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ORIGINAL PAPER

Socio-demographic determinants of earthquake risk perception: the case of the Corinthiakos Gulf, in Greece

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Abstract
Risk perception has been widely recognized as an essential factor in shaping attitudes and behaviors of individuals and communities proactively, during and after the experience of extreme catastrophic events. Its importance derives out mostly due to its intrinsic relationship with socioeconomic parameters and capacity building of communities affected by such events. The aim of this paper was to elaborate on the demographic and socioeconomic determinants of earthquake risk perception of populations living in an extremely earthquake-prone environment. For this purpose, a population sample of municipalities in the Corinthiakos Gulf in Central West Greece was examined. The sample (230 men and 276 women) was randomly selected from three coastal municipalities of the Gulf: Aigialeia, Nafpaktia and Corinthos. Multi-adjusted linear regression analysis was performed to reveal the determinants of the participants' perceptions regarding earthquake risk. Findings revealed that mean earthquake risk perception score was moderate in both men and women and notably lower for the participants living in the municipality of Nafpaktia, as compared to the participants of the other two study areas. Earthquake risk perception varied significantly according to age, sex, income and building construction period (of assets resided or used by the participants). Younger strata, especially young men, and households of lower-income status tend to correlate to lower earthquake risk perception. Moreover, individuals living in newly constructed buildings presented lower earthquake risk perception levels. Also, increased individuals' earthquake safety information provided by state agencies and local civil protection authorities was associated with increased risk perception. Issues like education, household structure, building earthquake insurance, savings and trust in civil protection authorities were not associated with risk perception. From a policy design point of view, such findings provide noteworthy insights for local communities and civil protection authorities allowing to identify vulnerable population groups and to provide noteworthy insights to design targeted measures and policies in the making of a safe and resilient environment.

Keywords Earthquake risk · Risk perception · Disasters · Corinthiakos Gulf · Greece

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1 Introduction

As it has been extensively revealed, it is evident that the extent of losses and damages due to natural disasters depends not only on the physical features of the hazard per se (i.e., intensity, duration, scale), but also on the local community capacities to respond, cope with and adapt to disastrous events (Wisner et al 2004; Thomalla et al. 2006). These capacities are closely related to perceptions and attitudes of individuals toward the risk that they are confronted with (Slovic 1987). In this respect, risk perception is defined as the subjective judgment that individuals of a community make about the characteristics and severity of a potential threat (Slovic 1992, 1999; IPCC, 2018). Risk perception as such directly influences human behavior actions before, during and after an event (Dominey-Howes and Minos-Minopoulos 2004). Flawed and/or limited risk perception—driving individual (or collective) behaviors and decisions—has been associated with increased losses and disastrous effects caused by catastrophic events (Sniedovich and Davis 1977). Nonetheless, increased risk perception (among others) allows for better integration of preventive strategies to local communities, enabling, thus, effectively communicating risk information, setting safety policy and formulating appropriate and operative emergency-contingency plans (Lave and Lave 1991; Slovic et al. 1982).

Risk perception studies have revealed a variety of determinants that influence (positively or negatively) individuals' behaviors and attitudes. The most often employed determinants fall within the following interlinked categories: psychometric, demographic, and socioeconomic. Regarding psychometric determinants, studies have focused more on risk awareness (Kellens et al. 2011; Armas¸ and Avram, 2009), perceived likelihood of a future devastating event (Lindell and Whitney 2000), the affect (Kung and Chen 2012; Tian et al. 2014) and perceived consequences (Rustemli and Karanci 1999; Lindell and Perry 2000). In the context of demographic and socioeconomic studies, the most recurrently elaborated risk perception determinants have been age, sex and education (Armas 2006, 2008; Lindell et al. 2009; Tekeli-Yeşil et al. 2011; Beck et al. 2012; Kung and Chen 2012; Tian et al. 2014; Bronfman et al. 2016; Fernandez et al. 2018; Qureshi et al. 2021), income levels (Slovic 2000; Paton et al. 2003; Tian et al. 2014; Lo and Cheung 2015), household structure (Lindell et al. 2009, 2016; Tekeli-Yeşil et al. 2011; Xue et al. 2021; Qureshi et al. 2021), employment status (Mileti and Darlington 1997) and building quality characteristics (e.g., construction period, land ownership patterns) (Lindell and Whitney 2000; Armas 2006; Eraybar et al. 2010; Tekeli-Yeşil et al. 2011; Tian et al. 2014). The literature has, also, identified previous disaster experience (Burningham et al. 2008), trust (especially regarding state governance and civil protection authorities) (Slovic 1987; Bronfman et al. 2016), savings (Dwyer et al. 2004), insurance coverage (Kunreuther et al. 1978; Palm et al. 1990; Mulilis et al. 1990; Dwyer et al. 2004; Athavale and Avila 2011; Xu et al. 2019), risk knowledge/information (Mileti and Fitzpatrick 1992; Lindell et al. 2016; Tekeli-Yeşil, et al. 2011) and cultural differences in values and worldviews (Siegrist and Árvai 2020) as much influential determinants of risk perception.

Despite the growing number of studies in the international literature regarding risk perception of natural hazards, in the case of Greece, interest on the matter has been limited; this is rather peculiar, since we are dealing with a country that it has been highly vulnerable to disasters and one could expect a far more accentuated concern on the matter (Diakakis et al. 2021). More specifically, Greece has experienced historically numerous catastrophic events whether of natural, man-made or Natech nature. In particular, regarding earthquakes are classified as one of the most earthquake-prone countries in Europe (Makropoulos et al. 2012).

In this respect, most studies in Greece have been concentrating on the issue of earthquake vulnerability and resilience, denoting a strong theoretical and policy interest (Sarris et al. 2010; Karababa and Pomonis 2011; Giannaraki et al. 2019; Pnevmatikos et al. 2020; Coccossis et al. 2021). As stated already, however, risk perception studies are rather limited and disjointed. Related research on individuals' risk perception has been carried out mainly in volcanic risk areas (Dominey-Howes and Minos-Minopoulos 2004), flood risk areas (Papagiannaki et al. 2017; Diakakis et al. 2018), climate-related hazards (Kontogianni 2013; Diakakis et al. 2021) and multi-hazards environments (Karanikola et al. 2014, 2015; Katsigianni 2018; Papagiannaki et al. 2019). In this respect, the present work could be seen as a contribution in the study of risk perception in Greece and to further expand the much-needed debate.

Having said all these, the aim of this paper is to elaborate on the earthquake risk perception of populations in an exceptionally seismic-prone area in Greece: the Corinthiakos Gulf. The approach is based on elaboration of determinants deriving from two major interlinked categories, namely demographic and socioeconomic. In order to comprehensively evaluate earthquake risk perception based on the aforementioned categories, a latent variable called "earthquake risk perception" was introduced and composed by four psychometric elements, namely (a) risk awareness, (b) perceived worry, (c) perceived likelihood of a devastating event and (d) perceived potential of devastating consequences by a high-magnitude earthquake (> 6 Richter scale, which is considered an empirical threshold that is associated with significant consequences in human health and material damages). Evidently, knowledge provided through this proposed methodology on earthquake risk perception and its determinants could act as an innovative impetus for local communities and civil protection authorities, allowing to identify vulnerable population groups and to provide noteworthy insights to design targeted measures and policies in the making of a safe and resilient environment.

2 The case study area

The Corinthiakos Gulf in central west Greece, which is the key area of study (Fig. 1), is situated between the western edge of North Anatolian fault in the northern Aegean Sea and the subducting East Mediterranean lithosphere, and it is one of the most seismically active regions in Greece and the world (McKenzie 1972). In the long earthquake history of the Gulf,[1] several seismic events have caused the destruction of many cities and villages, severe damages and human losses with the 1995 Aigion earthquake (Ms = 6.2R) in the municipality of Aigialeia be the last intense seismic event that led to the loss of

[1] 1700–2022—earthquakes with Ms ≥ 6R: Nafpaktos (1703: 6.1R, 1714: 6.3R, 1756: 6.8R, 1769: 6.8R, 1909: 6.2R, 1917: 6.0R), Aigion (1748: 6.6R, 1817: 6.6R, 1888: 6.3R, 1995: 6.2R), Corinthos (1858: 6R, 1861: 7.5R, 1928: 6.3R, 1962: 6.8R) Xylokastro (1742: 6.0R, 1753: 6.2R, 1887: 6.5R), Galaxidi (1794: 6.7R, 1965: 6.2R, 1972: 6.3R), Patra (1785: 6.4R, 1804: 6.6R, 1806: 6.2R), Nemea (1876: 6.1R), Arachova (1870: 6.8R) Sofiko (1930: 6.0R), Itea (1970: 6.2R), Eratini (1965: 6.4R), Islands of Alkyonides (1981: 6.7R, 6.4R and 6.3R), Andravida (2008: 6.5R) (Organization for Earthquake Planning and Protection, 2022).

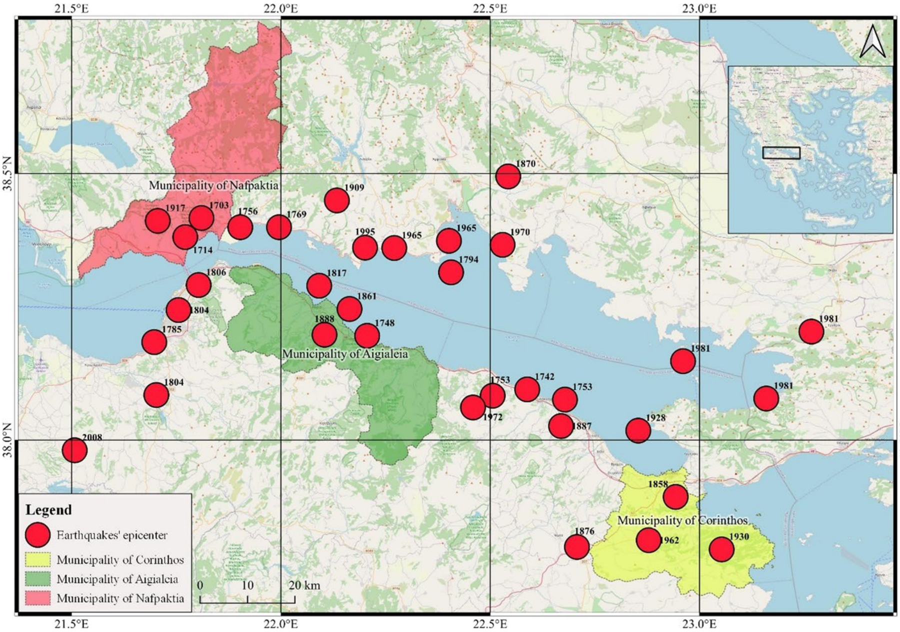

Fig. 1 Map of study areas in Corinthiakos Gulf (Municipality of Corinthos, Municipality of Aigialeia and Municipality of Nafpaktia) and earthquakes epicenters with Ms ≥ 6R (1700–2022) (Earthquake Planning and Protection Organization 2022)

26 people and resulted in major damages on buildings and infrastructures (Bernard et al. 1997) (Fig. 1). Moreover, the morphological and topographical structure of the Corinthiakos Gulf—composed by a hilly-mountain hinterland and plain costal zones—has shaped a linear urban development pattern that past decades, extending along its coastlines. The area is composed by fifteen (15) municipalities, and this study predominately focuses on three (3) of them: Municipality of Corinthos, Municipality of Aigialeia and Municipality of Nafpaktia. Thus, the selection of these three municipalities under study has to do primarily to their earthquake history and seismicity, as well as the variety of demographic and socioeconomic characteristics of the referent population (Mesimeri et al. 2018; Kaviris et al. 2021). The selected municipalities could be characterized as small medium-sized towns exhibiting presenting dynamic population growth trends, sharing a relatively comparable population size and surface area (the population size of the selected municipalities vary between 30.000 and 50.000 inhabitants, while surface area on average 700km^2) and experiencing rather similar socioeconomic developmental patterns (agriculture, commerce, maritime industries and tourism).

3 Methodology

3.1 Design

A population-based survey was conducted in the Corinthiakos Gulf, Greece, and specifically, in the municipalities of Aigialeia, Nafpaktia and Corinthos. The field investigation was taken place during March 2022; the questionnaire used in the survey was distributed and filled-in by face-to-face interviews.

3.2 Sample

A feasibility sampling procedure was applied in the study areas, targeting all-age adult population and according to age-sex distribution (in concordance to the latest Greek census—2011).[2] Participants in the survey were situated in public areas, workplaces and housing places. The sample consists of 506 adults, aged ≥ 18 years; of them, $n=230$ were men (46 ± 13 years, 18–76 years) and $n=276$ were women (41 ± 13 years, 18–87 years). All participants were voluntarily enrolled in the survey and provided their consent, prior to the interview.

3.3 Measurements

A semi-quantitative questionnaire was designed for the purposes of the study. The questionnaire was based on validated approaches that extensively been presented in the literature (Tversky and Kahneman 1973; 1974; