Chapter

Knowledge and Perception on Seismic Risk of Students in Mexico City Before the 2017 Earthquakes

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Abstract

This paper presents some of the results of a cross-sectional study conducted in Mexico City in 2015–2016. The approach has been the application of a questionnaire to a sample size of $n = 1489$. Six high schools participated in the study that are located within the seismic zones of the city. Some of the results and conclusions are given below: (a) 95% of the students have experienced an earthquake and 71% considered that earthquakes cannot be predicted; however, 29% did not know this fact; (b) 82.2% of students were all aware of the likelihood of an earthquake occurrence sometime in the future. (c) One of the key conclusions is associated with the need to educate the residents of the capital city on a more realistic scale of the size of an earthquake; this could be the "Modified Mercalli Intensity Scale" or similar. (d) More generally, the residents of the city should be educated with urgency on these basic concepts. The more effective is the communication on risks and consequences, the better may be their preparedness to earthquakes.

Keywords: risk perception, earthquake, Mexico City, students, education

1. Introduction

Communities have been exposed to disasters and extreme events. For example, earthquakes have caused destruction worldwide in recent years [1–7]. Some of them have triggered tsunamis with catastrophic consequences, such as in the cases of Indonesia in 2004 [1] and Japan in 2011 [3]. More recently, it is believed that a tsunami was triggered by a landslide caused by a volcanic eruption in Indonesia in 2018 killing hundreds of people [8].

Preparedness to natural disasters is essential to mitigate the impact of earthquakes. Research has shown that, for example, culture belief has an influence on people's reactions to risk [9–12]. Moreover, some studies have shown that in some cultures people shows a fatalistic attitude to earthquake disasters as acts of God [12] and that nothing can be done about it.

On the other hand, some scholars argue that emergency preparedness and reduction of vulnerability, among others, are strongly influenced by both past disaster experience and risk perception [13]. Moreover, it is thought that risk perception is a function of communication [13, 14]. That is, risk communication plays an important role between those in charge of making decisions, for example, on preparedness, disaster knowledge, and people exposed to seismic risk [13, 14].

This chapter presents some preliminary results of seismic risk perception and other natural hazards (e.g., volcanic eruption and floods). It also presents some results on the knowledge on some basic concepts related to the earthquake prediction, among others. The approach has been the application of a questionnaire to a sample size of n = 1489; the study has been conducted in 2015–2016. The results are discussed in the context of past earthquakes (i.e., those that occurred before the study was conducted) and the 2017 earthquakes that hit the capital city.

2. Research methods

A cross-sectional study was conducted in 2015–2016 in Mexico City; the sample size considered in the analysis was n = 1489. Six high schools decided to participate in the study, and all of them were located within the critical areas of the city, i.e., the seismic zones defined as "zones I, II, and III." A questionnaire was designed to capture the data on several issues related to seismic risk perception, other natural hazard perceptions, and knowledge on actions to take during the occurrence of an earthquake, among others (however, the results of the few questions are reported here). The questionnaire was pretested before the final application to the sample; it took about 25 min to complete. The questionnaires were applied from December 2015 to March 2016.

The analysis of the collected data was done by conducting frequency analysis, and the relationship among the variables was performed by conducting cross tabulations. Overall, a basic descriptive statistical analysis of the variables considered in the analysis is presented here; some of the results associated with an inferential analysis are presented elsewhere.

The results related to the following questions are presented in the next section:

a. "Have you experienced an earthquake?"

b. "How does the magnitude of an earthquake being measured?"

c. "Can an earthquake be predicted?"

d. "How likely an earthquake will occur in the future?"

e. "If any of these events happen in the future, how likely is it that it will affect you?"

3. Results and discussion

3.1 Experience and earthquake prediction

As mentioned in the previous section, the questionnaire was applied to a particular kind of population, i.e., students from six high schools in the capital city. The demographic characteristics were the following: the range of age were from 14 to 19 years old; the highest percentage of them was for the case of students with 16 years old (34.1%) and the lowest was represented by students from 14 years old (3.1%). Regarding the gender of the participants, 48.6% were women and 51.5% men.

