UNIVERSITY OF CRAIOVA **Series: Geography**
UNIVERSITATEA DIN CRAIOVA **Seria: Geografie**

Vol. 22 (new series) – 2021
Vol. 22 (serie nouă) – 2021

STUDY OF SEISMIC RISK PERCEPTION IN CRAIOVA MUNICIPALITY

STUDIU ASUPRA PERCEPȚIEI RISCULUI SEISMIC ÎN MUNICIPIUL CRAIOVA

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10.52846/AUCSG.22.1.04

Abstract: This study aims to evaluate the perception of the population regarding the potential danger generated by earthquakes in Craiova. Although it is located at a significant distance from the main seismic region of Romania (i.e. about 400 km from Vrancea), Craiova Municipality is still in an area with seismic risk according to the National Institute of Research and Development for Earth Physics (NIEP/INFP in Romanian). Regarding the seismic area in Romania, Craiova is classified at an 8 level on the MSK scale (according to Law no. 575/2001); moreover, the strong earthquakes produced in the last half-century had some notable effects on the territory of the municipality. In Craiova, the deficiencies concerning the anti-seismic education, the condition of the old constructions that are still used, the non-conforming structural changes brought to the buildings, etc. may increase the risk of an earthquake of medium and high magnitude. The present paper is based on the random sampling of 120 people from Craiova Municipality regarding their perception of earthquakes. It was found that half of them experienced at least one major earthquake (particularly that of 1977, which caused significant property damage and fatalities). The personal experience of such an earthquake or the participation in the simulative exercises of an earthquake in the city determines some of the respondents consider that they have learned how to behave during an earthquake. On the other hand, some of the respondents (especially the single or retired ones) expressed their lack of trust in the help they could receive during an earthquake.

Key-words: *seismic risk, perception, high level of concern, vulnerable buildings, Craiova.*
Cuvinte cheie: *risc seismic, percepție, nivel ridicat de îngrijorare, clădiri vulnerabile, Craiova.*

1. INTRODUCTION

In literature, it is considered that seismic risk can be evaluated by three important elements: a possible model of seismic threat, a group with several vulnerability functions that can estimate *the distribution of the percentage of loss for a set of intensity measure levels* and a prototype showing the space scattering of objects that are exposed to danger (Silva et al., 2015). Armaș (2006), but also many other specialists (Silva et al., 2015; Frolova et al., 2017; Khan et al., 2019) consider

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seismic risk a complex phenomenon, this fact being due to its direct and indirect effects, produced quickly or after a long time.

Specialists have focused on risk analysis and its perception since the second half of the twentieth century (Boholm, 1996), playing an important role in the political decisions of the world's states (Sjöberg, 1999; Sjöberg, 2002). Risk perception is different within a population, for example depending on gender characteristics (Gustafson, 1998). In general, studies that analyze the risk perceptions of a person use the psychometric method through questionnaires or opinion polls. The objectives of these studies are to highlight the population awareness of the proposed risk, the possible consequences, and the probability that the population will be exposed to such a risk (Slovic, 1992; Gustafson, 1998). Thus, the female and male populations may be concerned about the same risks, but the level is different, in the case of the former being higher. Perception of risk depends not only on gender but also on the level of trust in institutions and authorities and *unequal power relations* (Gustafson, 1998, p. 808).

Risk perception was initially analyzed in psychology and social science studies and disaster literature, too (Ho et al., 2008; Al-Nimry et al., 2015), becoming a term used in several fields that study the population perceptions of risk and its consequences (El-Kholy et al., 2012). Risk perception has become an important element in determining vulnerability, but also in studies analyzing disasters (Zhou et al., 2015), but differences have been identified between the risk perceived by the general population and that perceived by experts in the field (Garvin, 2001), leading to many obstacles to the introduction of disaster management policies (Frolova et al., 2017). Risk perception highlights the education level and information of the population about risk, being one of the most critical elements used to determine vulnerability (Carlino et al., 2008; Perry & Lindell, 2008; Khan et al., 2019). Studies have shown that the perception of risk is influenced by age, gender, education, and previous experiences of the population regarding earthquakes, but also by the damage caused by them (Armaș, 2006; Armaș, 2008; Armaș & Avram, 2008; Ainuddin et al., 2014).

Seismic risk evaluation involves a possible estimation of damage from an economic, social, and infrastructure point of view, this enabling experts to generate seismic risk maps (Frolova et al., 2017). Studies analyzing earthquake risk perception use semi-structured questionnaires or opinion polls that are applied to a certain number of residents in the study area (Armaș, 2006; Armaș, 2008; Armaș & Avram, 2008; Khan et al., 2019). These studies focus on the analysis of seismic risk perception according to certain indicators: socio-demographic (age, gender), socio-economic (income, education, occupation, type of housing, etc.), but also the characteristic elements of earthquakes and behaviors that must be adopted during their occurence. Armaș (2006), Armaș (2008) used certain tests (Pearson's chi-square test, z-ratio test, Kruskal-Wallis test) to demonstrate the relationship between risk perception and selected indicators.

Khan et al. (2019) demonstrated in their study, applied in a region of Pakistan, that the population that had previous experience with earthquakes tends

to have a higher perception of risk than others. The authors also analyzed the physical vulnerability of buildings, which they correlated with the perception of risk, showing that vulnerability influences the level of perception of earthquakes. Armaș & Avram (2008) demonstrated in the study conducted on the inhabitants of Bucharest that the female population tends to be more worried about earthquakes than the male population and they have prepared survival kits. Regarding dwellings, those that own properties tend to be more worried than the people living in rent (Armaș & Avram, 2008). In most cases, the respondents experienced at least one earthquake, which means that their perception is different from that of those who did not experience an earthquake, in the sense that they can be more cautious, have prepared survival resources, and they may be worried about the occurrence of a new earthquake, the level of concern being high among the elderly (Armaș, 2006; Armaș & Avram, 2008).

The present research starts from the premise that in a region with low to medium seismicity (the case of Craiova), where information on the effects of previous earthquakes is not enough, the vulnerability of buildings and population is a significant component of seismic risk. Although in Romania the subcrustal seismicity is concentrated near Vrancea (Fig. 1), there are several seismogenic areas and earthquakes with the epicenter in the country or near it can be felt in most of the territory. In the South-West Oltenia Region, the most vulnerable city to seismic hazards is Craiova, being classified at level VIII on the MSK scale (Law no. 575/2001). Craiova is located at a distance of approx. 300 km from Vrancea, but the effects of earthquakes in our country in the last half-century have been felt in the city.

The purpose of this paper was to analyze the perception of the population on the seismic risk in the city of Craiova, taking into consideration the previous earthquakes that had negative consequences on the urban center.

2. DATA AND METHODS

2.1. Study area

On the conditions of important values of a seismic intensity characteristic to major events in the past (Fig. 2) and recent simulations (Fig. 3, Fig. 4), the subject of the vulnerability of the Craiova population to earthquakes becomes one of interest. Following the 1977 earthquake, the seismic intensity was high in the south-eastern half of the country, but also in Craiova, when many buildings in the central part of the city were destroyed (Fig. 2). In case of earthquakes with an intensity higher than seven at the national level, the buildings in Craiova will be affected in a high percentage, especially the buildings built 50-60 years ago (Fig. 4).

In the municipality of Craiova, the outstanding residential areas of individual type (private houses, GF, GF + 1-2 floors) have a more important extension in the south and southwest of the city, in neighborhoods such as 1 Mai, Romanești, Catargiu, Brestei, Valea Roșie. These neighborhoods overlap on the 1st and 2nd terraces of the Jiu, where the vulnerability to seismic risk is very high due to the presence of sandy soils that intensify the effects of earthquakes (Craiova

Development Strategy, 2006). The collective residential areas of blocks of flats (GF + 3-10 floors) are characteristic especially for the northern part of the city, in the neighborhoods of Craiovița Nouă, Brazda lui Novac and Rovine, partially in Valea Roșie, where the vulnerability to earthquakes is lower.

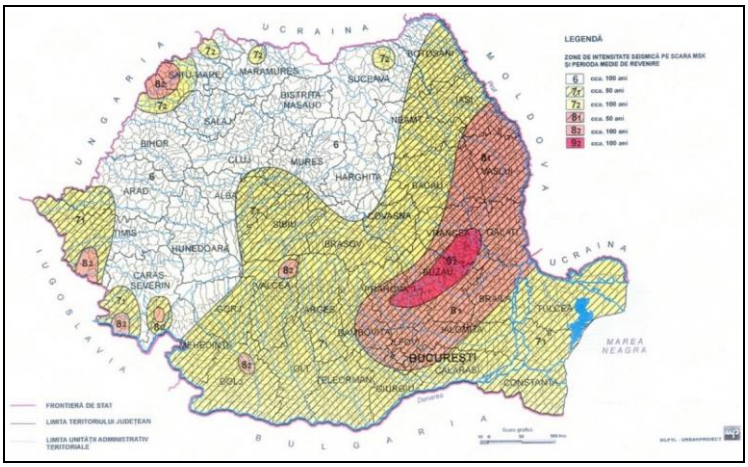
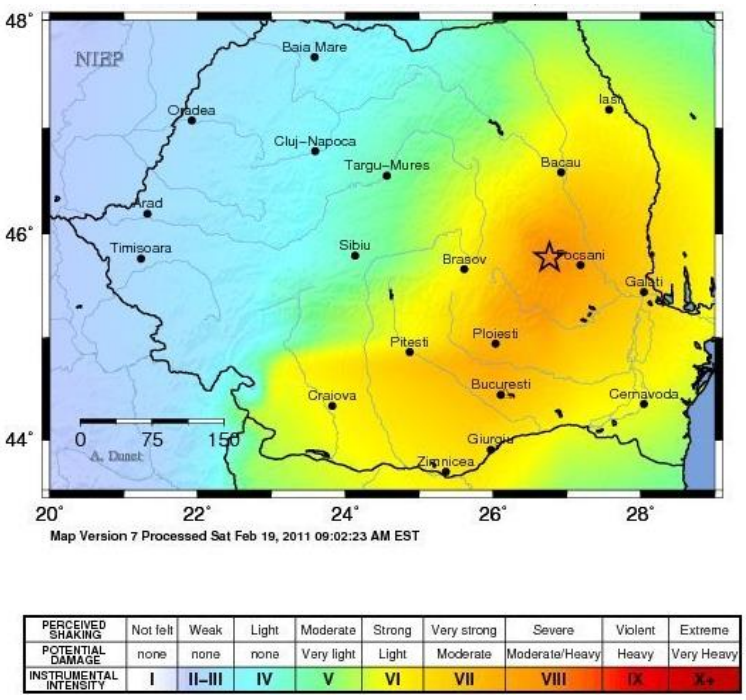


Fig. 1 Zonation of seismic intensity on the Romanian territory
(Source: Law no. 575/October 21, 2001)



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Fig. 2 Distribution of seismic intensity values: the earthquake March 4, 1977
(Source: INFP (a), 2021)

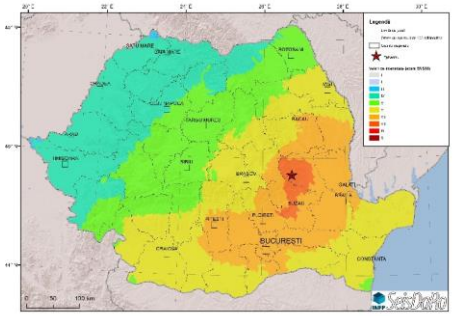


Fig. 3 Distribution of estimated intensity values, obtained for the simulated earthquake during the SEISM2018 exercise

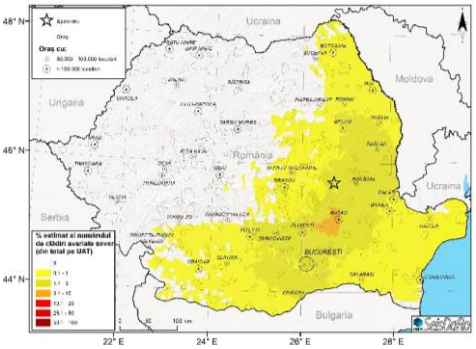


Fig. 4 Estimated share of residential buildings completely affected by the earthquake. Simulation in the SEISM2018 exercise

(Source: INFP (b), 2021)

In Craiova, there are many territorial differences in the age of the buildings. Thus, the new constructions, built after 1980 according to the strict standards that were implemented after the 1977 earthquake, are located in the northern, southern, and eastern parts of the city, in the neighborhoods Craiovița Nouă, Rovine, Brazda lui Novac, 1 Mai, Lăpuș Argeș and partly in Valea Roșie. Instead, buildings built before the 1980s, which are made of brick, have become the most vulnerable to earthquakes (their material is degraded); they are located in the central area of the city and the neighborhoods of Brestei and Romanești (www.teoalida.ro). They are used for various purposes: educational institutions (for example Colegiul Național 'Carol I' – Fig. 5, Fig. 6), public institutions (for example Instituția Prefectului Județului Dolj – Fig. 7), residential buildings and commercial spaces (for example Casa Albă – Fig. 8, Team store FC Universitatea Craiova– Fig. 9, Fig. 10).

The earthquake of March 4, 1977, caused damage in several areas of the country, mainly in urban centers. The most significant damage occurred in Bucharest, followed by Dolj, Iași, Prahova and Teleorman counties (Spignesi, 2005). Even if the epicentral area was Vrancea, the effects of this earthquake were also felt in the city of Craiova, where there were numerous material damages (destruction of important buildings) and human casualties (over 500 people were injured compared to about 11,300 in Romania), being the city in the south of the country that registered the highest number of victims, except for the municipality of Bucharest (INFP, c). The blocks in the central area of the city on Calea Unirii and Madona Dudu Street were severely damaged by the earthquake, which led to the demolition of some buildings, which were rebuilt after 1980 (Coman, 2019).

Fig. 5 Colegiul Național 'Carol I"
(Source: personal archive)

Fig. 6 Eastern part of Colegiul Național 'Carol I"
(Source: personal archive)

Fig. 7 Instituția Prefectului Județului Dolj
(Source: personal archive)

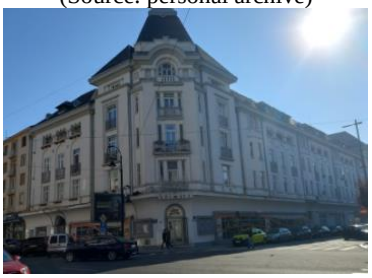


Fig. 8 Casa Albă
(Source: personal archive)

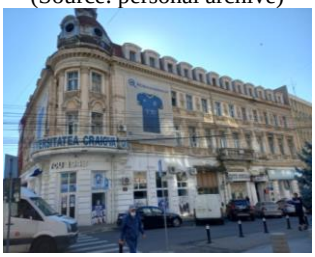


Fig. 9 Team store FC Universitatea Craiova
(Source: personal archive)

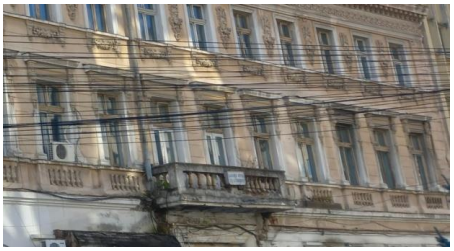


Fig. 10 Eastern part of Team store FC Universitatea Craiova
(Source: personal archive)

2.2. Data and methods

The perception of the seismic risk in Craiova was done after analyzing the answers of a questionnaire applied on a sample of 120 people, in physical format between March and April 2019, but also in electronic format between January and February 2021, through Google forms.

The survey included questions about the level of information, the behaviour during an earthquake, the methods to reduce the seismic risk, the measures that the respondents could take to be less affected, etc. The questionnaire was divided into two sections: in the first part, items related to demographic data were included (gender, age, occupation, education, type of building and its age, etc.) and in the second, items on seismic risk in Craiova and the population's perception of relevant

issues. The questionnaire was applied to people of different ages, students from different fields of study, including geography, teachers, people from different fields of activity, pensioners, etc. The values corresponding to the answers received are presented in a tabular format, in the results section. During this investigation, persons that experienced an earthquake were also requested to offer information on injuries they suffered and the adopted behaviour that enabled them diminishing negative effects, as well as suggestions of actions that should be adopted to reduce seismic risk, etc.

The applied questionnaire was based on specialized literature and adapted for the study area. It mostly includes closed questions for a quick analysis, but also open-ended ones through which respondents were able to provide detailed answers. The results showed that there are appreciable differences in the perception of seismic risk depending on certain factors, among the most important being the level of education and the media, previous experiences, age, these being detailed in the results section.

3. RESULTS AND DISCUSSIONS

Among the interviewees, the female population predominates – 74% (Fig. 11). As the male population is poorly represented (26%), it influenced the results of the analysis. The predominant age group is 20-39 years, which reflects the fact that most respondents felt only a few earthquakes with lower intensities, and the percentage of the population over the age of 60 (which could be representative for this study) is much lower (9%). The literature places this age group as the most vulnerable to earthquakes in a population, constantly having a high level of concern (Granger et al., 2001).

In general, people with higher education are not worried about earthquakes as Armaș (2006) points out for Bucharest; this is also the case for the respondents (48%), who are informed by reliable sources and have learned how to behave during an earthquake. Some respondents with secondary education, respectively high school (36%) are much more vulnerable to earthquakes, as they do not have enough information about earthquakes and are more worried.

In the present study, over 35% of respondents are landlords, which can cause some fear of earthquakes with regard to the building they live in (they could be affected), while only 15% are local tenants, who do not tend to be so worried because they have no responsibility to repair the damage in the event of an earthquake. Most respondents live in blocks of flats with more than 3 floors (58%), which can be dangerous in the event of an earthquake of more than 7 degrees on the Richter scale, especially if the blocks were built during the communist period. Regarding the age of the constructions, 50% of the respondents live in buildings built after 1980, which are much more stable, as they respect the strict standards that were implemented after the 1977 earthquake, which causes a lower level of concern. The residence in Craiova reflects the fact that over 40% of the respondents have been living for less than 15 years, these being part of the youth category, while only 16% have been living in the city for over 30 years.

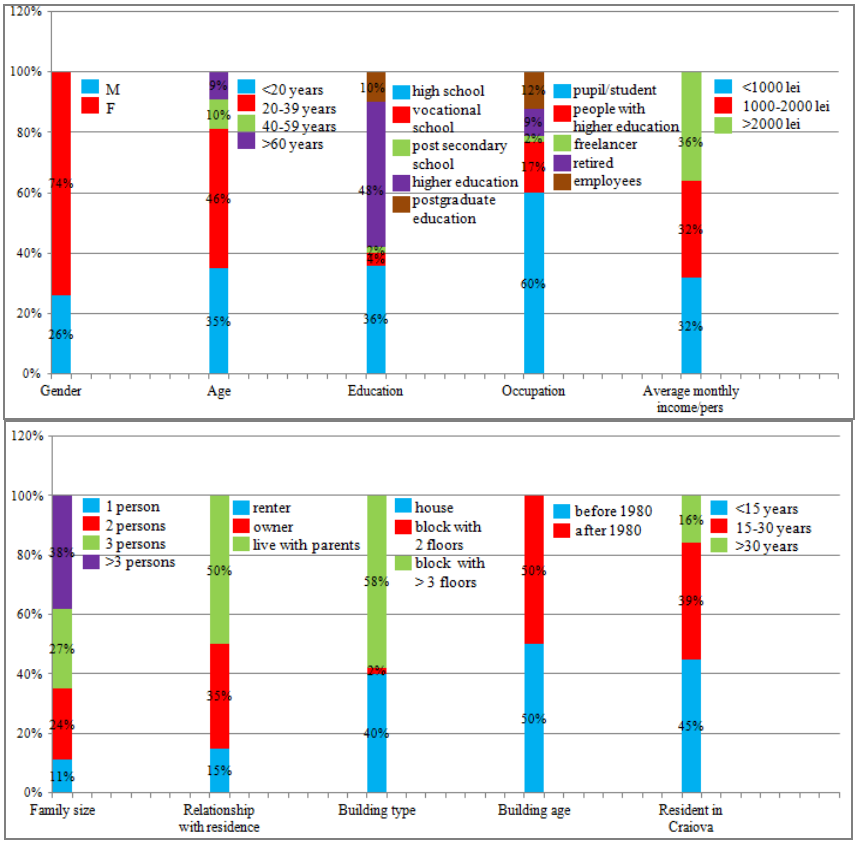


Fig. 11 Socio-demographic profile of respondents

(Data source: author's processing based on the answers in the questionnaire)

Frequently used media largely depends on the age of the respondents, young people using online sources, television and discussions with friends, while people over the age of 40 use print media and radio (Table 1). It is impossible to report earthquakes on time; over 50% of respondents believe that there is no technology needed to detect earthquakes before they occur because they have a high propagation speed. Information from uncertain sources or lack of concrete information has led 38% of respondents to say that earthquakes can be announced before occurrence via Ro-Alert text messages. This fact was also highlighted in the sources of documentation on the behavior during an earthquake, 18% being informed from discussions with friends or colleagues, which may reflect the lack of concrete information and only 31% of respondents participated in simulations performed by specialized institutions, such as the Inspectorate for Emergency Situations or SMURD. About 7% of respondents are skeptical and detached, do not consider that they need to be informed about earthquakes and they believe they will adapt when one occurs.

