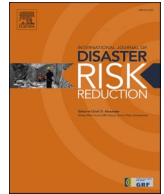




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# Bilingual challenges in earthquake risk communication: Analyzing media and perceptions in the San Diego region

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## ABSTRACT

The project presented in this paper investigates earthquake risk awareness and communication in the San Diego border region, focusing on vulnerable communities and minorities, specifically non-English speaking communities. By analyzing English and Spanish media coverage on earthquake risk over a decade within the San Diego region, this study discusses the role of journalism on shaping earthquake risk perception, as a catalyst for effective seismic preparedness, stressing the open challenges and needs. In addition, the results of an exploratory survey launched in the San Diego region suggest that diverse solutions to effectively communicate essential information on seismic risk shall be explored, mindful of the diversity and specific vulnerabilities of the population residing in the focus region. As communication in disasters management stands at the intersection of preparedness, mitigation and recovery, this study can play a role in achieving equitable, seismic resilient diverse communities.

## 1. Introduction

Earthquakes pose a serious threat for populations worldwide, as observed, for example, during the Türkiye-Syria earthquake sequence that struck the earth on February 6th, 2023 [1]. Particularly, this sequence of events showed earthquake professionals that additional parallel systems aimed at protecting the local social-communal infrastructure are needed besides seismic-resisting structures [1–4]. The capacity of a community to respond to disasters is indeed intrinsic to the local assets, accessibility to resources and overall disaster preparedness [5,6]. Within the four temporal stages identified in the hazard cycle, namely mitigation, preparedness, response and recovery [7], top ten actions are identified to mitigate the negative effects produced by earthquakes, such as developing a culture of preparedness, enforcing building codes, and retrofitting vulnerable structures [8]. Primary to these actions, educating the public, with care for the most vulnerable, is deemed essential to ensure that communities are aware of local earthquake risk [6,9,10]. Disaster preparedness, indeed, includes communication, as part of being prepared involves knowing if, when and where an event will occur, and how to respond [7,9]. Assessing public risk perception is also critical because the implementation of strategies is effective when the actual risk is in accordance with the individuals perceived risk, inevitably influenced by personal expressions and involvement [11]. Alongside the top ten priorities to achieve seismic resilient communities, Johnson [8] indeed identified the main barriers to their implementation to be risk awareness and uncertainty, and invited communities to take advantage of temporary “windows of opportunities”, such as changes in leadership or the occurrence of other disasters, to promote seismic awareness and

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advocacy [8].

The work presented in this paper collocates within this context, to better understand roadblocks to seismic risk communication and awareness in diverse communities, as catalyst elements to effective seismic measures [9,11]. Amongst the multiple factors that influence their implementation, this research focuses on the perceived role of media on hazard communication, exploring communities and minorities' preferences on risk communication. Whilst it is noted that isolating the direct impact of media on preparedness would require experimental and advanced statistical methods, the data collected in this research through media analysis and surveys explore how diverse individuals engage with journalistic content, and the extent to which they believe it influences their understanding of earthquakes. This data can be used by other researchers and specialists to understand the role of media in shaping public risk perception and improve the effectiveness of communication at large in diverse communities.

## 2. Research significance

To reduce the impact of earthquakes and enhance resilience, it is critical to motivate people to be prepared, by facilitating the formation of intentions and their conversion into actions [11]. As providing information on seismic risk is an appropriate strategy to support these intentions [11], the research presented herein investigates the perceived role of media in earthquake awareness, starting with the understanding of how earthquake news has been reported in San Diego, and how often San Diegans read about it. Acknowledging that scientific communication is a two-way process, i.e., without listening to people it is difficult to know what they value and provide relevant information [12], a survey was distributed online to local communities to collect information on how they receive and interpret seismic risk. The primary spoken language was also assessed to identify potential gaps between English and Spanish-speaking segments of the community. This study provides insights into public perceptions of the role of media in shaping risk awareness. Despite this work's regional focus, the insights derived herein may support other institutions responsible for risk communication of other hazards, to design effective user-centered strategies, and effectively reach diverse communities.

## 3. Earthquakes and media

Seismic risk is generally defined as a combination of the i) seismic hazard, i.e., the likelihood of an earthquake to strike, ii) exposure, i.e., local people, property, and infrastructure, and iii) vulnerability, e.g., how susceptible the exposed segments of population are to damage, including their adaptive and coping capacity [7]. As for the seismic hazard, available models consider the frequency of earthquakes of different magnitudes to map local hazard levels as in Fig. 1 [13]. Whilst local seismic hazard might be higher than depicted due to the potential amplification of ground motions by site-specific geology, e.g., varied local soil conditions, the "high hazard" classification in the focus region of San Diego informs about the criticality of earthquake awareness in the focus region. Although the map in Fig. 1 is available and openly accessible, people's perception of the risk of harm deriving by the seismic hazard may not align with it due to subjective factors, e.g., personal involvement and past experiences [14,15].

Media plays a major role in influencing people's awareness on regional seismic risk [16–20]. In the context of media analysis, it is recognized that awareness of seismic risk is necessarily a mediated one, given that most expressions of the problem are distant from laypeople's everyday life and thus tend to be significantly influenced by media [12]. Journalists themselves seldom experience events firsthand or gain direct, unmediated access to reality; their reporting is, instead, shaped through the perspectives of various social actors who serve as sources of information [21–28]. When building the story, discursive strategies are used to shape and frame reality

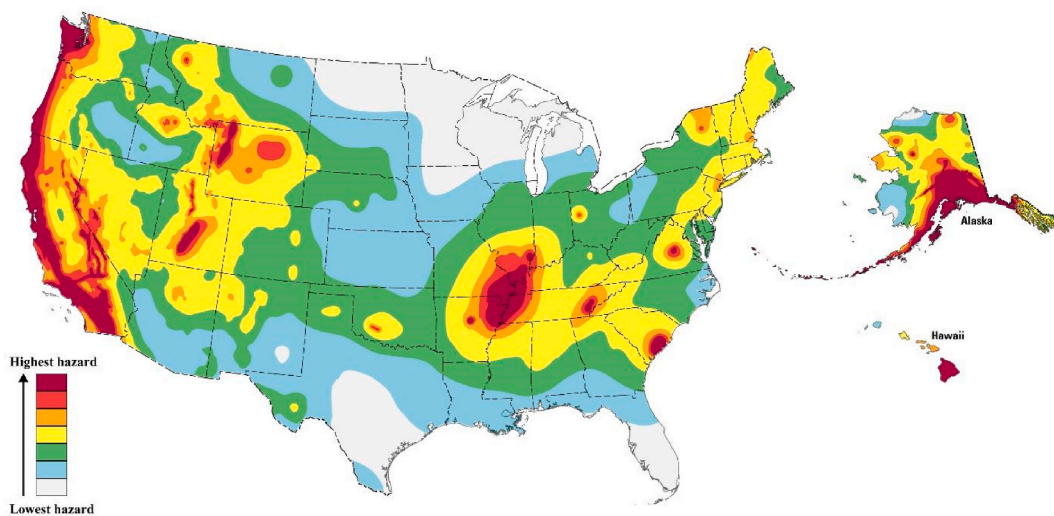


Fig. 1. Earthquake hazard map displaying peak ground accelerations with a 2 percent chance of being exceeded over 50 years for a firm rock site. Source: [usgs.gov](https://www.usgs.gov) [13].

through language to achieve a specific effect or objective [24]. This “manipulation” does not imply an illegitimate distortion of reality but rather the selective construction of meaning to influence understanding and perception, shaping how information is presented and the tone of message [27]. In this regard, researchers talk about the notion of “power” behind discourse, as it can be used to “(re)construct” and “(re)define” social realities, establishing a dynamic relationship between language and society [21,25,26]. Consequently, media representations of social issues, including seismic risk, largely depend on how journalists organize their stories and draw public attention to specific events and problems [24]. Narrative genres of mass media discourse can be divided into three large groups based on the subject and the way of presenting information, namely, informative-when based on factual reality; interpretative-when facts are elaborated and interpreted; and sensational-when emotional and imaginative narrations are developed [28]. Whilst informative media discourse is appreciated for presenting facts with objectivity and background, it may not be able to capture the attention of large audiences, often looking for the dramatic aspect of news, rich of sensationalism, personal stories and drama [29]. However, this narrative has the effect of casting risk in terms of harm connected to a specific event, confusing risk with hazard, and omitting the crucial element of decision making that makes risk a voluntary condition that can be reduced through action, thus missing on the opportunity to effectively inform the audience [30].

Although media coverage of scientific topics, including earthquakes, has increased significantly over time, media professional agendas pose important challenges to reporting scientific problems [16]. The literature points out that the media coverage of seismic risk, like other slow-onset risks, has typically been event-oriented, meaning that the issue makes it to the news when an earthquake happens [29]. Proximity and recency are central news values that inform a preference for framing disasters in terms of immediate costs rather than long-term consequences [12,16], without addressing critical behaviors and actions that can be taken in preparation to minimize future risk [16,29]. On the other end, warning messages about specific events that are likely to occur may fail to anticipate threats, offering information that is only “reactive” in nature, and not “proactive” [29], also missing an opportunity for fostering actions.

### 3.1. Risk communication

Effective risk communication requires collaboration among various groups [31]. While scientists strive to enhance public understanding, other actors, such as politicians, may polarize the discourse, with parties driven by electoral interests attempting to shape public perceptions of risk in their favor [21,32–34]. An example of risk miscommunication is offered by the 2009 L’Aquila, Italy, case, when four scientists, two engineers and a government official were charged with criminal manslaughter for not properly assessing and communicating earthquake risk and hazard in between seismic swarms, leading to aggravated earthquake aftermath [35–37]. This case study shows that information and awareness are required to enable individuals to define the problem, recognize the difference between seismic hazard and risk, identify trust and responsibility, and understand appropriate behavioral responses [31,38–40]. It also

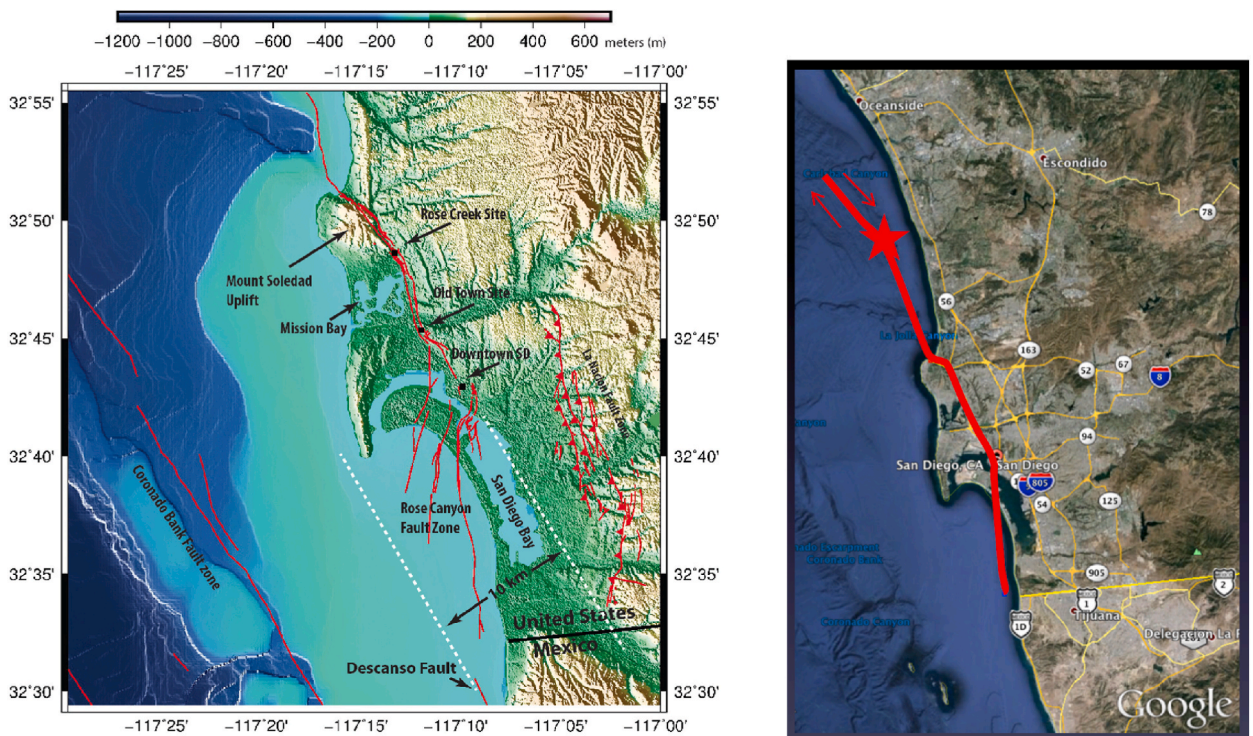


Fig. 2. a) Fault map in the San Diego region and b) Rose Canyon fault rupture assumed in the scenario. Figures from Rockwell 2020 [55].

acknowledges the two-way nature of scientific communication, which can disservice the community if information is disseminated without properly understanding the audience [12,32–34]. Negative outcomes may lie in underestimating laypeople’s decision-making competence, who may be easily blamed for failing to understand content that was neither clear nor relevant to them [12,32–34].

Adding to the complexity of effective risk communication, different cultural backgrounds and beliefs within sub-populations within communities may alter understanding [41–48]. Social groups, e.g., women, children, older people, ethnic minorities, people with literacy and language barriers, people with disabilities and those living in lower socio-economic conditions, differ from the majority population in the nature of their social networks, their access to hazard information, and their political power and economic resources [7]. Hence researchers must understand the needs of disadvantaged individuals, including linguistically diverse groups, to promote inclusive preparedness practices [6]. Other individuals’ dynamics may also influence the perception of risk. Psychological distance, for example, is a collection of personal experiences which are used by individuals to explain and make sense of situations and events [42]. Using temporal, social, spatial and hypothetical (i.e., uncertainty of the issue) components, individuals tend to use mental constructs to understand issues, such as earthquake events. The more abstract the construct, the more the event is perceived farther in time (e.g., not happening in a lifetime) and space (e.g., not occurring in “this” locations), as well as considered to happen to someone else (e.g., not in “this” community), if happening at all (i.e., hypothetical or uncertain dimension) [49–51].

### 3.2. The San Diego border region

The San Diego border region, bounded between the Pacific coastline and desert valleys, and by the international Mexican border on the South, is prone to earthquakes, floods, wildfires, and severe storms [14,43]. The seismic scene is dominated by the Pacific and North American tectonic plates, which can cause powerful earthquakes, greater than 7.5 magnitude, with effects in the larger San Diego region [52]. Other smaller local faults, like the Rose Canyon fault cutting through downtown (see Fig. 2), and the *Elsinore* and *San Jacinto faults* crossing the East County, can generate moderately-sized, but potentially damaging earthquakes [2,53,54]. In 2020, in occasion for the Earthquake Engineering Research Institute (EERI) National Conference in San Diego, an extensive scenario was developed assuming rupture of the Rose Canyon fault into a Mw 6.9 earthquake [55,56].

The 2020 EERI’s earthquake scenario report highlights how unprepared communities with vulnerable infrastructure pose a significant threat during earthquakes, as their limited coping capacity exacerbates structural collapses, disrupts critical services, increases casualties, and prolongs recovery efforts, leading to economic losses, social instability, and long-term psychological impacts [57,58]. The report intended to raise awareness on the potential harms of an earthquake, which could cause damage to buildings for an estimated \$38 billion, and outline important steps to enhance resilience [57]. To properly address this, San Diego’s diverse population must be considered. The Hispanic community is a significant and influential minority in this region, representing over 30 % of the county’s 3 million residents, also fostered by the proximity to the Mexican border, crossed daily by about 150,000 commuters [59]. As of 2022, almost 25 % of the San Diego residents were born outside of the United States, number that is larger than the national average of foreign-born residents of 13.6 % [59]. Statistics show that Mexico is the most common birthplace for the foreign-born residents of California [59,60], hence the focus of this study on Spanish-speaking communities.

## 4. Methods

This study involves an assessment of the current coverage on seismic risk and related earthquake hazard in the local English and Spanish media, to identify patterns and trends. Media articles were selected and analyzed as described in section 4.1. Concurrently with the media analysis, a survey was developed as in section 4.2 to know the perspective of the local communities on the perceived effectiveness of current local media strategies.

### 4.1. Media coverage analysis

The media coverage on earthquake risk was examined by collecting articles published in the San Diego region over the last decade. The 2012–2022 span was selected and deemed sufficient to offer a snapshot of media distribution over time and highlight current trends [61]. San Diego has a modest number of media outlets, of which ten were considered for their relevant volume of articles, including newspapers, digital platforms and television stations. Amongst these ten, four local news outlets were selected mainly for their publication language (English or Spanish) and the outlets’ distribution region and target audience, key to ensuring a comprehensive understanding of local communication and earthquake coverage. Additional criteria of selection include media’s established local impact, broad distribution, availability, and relevance, as well as their wide reach and influence within the target demographic, particularly among bilingual populations. The selected media are the *Union Tribune* (San Diego’s primary daily English-language newspaper), *El Latino* (the largest weekly Hispanic newspaper in San Diego County and the largest Hispanic-owned Spanish-language publication in California), *Times of San Diego* (an English-language, web-based outlet providing daily local news), and *San Diego Red* (a regional, web-based Spanish-language news outlet). The other outlets considered in the preliminary main list were excluded as they focus on business, economics, local food scenes, or cultural stories, or because of their predominant television-based format. While television-based formats, social media and other platforms offer valuable insights into public perception, they pose challenges related to data consistency and accessibility. Hence, additional media outlets were not considered in this study, but future research may benefit from incorporating other media types to broaden the scope of analysis.

The media articles published by the four selected local journals in the 2012–2022 decade were collected through electronic/on-line search, based on the following search terms: *earthquake*, *seismic risk*, *tremblor*, *seismicity*, *quake*.

This search initially shortlisted a total of 2067 articles, which were subjected to further screening in two steps, namely, i) reading the title, and ii) screening text and pictures. These two steps were critical in excluding duplicated documents and articles that did not focus on earthquakes, seismic risk, or preparedness issues. This selection did not consider any geographical restriction for the earthquake event per se, so articles on case studies or experiences happening in other regions or countries were not excluded as regarded useful in sensitizing the readers about earthquakes.

