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Evaluating seismic risk perception and preparedness in Romania through questionnaires designed to reveal geopatterns and attitude profiles

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Abstract. In order for strategies in seismic risk mitigation to be effective, they need to consider both the level of risk but also the needs and attitude of people subjected to the desired change. Questionnaires are one of the most common tools to assess the perception and preparedness of people to earthquakes, however we found that many designs and interpretations are limited to the obvious remarks and are not conceived or analyzed in ways enabling the determination of sociological profiles and geospatial patterns. Through this paper we show the potential of new questionnaire-based approaches and interpretations, highlighting aspects such as i) how well prepared in case of an earthquake people think and actually are depending also on their age, ii) does living in an area with high hazard values influences perception of risk and what is the difference between risk in locality versus individual risk, iii) is there a difference between how people with earthquake knowledge would behave in case of having an earthquake early warning solution compared to people with less knowledge or iv) which ways of communicating risk is considered more appropriate for different age groups. As input, we use more than 410 responses collected for most of Romania (out of which around half are for Bucharest Area), through two easy-to-fill online questionnaires: one focusing on earthquake perception as well as the level of knowledge and vision toward preparedness strategies, and another shaped as a checklist test, related to the individual level of preparedness.

Keywords: *earthquake, seismic risk, perception, Romania, preparedness, questionnaire*

INTRODUCTION

Attitude toward risk induced by natural hazards refers, in our view, to the way people perceive a certain risk (based on affective and cognitive response) and behave in order to mitigate its effects. This definition can be considered an adaptation of the theory of attitude proposed by Rosenberg and Hovland (1960). The fact that natural hazards such as earthquakes are unpredictable leads to ambiguity, which complicate the analysis of attitude, as compared to other domains where risk can be contained in more measurable parameters (economics for example). Event-relevant time-window analysis is of great importance, as attitudes toward natural hazards constantly change very much based on risk experiences – lived or heard – and their lessons reflected in practice. The assessment of the knowledge level toward the phenomenon, its damage potential (both at a general and individual level) but also of measures taken to prepare can reveal important information regarding the willingness to mitigate the risk (Shou and Olney, 2020). When considering also location of the respondent and best possible hazard and risk estimates, attitude patterns can be further identified and justified.

By finding proper tools and methods to investigate the attitude of people toward seismic risk and the way they perceive and are prepared or willing to be prepared, we believe that we can aid in understanding how to design more efficient

measures for communicating, mitigating the risk and building resilience. The key to effective measures lies in understanding sociological profiles (e.g., what makes people not take immediate measures to reduce seismic vulnerability, in correspondence with what they know about earthquakes and where they reside) and trying to make a difference not only at the level of perception (e.g., educate people about high-risk exposure) but more at the level of reaction (e.g., convince people that they need to act immediately at personal and community level for increasing reducing the risks).

Various studies aiming to evaluate seismic risk perception and preparedness – some talking also about attitude toward risk – were performed worldwide. Among the most representative we mention Paul and Bhuiyan (2010), Vicente et al. (2013), Crescimbene et al. (2015), Nicoll et al. (2016) or Oven and Bankoff (2020). These relied as starting point on one of the most common methods for collecting data – questionnaires. When looking at the analysis methods however, we found important limitations in design and interpretation (highlighted also by Bird, 2009), with few studies using cross-correlations to determine sociological attitude profiles or respondent location correlated with hazard and risk maps to identify geographical differences and the influence of living in high-risk areas.

In this study we present two questionnaires designed and interpreted in a manner to surpass the identified deficiencies. Responses were collected from only from Romania – European country with one of the highest seismic hazard and risk levels (Pavel et al., 2016, Toma-Danila et al., 2018 or Crowley et al., 2021), mainly but not only due to ground motion generated by intermediate-depth Vrancea earthquakes occurring at depths between 60 and 180 km, with magnitudes higher than 7, which can generate (considering also the high exposure and vulnerability) more than half of its territory. The straight-forward goal for these was to reveal the level of knowledge, preparedness and perception of Romania's population regarding earthquakes, but the research goal was to enable us, though statistical pivot analysis and geospatial analysis, to understand the public attitude toward risk, assisting to designing strategies with a more consistent impact on seismic risk mitigation. This initiative aims to fill-in the gaps of previous recent investigations, such as Armas (2008), Armas et al. (2017), Armas and Gavris (2016), Calotescu et al. (2018) or Ionescu et al. (2021), limited either in terms of location (many focusing solely on Bucharest), number of respondents or methodological approaches. Nevertheless, there are compatibilities with these (common questions such as "Do you have an emergency backpack?", among respondent profile typical questions such as age), setting premises for a joint response database analyzable also with reference to time dimension.

