

# Earthquake Risk Perception: The Case of Mexico City

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**Abstract:** Given the concerns of society in relation to natural hazards, nowadays the analysis of risk perception and communication play an important role in decision making of those in charge, for example, of Civil Protection. The analysis of risk perception and communication may be regarded not only as a presentation of the scientific calculations of risk, but also a forum for discussion on issues on broader ethical and moral concerns. The paper present some preliminary findings of the ongoing research project on earthquake risk perception of the population of Mexico City. It is hoped that the results of the research project may help to understand, to some extent, the degree of knowledge of the study population in terms of earthquake risk perception and preparedness, so that the impact of earthquakes could be mitigated.

**Keywords:** Earthquake, Mexico City, Risk Perception.

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## 1. INTRODUCTION

### 1.1. Earthquakes

Earthquakes may regarded as one of the most deadliest natural hazards on earth. Literally in seconds thousands of lives can be (and have been) lost due to its considerable amount of force of destruction. According to the data being registered since 1900, one earthquake of magnitude 8 or greater, 15 earthquakes of magnitude 7-7.9 and 134 earthquakes of magnitude 6-6.9 on the Richter scale are expected each year, worldwide [1]. It is also believed that the number of large earthquakes has remained relatively constant; however, the observed number of smaller earthquakes (of magnitude lesser than 6) has increased each year [2]. According to the International Federation of Red Cross (IFRC), during the first decade of the 21 century, 4,022 natural disasters have been reported, 284 (7%) of which were earthquakes [3]. Although they constitute a small share among the number of disasters, earthquakes are the major cause of death (55.7%) and cause US\$232,070 million worth of damage (22%) comparing to other natural phenomena [3].

### 1.1. Risk Perception and Preparedness

A natural hazard only becomes a disaster when it affects a human community that is exposed and vulnerable. Entities at risk are humans, infrastructure, buildings, utilities, etc. Seismic vulnerability of a community is "the degree of loss to a given element of risk or set of such elements" [4]. Moreover, some authors argued that "an earthquake is an event that can be prepared for in advance" [5]. Governments, local communities, and social organizations all should undertake measures for major earthquakes. Individuals also reduce the impacts of earthquake disasters by learning what to do before, during and after earthquakes and by taking a variety of personal safety measures [6-9].

Overall, risk, risk perception, and risk communication has been deal with from different perspectives; that is, risk from a quantitative perspective [10] and as a threat [11,12]. Slovic [11], for example, has described risk perception from different sources; i.e., geography, sociology, political science, anthropology and psychology [11]. The geographical perspective focuses in trying to understand human behavior for natural hazards; the sociological and anthropological approaches, on the other hand, have shown that perception and acceptance of risk have their roots in social and cultural factors.

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Finally, the psychological aspect addresses the fear level prior to the event and the confidence in a person's available resources. Slovic [13] argues that risk perception is related to three major factors: dread, familiarity and exposure. Other authors have found that factors affecting risk perception are usually not independent and vary across different hazard types and people [14].