When considering the experience of the participants in relation to earthquakes, **Figure 1a** shows the results. It can be seen that 95% of the students have experienced an earthquake; only 5% did not. This is consistent with the fact that the frequency of earthquake occurrence before the study was conducted in 2015 was unusually high.

For example, according to the "National Seismological Service" (SSN) statistics, from 1 January to 31 December 2014 (a year before the study), there were about 7588 earthquakes [5], that is, an average of 632 earthquakes per month. It also should be emphasized that there are seven strong earthquakes of magnitudes > 6.0. Moreover, earthquakes on the range of magnitudes 3.0–3.9 (i.e., 6343 events) were those that occurred most frequently in 2014. This was followed by those in the range of 4.0–4.9, with a total of 955 events [5].

When asked the following question, "can an earthquake be predicted?", the possible responses to the question were the following: "Yes," "No," and "I do not know" (**Figure 1b**). The results showed that about 71% of students responded "No," which may be regarded as the right answer. Interestingly, 29% of the participants did not know this fact (i.e., 9.4% "Yes"; 19.5% "I do not know"). Effectively, earthquakes still cannot be predicted. There has been a vast amount of studies published in the literature on this very topic [15–19].

3.2 Seismic risk perception

Also, we were interested to know how the participants perceived the seismic risk threat at that time of the study. The following question was included in the questionnaire, "how likely an earthquake will occur in the future?" The possible answers to the question were the following: "Not likely," "Somewhat likely," and "Very likely." The results are shown in **Table 1** and **Figures 2-4**.

Overall, students were aware of the likelihood of an earthquake occurrence sometime in the future when the study was conducted. That is, 82.2% (1212/1475) responded "Very likely" and 15.2% (227/1475) "Somewhat likely," and 2.4% (36/1475) considered "Not likely" for the occurrence of an earthquake.

The relationship between seismic risk perception and those variables related to gender, age, and schools is presented in **Table 1** and **Figures 2-4**. For example,

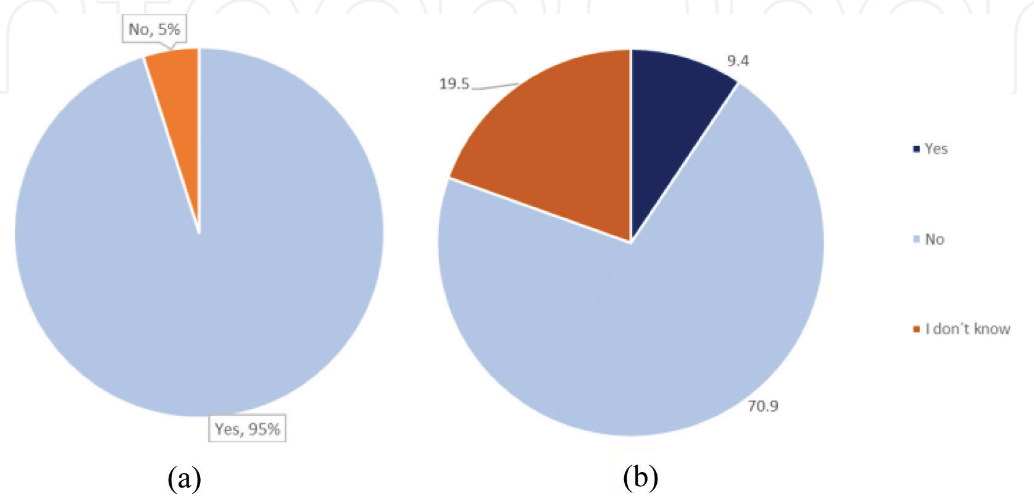

Figure 1.
Experience and the magnitude of an earthquake: (a) experience on earthquakes and (b) scale of the magnitude of an earthquake.