METHODS AND DATA

Responses were collected through two online questionnaires in Romanian, translatable as "**Earthquakes and You**" **(Q1)** and "**How well are you prepared in case of an earthquake?**" **(Q2).** Both can be viewed and filled-in on the Earthquake Mobile Exhibition (MOBEE) webpage, at https://mobee.infp.ro/chestionare. Figure 1 shows their overall aspect. Google Forms was used to create and manage the questionnaires, being an easy to implement, free, reliable and responsive solution, allowing also spreadsheet download of individual responses.

Q1 is intended to reflect the perception, level of knowledge and preferred sources of information of Romanian people when it comes to earthquakes. It consists of 18 questions (among which 4 for determining respondent profile) and it has a 6-minute average filling time. Almost all questions are mandatory – with only 4 more complex (therefore potentially making the responder more reluctant to continuing the questionnaire) being optional. For this article we had 423 answers from all over Romania, with a distribution shown in below figures. A removal of duplicate answers was performed (pre-filtering), leading to the erase of 4 answers. Some answers were designed to act as validation or invalidation of self-evaluation, leading to the development of a sociological profile; by asking "How much you know about earthquakes?" and then asking three questions aimed to evaluate if the respondent does really have knowledge regarding earthquakes in Romania ("How soon you think that a next major earthquake could happen?",

"What is earthquake magnitude?" and "In which areas are there earthquakes with damage potential?"), checks upon the confidence in earthquake knowledge were able to be performed. For this purpose, qualitative responses were turned in quantitative values based on an expert-judge based ranking system from 1 to 5, averaged and compared. By then making links with respondent location, age, perception of risk in their locality and on themselves or declared reaction to an earthquake early warning alert, important observation regarding the perception and attitude toward seismic risk of specific groups of people can be revealed. Q1 also has questions referring to the preferred ways to receive information about earthquakes and what could convince respondents to take immediate actions toward preparedness – a critical issue in Romania.

Figure 1. Screenshots of Q1 and Q2

Q2 comes in the form of a test, with mandatory answers. At the beginning, respondents are asked to auto-evaluate themselves (on a 1-to-10 scale) in terms of how well prepared to an earthquake they think they are. Then, 10 questions are given, requiring a simple "yes" or "no" answer – each "yes" accounting as one "preparedness" point. Questions to the test are:

1. Do you have an emergency backpack?
2. Do objects in your home which could cause severe injuries (furniture, TV, central heating systems, paintings etc.) are well fixed?
3. Are heavy objects in your library or office placed on the bottom shelves?
4. Can you quickly shut-down the gas, water and electricity supply?
5. The bed where you sleep is away from falling objects (including the closet) or windows?
6. Can you tell in 5 seconds which is the safest place in your home, in case of an earthquake?
7. Have you got a functioning fire extinguisher in your home?
8. Do you have basic first-aid knowledge?
9. Prior to this test, were you informed about what to do in case of an earthquake?
10. Do you and your family have a joint plan in case of emergency situations?

Q2 has a 3-minute average filling time. 625 answers were available upon writing this article, making it more popular than Q1 (we almost always disseminated both links to audiences). Questions were initially tested against experts in the field who should have a higher preparedness level, and it proved to be very difficult for them to get the maximum of 10 points; this aspect is considered by us as positive, given that no one should consider themself as perfectly prepared for a disaster, but acknowledge instead the need for continuous preparedness. The difficultness of getting the maximum points also set premises for identifying potentially malicious respondents. Given that 30 respondents (out of which 23 between 14 and 18 years old) had 10 points both in auto-evaluation and in the test or 0 points in both, their answers were removed, being rendered as false.

For both questionnaires, we asked at the end 4 questions referring to respondent profile:

- Two about county and locality of residence; a limitation in our collecting of geodata was not to add geolocation features, which would have provided a benefit, as long as the location would have been correct (as people not always fill in the questionnaire from their locality of residence). Since the launch of questionnaires, multiple script editors or plugins enabling the use of geolocation in Google Forms were launched. Also, other platforms have this capability, more and more important as respondents use mostly mobile devices with GPS.
- One referring to age group: <14, 14-18, 19-25, 26-34, 35-50, 51-70, >70 years
- One referring to sex: male or female

Although typical for most questionnaires, a question related to respondent's level of education was not added, since we considered that in Romania the discrepancy between similar forms of education in various institutions can be considerable and our evaluation regarding the level of knowledge regarding earthquakes can provide a more relevant insight on the actual preparedness of the individual, with age also providing info to make differentiations.

Figure 2 shows the age distribution of the respondents, which has a good proportion of young, middle age and old people. There are 1.5-1.6 times more answers from females (which are generally more conscious in providing feedback to questionnaires); male respondents tend to have older ages than females, which might show the lack of interest for younger male on the topic of questionnaires. There can be seen the wider interest for Q2, which reflects preparedness evaluation to be the first priority for most respondents.

