

Research Article

Multi-hazard Awareness, Risk Perception and Fear to Earthquakes: The Case of High-school Students in Mexico City

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*Keywords*Earthquake
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Mexico City**ABSTRACT**

A cross-sectional study was conducted in 2015 for the case of students at a high school in Mexico City; the sample size was $N = 302$. The aim of the study was to assess the level of hazard awareness, risk perception, and the negative emotion related to fear during earthquakes. Some of the main findings were the following: (a) regarding the multi-hazards (natural, environmental, psychosocial, technological, sociological) considered in the study, earthquakes and 'crime & delinquency' were perceived as the top two threats to the participants of the study, and in that order; (b) the perceived hazards that may cause physical harm were earthquakes and 'crime & delinquency' and in that order; (c) women fear the most during an earthquake [$\chi^2(2, n = 301) = 17.614, p < 0.001$].

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Natural hazards in combination with a community that lacked an adequate preparation for such events, have caused a considerable damage to people, property, and economical losses [1,2]. For example, those communities in seismic prone regions, worldwide, are vulnerable to earthquakes given the fact that they lack earthquake resistant homes, earthquake early warning systems, among others [1,2] (i.e., earthquakes still cannot be predicted [3,4]).

In addition to the individual natural hazards (e.g. earthquakes), there is an increasing evidence that hazards are found in combination with other threats, i.e., natural, environmental, psychosocial, technological, sociological, etc. [5–13]. The interconnectedness of these multi-hazards has been recognised in the Sendai Framework for Disaster Risk Reduction in 2015 and the Sustainable Development Goals [11]. These organizations, among others, have encouraged communities to develop an adaptation strategy to deal with such threats [11,14].

In order to be able to develop such strategies, it becomes necessary to be aware of such multi-hazards and the risk associated with them. Within this context, risk perception plays a fundamental role in adopting some form of protective action to mitigate the impact of these hazards [11,15]. However, it has been found that there is not a proportional relationship between the level of risk perception and the rate of taking protective actions, i.e., higher level of risk perception is not always linked to protective action ("risk perception paradox") [11,15].

Risk perception has also been envisaged as having cognitive and emotional components [16]; for example, the six 'basic' emotions proposed by Ekman [17]: i.e., fear, anger, happiness, sadness, disgust, surprise. Several studies have been conducted and reported in the literature on emotional and behavioural reactions to earthquakes [18–24]. In the present case study, we are dealing with fear to earthquakes; according to the Oxford dictionary, fear is defined as "the bad feeling that you have when you are in danger, when something bad might happen, or when a particular thing frightens you" [25]. In this context, fear to earthquakes may be defined as a feeling that something bad might happen to those experiencing one.

In relation to earthquakes, previous research has shown that fear has been the most frequent emotion experienced by individuals during earthquake occurrence [18–20,23]. However, results have also shown that other emotions are experienced by earthquake survivors, e.g., in a study conducted on the Umbria-Marche earthquake in Italy, 13.1% of the respondents experienced 'surprise', 12.1% 'sadness', etc. [23]. Hence, it may be argued that during an earthquake occurrence, people experience several types of emotions.

Research has also been conducted on issues related to hazard awareness, preparedness, vulnerability and resilience, among others, and widely reported in the literature [e.g. 26–32]. For example, in a multi-hazard awareness study conducted in Morocco; it has been found that floods and earthquakes represent the top two threats to local communities [26].

The paper presents the results of a cross-sectional study on the hazards awareness and risk perception for the case of high school students in Mexico City. The paper gives an account of the key findings of the research project.

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2. MATERIALS AND METHODS

A cross-sectional survey has been conducted to several preparatory schools in Mexico City in 2015; the schools were in different parts within the city (i.e., in the three geotechnical zones). However, only the collected data of one of these schools are presented here, and with a sample size, $N = 302$. The survey questionnaire included over fifty questions, however, only a few have been considered herein, and some of them are based on Ronan et al. [32]. The results presented here include those associated with hazard awareness, risk perception, and some psychological issues in relation to negative emotions (i.e., fear) during earthquake occurrence.

In order to analyse the descriptive information, frequency analysis has been conducted. Further, the validity of the working hypothesis, on the other hand, was considered at a significance level of $\alpha = 0.05$. Furthermore, the relationship between the independent and dependent variables have been assessed by applying the contingency tables and Pearson's chi-square tests.

Table 1 shows the demographic characteristics of the sample considered in the present analysis. It can be seen that the range of the age of the respondents varied from 14 to 19 years old ($M = 16.39$; $SD = 1.203$).

The percentage of men was higher than women (i.e., 55.0% vs. 45.0%). Finally, in the capital city, the schooling system covers two shifts: i.e., the morning and afternoon shifts. In general, the morning shift covers from 07:00 to 14:00 h (55.3%); the afternoon shift, on the other hand, covers from 16:00 to 22:00 p.m. (44.7%).

3. RESULTS AND DISCUSSION

3.1. Multi-hazard Awareness

To assess the multi-hazard awareness of respondents of the present study, the following question was included in the questionnaire: “which are the two most likely hazards that could affect you at school and home?”. The types of hazards considered as possible response to the question were the following: natural hazards (“earthquakes”, “floods”, “hurricanes”, “landslides”, “volcanic eruptions”), environmental (“environmental pollution”), psychosocial (“bullying”), and sociological (“crime & delinquency”). It should be highlighted that

Table 1 | Demographic characteristics of the participants of the study, $N = 302$

Variables	N (%)
Age (years)	
14	12 (4.0)
15	69 (22.8)
16	75 (24.8)
17	95 (31.5)
18	38 (12.6)
19	13 (4.3)
Gender	
Women	136 (45.0)
Men	166 (55.0)
Schooling mode system	
Morning	167 (55.3)
Afternoon	135 (44.7)

all these hazards are present in the Capital City [33] (see Section 3.5 for further details). The results are shown in Table 2.

When considering natural hazards, the perceived two hazards that may affect the participants at home were earthquakes (85.5%) and floods (16%). However, when considering all types of hazards considered in the analysis, the results show that the two perceived hazards that could affect the participants were earthquake (85.5%) and ‘crime & delinquency’ (64.1%). In general, respondents perceived that earthquakes represents the major threat to them when at home.

But, what about the two perceived hazards at school? Again, the results show that earthquakes are the cause of concern by the respondents, with 81.6%; this was followed by ‘crime & delinquency’ and ‘bullying’, both with 47.3%, when considering all types of hazards (Table 2).

In summary, the results highlighted that the following types of hazards were those that participants most worry about both at home and at school: natural (earthquake), environmental (environmental pollution), psychosocial (bullying), and sociological (‘crime & delinquency’).

3.2. Multi-hazard Risk Perception

In an attempt to assess the perceived vulnerability and risk, the following question included in the questionnaire: “should one of these events occur in the future, how likely is it that it could hurt you or your family?”. It should be emphasised that within the response options, a technological hazard was included this time (i.e., ‘Fire & Explosion’). The results are shown in Table 3.

The possible responses to the question were the following: “1 = Unlikely”, “2 = A chance”, and “3 = Likely”.

The top four hazards that have been perceived as having a “better than a chance” to cause physical harm to the participants of the

Table 2 | Perceived multi-hazards at home and school

Hazards at home		Hazards at school	
Hazard	%	Hazard	%
Floods	16	Floods	8.2
Hurricanes	2.3	Hurricanes	2.0
Earthquake	85.5	Earthquake	81.6
Landslide	6.6	Landslide	1.6
Volcanic eruption	3.1	Volcanic eruption	1.6
Environmental pollution	20.7	Environmental pollution	10.6
Crime & delinquency	64.1	Crime & delinquency	47.3
Bullying	1.6	Bullying	47.3

Table 3 | Perceived event occurrence and physical risk perception

Hazard	% “Likely”	Mean	SD
Floods	24.1	2.04	0.664
Earthquake	87.6	2.85	0.427
Landslide	10.7	1.66	0.663
Volcanic eruption	14.0	1.75	0.687
Environmental pollution	69.2	2.66	0.534
Crime & delinquency	81.9	2.80	0.458
Fire & explosion	65.6	2.60	0.602

study were: earthquakes (SD = 2.85), ‘crime & delinquency’ (SD = 2.80), environmental pollution (SD = 2.66), and ‘fire & explosion’ (SD = 2.60) (see Section 3.5 for a discussion on these findings).