	"Not likely", N (%)	"Somewhat likely", N (%)	"Very likely", N (%)
Age			
14	0 (0.0)	12 (26.1)	34 (73.9)
15	17 (5.2)	67 (20.7)	240 (74.1)
16	9 (1.8)	65 (12.9)	430 (85.1)
17	5 (1.3)	62 (15.6)	329 (82.9)
18	4 (2.6)	15 (9.7)	136 (87.7)
19	1 (2.1)	6 (12.5)	41 (85.4)
Gender			
Women	10 (1.3)	107 (14.1)	644 (84.2)
Men	26 (3.6)	120 (16.8)	566 (79.3)
Schools			
School 1	2 (1.1)	20 (11.4)	154 (87.5)
School 2	2 (1.0)	16 (7.8)	186 (91.2)
School 3	5 (1.4)	37 (10.7)	303 (87.3)
School 4	8 (2.7)	29 (9.7)	262 (87.6)
School 5	13 (4.9)	111 (41.7)	142 (153.4)
School 6	6 (3.3)	14 (7.7)	163 (89.1)

Table 1.
Seismic risk perception.

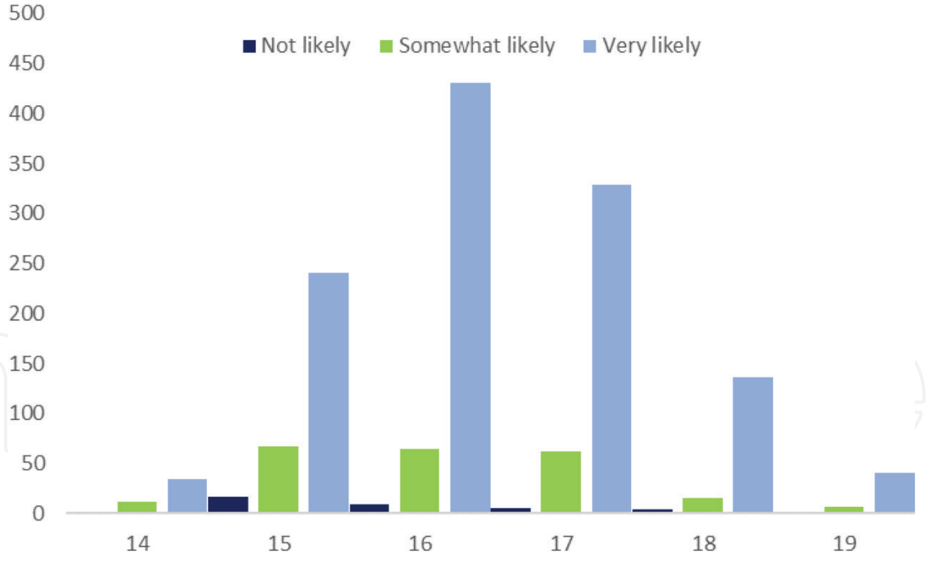

Figure 2.
Seismic risk perception and age of the participants.

when considering the age of the participants, interestingly, participants whose age was 16 years old were the ones that score the highest percentage (29.2%, 430/1473), which was followed by students from 17 (22.3%, 329/1473), 15 (16.3%, 240/1473), and 18 years old (136/1473). On the other hand, only 2.5% of the participants were unaware of the threat of seismic risk at the time of the study. Overall, it may be argued that about 70% of the participants are aware of the seismic risk (**Figure 2**).

Figure 3 shows the results of the relationship of the variables related to earthquake risk perception and the variables related to the gender of the students.