After the manual screening, a total of 539 articles complied with the selection criteria listed above were further analyzed and divided by journal and year of publication. A framework analysis of media discourse was used to classify the journals into factual reports, sensationalized narrative or editorial message. Specifically, the categorization of journal articles was based on a qualitative content analysis approach, where articles were assessed according to key linguistic and structural features, such as the text and context utilized in the construction of meaning of the media article. For example, articles classified under “human stories and drama”, i.e., sensational articles, emphasized emotional narratives, personal experiences, or sensationalized elements, often using subjective language and dramatic framing. In contrast, “articles presenting facts in a neutral way”, i.e., informative, were characterized by objective reporting, reliance on expert opinions, and a straightforward presentation of data without emotive language. To enhance the efficiency and consistency of this classification, large language models (e.g., OpenAI GPT-4o) were used to assist in the initial categorization of articles based on predefined linguistic and thematic markers. The results were then reviewed and validated to ensure accuracy and minimize subjectivity. Results of this classification are presented in Section 5.1.

## 4.2. Survey

Responses from a sample of the local community living in the San Diego region were gathered through a survey with multiple choice answers. A digital survey was developed in Qualtrics [62] and shared locally with the community. The recruitment period totaled approximately five months, over which flyers were attached around campus and digitally distributed through local events at San Diego State University (SDSU). The survey consisted of thirteen questions divided in three macroblocks to include 1) information on the primary spoken language (English versus Spanish) and social dimension of the respondent, 2) seismic risk awareness (as based on previous earthquakes) and perception, and 3) the perceived role of media and preferred channel to communicate seismic risk. These macroblocks are indicated by different shadings in Table 1, which also provides information on the measures adopted to evaluate the survey responses, i.e., binary (yes/no) or Likert [63] scales. These methods of assessment, i.e., binary (yes/no) or Likert [63] scales, are widely accepted in social research and offer detailed data for analysis.

Whilst the characteristics of the participants were not directly recorded, traits of the survey takers may be inferred by the target community where the flyers were mainly distributed. SDSU has a large Hispanic population, with 34.7 % of students identifying as Hispanic or Latino [59]. About 40 % of students are first-generation college attendees, likely to have family members who primarily speak Spanish at home [64]. Participants were self-enrolled and decided autonomously to take part in the survey. They were also

**Table 1**  
Survey variables used in this study.

Category/research question	Variable	Survey question	Measure
Respondents' characteristics	Language	Do you believe that Spanish is the primary language spoken in your family?	Binary – yes or no
	Language spoken at home	In your family is there anyone who exclusively speaks Spanish?	Binary – yes or no
Social dimension	Family	Have you discussed earthquake-related information received through the media with your family or household members?	Binary – yes or no
Experience with earthquakes	Reported experience	Have you experienced any previous earthquakes in our area?	Binary – yes or no
Earthquake risk perception	Risk	In your opinion, what is the earthquake risk in our community?	5-point Likert scale – from none to very high
	Impact	How do you think an earthquake would impact infrastructure, buildings, and utilities in our community?	3-point Likert scale – from minimum to significant disruption
	Perceived structural safety	In your opinion, do you believe that your home is a safer location during an earthquake compared to the Snapdragon Stadium?	Binary – yes or no
Media communication	Perceived self-awareness	Do you overall feel adequately informed about the earthquake risks specific to our area?	Binary – yes or no
	Preferred language	If you were to experience a large magnitude earthquake, would you like to receive information in English or Spanish?	Binary – English or Spanish
	Preferred channel of communication	If an earthquake were to happen, how would you prefer to receive information in the first 24 h?	Options – Television, radio, Internet <sup>a</sup> , newspaper or magazines, other
	Frequency	How often do you come across earthquake-related information in the media?	5-point Likert scale – from never to daily
	Effectiveness at personal level	In your opinion, how effective is the media in providing timely and accurate information about earthquakes?	5-point Likert scale – from very ineffective to very effective
	Effectiveness at community level	Do you believe the media has played a significant role in increasing public awareness and preparedness for earthquakes?	Binary – yes or no

<sup>a</sup> Includes websites, news apps, social media.

encouraged to share the survey with their family members and friends, helping to expand participation and ensure broader representation of the community.

As it is recognized the influence of opinions and subjective evaluations on earthquake awareness (often referred to as “risk perception”) [65], the first question block included multiple questions, see Table 1. To explore how individuals intuitively assess risk in familiar settings, the second macroblock includes the comparison between the Snapdragon stadium and participants’ homes. While specific data on the year of construction or exact locations of participants’ homes was not collected, looking at the age of the housing stock in San Diego yields some insight [57]. If about 15 % of houses were built after the 1994 seismic code updates, the Snapdragon Stadium was designed in 2020 following seismic standards [66]. This fact could contribute to a more favorable perception of its structural safety [65]. This question also serves an important role in clarifying the distinction between risk and hazard for respondents. While seismic hazard refers to the natural occurrence of earthquakes, risk includes the built environment’s ability to withstand seismic events. By prompting respondents to consider the relative safety of different structures, this question aimed to draw their attention to recognizing that risk is shaped not only by earthquake likelihood, but also by the resilience of the infrastructure exposed to it.

The survey was overall designed for balance and engagement, being concise to minimize respondent fatigue and disengagement, and to avoid any perceived lack of anonymity or confidentiality in the responses. To ensure a positive survey experience for the respondents, no time limit was set to allow the respondents to proceed at their own pace.

5. Results

Results of the media analysis and survey responses are presented to characterize the understanding of earthquake risk across the focus region. Further interpretation and implications of these results are discussed in Section 6.

5.1. Media coverage results

The results show that articles on earthquake related issues are relatively frequent in the San Diego region. A total of 539 earthquake-related articles distributed over the decade of interest (see Fig. 3) feature reports on seismic activity, coverage of earthquake drills and discussions on fault lines, hence deemed able to convey useful earthquake information to the focus region. Assuming an average number of 52 weeks per year, 539 relevant articles correspond to approximately one relevant article per week over the period under consideration, which may be considered a medium-low coverage for a region prone to earthquakes, where information is critical for an effective preparation [12,18,67]. It is also noted that the article selection did not impose geographical restrictions on earthquake events, including articles on case studies or experiences from other regions or countries, impacting awareness and preparedness on public perception.

Regardless of the language of publication, Fig. 3 shows a peak in publications centering between the 2016–2017 years. Possible explanations for this trend may be found in the devastating 2017 Puebla earthquake followed by the Chiapas earthquake just a couple of days after, totaling almost 500 casualties and \$12 billion in damage [68].