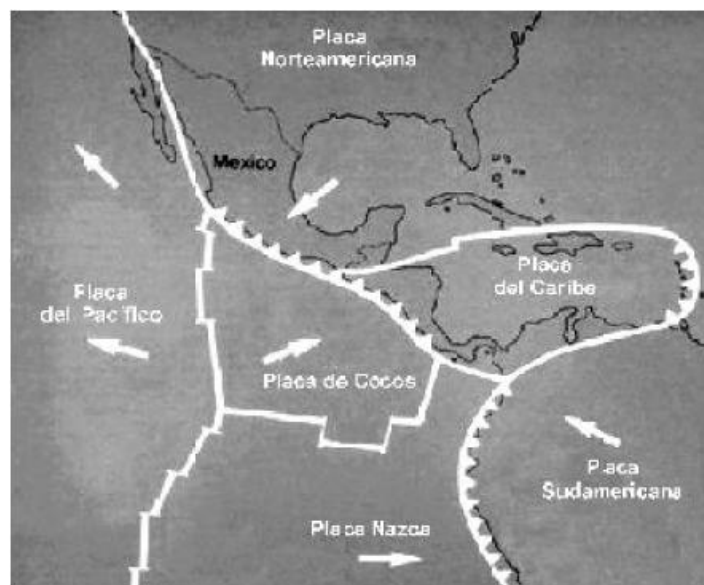
A number of studies have been conducted worldwide and reported in the literature addressing knowledge on seismic risk, earthquake risk perception and willingness to take action to reduce seismic risk [15-21]. However, there is not such a study related to Mexico City. The authors are part of a research team conducting research on risk perception and risk communication related to seismic risk in Mexico City and other states of the country. The paper addresses some results of a pre-test of a survey instrument being designed for a big scale application.

## 2. THE SEISMICITY OF MEXICO AND THE 1985 EARTHQUAKE

### 2.1. Seismicity of Mexico

Situated atop three of the large tectonic plates that constitute the earth's surface, Mexico is one of the most seismologically active regions on earth. The motion of these plates causes earthquakes and volcanic activity. Most of the Mexican landmass rests on the westward moving North American plate. The Pacific Ocean floor off southern Mexico, however, is being carried northeast by the underlying motion of the Cocos plate. Ocean floor material is relatively dense; when it strikes the lighter granite of the Mexican landmass, the ocean floor is forced under the landmass, creating the deep Middle American trench that lies off Mexico's southern coast (Fig. 1). The westward moving land atop the North American plate is slowed and crumpled where it meets the Cocos plate, creating the mountain ranges of southern Mexico. The subduction of the Cocos plate accounts for the frequency of earthquakes near Mexico's southern coast. As the rocks constituting the ocean floor are forced down, they melt, and the molten material is forced up through weaknesses in the surface rock, creating the volcanoes in the Cordillera Neovolcánica across central Mexico [22].

**Figure 1: Mexico and tectonic plates. [23].**



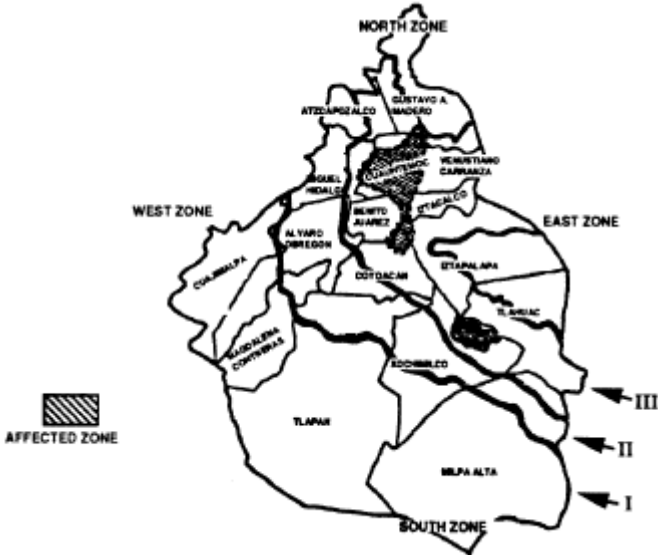
### 2.2. The 1985 earthquake

On September 19, 1985, at 7:19 local time, an intense earthquake with a magnitude of 8.1 on the Richter scale struck the country. The epicentre was located near the coast of the state of Guerrero, about 400 kilometres southeast of Mexico City, at 17.8 degrees north latitude and 102.3 degrees west longitude. The global area affected by the seismic shock waves was estimated at 800,000 square kilometres making this earthquake one of the most powerful in the history of the country (Fig. 2) [24]. One of the most affected was Mexico City (Fig. 3).

**Figure 2: Affected area of the seismic shock waves. [24].**



**Figure 3: The affected areas of Mexico City. [24].**



The following day, at 19:40 p.m. local time, a second seismic movement measuring 7.5 on the Richter scale, with an epicentre at the same place, caused panic in the population despite the fact that the damages were minor when compared to the devastating magnitude of the first. It is believed that during the following 45 days after the earthquakes of September 19 and 20, more than 150 secondary earthquakes were registered, with varying magnitudes between 3.5 and 5 on the Richter scale. [24].

According to the official figures the earthquake caused the death of 6000 people and about 30,000 people were injured, and 150,000 were left homeless. [23].

**3. METHODS**

Interviews were conducted by using a version of the questionnaire being designed for a much bigger scale. Essentially the first version of the questionnaire was tested and administered in November 2013 by student interviewers from the Institute. The instrument was divided into three parts: (1) demography (age, gender, occupation, religiosity, economic status, where they live, etc.), (2) perception of seismic risk, and other hazards; the possibility of being affected by it and to suffer losses; the degree of expectation for getting support from authorities, and (3) the level of adaptation to seismic risk, including the education about minimizing risk.

The sample size was randomly composed and the subjects were self-selected as willing to talk about earthquakes. This may not be representative of the City population; however, we are hoping to conduct a probabilistic sample and to make the findings representative for the population under study.

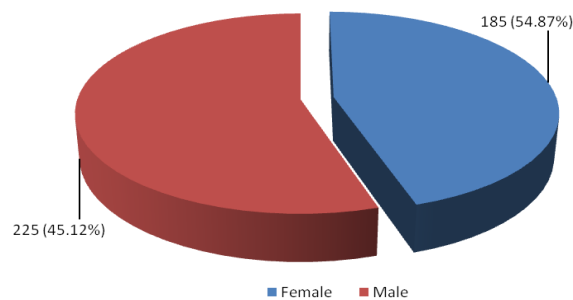
## 4. THE RESULTS

The results of some of the entries of the survey instrument are presented in the section; the result are descriptive in nature.

### 4.1. Demographics

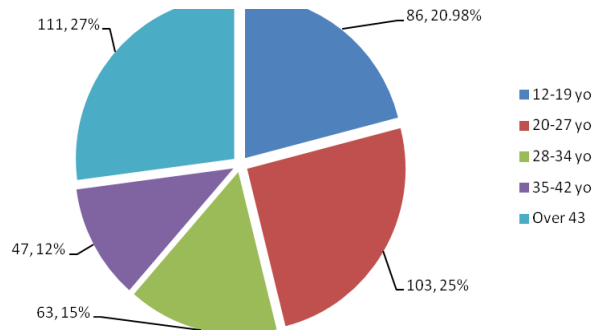
Fig. 4 shows the demographic characteristics of the respondents. The sample size was 410 participants. A total of 225 (54.87%) were male and 185 (45.12%) female.

**Figure 4: Gender of the participants.**



The questionnaire included a question with several categories regarding the age of the respondents. According to the results shown in Fig. 5, it can be seen that most of the respondents were over 43 years old (27.07 %), which could be interesting in the study; this is because these participants have experienced the 1985 earthquake (i.e., a person of 43 years old was about 16 when the earthquake struck the capital City) and their experience is important in our research. There has been some studies that have found that past experience are more proactive, for example, in taking preventive measures. [15,18].