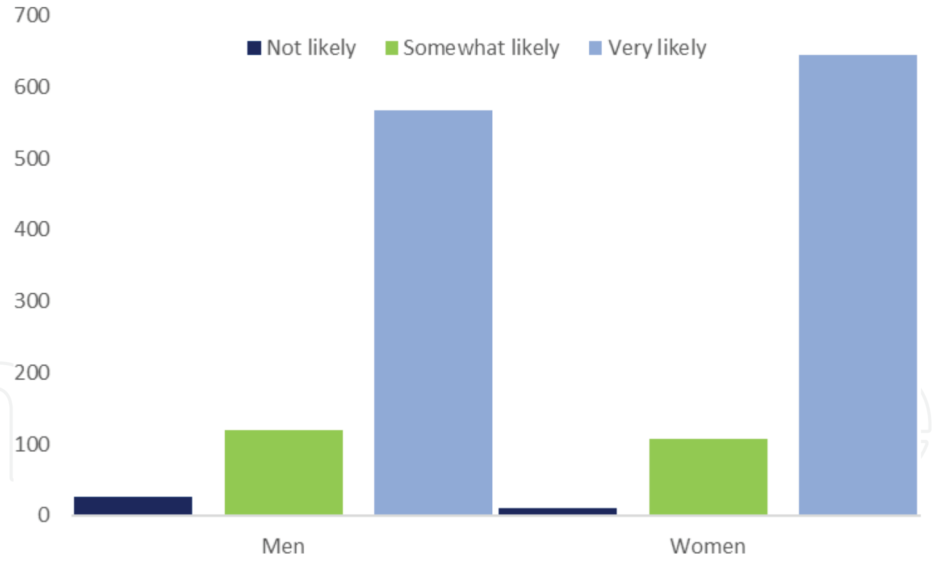

Figure 3.
Seismic risk perception and the gender of the participants.

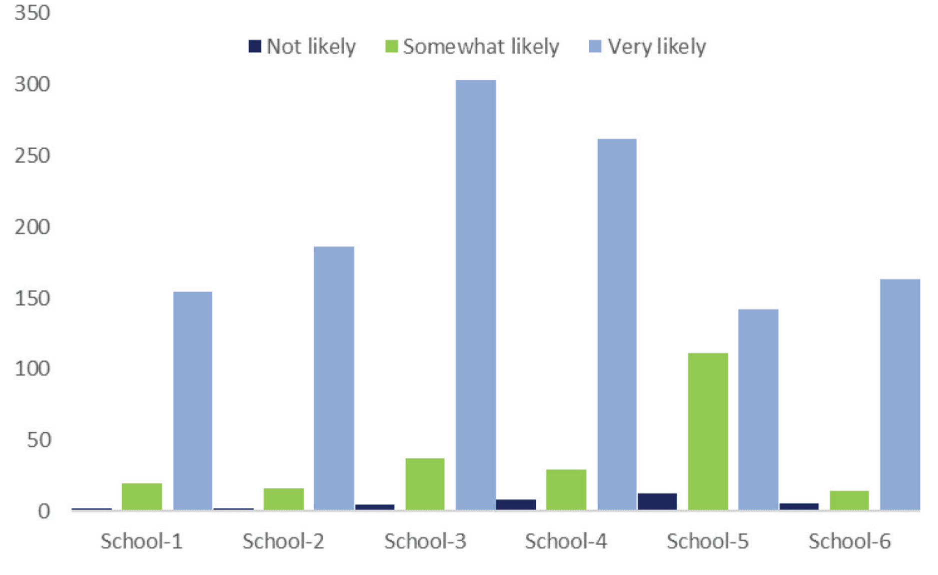

Figure 4.
Seismic risk and the schools located in different seismic risk zones of the city.

From the figure, it can be seen that women were more aware of the seismic risk (i.e., "Very likely") than men, with 43.7% (644/1473) and 38.42% (566/1473), respectively.

Finally, when considering the schools (**Figure 4**), the one which is located within the zone of highest seismic risk (i.e., school 3) scores the highest percentage of the likelihood of an earthquake occurrence (20.6%, 303/1473); this was followed by school 4 (17.8%, 262/1473).

3.3 Seismic risk vs. other natural hazards

As in many places in the world, Mexico City may be affected with a number of natural hazards, and among them are earthquakes, floods, and volcanic eruptions (e.g., the "Popocatépetl" volcano, which is located at about 72 km from the capital city). In order to assess the awareness of the participants of the study on these hazards, the following question was included in the questionnaire: "If any of these events happen in the future, how likely is it that it will affect you?"

The results showed that earthquakes were regarded as an event "Very likely" to occur in the future at the time of the study, that is, "Very likely" (82%, 1210/1475), "Somewhat likely" (15.5%, 228/1475), and "Not likely" (2.5%, 37/1475). Then it was followed by floods ("Very likely" (27%, 398/1475); "Somewhat likely" (53.9%, 795/1475); "Not likely" (19.1%, 282/1475)). Finally, volcanic eruption came third ("Very likely" (18%, 265/1474); "Somewhat likely" (43.4%, 639/1474); "Not likely" (38.7%, 570/1474)).

Table 2 shows, on the other hand, the results of the relationship between the participants' perception on other natural hazards and the gender of the participants.

Overall, it can be argued that the participants of the study were aware of the likelihood of the occurrence of these events. Effectively, seismic events were at the top of this likelihood, given that earthquakes occurred very often prior to the study (i.e., in 2014 as shown in Section 3.1).

Regarding floods, usually the capital city is heavily affected with heavy rains (and in particular during the raining season). For example, apart from the households and avenues being flooded, the public transport system is also affected and consequently the urban mobility. In particular, the Metro transport system, for example, during the raining season, the metro lines (some of them) are usually flooded. For example, in relation to this problem a politician said this:

> *"The strongest crisis due to rain that occurred in the Metro last year began in May, when due to the saturation in the drainage network, the water flooded in from outside to the corridors of Cuatro Caminos, Pantheons, and Tacuba stations. (Metro) Line 2 reaching up to 15 cm in height. This week in Mexico City we have already started with the first heavy rains of the year, and due to the climate change, that we are experiencing, it is difficult to know exactly when storms can occur, so the Metro must be prepared not to suffer damages, guarantee the service and protect (the) users." [20]*

Finally, the participants' perception on the occurrence of a volcanic eruption was "Not likely" (38.7%, 570/1474). Interestingly, there was an eruption in 2017 and 2018. That is, at about 17:54 in 2017, the Popocatépetl volcano exhaled a "fumarole" of about 4 km [21]; similarly, in 2018, the volcanic registered an explosion at about 18:58 [22]. It is important to mention that every time an eruption occurs, usually the areas where the participants came from are unaffected by these eruptions.

	"Not likely", N (%)	"Somewhat likely", N (%)	"Very likely", N (%)
Earthquake			
Women	10 (1.3)	107 (14.1)	644 (84.6)
Men	26 (3.6)	120 (16.8)	566 (79.3)
Volcanic eruption			
Women	298 (39.2)	335 (44.1)	127 (16.7)
Men	272 (38.1)	304 (42.6)	138 (19.3)
Floods			
Women	162 (22.7)	120 (15.8)	235 (30.9)
Men	120 (15.8)	389 (54.5)	162 (22.7)

Table 2.
Seismic risk perception on other natural hazards.

Given the results presented above, it may be argued that participants considered seismic risk as their top threat when compared to floods and volcanic eruptions. Effectively, the two powerful earthquakes in 2017 that hit the capital city demonstrated that their worries came true.

3.4 Richter vs. Mercalli scales

Regarding the question "how the magnitude of an earthquake is measured?", the possible responses to the question were the following: "Mercalli," "Richter," and "I do not know" (the results are presented in **Figure 5**). As expected, most of the participants considered "Richter" (i.e., 96%). Only 3% did not know, whereas only 1% considered "Mercalli."

However, the above raises the question as to whether the high percentage of the participants (96%) really knows the meaning of the Richter scale. Two key concepts regarding the measure of the size of an earthquake are magnitude and intensity [23]. The seismic energy released during an earthquake occurrence is measured by the magnitude, and it is commonly measured in a Richter scale. However, "Richter magnitude" (it is believed that it was named after Charles Richter who proposed the measure), may be regarded a measure only appropriate for earthquakes originating in California, USA [23]. Given this confusion, the moment magnitudes have become a universally appropriate scale (M_w) [23].

But what is the intensity of an earthquake? How is it measured? It is thought that intensity measures the consequences of an earthquake; that is, it is based on the observations made by people (as opposed to the Richter scale which employs instrumental measurements), and, consequently, it varies from place to place. The intensity is measured by what is known as the "Modified Mercalli Intensity Scale" (MMIS) [24].

What can we say about this in the context of the earthquakes that occurred in Mexico City in 2017? Was the Richter scale meaningful to the participants of the study? Was it meaningful to the residents of the capital city? The answer may be probably no. In fact, following the 2017 earthquakes, there was a debate on the mass media on this very issue. That is, it was a confusion among the residents of the city regarding the "intensity" felt by them during the two earthquakes that occurred on 7 and 19 September 2017. That is, for the earthquake on September 7 (magnitude of 8.1), with epicenter on the Pacific coast, the shaking was felt not that strong as the one on September 19 (with a magnitude of 7.1). Moreover, the consequences of the

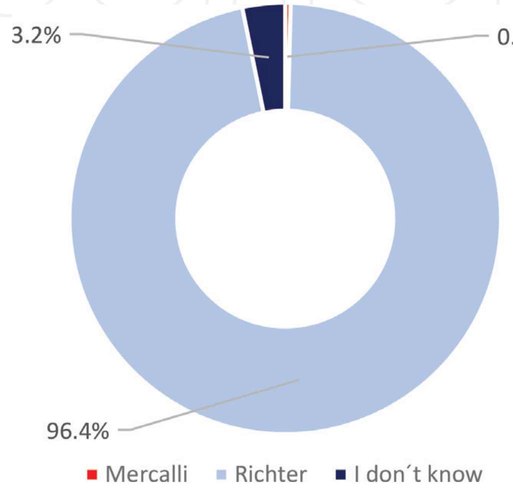

Figure 5.
Responses on the magnitude of an earthquake.

latter were severe in the city killing hundreds of people, but with a 7.1 of magnitude. These facts caused confusion among the residents.

For example, in an interview, the head of the "National Seismological Service" (SSN) argued that in relation to the earthquake on September 19, 2017

> *"although it was smaller (the one on 19 September) than (the one on) the 7th of this month (September) and emitted less energy, "it was more intense for Mexico City because we are closer to the epicenter and because of the vulnerability of some areas (of the city) because are located in the lacustric soil." [25]*

Moreover, the head of the SSN went on saying that

> *if people say it (the one in 19 September) was stronger than the one on 7 September or the one in '85 (1985), they are right, it is their perception, but it was smaller in size and energy released [25].*

The above clearly illustrates the difference between magnitude and intensity of an earthquake. Moreover, it may be argued that for the general public, it may be easier to understand the effects brought about, for example, by the two earthquakes just mentioned above in the context of the Mercalli Scale. Furthermore, it may be argued that people need to be well educated on these basic concepts. Also, it is of paramount importance to educate the residents of the capital city, for example, that damages caused by earthquakes depend on the distance from the epicenter, the type of soil, etc. Ultimately, the more effective is the communication on seismic risks and consequences, the better may be their preparedness to earthquakes.

3.5 Education on seismic risk

Respondents of the study were also asked whether they would like to be further educated on topics associated with seismic risk (the possible responses were "Yes" and "No"). The results showed that 83.5% of the students wanted to learn more on earthquakes and 16.5% showed no interest at all on this (**Figure 6**).

Table 3 shows the results of the relationships of the variables considered in the analysis. Overall, when considering the age of the participants of the study, those whose age were 15, 16, and 17 years old showed more interest in learning more on earthquakes (69.5%, 1027/1479). On the other hand, women score a higher percentage than men in the willingness to learn more on seismic risk (i.e., 44.9%, 664/1479 vs. 38.6%, 571/1479). Finally, when considering the location of the participant schools, school 3 scored the highest percentage on their willingness to be educated on this very important and necessary subject (i.e., 19.6%, 290/1479).

Effectively, the results showed that there was (and still is) a great interest in learning more on seismic risk, for example, on what actions to take before, during, and after the occurrence of an earthquake. Moreover, the recent earthquakes in 2017 demonstrated that Mexico City's residents lacked an adequate preparation. Furthermore, it may be argued that organizations in charge of responding to the emergency (i.e., after the earthquake) were deficient in many respects, for example, the capacity of the rescue team in dealing with rescue during the emergency (e.g., in both aspects of "human" and infrastructure capacity). In most of the cases, the affected residents were themselves looking for their friends, relatives, etc., under the rubble. This clearly showed that emergency response teams need to be better prepared and well trained to cope with emergencies, such as those after the occurrence of the two earthquakes.

Students were also asked in which ways they would like to learn more on the subject; the possible answers were the following: "books," "the Internet," "at school,"

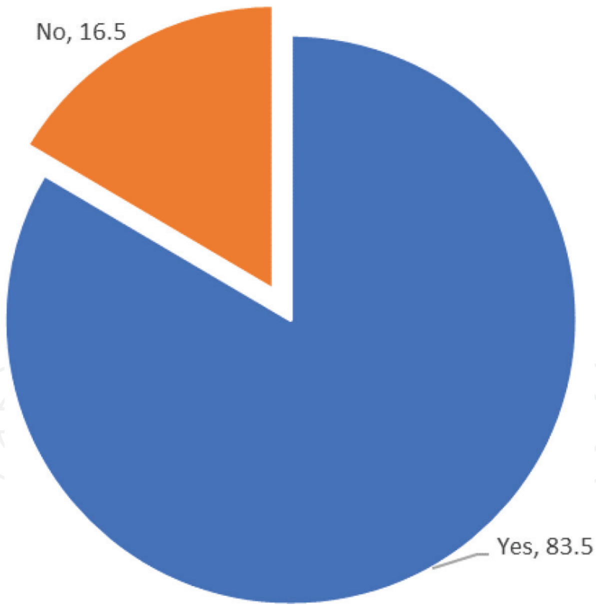

Figure 6.
Learning more on seismic risk.

	Yes, N (%)	No, N (%)
Age		
14	35 (2.8)	10 (4.1)
15	272 (22.0)	58 (23.8)
16	424 (34.3)	82 (36.6)
17	331 (26.8)	64 (26.2)
18	133 (10.8)	22 (9.0)
19	40 (3.2)	8 (3.3)
Gender		
Women	664 (53.8)	95 (38.9)
Men	571 (46.2)	149 (61.1)
Schools		
School 1	160 (13.0)	18 (7.4)
School 2	173 (14.0)	29 (11.9)
School 3	290 (23.5)	57 (23.4)
School 4	244 (19.8)	56 (23.0)
School 5	211 (17.1)	57 (23.4)
School 6	157 (12.7)	27 (11.1)

Table 3.
Relationship between the variables regarding to the willingness to learn more on seismic risk.

"civil protection," "radio-TV," and "others" (the results are shown in **Figure 7**). The frequency data showed that the participants considered "civil protection" as the preferred option to learn more on earthquakes (44.1%, 549/1245). This was followed by "school" (22%, 274/1245) and finally "the Internet" (20%, 249/1245).

Table 4, on the other hand, shows the results of the relationships between variables considered in the analysis. In general, when considering the age of the participants of the study, those whose age was 16 years old showed more interest in

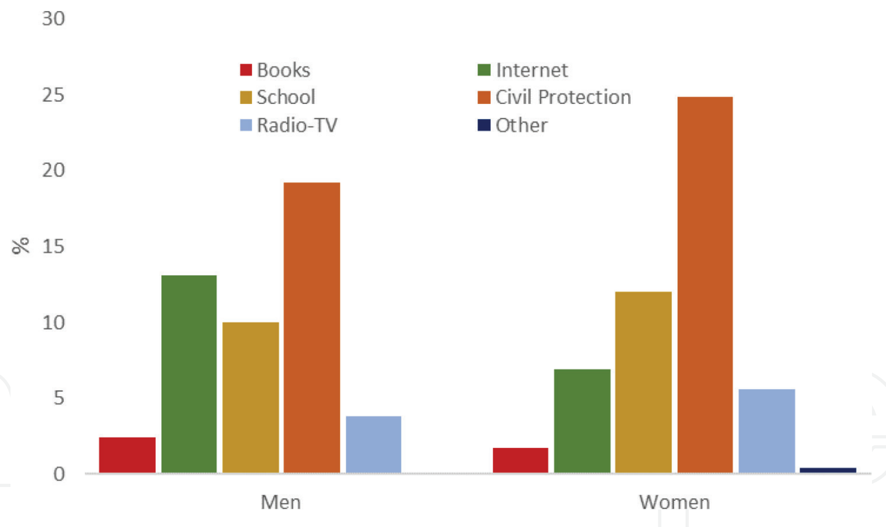

Figure 7.
Preferences in learning more on seismic risk.