As for the article classification in different discourses typical of media articles, it is observed that more than 90 % of the analyzed articles are informative, with the rest being editorial or sensational. These results align with the stated goals of seismic risk

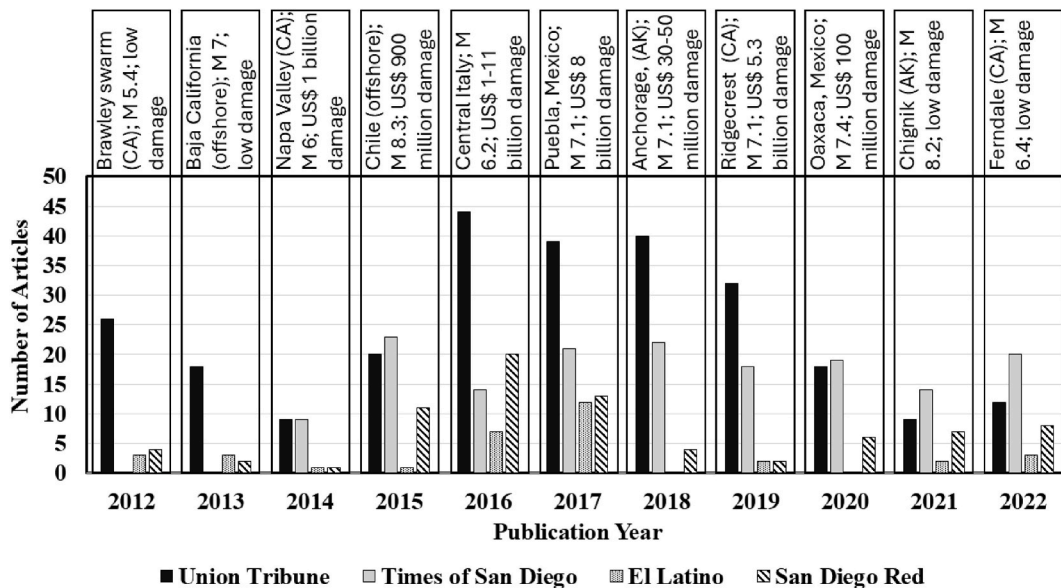


Fig. 3. Distribution of media articles in local journals on earthquake-related topics over the considered time span, with notes on the occurrence and magnitude of the most critical earthquake event in each year.

communication, namely share information, raise awareness, change behavior and beliefs, and increase preparedness [20].

## 5.2. Survey responses

The results of the multiple-choice survey provide preliminary insights into the earthquake risk perception and media consumption habits of local communities in the focus area. The responses provided by 141 survey takers are statistically analyzed to identify trends discussed in Section 6. As recommended for smaller sample sizes, the Fisher's Exact Test was used in the following statistical analysis as the non-parametric method to calculate the probability of obtaining the observed distribution of values in a contingency table [69]. The statistical measure used to determine the strength of association between two variables is the Cramer's V, where a value of 0 indicates no association between the variables and 1 a perfect association [62]. The stronger the association between two variables, the closer the Cramer's V value is to 1 [62]. Additionally, the p-value is reported to determine the statistical significance of the association. The p-value is the measure of statistical significance, indicating whether the relationship between the two variables is consistent enough that it is unlikely to be a coincidence. A value less than 0.05 means that a relationship is "statistically significant", unlikely to be a coincidence [62].

### 5.2.1. Responses on social dimensions

Results from the first set of questions (i.e., information on the respondent's primary spoken language and social background, see Table 1) reveal that 33.1 % of the 130 respondents identify Spanish as their primary language. Additionally, 34.9 % of the 129 respondents have a family member who speaks only Spanish, which aligns with the anticipated percentage of Hispanic presence in the focus region (see Section 3.1). Whilst this information cannot suggest a definitive correlation between Spanish speakers and Latinos living in San Diego, it will help contextualize the survey results and provide insight into the local role of the media.

Table 2 illustrates the correlation between speaking Spanish as the primary language and having family members who exclusively speak Spanish. Notably, nearly 30 % of respondents who do not identify as Spanish speakers have some family members who only speak Spanish. This finding is statistically significant at  $p < 0.00001$ , with a Cramer's V effect size of 0.60. It is also observed that 74.2 % of the 128 respondents have experienced at least one past earthquake event.

### 5.2.2. Responses on earthquake risk perception and previous experience

The results of the second macroblock (i.e., seismic risk awareness and risk perception, see Table 1) indicate that 38.1 % of the 126 respondents perceive the earthquake risk as moderate, followed by 30.2 % who view it as high risk, 27.8 % as low risk, and 3.2 % as very high risk. Only one respondent indicated that there is no seismic risk. While the question specifically asked about risk, it is possible that some respondents interpreted it as referring to hazard instead. To further investigate this, respondents were also asked about the perceived impact of an earthquake. The results show that 50.8 % of the 126 respondents rate the potential disruption from seismic events as having a moderate impact, followed by 32.5 % who believe it would have a minimal impact and 16.7 % who expect a significant impact. These results have a medium-high statistical significance, with a p-value of 0.00315 and a Cramer's V effect size of 0.303, see Table A1 in the Appendix. The breakdown of these results into the two main social groups identified in this survey is graphically shown in Fig. 4. The distribution of responses is similar between both groups, with no statistically significant difference between risk and damage perception based on the respondents' spoken language, regardless of the marginally higher percentage of English speakers who perceive a high level of risk, see Fig. 4. Looking at the respondents who experienced a past earthquake may provide insight on the role individual experiences play in earthquake risk perception. Particularly, all the respondents that rated the earthquake risk as very high had experienced a previous earthquake. A similar trend is registered in the belief of earthquake disruption, with significantly lower responses rates and lower scores of expected risk and seismic damage and/or disruption amongst those who did not experience past events. However, it is noted that the statistical significance of these results is not sufficient to draw solid conclusions on these relations, see Tables A2 and A3 in the Appendix.

Results of this survey show that 45.8 % of the 120 respondents think that their homes are safer than the Snapdragon Stadium, which was constructed in 2022, and only 39.7 % of the respondents feel adequately informed about earthquakes.

Noteworthy, more than 70.0 % of those who feel prepared have experienced a previous event. Fig. 5 shows a very similar breakdown for Spanish and English speakers on the perceived level of seismic preparedness in their area.

The survey results show that only half of the 136 respondents share earthquake-related information from the media with their family or household members. Of these, 27.1 % of Spanish-speaking respondents discuss earthquakes with close family members, compared to 38.6 % of English-speaking respondents. Given the similarity of these percentages, no statistically significant relationship can be established. However, a statistically significant relationship is observed between feeling informed and discussing earthquake-related topics with family members, with a p-value of 0.0143 and a Cramer's V effect size of 0.233, see Table 3.

**Table 2**

Cross table relating the primary language spoken by the respondents and their families.

Spanish is the primary spoken language in the family	Someone in the family exclusively speaks Spanish	
	No	Yes
Yes	11.9 %	71.1 %
No	88.1 %	28.9 %

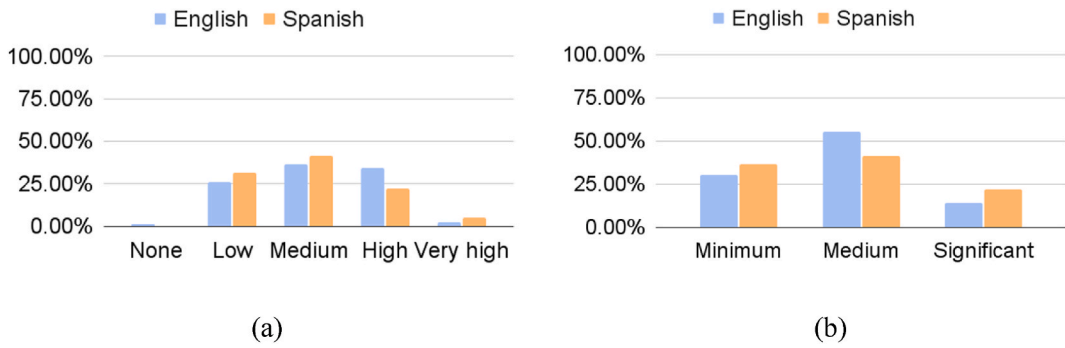


Fig. 4. English versus Spanish-speaking responses on a) belief of earthquake risk knowledge and b) belief of earthquake disruption and damage perception.

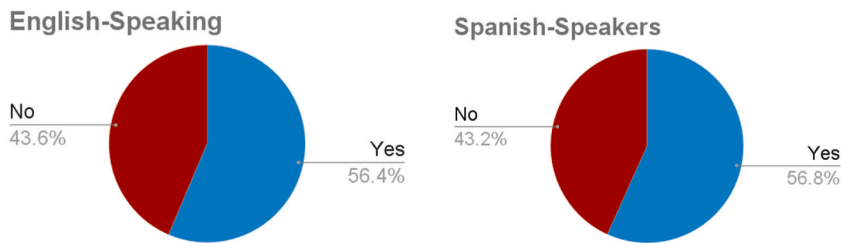


Fig. 5. Responses from English and Spanish speakers on the perceived level of seismic preparedness in their area.

5.2.3. Responses on media communication

The third macroblock of questions deals with the perceived role of the media about earthquake awareness and preparedness, see Table 1. The results indicate that 56.5 % of the 115 respondents, 18.0 % of which primarily speak Spanish, believe the media has significantly contributed to raising public awareness and preparedness for earthquakes. The survey also provides information on how often respondents encounter earthquake-related information in the media. 79.8 % of the 119 respondents rarely encounter earthquake-related information in the media, while 10.9 % come across it once a week, and 3.4 % encounter it several times a week. Additionally, 5.9 % of the survey takers have never found earthquake-related information in the media. Fig. 6 breaks these percentages between Spanish and English speakers to inform on different perspectives. 3.8 % of English-speaking respondents and 2.5 % of Spanish-speaking respondents encounter seismic-related information multiple times, while over twice as many English speakers (13.9 % compared to 5.1 %) come across it once a week. A higher percentage of Spanish-speaking respondents either never (7.5 %) or rarely (85.0 %) read earthquake-related media compared to their English-speaking counterparts, where 5.1 % never and 77.2 % rarely engage with such information. This data, however, does not support a statistically significant relationship between the language spoken by respondents and the frequency with which they read earthquake-related media articles.

The results indicate that 65.5 % of the 116 respondents rated the media’s role in providing timely and accurate information about earthquake events as between neutral and somewhat effective, and about the same amount believes that media did not play a significant role in earthquake risk awareness and preparedness. There is a statistically significant relationship between the perceived media effectiveness in providing timely information about earthquakes to the role media played in increasing seismic risk awareness and preparedness, with a p-value of 0.00106 and an effect size Cramer’s V coefficient of 0.375, see Table A4 in the Appendix.

Statistical correlation is found between respondents’ sense of being adequately informed about earthquake risk and the perceived role of the media in raising seismic risk awareness and preparedness, see Table 4. The analysis shows a p-value of 0.000586 and a Cramer’s V effect size of 0.322. Similarly, statistical significance is observed between the media’s effectiveness in providing timely information and respondents’ sense of being adequately informed about earthquake risk, see Table A5 in the Appendix, with a p-value of 0.00106 and a Cramer’s V effect size of 0.375.

Table 3

Cross table relating the perceived knowledge about earthquake risk in the community and the discussions of this topic with family members.

Feels adequately informed about risk	Discussed seismic risk with family members	
	Yes	No
Yes	50.8 %	28.1 %
No	49.2 %	71.9 %



Fig. 6. Responses from English and Spanish speakers on how often they read earthquake-related media.

Table 4

Cross table relating the role media played in increasing seismic risk awareness and preparedness to the respondents’ sense of being adequately informed about earthquake risk.

Media increases seismic risk awareness and preparedness	Feels adequately informed about earthquake risk	
	Yes	No
Yes	76.1 %	43.5 %
No	23.9 %	56.5 %

Fig. 7 shows the breakdown of these results into English and Spanish speakers, highlighting a higher percentage of English-speaking respondents finding the media to be somewhat effective (35.9 %) compared to those who rated it as ineffective (19.2 %). Respondents who identified Spanish as their primary language gave similar ratings (26.3 % and 28.9 %, for effective and ineffective, respectively). However, these results do not highlight a strong statistical relevance.

Finally, respondents were asked what their preferred channel of communication in the first 24 h after an earthquake would be. Of the recorded 136 responses, the Internet (including social media, websites and news apps) lead the preference with 44.6 % votes, followed by 25.8 % preferences for television, 17.9 % for the radio, and 8.3 % votes for other methods such as text messages, phone alerts, and similar warning systems. Lastly, newspapers or magazines received 3.3 % of votes. When broken down by language, both groups showed similar trends, though Spanish-speaking respondents displayed a slightly higher preference for direct texting and phone alerts compared to the other group, see Fig. 8. Therefore, no statistically meaningful conclusions can be traced to connect the preferred spoken language and media habits.

6. Discussion

This study aims to enhance earthquake resilience by examining how media influences public awareness and risk perception in San Diego, using news analysis and community surveys to inform more inclusive and user-centered risk communication strategies. The results and implications of these two complementary components are discussed to highlight key trends and recommendations.

6.1. Discussion on media coverage results

From the media count and analysis, it is observed that English-language media published 74 % more earthquake-related content than Spanish-language media during the period under consideration. Whilst this result may be justified by the fact that Spanish-language media target a smaller part of the population, it may point out to systemic challenges in media representation, which often results in key segments of the population being under-informed about potential risks, and under-represented or excluded from

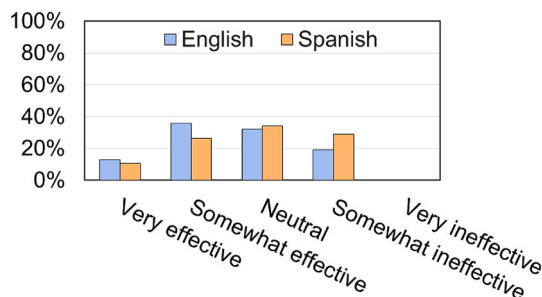


Fig. 7. Responses from English and Spanish speakers on how effective the media is in providing timely and accurate information about earthquakes.

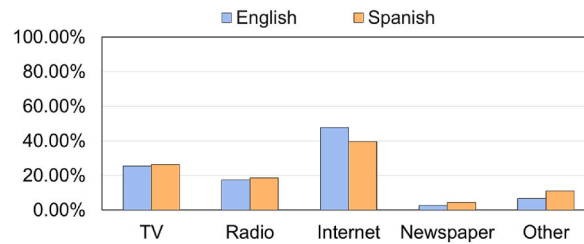


Fig. 8. English versus Spanish speakers' responses on the preferences for receiving information.

preparedness strategies [43]. This issue is significantly relevant in disaster risk communication, where timely and accurate information is crucial for all community members [70]. This gap in media coverage, added to other socio-economic vulnerabilities, may hinder the ability of Spanish-speaking communities to adequately prepare for earthquakes, as seen in similar contexts where language barriers reduce access to crucial risk communication (e.g., tornado warnings in Oklahoma and Saragosa, Texas tornado and the hurricane Katrina [71], or California's wildfires [3,44,46]). This also underscores the importance of advocating for strengthening collaboration between media outlets and community organizations to address language barriers and enhance the effectiveness of disaster communication efforts [45–48]. However, while studies suggest that information access is a key factor in seismic resilience, it must be coupled with other elements such as understanding, trust in the source, and the motivation to act [7,11]. Thus, while the information gap may influence resilience, it is likely one of several contributing factors, rather than the sole determinant [67]. Furthermore, even well-informed individuals may still not take the necessary steps due to other barriers, including resources limitations and lack of community support [17].

As for the type of discourse found in the analyzed articles, low personalization and dramatization biases are expected in this narrative, being >90 % classified as informative and very few being editorial and sensational. Whilst this type of media discourse is appreciated for presenting facts with objectivity and background, it may not be able to capture the attention of large audiences. Indeed, studies showed that the dramatic aspect of news attracts many readers, looking for sensationalism, personal stories and drama [29]. A better balance of these two narratives could be more effective in informing the local community about earthquake risk, making the information comprehensible for the readers and allowing them to take informed actions.

## 6.2. Discussion on survey results

Results of the survey substantiate the discussion about the need for a larger spread and awareness of earthquake related information, regardless of the primary spoken language. Despite low statistical relevance, results show that over twice as many English speakers come across earthquake-related media once a week, and that a higher percentage of Spanish-speaking respondents either never or rarely read earthquake-related media compared to their English-speaking counterparts. Particularly, the analysis highlights that those who do not feel adequately informed tend to not discuss seismic related information with their family members. This outcome can also be positively viewed, as uninformed individuals may otherwise unintentionally share inaccurate information, which could worsen the situation.

The correlation between speaking Spanish and having a family member who exclusively speaks Spanish is also examined to explore potential barriers in risk communication within bilingual or non-English-speaking households. Being able to speak Spanish does not necessarily mean that individuals do not understand English; however, if some family members only speak Spanish, they may rely on others in the household for information. Understanding this dynamic is crucial for assessing how risk messages are received and disseminated within these communities and for improving the accessibility and effectiveness of earthquake communication strategies for Spanish-speaking populations.

As for the perceived role of media in earthquake communication, the statistical correlation observed between survey respondents' perception of earthquake risk information and the perceived role of media in raising seismic risk awareness hints at a potential positive effect of media communication, see Tables A4 and A5. Survey respondents also indicated their preferred media channels for receiving emergency information, providing valuable insights for future studies on effective communication strategies during earthquakes. However, it is noted that with the rise of social media alternative platforms for risk communication need to be explored with particular attention to misinformation and the spread of rumors [44,72,73].

When talking about earthquake risk perception, it is important to collect background information about previous earthquake experiences. In fact, it is suggested in the literature that experiencing an event may affect not only the perception of probability of recurrence [3], but also the behavior and psychological distance to the event [49–51]. The results show that those who had not experienced past events expect lower levels of seismic damage and disruption, and more than 70 % of those who feel prepared for an earthquake have experienced a previous event. However, the analysis of the survey data does not show a significant statistical relevance that would highlight psychological distance from earthquake events, in line with [50].

## 6.3. Limitations

This study presents some limitations discussed in this section. In the context of this study, the decision to focus on four media outlets

was based on their prominence in the region and their ability to provide a representative sample of media coverage. However, it is acknowledged that this selection may limit the scope of the analysis and introduce some bias. Future studies could benefit from incorporating additional media types, such as social media, to provide a more comprehensive understanding of public risk perception. Regarding the survey, the amount of responses collected may hinder the statistical relevance of the analysis of the data. In addition, the self-selecting nature of the survey may potentially skew the results, as respondents may have a pre-existing interest in earthquake preparedness. The relationship between primary spoken language and media information can thus only be inferred with an overall medium statistical confidence. Nevertheless, these results provide important perspectives on the perceived role of media and the level of seismic preparedness of communities in San Diego. It is also noted that the survey provides limited information on whether the respondents know the difference between hazard and risk, a key issue in building communities coping capacity. When risk is transformed into hazard (often times with the help of the media), the crucial element of decision making that makes risk a voluntary condition goes missing, compromising what can be achieved through action. Further surveys could explore this in more detail with direct questioning.