On the other hand, the bottom three were floods, volcanic eruption, and landslide.

3.3. Experiencing Earthquakes

The questionnaire included a question intended to elucidate whether the participants have experienced earthquakes. In particular, respondents were asked the following question: “Have you experienced an earthquake?” The possible answers were either “Yes” or “No”. The results showed that most of the participants have experienced an earthquake (98.7%; 298/302).

This may be explained given the fact that in 2014, an unusual number of earthquakes occurred in that particular year (it should be highlighted that the study was conducted in 2015) [33]. For example, there were three relatively strong earthquakes with magnitudes ranging from M5.4, M5.9, and M7.9 [33]. These events caused panic and anxiety among the residents of the city; however, there were neither property damages, nor life threatening situation.

3.4. Level of Fear during Earthquakes

One of the factors related to psychological issues that has been addressed in the study is that related to the level of fear during earthquakes. In the context of the previous question (Section 3.3), students were asked the following question: “what was your level of fear during that earthquake?” Respondents were asked to rate their answers according to the following options: 1 = “Not at all”, 2 = “Little”, 3 = “A lot” (That is, ‘fear’ was measured with three levels; however, it should be highlighted that in similar studies, the intensity of fear was measured as a continuous variable, for example in Prati et al. [24], respondents were asked to rate their perceived intensity of fear on a scale ranging from “0 to 100” [p. 104].).

Overall, the frequency data show that most of the participants experienced “Little” fear during the earthquake (59.8%; 180/302) (Figure 1). Further, almost 40% of the participants of the study reported no fear at all (20.6%; 62/302) and 19.6% reported “A lot” of fear (59/302).

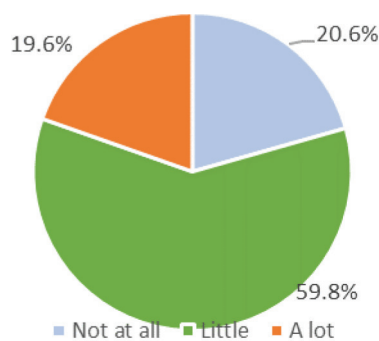


Figure 1 | Responses to the question related to fear during an earthquake occurrence.

In order to assess the relationship of the variables considered in the study (gender, age, and the schooling mode system, see Table 1), cross-tabulations were constructed, and the results are shown in Tables 4–7 (The percentages given in these tables are within the variables shown in columns; the total percentages in columns may not add up to 100% because of decimal rounding. Further, differences in total $n = 302$ are due to missing values in items.).

When conducting chi-square tests, the results showed that neither the variable age [$\chi^2 (2, n = 301) = 0.969, p = 0.616$, Cramer’s $V = 0.057$], nor the schooling mode system [$\chi^2 (2, n = 301) = 2.605, p = 0.272$, Cramer’s $V = 0.093$] were associated with the level of fear during earthquakes.

Table 4 | Results of the relationship between gender and the level of fear to earthquakes

Variables	Male	Female	Total
	N (%)	N (%)	N (%)
“Not at all”	41 (30.1)	21 (12.7)	62 (20.6)
“Little”	78 (57.4)	102 (61.8)	180 (59.8)
“A lot”	17 (12.5)	42 (25.5)	59 (19.6)

Table 5 | Results of the relationship between the age category and the level of fear

Variables	≤16	≥17	Total
	N (%)	N (%)	N (%)
“Not at all”	33 (21.3)	29 (19.9)	62 (20.6)
“Little”	95 (61.3)	85 (58.2)	180 (59.8)
“A lot”	27 (17.4)	32 (21.9)	59 (19.6)

Table 6 | Results of the relationship between the schooling mode system and the level of fear

Variables	Morning shift	Afternoon shift	Total
	N (%)	N (%)	N (%)
“Not at all”	30 (18.1)	32 (23.7)	62 (20.6)
“Little”	106 (63.9)	74 (54.8)	180 (59.8)
“A lot”	30 (18.1)	29 (21.5)	59 (19.6)