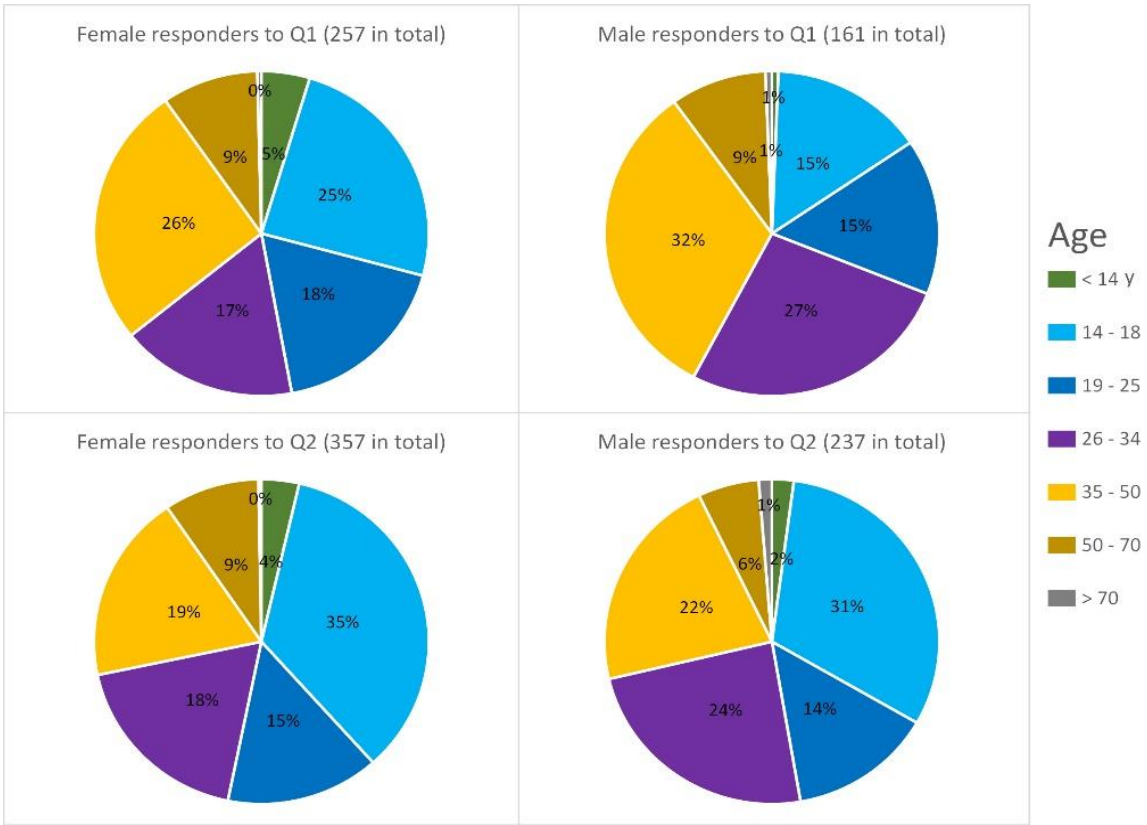

Figure 2. Distribution of respondents according to their age intervals and sex, for Q1 and Q2, as well as the total number of pre-filtered responses

The questionnaires were initially promoted on the INFP and partners social-media pages in 2018 (that is why 42% of Q1 and 38% of Q2 responses are from April 2018), but also later through educational webinars and events. As such, the main sources for responses were Facebook subscribers of the INFP page, school students and teachers, participants to science fairs and scientific events or

people searching for earthquake preparedness information on the MOBEE webpage. By using the individual response timestamp (date when the answer was sent) and location, patterns related to events in particular schools, followed by surges of answers (or local scale advert), can be and were identified. For example, 50 answers in Bucharest and Teleorman county in January 2021 for Q2, after months with small and dispersed number of answers. No major or moderate magnitude earthquake occurred in Romania in the 2018-2021 period for which most questionnaire data is available; the interest after a considerable earthquake would have probably resulted in many answers from multiple counties. It can be considered that among the target audience are people more prone to have fresh information regarding earthquake and preparedness, providing a bias on the results; answers to the question "Where did you get and would get info regarding earthquakes?" provides some hints, about 65% of respondents declaring that they have information regarding earthquake from websites or initiatives of authorities. However, results interpreted through our methods showed that either some people weren't paying attention to the information that they had just received, either they did not had time to prepare for an earthquake, answers to Q2 showing the level of preparedness before (hopefully) applying the mitigation measures just found out.

In order to analyze results and draw conclusions regarding the mentality of respondents we processed spreadsheets with individual responses for the questionnaires with two software: Excel from Microsoft (relying heavily on PivotTable for cross tabulations) and ArcMap from ESRI for maps and geospatial analysis.

