries.[1] The consequences of disasters such as psychopathological symptoms and emotional problems in children and adults are unavoidable.[2,3] Emotional impacts are as great as physical ones, in other words, they are interrelated. Although the amount of injuries, destruction and the loss of income are noticeable in physical effects but recovery is essentially judged through the feeling of people in coping with their lives and livelihood.[4]

Natural disasters are caused by natural hazards which overwhelm local response

capacity; also they have significant effects on the social and economic development of the region. Furthermore, natural disasters create situations which cause difficulties and challenges in public health and a humanitarian nature.[5] There is an increase of risks and vulnerabilities derived by natural disasters on the globe. It is clear from Bam Earthquake 2003, Indian Ocean Tsunami 2004, Kashmir Earthquake 2005 and Haiti Earthquake 2009 etc. Thus, there is a sharp rise of vulnerability of human beings and society's health to natural catastrophes.[6,7]

During the previous decades, the most frequently affected continent has been Asia which has witnessed of many earthquakes and tsunamis.[8] From the 225,000 deaths caused by the 2004 Indian Ocean earthquake and tsunami,[9] to 73,276 deaths by the 2005 Pakistan earthquake,[10] 69,200 deaths by the 2008 China Sichuan earthquake,[11] and 15,839 deaths by the 2011 Great East Japan earthquake.[12] Not only did Asian countries confronted huge amount of loss from the devastating disaster, but also they experienced critical outcomes from the long lasting post-earthquake hardships.[13] In this regard, there is growing awareness of the need to prevent, and be better prepared for high consequence low probability events.[14]

In the context of public health, Chester (2002) underlines that "86 of 100 major cities of developing countries are exposed to destructive hazards (earthquakes, tsunamis, floods, volcanic eruptions, etc.) and it can be enumerated a big challenge to human health. The consequences of such exposure and the conditions of urban development in developing countries are extremely harmfull.[15]

Before the occurrence of a disaster, it would be a good idea that both administrative people and residents in local communities design a plan of community-based disaster-preparedness and measures regarding human beings health by themselves.[16] Drills and exercises are acceptable practices which evaluate the capabilities, readiness, and abilities of emergency service personnel. The drawback of such exercises is that people are not eager to participate in this activities.[17] In order to be successful; it is advised that residents should join to community-based disaster preparedness activities.[18]

Considering civil engineering and urban planning, destructive outcomes and injuries associated with earthquakes vary enormously from one event to another. There are many factors related to the number and severity of injuries, such as the magnitude of the earthquake, its proximity to a populated area, the soil type, building construction, time of day and population characteristics and behaviors.[19] Of many factors associated with the influence of earthquake on human health, building collapse is a significant element associated with fatal injuries.[20] The force of the earthquake is not the only cause of death. Secondary hazards such as firestorms and tsunamis can also wreak havoc and a high death tool. By combining the principles of civil engineering and urban planning regarding natural hazards, human safety may improve.

This paper is concentrated on the comparison of physical vulnerability in two sites of the Tabriz town, northeastern Iran zone 1 which is known as official and non-official districts. The findings of this article will identify the places with high risky areas regarding public areas.

Materials and Methods

In order to assess the vulnerability of study area, the adopted methodological approach considers multi-criteria techniques with the aim of taking into account the different aspects that contribute to recognize vulnerable tissues in both regions of formal and informal textures. The first part of the proposed methodology is to select a set of assessing criteria which provides a basis for evaluating the vulnerability. In fact this is the most essential part in the overall debate, because we need to make sure that the selected criteria are sufficient to indicate the overall risk of urban areas as a mixture function of vulnerability and earthquake hazards. It is also the most time consuming stage of the proposed methodology because it involves

the collection and preparation of the date that will serve as input to the earthquake evaluation.

In order to have a logical basis for choosing the criteria, pursuing Malczewski's recommendation is advised. Malczewski states that a criterion which is considered comprehensive and measurable is a good one.[21] In the present work we suggest 7 criteria upon which we base the vulnerability assessment. Our selection of these criteria has been based on the framework of assessing vulnerability developed by DrAhadnejad.[22] Therefore in this study, seven available criteria including the building date, building quality, land use type, land cover, unit area, number of floors, construction density and type of materials are used, which each of these criteria are divided into some sub-criteria and subsequently these criteria are weighted using AHP (Expert choice tool) approach through employing Delphi method. In selecting these criteria we attempted to cover all aspects of possible vulnerability. The intended data and layers were collected from census of housing and population in 2011.

City of Tabriz as one of the major cities of Iran, located in active seismic areas is an earthquake prone region based on the historical records available. Tabriz north fault is known as one of the hazardous faults of the Iran country. This fault makes this city and especially zone 1, the most dangerous region in comparison to the other zones and cities. Additionally, this fault is enumerated as one of the rudimentary tectonic structures in the north-east side of the Urmia Lake.[23] The following major earthquakes have occurred in connection with the Tabriz North Fault (Table 1).

Tabriz zone 1 with 211340 occupants is in the range of the most populous zones of Tabriz located in north side of the town. By considering fault maps of the town, it can be understood that this zone has been placed in the nearest district to Tabriz north fault [Ibid]. Tabriz zone 1 is divided into 5 regions (Fig. 1). Region 1 is considered as planned district, while region 5 is recognized as informal residential area.

Table 1: Major occurred earthquakes related to north fault of Tabriz (Source: Firuzi, 2009)[24]

Date	Magnitude	Intensity
858. AD	6	VII
1042. AD	7.6	X
1721. AD	7.7	X
1780. AD	7.7	X
1960. AD	5.1	VI, VII

This paper examines the physical vulnerability of both formal and informal residential areas (region 1 and 5) against earthquakes.

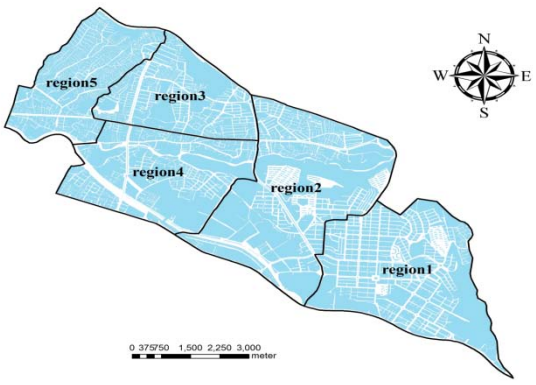

Fig. 1: Tabriz, zone 1

Analytic hierarchy process

One of the commonly used methods for systematic and structured analysis and decision making in difficult situations is Analytic Hierarchy Process (AHP). The AHP is a structured and flexible method which solves complicated problems.[25] This method structures the problem into a hierarchical framework. It is based on decision-making technique which includes both qualitative and quantitative aspects of decisions.[25] It lessens complicated decisions to a series of binary comparisons and afterward synthesizes the obtained results. AHP is a three part procedure that consists of recognizing and organizing decision goals, criteria, restrictions and alternatives into a hierarchy; and the synthesis, using the solution algo-

rithm of the obtained results of the comparisons over all of the stages.

The first stage in the AHP procedure is that the decision problem should be decomposed into a hierarchy that includes most major elements of the decision problem. In developing a hierarchy, the ultimate purpose of the decision which is ready is the top level. Then, the hierarchy descends from the general goal to the most particular elements of the problem until the level of attributes be obtained. The hierarchical structure includes: goal, attributes, objectives, and alternatives, but there are various elements or combination of elements which could be related to a specific decision problem [ibid].In a GIS-based multi- criteria analysis, all the alternatives are represented in GIS databases. Each layer encompasses the attribute values allocated to the alternatives, and each alternative (e.g. cell or polygon) is related to the higher-level elements (i.e. attributes). In the context of this paper, a typical three-level hierarchy of goal, objectives and attributes has been considered in order to demonstrate the spatial AHP procedure. The weights of criteria and sub-criteria are shown in Table 2.

Table 2: The obtained weight of both criteria and sub-criteria

Main Criteria	AHP W.	Sub-Criteria	AHP W.
Types of construction material	0.449	Steel structure	2
		Concrete structure	3
		Brick and iron structure	7
		Non-structured	1
Building date	0.15	Under 10 years	2
		10-20 years	3
		Higher 20 years	7
Building quality	0.12	New-built	2
		Usable	3
		Need to be repaired	5
		Non-structured	1
		Need to be refurbished	9
Number of floors	0.09	Non-structured	1
		1 floor	2
		2 floors	3
		3 floors	5
		4 floors	7
		5 floors and higher	9
Land cover	0.07	0-25%	3
		25-50%	5
		50-75%	7
		75-100%	9
Land use	0.05	Athletic and non-structured	1
		Ruined place	9
		Residential area	8
		Trade district	7
		Educational-therapeutic	5
		Facilities and equipment	3
		Official-military	2
Unit area	0.03	Under 100	9
		100-250	7
		250-500	5
		+500	3
Building density	0.04	0-100	2
		100-200	3
		200-300	5
		300-400	7
		+400	9

In this paper, the deducted weights of the criteria (Based on expert choice) and sub-criteria has by related experts using Delphi method, are entered into GIS software. Afterward, the obtained layers of each criteria based on their AHP weights in GIS will be entered to Idrisi software. Since our initial goal was to map the areas of high risk in the study area, we utilized a set of procedures to standardize and combine data layers to create composite risk maps (Fig. 2). Standardization of each data layer to a common set of values was performed using the FUZZY module in the Idrisi32 software.[26] This module is designed in a way that it can specify each pixel in an image to a fuzzy set by evaluating the series of fuzzy set membership functions. The most privilege of this method for our work is that setting hard or arbitrary established thresholds between different levels of risk can be avoided. In addition, it simplifiesfurther integration of layers in the generation of compound risk maps, that takes into account the major risk indicators for which we have data, i.e., building date, building quality, land use type, land cover, unit area, number of floors, construction density and type of materials. The last indicator was derived by handling a 7 X 7 frequency filter to rasterized vulnerability portions for which we had crash data. The filter approach calculates the units of pixels in the 7X7 kernel so that portions which fill more space receive a more value in the output raster layer.

Fuzzy sets are those sets or a (class) which there is no sharp boundaries, namely, there is a gradual transition between membership and non-membership of a location in the set.[27] A fuzzy set is featured by a fuzzy membership grade that ranges from 0.0 to 1.0, representing a complete membership from a non-membership due to a continuous increase. Four fuzzy set membership functions are provided in IDRISI: Sigmoidal, J-Shaped, Linear and User-defined.

We used linear fuzzy function at this paper. Integration of the data layers to create compound vulnerability risk maps was carried out using the Multi-Criteria Evaluation (MCE) module, also in Idrisi32. Multi-criteria evaluation is a decision making tool. A decision is a selection between alternatives. Criterion is known as a basis for a decision. In a multi-Criteria Evaluation, the purpose is to combine a set of criteria in order to gain a single composite basis for a decision based on a specific objective, for instance, a decision might be made according to the areas which are appropriate for industrial development. Criteria may consist of slope gradient, exclusion of reserved lands, proximity to roads and so on. Through a MCE, these criteria images representing suitability may be integrated to object a single suitability map from that the final choice will be created.

Like the Fuzzy module, the MCE procedure allows for the combination of factors using a variety of functions. We utilized a linear-weighted function, in which factor weights were adjusted incrementally in steps of 0.05 and 0.10 (Table 1). Factor weights are very important because they specify how individual factors will trade off comparative to each other. In terms of a linear weighted integration, the higher factor weight the more influence that factor has on the final compound risk map. We executed a factor weight sensitivity analysis by varying both the indicator weights and the type of fuzzy function, thus creating a final set of MCE compound vulnerability maps. Ethical approval of this study was gained from the Research Ethics Committee.

Results

Fig. 3 shows the results of our analysis for determining the vulnerable tissues regarding both formal and informal districts of study area (Region 1 and 5). As in all risk maps generated, this particular example produces data scaled from zero (no risk) to 1 (maximum risk). In this respect, we divided the obtained results to 5 classes from 1 (minimum vulnerability) to 5 (the maximum vulnerability) (Fig. 3). One of the unique features of the study area is existence of two

opposite districts which are known as formal and informal settlements (region 1 and 5).

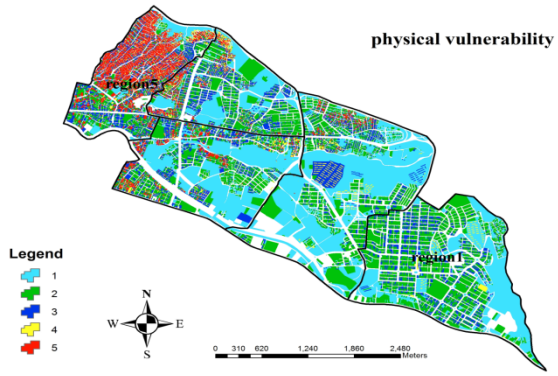

Fig. 2: Map of physical vulnerability areas in Tabriz zone 1

According to field studies, the official and also informal tissues were identified. Based on these observations, the north-west side of the study area (Seylab district) is recognized as informal residential area. This tissue is identified as one of the most crowded areas with high rate of building and population density. In addition, the absence of spatial planning in construction of buildings of this area has made the condition even worse. Otherwise, the planned or official area (Valiasr town) has been placed in the south-east side. The visual obtained result clearly shows the vulnerable areas. As observed, the most risky area in terms of physical vulnerability is where, which was identified as unplanned area (Seylab district). In this case, the mentioned conditions have exposed 30 percent (62300 citizens) of the zone 1 residents in high risk. The obtained results also show the importance of planning before construction of a district. However, the Valiasr region as a planned tissue mostly is in low vulnerability condition.

The percentage results in terms of physical vulnerability show that the study area is greatly in desirable condition. In this respect, the spectrums of very low and low vulnerability jointly are included 66% of the region. It should be noted that, this amount has been taken by considering non-structured spaces. The moderate vulnerability obtains 17% the same as the high risky condition with 17% vulnerability.

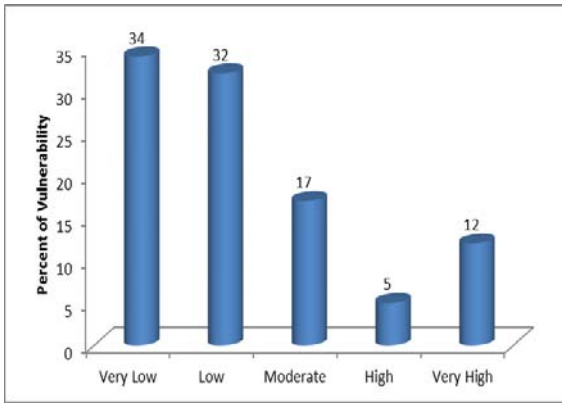

Fig. 3: Percentage diagram of physical vulnerability of Tabriz zone 1

Discussion

The residents are forced to occupy unused or inappropriate lands due to the lack of secure land or housing tenure. For instance, during the years 1991 to 1997, 1.5 million people were sent out from central areas of Shanghai and Beijing.[28] Many hazardous geographical factors such as landslide or flood prone areas, unsafe, polluted environments or being located in seismic region cause the informal residential locations unused or undesirable.[29] Based on the field studies in the study area, it became revealed that, the district which is identified as slum or informal residential area is in undesirable condition which mentioned above. This circumstance in region 1 is completely vice versa and the occupants in are in desirable situation.

Slum housing is built poorly with substandard and flammable substances. The houses built against hillsides are prone to landslides in heavy rains; in addition, inferior building standards lead to death of many people from natural disasters, especially where urbanization and poverty are the main concerns,[30] In 2003 in Bam, Iran, 32,000 people died,[23] because of poor structural quality of houses which has a major role in natural catastrophes. An earthquake occurred in California with the same magnitude and it caused to the death of only two people.

There are other accidental injuries such as falls and burns which could be related to the environmental issues.[31] Physical features of slums not only make the consequences worse but also prevent the rescue efforts.[32]

In the present paper, we obtained the statistics of the criteria and sub-criteria from 2011 public census. In this respect, informal settlements of the study area (region 5) are in poor condition in terms of some criteria including Land cover, Building date, Brick and iron structure and Building density. In the context of Land cover, more than 52% of the region is in the rate of +75 percent. In terms of building date, about 48% of the buildings of the region are more than 20 years old which is relatively undesirable. In case of material, near to 55% of the buildings have been made of poor materials (e.g. brick and iron structure), which has made this region more vulnerable against earthquake.

The difference in those death tolls comes from building construction and technology.

After an earthquake in such areas, some epidemic infections such as pertussis appears in the regions which are overcrowded that causes some other diseases like SARS or influenza.[33,34] These are few consequences of occurring earthquake in un-planned areas.

On the other hand, region 1 which is known as planned area has different conditions. In this manner, existence of systematic planning such as creating sufficient campus, ample green spaces, modern urbanism and so on have promoted the safety of the region. Based on the statistics, in terms of land cover, more than 80% of the region is in the rate of -75% covering. In case of building date, near to 70% of the area is new built-up and in terms of material used for building, about 80% of buildings of the region have appropriate materials (steel and concrete structure). The mentioned statistics have made this region less vulnerable.

The purpose of this public health risk assessment is to provide health organizations in both formal and informal agencies, donor agencies and local authorities currently working with populations affected by the emergency in Tabriz City, with up-to-date guidance on the giant public health threats faced by the earthquake-affected people.

As observed, the people settled in the red-selected area will suffer from the health impacts of the earthquake more than the other area's residents. Many groups of people now accept that human activity itself has created the proper or bad conditions for disaster calamities. This is partly because of increasing awareness that through omission or improper response, the workings of social systems have made a disaster out of a condition that otherwise might not have been serious, additionally there has been an increasing in grasping that hazards are natural, but that for a hazard to become a disaster it has to influence vulnerable people. During the recent decade has seen increasing use of various concepts of vulnerability by academics and development practitioners. These are also indicative of how hazards can be analyzed as the product of political and economic factors.

By using field studies, it was revealed that the most hazardous area in terms of examined criteria is corresponded to poor area of the town. This shows a direct relationship between vulnerability and poverty and therefore, in such areas with high rate of poverty, people are much more vulnerable in terms of health conditions. Similar extreme earthquake events have very different effects on people health and poverty depending on which region or country they strike. This is another insight which illustrates that disasters are not solely natural.

Decreasing the impact of natural disasters in urban areas cannot be solved in one night or within the period of the International Decade (1990-2000). Some changes should be made such as people's attitudes towards a conviction which could be organized to resist disasters and the ways to implement it. Furthermore, building a "culture of prevention" is another factor which should be taken into considerations.

The reason that why some negative trends exist is that some solutions are not easy to be required. Every year, building

codes and making policies are ignored and zoning regulations are neglected as societies have a tendency to expand the areas which are prone to natural disasters.

Some actions should be taken in order to prevent next disasters. Although some early responses regarding natural disasters and socioeconomic vulnerabilities are cost-effective and manageable, it is time to take some actions. The post-disaster period is a good time to commence disaster and vulnerability reduction programs and policies due to two factors: greatness of public awareness and political will which prevent these policies to become true.

Political commitment, locally and nationally, is the most crucial precondition to address the risks of urban disasters. Moreover, international support for local capacity building in high-risk regions is also important to be considered, but the priority is the responsibility of individuals, city authorities, and national authorities to guarantee safer cities.[35]

Buildings are not designed to be ruined under pressure of earthquake. To make the buildings stronger or safer, we have to respect building code (policies) in designing. Building code adjust the design and buildings construction to help keep communities safer and healthier.The purpose of seismic provisions in the code is to protect people's lives and their safety and allow them to leave the ruined and damaged buildings. The aim of this new design is to evaluate the withstand of buildings against a moderate earthquake without noticeable damage and a major earthquake without collapsing.[36]

In order to be well-prepared for an earthquake, the adoption and enforcement of modern building codes is a crucial factor. Building codes provide the minimum acceptable standards which are necessary for regulating the design, constructing and maintaining of buildings in order to protect the health, safety and general welfare of the residents of the buildings. Modern codes are the unified documents which are established based on scientific and engineering principles which have been checked by technical experts, construction professionals, enforcement personnel and the products industries.[37]

Conclusion

We analyzed physical vulnerability of both formal and informal settlements of Tabriz zone 1. The obtained result proves that in most cases, natural hazards are not solely the main threat for citizens' health, while lack of attention to plan systematically for human settlements is the most important threat for community health. Throughout disaster management, interventions must focus on equity in order to reduce current disparities and ensure that existing inequalities are not widened by disasters. In addition, the medical facilities are important criteria in high risky areas for mitigating hazard. We can move from understanding to action, and improve the lives of people who live in slums right now.

Acknowledgments

We thank our colleagues who work for promotion of human health in cities and the resilient members of these communities who have given us insight into the challenges to good health in cities that they face every day. In addition, we appreciate from Zanjan University for supporting us in terms of financial aids.

Competing interests

The authors declare that there is no conflict of interest.

References

1. Burnham GM. Public health guide for emergencies. In: E Christensen Rond, editor. Disaster definitions. 2nd ed. Baltimore: Johns Hopkins Bloomberg School of Public Health Publishing; 2008.
2. Miller TW, Basoglu M. Posttraumatic stress disorder: The impact of life stress events on adjustment. *Int Psychiatry* 1992;7:209-217.

3. Rubonis AV, Bickman L. Psychological impairment in the wake of disaster: the disaster-psychopathology relationship. *Psychol Bull* 1991;109:384-399.
4. Gluckman P. The psychosocial consequences of the Canterbury earthquakes: A briefing paper. New Zealand: Office of the Prime Minister's Science Advisory Committee Publishing;2011.
5. Inter-Agency Standing Committee (IASC). Operational Guidelines and Field Manual on Human Rights Protection in Situations of Natural Disaster, Human rights and natural disasters. Washington DC, US: Brookings-Bern Project on Internal Displacement Publishing; 2008. [cited 2012] Available at: http://www.brookings.edu/idp
6. Thomalla F, Downing T, Spanger-Siegfried E, Han G, Rockström J. Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters* 2006;30:39–48.
7. Naghii MR. Public health impact and medical consequences of earthquakes. *Public Health* 2005;18:216-221.
8. United Nations: secretariat of the International Strategy for Disaster Reduction. Earthquakes caused the deadliest disasters in the past decade. Geneva, Switzerland: International Strategy for Disaster Reduction; 2010. [Cited 2012]. Available at: http://www.unisdr.org/archive/12470
9. Centers for Diseases Control and Prevention. Rapid health response, assessment, and surveillance after a Tsunami --- Thailand, 2004--2005. *MMWR Surveill Summ* 2005;54:61–64.
10. Sullivan KM, Hossain SM. Earthquake mortality in Pakistan. *Disasters* 2010;34:176–183.
11. Jia Z, Tian W, He X, Liu W, Jin C, Ding H. Mental health and quality of life survey among child survivors of the 2008 Sichuan earthquake. *Qual Life Res* 2010;19:1381–1391.
12. National Public Safety Commission. Damage Situation and Police Countermeasures associated with 2011 Tohoku district. Japan: Emergency Disaster Countermeasures Headquarters. National Policy Agency of Japan Report; 2014 [Cited 2014]. Available at: https://www.npa.go.jp/archive/keibi/biki/higaijokyo_e.pdf
13. Jia Z, Shi L, Duan G, Liu W, Pan X, Chen Y, Tian W. Traumatic experiences and mental health consequences among child survivors of the 2008 Sichuan earthquake: a community-based follow-up study. *BMC Public Health* 2013;13:104.
14. Cruz AM, Okada N. Methodology for preliminary assessment of Natech risk in urban areas. *Nat Hazards (Dordr)* 2008; 46:199-220.
15. Segawa Sh, Nishii O, Hayashi A, Iskenderoglu A, Bash M. The Study on a Disaster Prevention/Mitigation Basic Plan in Istanbul, 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004.
16. Lindell MK, Perry RW. Household adjustment to earthquake hazard: A review of research. *Environ Behav* 2000;32:461–501.
17. Simpson DM. Earthquake drills and simulations in community-based training and preparedness programmes. *Disasters* 2000;26:55-69.
18. Méheux K, Dominey-Howes D, Lloyd K. Operational challenges to community participation in post-disaster damage assessments: observations from Fiji. *Disasters* 2010;34:1102-1122.
19. Barbat AH, Carreño ML, Pujades LG, Lantada N, Cardona OD, Marulanda MC. Seismic vulnerability and risk evaluation methods for urban areas. A review with application to a pilot area. *Structure and Infrastructure Engineering* 2010;6:17-38.
20. Shoaf KI, Rottman SJ. Public health impacts of disasters. *Australian Journal of Emergency Management* 2000;15:58-63.
21. Malczewski J. GIS and Multi-criteria Decision Analysis. New York: John Wiley & Sons Publishing; 1999.
22. Ahadnejad M. Modeling of urban vulnerability to earthquake[PhD dissertation]. Tehran: University of Tehran, Faculty of Geographical sciences and planning ; 2008. [In Persian]
23. Ahmadi L. Spatial analysis of crisis management in central district of the cities using GIS (case study: C.B.D of Tabriz) [Master thesis]. Isfahan: University of Isfahan, Faculty of Geographical sciences and planning; 2011. [In Persian]
24. Firuzi M. A Study on Geotechnical features of alluvial of Tabriz path 2 railway using persiometric tests [Master thesis]. Isfahan:University of Isfahan, Faculty of sciences; 2009. [In Persian]
25. Saaty TL. The Analytic Hierarchy Process. New York: McGraw-Hill Publishing; 1980.

26. Eastman RJ. Idrisi taiga tutorial. USA: Clark University,Clark labs; 2009.
27. Zadeh LA. Fuzzy Sets. *Inf Control* 1965;8: 338-353.
28. Zhang Y, Fang K. Is history repeating itself? From urban renewal in the United States to inner-city redevelopment in China. *Journal of Planning Education and Research* 2004;23:286–289.
29. Dhara VR, Dhara R. The Union Carbide disaster in Bhopal: A review of health effects. *Arch Environ Health* 2002;57:391-404.
30. Jackson J. Fatal attraction: Living with earthquakes, the growth of villages into megacities, and earthquake vulnerability in the modern world. *Philos Trans A Math Phys Eng Sci* 2006;364:1911–1925.
31. Bartlett SN. The problem of children's injuries in low-income countries: A review. *Health Policy Plan* 2002;17:1-13.
32. Sapir D, Lechat M. Reducing the impact of natural disasters: Why aren't we better prepared? *Health Policy Plan* 1986;1:118-126.
33. Siegel C, Davidson A, Kafadar K, Norris JM, Todd J, et al. Geographic analysis of pertussis infection in an urban area: A tool for health services planning. *Am J Public Health* 1997; 87: 2022-2026.
34. Davis M. The monster at our door. The global threat of avian flu. New York: The New Press; 2005.
35. International Decade for Natural Disaster Reduction (IDNDR). Cities at Risk: Making Cities Safer, Before Disaster Strikes. USA: International Decade for Natural Disaster Reduction Publishing;1996.
36. Thompson B, Hutchinson J. British Columbia building code. USA: Building and Safety Standards Branch, BOABC Seminar; 2012.
37. Insurance Institute for Business & Home Safety. Importance of Strong Building Codes in Earthquake-Prone States. USA: Tampa, Florida and Richburg, South Carolina. BHS; 2013.