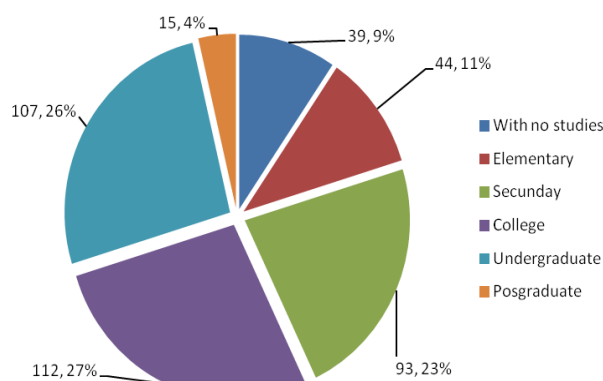
**Figure 5: Age of the participants.**



25.12 % of respondents aged between 20 to 27 years old. This percentage of participants did not experienced an earthquake of the magnitude similar to the 1985 earthquake; however, there have been several earthquakes in recent years. A total of 86 (20.98%) teenagers participated in the survey. Their responses are of great interest in our study. According to studies conducted elsewhere show that youngsters with earthquake hazard education, discussed such issues with their parents and this effectively encourage adult participation and preparedness in case of an earthquake [19]. In fact, there is evidence that youngsters that received earthquake education preparedness contributed significantly in sharing their knowledge with their family members during and after the L'Aquila earthquake in 2009 [19].

Fig. 6 shows the level of education of the participants. Education is one of the key variables that needs to be consider when assessing the preparedness of seismic risk. Research has shown that educated people tend to implement proactive measures to seismic risk [15,16]; for example, a study conducted in Turkey [15] showed that well educated people are retrofitting their houses as a proactive measure to withstand earthquakes. In the same study, the results showed that less educated people are not willing to retrofitting their houses.

**Figure 6: Educational level of the participants.**



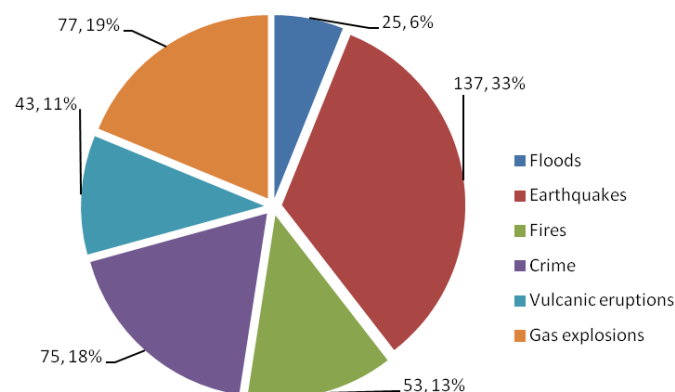
The education level can also contribute to the perception of seismic risk and consequently the required level of awareness of seismic risk. For example, the results of a research conducted on earthquake risk perception in Morocco concluded that less educated people took a fatalist attitude towards seismic risk.; for example, the study found that the less educated "were more likely to deny the significance of scientific assessment and forecasting, and that level of protection from devotion and/or prayer was above all more important and effective [20].

Fig. 6 shows that 79% of the participants have at least the elemental level of education; 20%, on the other hand, do not have any. In our study we are very interested in their seismic risk perception given the fact that they may be more vulnerable to earthquake preparedness.

#### 4.2. Earthquake And Other Hazards Risk Perception

The results of the risk perception to six categories of hazards is shown in Fig. 7. As expected, seismic risk is the highest concern of the participants of the survey with 33% (137). This may be due to the fact that recently there were three earthquakes with magnitudes 6.5, 6.3 & 6.2, on the Richter scale, respectively. Moreover, the news about the devastating consequences of recent earthquakes such as Haiti (2010), China (2008), among others, influenced their seismic risk perceptions.

**Figure 7: Risk perception.**



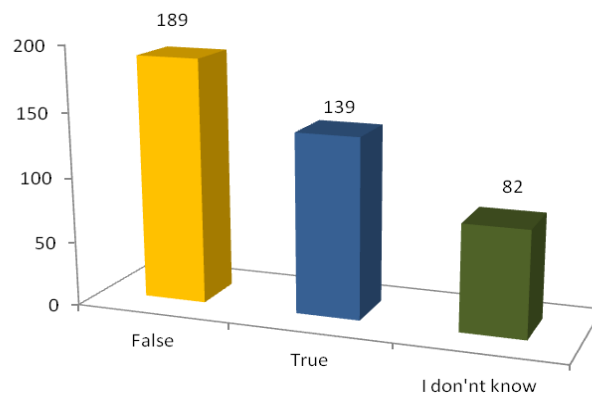
The second concern of the respondents is 'Gas explosions'. This was quite surprising for us given the fact that there are not that many related accidents, at least not in Mexico City. However, one reason for this could be the devastating consequences of two major gas explosion events; the first, an explosion occurred in San Juanico in 1984 where about 500 people lost their lives [25]; The second, an accident related to gas pipeline explosions in Guadalajara in 1992 (212 people were killed, 69 missing, 1470 were injured) [26]. Crime came third in the list; this also was very surprising, given the fact that the crime committed by the drug cartels is very much in the news every day. Fire risk and volcanic eruptions came fourth and fifth, respectively. Finally, 'flood' occupy the last in the list with 6.2 %.

#### 4.3. Knowledge On Seismic Risk And Preparedness

In the following entry: "Many small earthquakes avoid a large one", the participants were asked to respond according to the following options: "False", "True", and "I don't know". This was included in the questionnaire survey because in Mexico City exists the myth that "it is better to have many small earthquakes instead of a large one"; Fig. 8 shows the results.

46% (189) of the respondents considered the statement as "False"; this could be considered as a correct answer. That is, in order to understand the Richter scale, it may be helpful if it is compared to the energy released by an atomic explosion. It is estimated that an atomic bomb of 13 kilotons (13,000 tons of TNT) releases energy equivalent to a magnitude 5 tremor. While 32 atomic bombs equivalent to the energy released during an earthquake of magnitude 6, so a Grade 8 earthquake energy is equivalent to 32,000 tremors grade 5 so we would have to withstand 32,000 tremors to release the energy of a major event. [23].

**Figure 8: Risk perception on the frequency of earthquakes.**



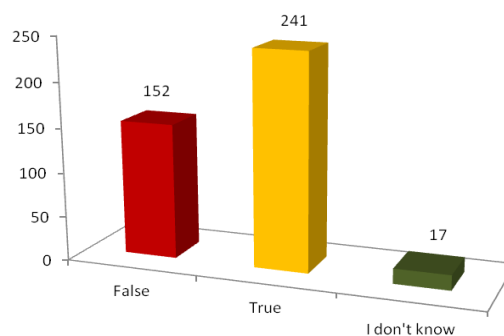
There has also been evidence that supports that this statement is incorrect. For example, in 2009, a 'Risk Committee', composed of scientific experts on earthquakes, met in L' Aquila (Italy) on March 31, 2009 given the fact that there were continuous tremors that shook central Italy. After 45 minutes of discussion, they concluded that there was no real danger. However, on the night of 6th April, an earthquake struck killing 308 people, injured 1,500, 65,000 were left homeless and 20,000 buildings collapsed. [19].

Since then, it has been a great debate in that country about the irresponsibility of the Civil Protection authorities. Recently, it has been reported that [27]:

*"The six scientists and a former government official were all members of the Major Risks Committee which met in the central Italian city on March 31, 2009, after several small tremors had been recorded in the region. At the time, they ruled that it was impossible to determine whether the tremors would be followed by a large quake, in a judgment which reassured residents. One of the group famously advised them to relax with a glass of wine. Just six days later, a 6.3 magnitude quake devastated L'Aquila."*

The questionnaire included the following statement: "During an earthquake, it is best to leave the building immediately", the participants were asked to respond according to the following options: "False", "True", and "I don't know". The results are shown in Fig. 9.

**Figure 9: What to do during an earthquake.**



Two of the recommendations issued by the Mexico City's Civil Protection organization about what to do during an earthquake are listed in Table 1.

**Table 1: Two examples of what to do during an earthquake.**

No	Description
1	Keep calm and get in security zones during an earthquake and try to protect yourself as best as possible. Most of those injured in an earthquake occurred when people tried to enter or leave the house or buildings.
2	If you are in a building , stay where you are , do not try to use the elevators or stairs during the quake.

58.8 %, the majority of respondents, answered as "true" to the statement. Only 37 % responded as 'false' (but this not necessarily means that they knew the answer) .

**Figure 10: People who experienced the 1985 earthquake (left) vs people who did not (right).**

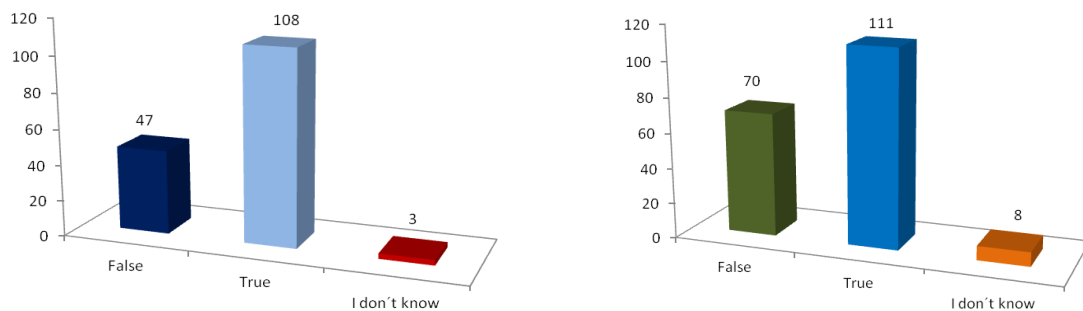
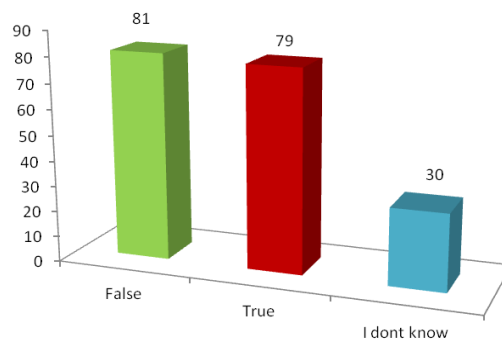


Fig. 10 shows the results for the same statement for those respondents that experienced the 1985 earthquake (Fig. 10- Left) and the respondents that did not (Fig. 10-Right). The results show that the majority of both categories of the respondents have not learned the lesson (108 and 111, respectively). It can be argued that such a recommendation if followed, could save many lives.

**Figure 11: Falling objects during an earthquake.**



According to all the photographic evidence that have been revised as well as the relevant literature in the present research project on earthquakes worldwide; a key factor appears apparent and it is associated with 'falling objects'. Falling objects may be considered as one of the factors that cause deaths during earthquakes. Given this, the following statement was included in the questionnaire: "Falling objects are the most dangerous during earthquakes". Similarly, the participants were asked to respond according to the following options: "False", "True", and "I don't know"; the results are shown in Fig. 11. The results show that the majority of the participants are well aware of this fact.



## 5. CONCLUSION

As mentioned in the Introduction section, the results presented here are not conclusive; however, they represent a starting point for a much bigger scale study. In fact, we tested the instrument and found several limitations in relation to, for example, the wording of the statements were confusing for many of the participants. However, from the results presented here we can say that:

{a} The preliminary results show that the survey participants do not have the culture of prevention in relation to seismic risk.

{b} The participants also showed insufficient knowledge about the right actions to take during an earthquake.

{c} The participants (those who experienced the 1985 earthquake as those who did not) have not learned the basic lesson (as recommended by Civil Protection) not to immediately leave the building during the quake.

{d} Finally, the above sums up well the preliminary conclusion that the sector of the population surveyed are not prepared for these events.

## Acknowledgements

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