	Books, N (%)	The Internet, N (%)	School, N (%)	Civil protection, N (%)	Radio-TV, N (%)	Others, N (%)
Gender						
Women	21 (41.2)	86 (34.5)	149 (54.4)	310 (56.5)	70 (59.8)	5 (100.0)
Men	30 (58.8)	163 (65.5)	125 (45.6)	239 (43.5)	47 (40.2)	0 (0.0)
Age						
14	6 (11.8)	11 (4.4)	8 (2.9)	15 (2.7)	0 (0.0)	0 (0.0)
15	12 (23.5)	59 (23.7)	53 (19.3)	124 (22.6)	25 (21.4)	2 (40.0)
16	16 (31.4)	80 (32.1)	92 (33.6)	195 (35.5)	34 (29.1)	2 (40.0)
17	14 (27.5)	66 (26.5)	73 (26.6)	139 (25.3)	37 (31.6)	1 (20.0)
18	3 (5.9)	24 (9.6)	42 (15.3)	59 (10.7)	14 (12.0)	0 (0.0)
19	0 (0.0)	9 (3.6)	6 (2.2)	17 (3.1)	7 (6.0)	0 (0.0)
Schools						
School 1	7 (13.7)	22 (8.8)	31 (11.3)	89 (16.2)	7 (6.0)	2 (40.0)
School 2	4 (7.8)	22 (8.8)	60 (21.9)	65 (11.8)	15 (12.8)	1 (20.0)
School 3	10 (19.6)	80 (32.1)	54 (19.7)	129 (23.5)	28 (23.9)	1 (20.0)
School 4	15 (29.4)	47 (18.9)	48 (17.5)	107 (19.5)	23 (19.7)	0 (0.0)
School 5	7 (13.7)	51 (20.5)	52 (19.0)	100 (18.2)	25 (21.4)	1 (20.0)
School 6	8 (15.7)	27 (10.8)	29 (10.6)	59 (10.7)	19 (16.2)	0 (0.0)

Table 4.
Preferences in learning more on earthquakes.

learning more on earthquakes through "civil protection" organization (35.5%), followed by "school" (33.6%), "the Internet" (32.1%), and "books" (31.4%). Further, women score a higher percentage than men in the willingness to learn more on seismic risk through "civil protection" (i.e., 56.5% vs. 43.5%). Finally, when considering the location of the participant schools, school 3 scored the highest percentage on their willingness to be educated by "civil protection" on the subject (i.e., 23.5%).

The results clearly showed the need to educate the residents of the capital city, that is, not only students but also the general public, on issues such as those topics covered here and others relevant to specific actions to take before, during, and after an earthquake occurrence.

4. Conclusions

This chapter has presented some of the results of a cross-sectional study conducted in Mexico City in 2015–2016. The approach has been the application of a questionnaire to a sample size of n = 1489. Six high schools participated in the study are located within the seismic zones of the city. Some of the results and conclusions are given below:

a. About 95% of the students have experienced an earthquake, and 71% considered that earthquakes cannot be predicted; however, 29% did not know this fact.

b. About 82.2% of students were all aware of the likelihood of an earthquake occurrence sometime in the future; the occurrence of the two strong earthquakes that hit the city in 2017 confirmed their perception.

c. In relation to the question related to how the size of an earthquake is measured, as expected, 96% of the participants considered the "Richter" scale; however, this raises the question as to whether the participants really know the meaning of the scale.

d. One of the key conclusions is associated with the need to educate the inhabitants of the capital city on a more realistic scale of the size of an earthquake; this could be the "Modified Mercalli Intensity Scale" (MMIS).

e. More generally, the residents of the city should be educated on these basic concepts. Moreover, the more effective is the communication on risks and consequences, the better may be their preparedness to earthquakes.

f. It appears that civil protection should take the lead in designing an education program on seismic risk, which could be implemented at schools; moreover, it should be implemented with urgency.

Some future research is needed, such as that associated with an inferential analysis of the collected data.

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Conflict of interest

The authors declare that they have no competing interests.

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