RESULTS

For Q1, the distribution and number of respondents (after removing duplicate answers) can be seen in Figure 3, in which we take advantage of the information regarding county of residence to perform statistics referring to the fear toward earthquakes and self-evaluated level of preparedness, in relation with seismic hazard. It can be clearly seen that people in areas with high hazard levels (usually similar also in terms of risk levels, given the overall high vulnerability of buildings in Romania) fear more about the earthquake. However, they did not declare to be more prepared in terms of information they have about earthquakes; on this aspect, people are generally modest. The fact that respondents in Timisoara and Arad counties, where earthquakes in 1991 generated significant panic and localized damage and loss of lives, do not report a moderate or high fear of earthquakes shows that, compared to well-known wide-spread dangerous intermediate-depth earthquakes in Vrancea, crustal earthquakes taking place not so often are of lesser importance in the perception of people (we would have said young, but all respondents in these counties were older than 25 years).

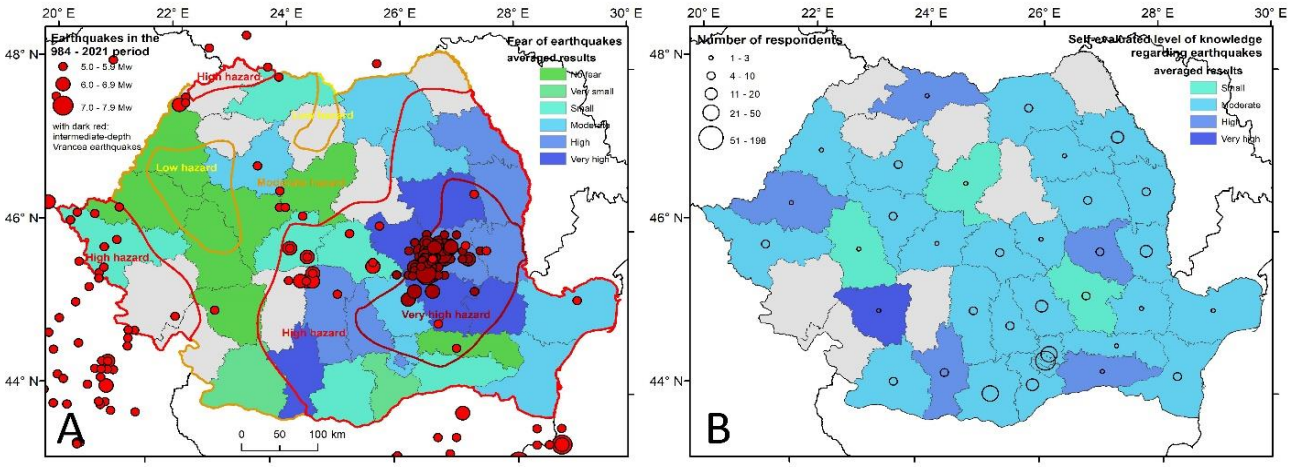

Figure 3. Maps showing averaged results for (A) the question "Which natural hazards are you most afraid of?", overlapped with moderate or major earthquake epicenters (source: BIGSEES, 2017) and qualitative probabilistic seismic hazard results of the Ro-Risk Project (IGSU, 2017), for the 1:1000 period, and (B) the question "How much you think you know about earthquakes?"

Figure 4 shows results of averaged responses referring to the perception of earthquake effects in the locality of residence and at individual level. Especially in counties closer to the Vrancea seismic source, people acknowledged the higher damage potential; but many considered their situation to be better than the overall level of their locality – which partially shows a limitation in perceiving the non-neglectable influence of indirect damage.

As stated earlier, a validation or invalidation of self-evaluation, helping in the understanding of perception toward personal preparedness and the development of a sociological profile, was performed. Figure 5 shows the results. The averaged ranking values from 1 to 5 were further reclassified in qualitative terms reflecting the level of knowledge, with further work being needed to justify some of the subjective decisions in the ranking process. It is interesting to see that most people considered that they have little or significant knowledge regarding earthquakes, but most were a level lower after answering three relevant earthquake-related questions. This generally shows that respondents were not influenced so much by the teaching or relation with INFP and its educational resources, even though for younger age groups, the distribution toward knowledge acknowledged is better.

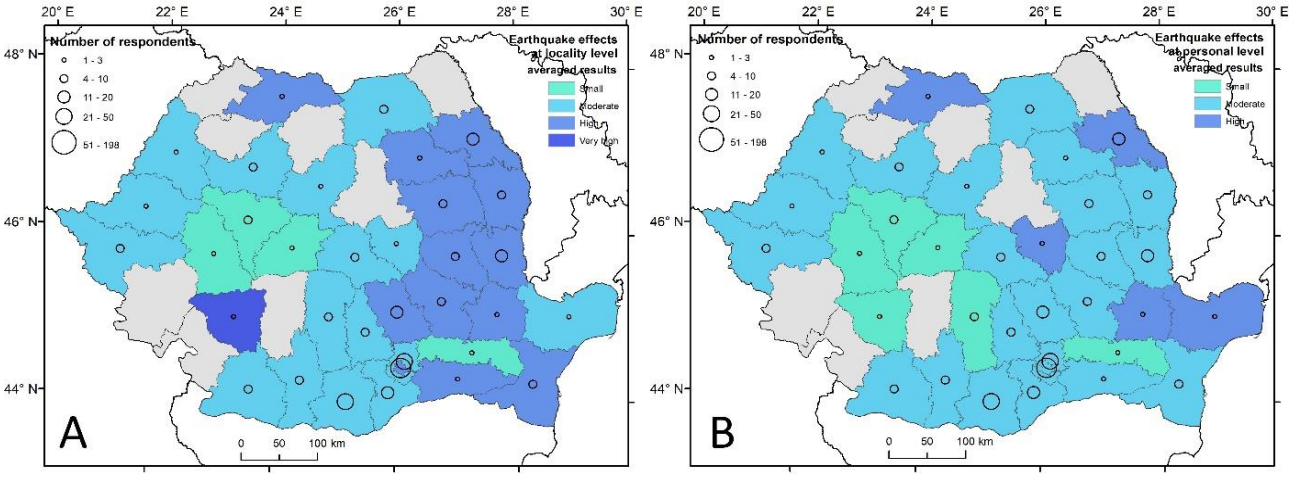

Figure 4. Maps showing averaged results for (A) the question "How significant could the effects of an earthquake be in your locality?" versus (B) "How significant could the effects of an earthquake be at personal level: on you, your family and residence building?"

The statistics showed in Figure 5 were used to analyze more in detail the profile of respondents to the question "You receive on your phone a message from the Romanian Earthquake Early Warning System (REWS; documented in Marmureanu et al., 2021), mentioning that an earthquake with magnitude 7.7 had just occurred in Vrancea Area; you know you should have around 20 seconds to do something. How do you react (if at ground floor, 2nd and 5th floor)?". Our supposition was that people with a good knowledge regarding earthquakes would not declare to leave the apartment, even if at ground-floor level, this being a considered a dangerous behavior given also the limited notification time-window. However, there are more complex aspects to take into account. Regardless of knowledge about earthquakes, living in a vulnerable building clearly favorites the decision of leaving the building, so answers to the previous question ("How significant could the effects of an earthquake be at personal level) would be relevant to also consider.

Responses, reflected by Figure 6, show that quite many people (40% in total) would be tempted to leave the apartment, if living at ground floor. People with a higher level of knowledge regarding earthquakes actually declared to be more in favor of leaving the apartment (also a visible maximum for the living at the 2nd floor situation), which shows both that they trust in their quick reaction, but also the limitations of their knowledge toward preparedness. Also, there is a conflictual believe in them, given that they also mentioned taking shelter under the door frame or under a table as good options. Fortunately, many people, regardless of their knowledge regarding earthquakes, declared that living higher in the building would not make emergency evacuation upon receiving REWS notifications suitable – at least declaratively.

A

Knowledge based on averaged test responses	Knowledge based on self evaluation: No knowledge	Very little	Little	Significant	High
No knowledge	1		4	8	3
Very little	2	7	105	87	10
Little	1	10	55	92	8
Significant			5	16	2
High			1		1

B

Knowledge based on averaged test responses	Knowledge based on self evaluation: No knowledge	Very little	Little	Significant	High
No knowledge			3	5	2
Very little	1	3	33	28	5
Little		1	3	11	
Significant			3	2	
High					

< 19 years old

C

Knowledge based on averaged test responses	Knowledge based on self evaluation: No knowledge	Very little	Little	Significant	High
No knowledge			1		1
Very little		2	17	12	1
Little		1	14	19	1
Significant			1	1	
High					

19 - 25 years old

Figure 5. Relations between self-evaluated level of knowledge versus test-based evaluation of knowledge, for all respondents (A), for people younger than 19 years old (B) and between 19 and 25 years old (C). Values represent number of responses.