Most respondents (about 90%) would participate in seismic risk information programs organized in Craiova, which reflects the desire to know the rules and

methods of evacuation for their safety and only 13% are reluctant and consider that these exercises are useless.

In this questionnaire, an exercise was proposed to see if they know the rules of earthquake protection. Over 60% of them would be sheltered under the door frame/doorstep because it is the strongest place in the house, and the required shelter time would be a maximum of 40 seconds for most respondents (69%), reflecting the fact that they are informed about these rules or learned from previous experiences. Of the actions taken by respondents after the quake ended, most would choose to help those injured nearby and ensure that family members are safe (57%) and only 7% would check the home, gas installation or electricity for the safety of the building (Table 1).

A very high percentage of respondents (approx. 60%) have a high level of concern regarding the building in which they live, but only 17% of them have taken action, and 40% intend to take action in the future to reduce the negative effects of earthquakes. Among the most important measures adopted by the respondents are physical and mental training, home and property insurance, systems for reducing seismic risk in the home, choosing a well-established block, first aid kits, and adequate documentation. In the case of these people, only 15% would choose to change their place of residence (Table 1) knowing that they live in an area of seismic risk because they do not have sufficient financial resources and would have problems adapting (especially the elderly).

Life, property or housing insurance has been taken out by more than half of the people (Table 1), considering it a necessity and liability and hoping that they will be able to cover the damage in case of an earthquake. However, even in this case, there are pessimistic respondents who are less informed about the benefits of insurance, being convinced that they will not receive help after an earthquake (lack of access to technology and information for the elderly highlighted a small percentage of respondents who did not know of the existence of insurance).

The information provided by the respondents regarding the situation of the blocks of flats in which they live reflects the fact that only 28% of them have technically expert buildings to establish earthquake resistance, as stated in the local press that the number of buildings assessed is low.

The earthquakes produced in the last century in Romania affected a large part of the population, but among the respondents, only 45% of them felt them. Young people had the experience of the most recent earthquakes, respectively those of 2004, 2018 and 2019, with reduced intensities and adults experienced the worst earthquakes in the country, such as those in 1977, 1986 and 1990. More than half of those surveyed (59%) did not experience any earthquakes in the building where they currently live (Table 1) and 41% experienced less than three earthquakes, being affected to a small extent, physically, emotionally and materially.

In the event of a high-intensity earthquake, the most vulnerable are old constructions, built before 1978 or which are not properly designed according to the legislation in force, the respondents considering that they are the most unstable and will be affected, reflecting good information, and the fact that some people

know these details from their own experience (Table 1). The reduction of seismic risk must be achieved, mainly, through the technical expertise of the blocks because, in Craiova, most buildings are not evaluated (as evidenced by the answers provided by respondents), but also by consolidating them with durable construction materials. Another necessary method is to inform and prepare the population, the respondents being eager to participate in exercises carried out by various institutions specialized in the field of risk.

Table 1 Processing the answers provided by the respondents

Question	**Answer options**	**%**
What media do you use most often?	TV	38
	Radio	13
	Written press	17
	Talking with friends	18
	Other sources (internet, books)	14
Do you think that earthquakes can be announced on time so that you can be sheltered?	Yes	38
	No	50
	I do not know	12
How do you know to behave before, during and after an earthquake?	-I documented myself	44
	-I talked to friends, family, colleagues	18
	-I participated in the campaigns and exercises carried out by ISU and other institutions	31 3
	-I do not know these rules	4
	-I am not interested in these rules; if there is an earthquake, I shall orient myself	
We suggest an exercise: you feel an earthquake and you are at home. Where do you shelter and how long does it take you to do this?	Under the table	22
	Under the door frame	69
	Outside	3
	Under a sturdy object	5
	In the bedroom	1
	40 seconds	69
	1-5 minutes	27
	10 minutes	3
	30 minutes	1
The earthquake has stopped and you are safe. What are you doing urgently?	-I help people around me / my family	57
	-I shelter	7
	-Check if the house was destroyed	1
	-I am leaving the house safely	18
	-I continue my activity	2
	-Call 112	2
	-Check the gas / electricity / water installation	5 6
	-I am calming down	2
	-Nothing	
Do you think you should receive RO-Alert notification after an earthquake?	Always	74
	Sometimes	17
	No	7
	I do not know	2

Are you afraid that you might be affected by an earthquake where you currently live?	Yes, often Yes, sometimes No	14 45 41
Have you taken action or are you planning to change something in your future so that earthquakes affect you less?	I took action I intend to take action I have not taken action and I do not intend to take it	17 40 43
Has the building you live in been technically examined to determine earthquake resistance?	-It has not been examined or verified -It has not been examined, but periodic checks are made on the ceilings, balconies, roof -Yes -I do not know	36 8 28 28
Have you experienced any of the following very important earthquakes produced in our country - 1940, 1977, 1986, 1990, 2004, another?	Yes No	45 55
How many earthquakes have you experienced since living in this building?	One Two-three Over three No one	19 14 8 59
How strongly were you affected by the earthquakes? (only those who experienced an earthquake)	*Materially (1- minor damage, 5- major damage)* 1 2 3 4 5 *Physically (1-insignificant, 5- significant)* 1 2 3 4 5 *Emotionally (1-weak, 5-intensive)* 1 2 3 4 5	 92 2 2 1 3 88 5 0 2 5 74 12 3 3 8
In your neighborhood, what elements do you think are conducive to earthquake damage?	-Old buildings -Constructions made improperly -Weakening the construction structure through modifications made -Lack of anti-seismic education of the population -I do not know	29 28 17 23 3
What do you think are the best ways to reduce seismic risk in the neighborhood where you live in?	-Demolition of old or dilapidated buildings -Evaluation and consolidation of buildings -Information / training of the population -I do not care -Nothing would help	16 44 37 0 1 2

	-I do not know	
Who do you hope will help you immediately in the event of an earthquake?	-Family, friends, neighbors -Staff of specialized institutions (ISU, SMURD, etc.) -No one -I do not know	39 54 7 0
How do you think you will be helped in case of an earthquake?	-Health care -House -Construction materials -Money -I would not get help -I do not know	52 13 10 10 8 7
Have you taken out insurance (for life, property, house) in the event of an earthquake?	Yes No	65 35
Would you choose to live in another area because of the potential danger of an earthquake?	Yes It is not necessary I never thought	15 62 23

The people surveyed are relatively skeptical about the help they could receive in the event of a strong earthquake because they have a low degree of confidence in the institutions, only 50% considering that they will receive help from ISU or SMURD, but also lack trust in others (less than 40% hope they will be helped by friends or neighbours). Respondents' thinking is negative and they are skeptical, considering that they will not receive any help (8%), this being amplified by previous experiences with earthquakes (they did not have support from the family in the earthquakes of 1977, 1986, etc.) and only half of them hope to receive medical care.

4. CONCLUSIONS

The seismic risk in Craiova has become a serious problem, especially in the context of the earthquake that occurred in 1977, which affected many buildings in the central area of the city, causing the demolition of some of them.

Following this questionnaire, it was found out that respondents felt at least one earthquake, participated in simulations or tried to document themselves, which led to a lower level of concern. Most people live in four-floor blocks of flats that are exposed to seismic risk but are reluctant to change their residence, especially the elderly, retirees who do not have the necessary income for a new building and who may have difficulty in adapting.

The level of seismic risk perception is largely influenced by demographic issues, especially age and level of education. In general, older respondents are seconded, the level of information on earthquakes is lower than in the case of young people and they are not updated at the current period. In case of an earthquake, they would act according to previous experiences (access to technology is relatively low). Instead, young respondents have positive thinking,

are frequently documented from official sources, and want to participate in earthquake simulations if they are organized in the city to find out how to behave and what measures to take.

This study could be an important source of information for the inhabitants of Craiova, to be documented about the seismic vulnerability and the measures to be taken, but it can be an essential contribution to the specialized literature, as studies analyzing the seismic risk levels in the city are very low. The study could also be aimed at local authorities who could apply various methods to reduce seismic risk, such as building consolidation and technical expertise, conducting earthquake simulation exercises and informing all residents (organizing seismic training, first aid courses, disseminating posters, brochures or videos in public spaces, educational institutions, various institutions, on social networks and on various websites) about the behavior they should adopt, in collaboration with institutions specialized in risk mitigation.

These measures contribute to the development of appropriate behavior during an earthquake, but also after its end. The implementation of technical methods (expertise and consolidation of buildings) can have significant influences on the perception of the population, in the sense that the level of concern could be lower (residents do not fear that the building in which they live may be affected by earthquakes).

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