Although this study focuses on bilingual communities in the San Diego border region, its findings have significant potential to contribute to global risk reduction strategies. The proposed methodology is broadly applicable and can be adapted to systems that currently fail to incorporate financial, demographic, and social factors into their disaster preparedness plans.

## 7. Concluding remarks

This study examined earthquake-related media coverage in San Diego, assessing its frequency and role in informing local communities. The relevance of earthquake-media in providing useful information to local communities was assessed through a survey aimed at gathering insight on the community's perception of risk and local earthquake awareness, with a focus on language minorities to address equity in risk communication. The 141 survey respondents included one-third Spanish speakers.

Results of the media analysis revealed a significant disparity, with Spanish-language coverage at just one-quarter of its English counterpart, leaving Spanish-speaking communities less informed. This gap is reflected in survey findings, where 85 % of Spanish speakers reported rarely receiving earthquake-related information, while English speakers were twice as likely to encounter it weekly. In addition, despite an annual average of 52 published articles, 60 % of respondents feel uninformed about earthquake risks. Limited access to information and a lack of perceived threat may contribute to this outcome, added to the absence of engaging storytelling in most of the analyzed media articles. A more balanced approach combining facts with compelling narratives could improve seismic awareness.

Though based on a limited sample, this study underscores the need for more inclusive risk communication strategies to enhance disaster resilience. By addressing the specific needs of minorities (including individuals with diverse access requirements, those facing financial constraints, limited social connections, or reduced capacity and support) the proposed approach and the results of this study can be used to promote equity in risk communication and support more inclusive and effective disaster planning in different geographic settings.

## CRedit authorship contribution statement

**Gloria Faraone:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Formal analysis, Conceptualization. **María Olga Pérez Arroyo:** Supervision, Methodology, Conceptualization. **Phillip Scott:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Alyssa Yearick:** Writing – original draft, Visualization, Validation, Investigation, Formal analysis, Data curation.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix. additional statistical analysis of the results of the survey

Additional cross tables comparing various survey variables are included in this Appendix to enhance readability and further support the study's findings presented in the main body of the paper. When relevant, the results of the statistical analysis are presented in terms of p value and effect size Cramer's V coefficient in the following.

**Table A1** shows medium-high statistical significance of the responses to the survey questions: "In your opinion, what is the earthquake risk in our community?" and "How do you think an earthquake would impact infrastructure, buildings, and utilities in our community?". The statistical analysis of this data shows a p-value of 0.00315 and a Cramer's V size-effect coefficient of 0.303.

**Table A1**

Cross table relating the perceived earthquake risk in the community to the perceived earthquake disruption in the community.

Perceived earthquake disruption in the community	Perceived earthquake risk in the community				
	Very high	High	Medium	Low	None
<b>Significant</b>	50.0 %	23.7 %	12.5 %	11.4 %	0.0 %
<b>Medium</b>	50.0 %	63.2 %	56.3 %	31.4 %	0.0 %
<b>Minimum</b>	0.0 %	13.2 %	31.3 %	57.1 %	100.0 %

Tables A2 and A3 relate the experience of a past earthquake to the perception of risk and disruption, respectively. Table A2 relates the survey questions: “Have you experienced any previous earthquake in our area?” and “In your opinion, what is the earthquake risk in our community?”. Table A3 relates the survey questions: “Have you experienced any previous earthquake in our area?” and “How do you think an earthquake would impact infrastructure, buildings, and utilities in our community?”. These tables show that the statistical significance of these results is not sufficient to draw solid conclusions on the relation between previous experience and perceived risk and damage.

**Table A2**

Cross tables relating the experience of a previous earthquake with the perceived earthquake risk in the community.

Experienced an earthquake	Perceived earthquake risk in the community				
	Very high	High	Medium	Low	None
<b>Yes</b>	100.0 %	76.3 %	72.9 %	71.4 %	0.0 %
<b>No</b>	0.0 %	23.7 %	27.1 %	28.6 %	100.0 %

**Table A3**

Cross tables relating the experience of a previous earthquake with the perceived earthquake disruption in the community.

Experienced an earthquake	Perceived earthquake disruption in the community		
	Significant	Medium	Low
<b>Yes</b>	71.4 %	73.4 %	75.6 %
<b>No</b>	28.6 %	26.6 %	24.4 %

Table A4 statistically relates the survey questions: “In your opinion, how effective is the media in providing timely and accurate information about earthquakes?” and “Do you believe media has played a significant role in increasing public awareness and preparedness for earthquakes?” The data presented here shows statistical significance with a p-value of 0.00106 and an effect size Cramer’s V coefficient of 0.375.

**Table A4**

Cross table relating the perceived media effectiveness in providing timely information about earthquakes to the perceived role media played in increasing seismic risk awareness and preparedness.

Media effectiveness in providing timely information about earthquakes	Media increases seismic risk awareness and preparedness	
	Yes	No
<b>Very effective</b>	20.0 %	2.0 %
<b>Somewhat effective</b>	40.0 %	24.0 %
<b>Neutral</b>	26.2 %	42.0 %
<b>Somewhat ineffective</b>	13.8 %	32.0 %

Table A5 statistically relates the survey questions: “Do you overall feel adequately informed about the earthquake risks specific to our area?” and “In your opinion, how effective is the media in providing timely and accurate information about earthquakes?” The data presented shows statistical significance with a p value of 0.00106 and a Cramer’s V effect size of 0.375.

**Table A5**

Cross table relating the media effectiveness in providing timely information and the respondents’ sense of being adequately informed about earthquake risk.

Feels adequately informed about earthquake risk	Media effectiveness in providing timely information about earthquakes			
	Very effective	Somewhat effective	Neutral	Somewhat ineffective
<b>Yes</b>	71.4 %	50.0 %	23.7 %	30.8 %
<b>No</b>	28.6 %	50.0 %	76.3 %	69.2 %

## Data availability

Data will be made available on request.

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