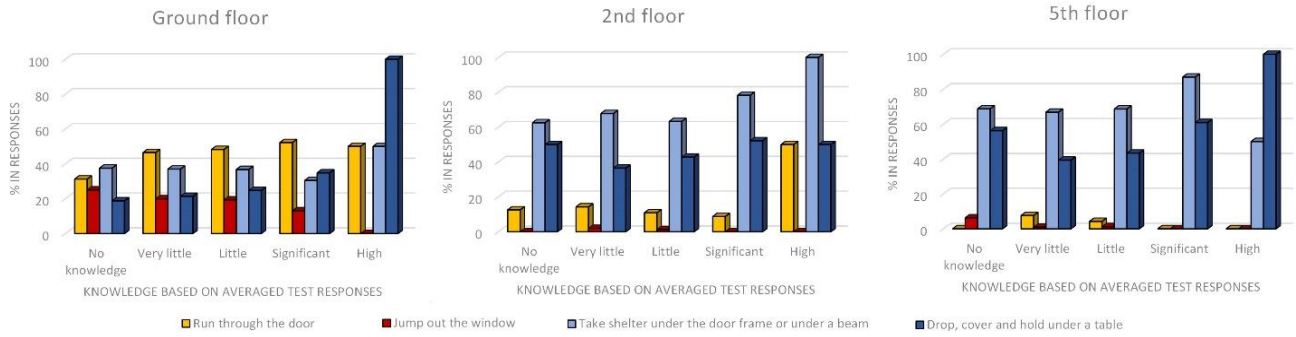

Figure 6. Responses to the question "You receive on your phone a message from REWS, mentioning that an earthquake with magnitude 7.7 had just occurred in Vrancea Area; you know you should have around 20 seconds to do something. How do you react (if living at different floor heights)?"

Figure 7 presents responses referring to what would convince people to take immediate measures to improve their safety to earthquakes. As it turns out, earthquake preparedness exercises are a top choice but also online risk awareness campaigns and a better understanding of earthquakes. Brochures, speeches or TV spots seem to be among the forms with the lowest mobilizing impact (TV especially for the young generation). A major or at least moderate earthquake in Romania would probably shake things also toward preparing for other earthquakes, but to see so many responses declaring that such an event would start what should be started in advance is worrying. In Figure 8 are analyzed the answers to the question "Where did you get and would get info regarding earthquakes?". Most answers refer to official websites of research and disaster management institutions (with a dominant role in the future) and YouTube videos, and not so many to museums or TV news. The impact of NGO and government initiatives seems very small in present, being more desired in the future by all age categories. Again, books or newspapers are less preferable as a source of information, also in the future, as digital devices take over. Real experiences – in schools, earthquake exercises or museum, are requested, but not as much as digital resources apparently which are instant to access.

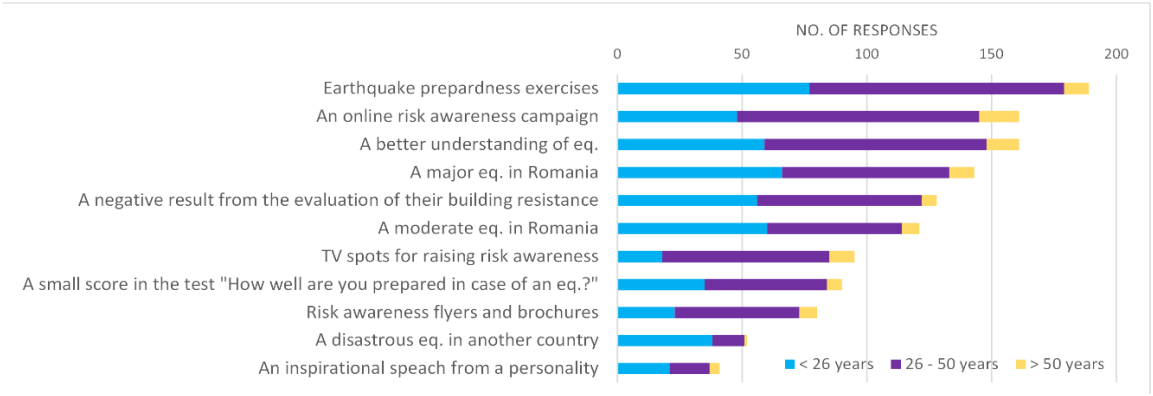

Figure 7. Responses to the question "What would convince you immediately to take measures to improve your safety to earthquakes?"

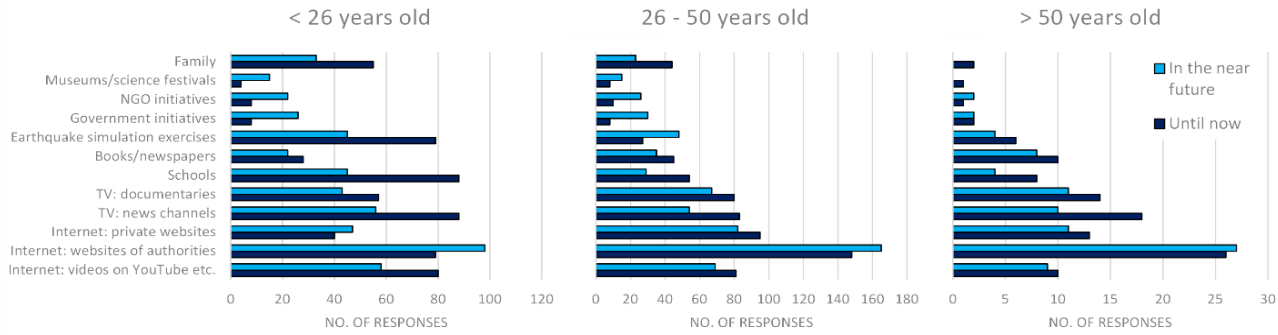

Figure 8. Answers to the question "Where did you get and would get info regarding earthquakes?"