Table 7 | Results of the relationship between the gender and the level of fear of the participants of the study when controlling for the age group category

Variables	Male	Female
	N (%)	N (%)
≤16		
“Not at all”	20 (31.3)	13 (14.3)
“Little”	37 (57.8)	58 (63.7)
“A lot”	7 (10.9)	20 (22.0)
≥17		
“Not at all”	21 (29.2)	8 (10.8)
“Little”	41 (56.9)	44 (59.5)
“A lot”	10 (13.9)	22 (29.7)

However, it was found that the variable related to gender was associated with the level of fear of earthquakes of the participants of the study, $\chi^2(2, n = 301) = 17.614, p < 0.001$, Cramer's $V = 0.242$.

In particular, it was found that women feared “A lot” during the experienced earthquake when compared with men (i.e., 25.4% vs. 12.5%).

To further investigate the influence of the variable related to the category of age, a multivariable analysis (i.e., by ‘controlling’ for the age categories) was conducted, and the results are shown in Table 7.

It has been found that only those participants (men and women) with the age category ≥ 17 years old were associated with “Little” fear during the earthquake, $\chi^2(2, n = 146) = 10.408, p = 0.005$, Cramer's $V = 0.267$. In particular, the results highlighted that men experienced “Little” fear when compared to women (i.e., 29.2% vs. 10.8%).

3.5. Discussion

Regarding the multi-hazard awareness and risk perception, the results showed that respondents' perceptions may be regarded as consistent with what has been happening in the City; i.e., prior to 2015 when the study was conducted (Section 2) (It may be argued that these results are relevant even today). That is, the residents of the Capital City have been exposed to these multi-hazards [33–43]. For example, earthquakes and ‘crime & delinquency’ were the top two hazards that were perceived as threats at home and school. These were followed by environmental and technological hazards. Each of these will be briefly discussed.

Effectively, Mexico City (and those communities living along the Pacific coast of the country) is prone to earthquakes [19,33]. For example, one of the strongest earthquakes that hit the capital city was in 1985 (M8.1); it is believed that thousands of people were killed [19,33]. That is, earthquakes occur all the time. This finding has demonstrated that students were aware of such events at the time of the study. For example, the two most recent strong earthquakes that occurred on 07 (M8.2) and 19 (M7.1) September 2017. It is thought the 19 September earthquake affected more than 28 million people, 54,000 schools, 5700 hospitals, etc. [44]. Therefore, the findings are consistent with the perceived earthquake threats of the participants of the study.

‘Crime & delinquency’, on the other hand, was the second hazard that was perceived as a threat to the participants of the study at home and school. There has not been (and there is not) a day without news on the mass media related to crime in the Capital City; several studies on this have been reported in the literature [33,35,38–40]. It is believed that during 1990–2005, the pattern of violent crime rate decreased during this period [39]. However, since December 2006 when the Federal Government launched what is now called the “Drug war” [i.e., a military offensive against the so called ‘Drug Traffic Organizations’ (DTOs)], there has been a surge in violent crime rates [39].

Enamorado et al. [39] reported that in 2005, “the total rate of homicides was close to 11 per 100,000 individuals”; further, the authors reported that “by 2010, it was 18.5 per 100,000 individuals” (p. 129). Furthermore, it is believed that in 2005, the number of people being killed by non-drug related crime was 7000 [39].

According to the 2015 Child and Youth Survey [40], 75.4% of the children (6–9 years old), 59.7% (10–13), and 70.3% (14–17) felt unsafe on the streets. Further, the study concluded that most Mexicans felt unsafe on the streets and this is more accentuated in children and young boys.

Hence, regarding ‘crime & delinquency’, the results of the study are consistent with what has been happening and reported in the literature.

The results also showed that one of the worries of the students is that related to the ‘environmental pollution’ in the Capital City. Several studies have given an account on this and reported in the literature [9,34,36,41,43]. Further, on 20 November 1989, an ‘environmental contingency’ plan was implemented in the city. An environmental contingency has been defined as “an eventual and transitory situation declared by the authorities, when a high concentration of O_3 and/or PM10 or PM2.5 pollutants occurs or is anticipated, based on objective analyses, forecasts or monitoring of environmental air pollution, derived from human activities or natural phenomena that affect the health of the population or the environment” [43].

For example, one of the measures taken has been that motor cars are not allowed to transit in the city during certain days [41,43] (other measures such as children staying indoors, etc., can be found in Gobierno [43]). Again, the results are consistent with environmental hazards in the city.

Finally, the fourth technological hazard that students were worried about is that related to ‘Fire & Explosion’. This is a typical case of what is called ‘low frequency-high impact’ events (it may be argued that earthquakes follow this pattern too). There have been several fire and explosion events in the metropolitan area of the Capital City. For example, four of the major events occurred in the period between 2000 and 2008; other examples are given in Santos-Reyes and Gouzeva [33] and Lozano et al. [42]. In 2000, a fire and explosion occurred involving ten trucks; in 2008, there was a spill of a hazardous material (i.e. Kerosene) that forced the evacuation of 150 families in the metropolitan area of the city. Again, the participants of the study showed their level of awareness of the existing technological hazards, such as ‘fire & explosion’.

It is worth mentioning that research on the psychological issues related to emotions started since the 70s. For example, Ekman [17] proposed the ‘basic’ emotions, namely: fear, happiness, surprise, anger, sadness, and disgust. Some authors have used these ‘basic’ emotions to understand the emotional response of people during an earthquake occurrence [19,23,24].

However, in our study we did not use these categories of emotions, but the perceived level of fear during an earthquake occurrence was assessed with the following responses: “Not at all”, “Little”, and “A lot” (Section 3.4).

According to the frequency data in our case study, 19.6% of the respondents reported “A lot” of fear during an earthquake (59.8% responded “little” and 20.6% “not at all”). Similar findings have been reported in a study that was conducted in New Zealand. That is, about 14% of children reported often feeling ‘upset or scare’ when thinking or talking about earthquakes; 25% reported no upset, and 60% reported some level of fear [32].

When conducting chi-square tests, it has been found that gender was significantly associated with fear. That is, women fear “A lot” of

earthquakes when compared to men. When considering the age of the respondents, on the other hand, the age category ≥ 17 years old was associated with “Little” fear of earthquakes.

The limitations of the study were the following: first, the design of the study was non probability, which means that the findings should not be generalised to the whole population of high school students of the Capital City; second, the sample size of the present study was relatively small, i.e., $N = 302$; future research may involve the analysis of the collected data on several high schools in the City. Third, the present study was conducted with no earthquake disaster as a precedent; that is, prior to 2015 (when the study was conducted) several minor earthquakes occurred but not damage was reported [33].

Further research may include the analysis by considering the geo-technical seismic zones of the capital city where the school facilities are located.

4. CONCLUSION

The paper has presented the results of a cross-sectional study on the participants’ level of multi-hazard awareness, risk perception and emotional reaction related to fear during earthquakes. The study was conducted in 2015; the sample size was $N = 302$, and for the case of a high school located in Mexico City. The key findings/conclusions are summarised as follows:

- (a) The perceived two hazards that may affect students at home and school were earthquakes and ‘crime & delinquency’ and in that order.
- (b) The perceived two hazards that may cause physical harm (Table 3) to the participants and family were earthquakes and ‘crime & delinquency’ and in that order.
- (c) Most of the participants of the study have experienced an earthquake 97.8% (298/302).
- (d) Regarding the negative emotion related to fear during earthquakes, 19.6% experienced “A lot” of fear, 59.8% “little” and 20.6% feared “not at all” of earthquakes.
- (e) The chi-squared results showed that women experienced “A lot” of fear during earthquakes when compared to men.
- (f) When considering the multi-hazards (natural, environmental, psychosocial, technological, sociological) considered in the present study, earthquakes were perceived as the top threat to the students considered in the analysis.
- (g) More generally, these findings may assist key decision makers on disaster reduction in the Capital City to device programmes aiming at better educating children to multi-hazards. By doing this, children may be better prepared to mitigate the impact of earthquakes.

CONFLICTS OF INTEREST

The author declares no conflicts of interest.

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