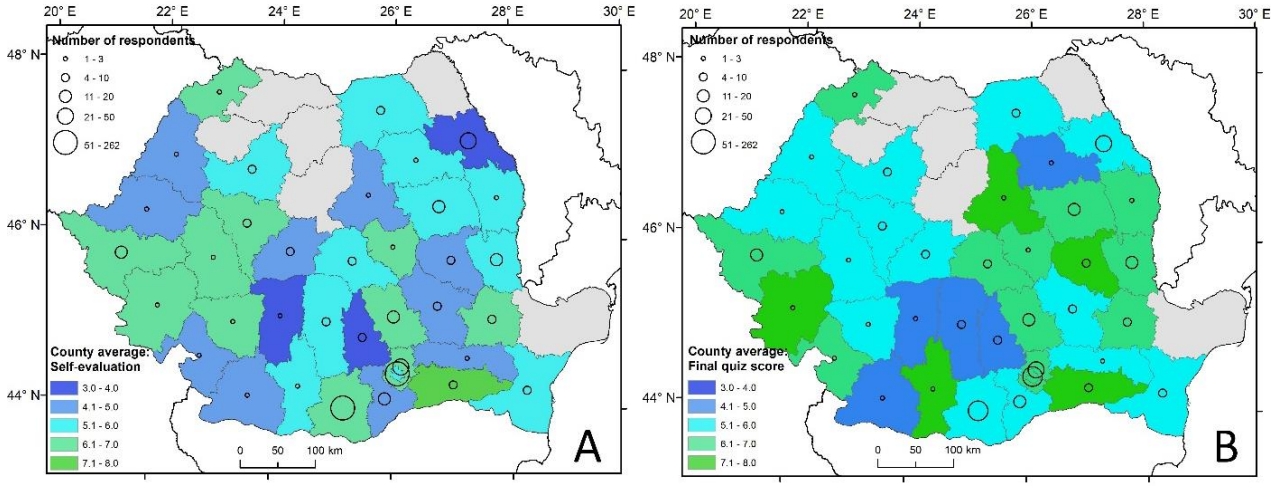

Figure 9. Average self-evaluation scores collected before the test (A) versus average scores obtained after the test (B)

For Q2 we had at least 3 respondents in 25 out of 41 counties plus Bucharest, making possible a preliminary evaluation of spatial correlations between the awareness and preparedness of people to seismic risk and their exposure. 44.1% of the total number of answers were from residents of Bucharest, 7% from nearby Ilfov county and 12% from Teleorman county; these are areas highly affected by the 1977 Vrancea earthquake and with a significant level of seismic risk nowadays, so there are interesting conclusions to draw. Figure 9 shows, in comparison, averaged results of self-evaluation and averaged test results. As it can be seen, people are generally less confident about their preparedness level than they prove to be after the test – at least if they answered honestly. In many counties near the Vrancea Seismic Source (such as Vrancea, Bacău or Galați), this phenomenon is more evident, showing

that, at the level of perception, people are aware that they are not well prepared against a seismic hazard that they acknowledge.

Figure 10 reveals in more detail the distribution of scores as one compared to the other or per age groups. As mentioned earlier, the 28 answers with 10 and 10 scores seem a false information to be removed in interpretation – especially also because it belongs to very young responders which cannot possibly be so well prepared for an earthquake, especially since they did not experience a major one and can hardly imagine what needs to be done in critical moments. The typical self-evaluation score is 5, which corresponds to the trend which has been seen in Q1. Young people tend to consider themselves to be more prepared to an earthquake then they seem to be. For the majority of respondents, there is no significant difference in the self-evaluated score and their results (no more than 2 points), and the roughly linear distribution and the concentration of values in the 5-8 range proves that our test is well designed.

Through Q2 the analysis of frequently missed questions we can tell which are the least taken preparedness measures:

- **"Have you got a functioning fire extinguisher in your home?": 85% answered „No" on average**, with no significant distribution per age group.
- **"Have you prepared an emergency backpack?": 79% answered „No" on average**, although 61% of respondents under 14 years and 66% of respondents between 14 and 18 years old said so.
- **"Do you and your family have a joint plan in case of emergency situations?": 68% answered „No" on average**, although people over 26 years old had lower percentages, around 63-66%.

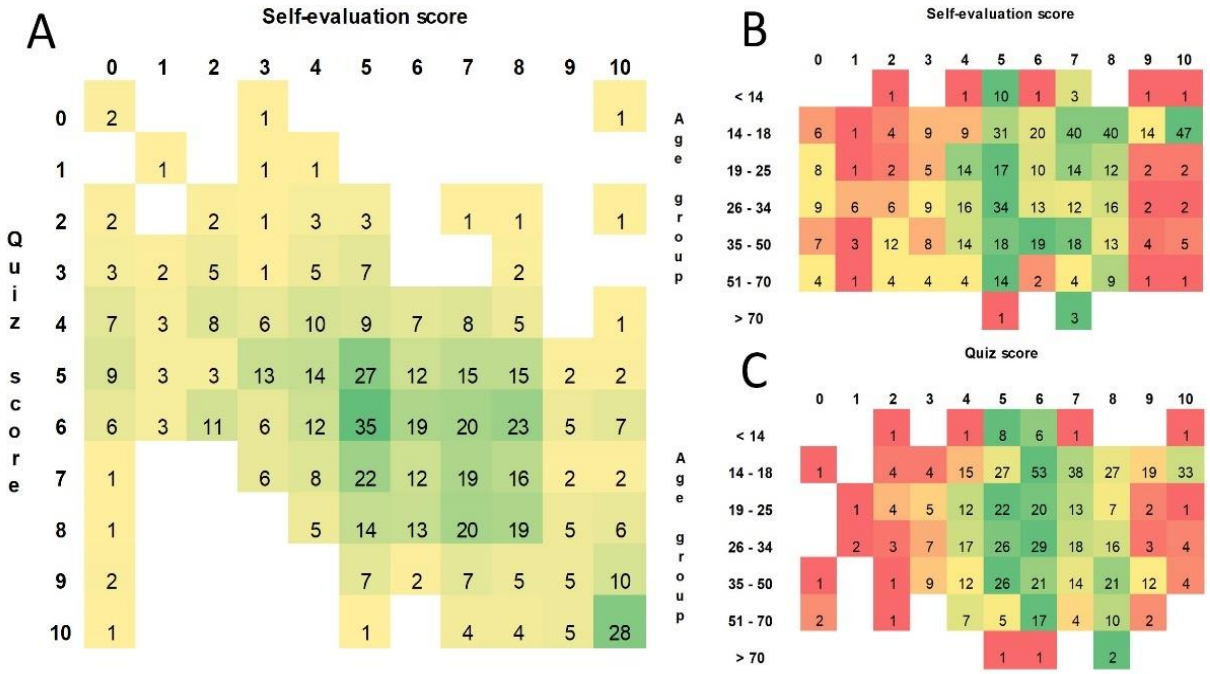

Figure 10. Matrix visualization of cumulative answers to A) self-evaluation scores versus final results and these scores depending on age group, colored according to min and max values distinctively per row (B and C)

CONCLUSIONS

This study introduces a new way of looking at perception and preparedness to earthquakes, showing its potential in telling a more complete story (also from a geographical perspective) about the people attitude toward risk and risk reduction. Questionnaires have a long tradition in the field, but we show that new design (not necessarily making them long and complex) and interpretation can reveal important patterns which can contribute to better targeted and of greater impact mitigation efforts. By evaluating for example what people think they know and really know about earthquakes,

how well they are anchored in the seismic risk problem, considering their exposure, or what they consider to be of impact considering their age, we can be able to understand how to approach the "resilience to change" in terms of earthquake preparedness.

Results based on our two questionnaires can be considered preliminary and further responses, also from multiple target groups and a wider national focus, are needed. Still, there are important findings to mention, which we expect to be stable also after more data is collected:

- people closer to Vrancea seismic source (up to 200 km epicentral distance) are, as expected, more afraid of earthquakes. However, their level of preparedness is not higher compared to others. Many declare that at personal level they will not be as affected as the overall level in their localities, but even if this statement sustains, making them understand that their involvement in forming a resilient local community is highly needed is an important next step.
- respondents tend to be modest in self-evaluating their level of knowledge and preparedness to earthquakes (with young people overestimating their level a bit); generally, they prove to be right – with not many answering basic questions regarding earthquakes in Romania and preparedness adequately, even if some form of information prior to the test (from the MOBEE website or INFP initiatives for example) is to be suspected.
- if notified prior to 20 seconds that an earthquake is going to be felt (by the Romanian Earthquake Early Warning System), many people (regardless of knowledge level about earthquakes) answered that they would quickly leave the building, if being present at ground floor. If they would be at 2th or 5th floor, much fewer would try to leave. That is an important indication of why REWS notifications for large public is a risky decision, clearly needing to be accompanied by proper preparedness campaigns and regular emergency exercises, but also research toward the real behavior of people in earthquake situation.
- people answered that earthquake preparedness exercises, online risk awareness campaigns and resources and a better understanding of earthquakes would convince them to take immediate measures to improve their safety to earthquakes. Classical forms of communication, via TV or flyers and brochures, doesn't seem to be relevant in the future, at least in terms of mentality.

This study doesn't stop here. By collecting more answers (also trying to reveal time-dependent differences), refining our interpretation process and making links with other similar initiatives in Romania but not only, we hope to better understand the seismic risk problem in Romania and proper ways to address it.

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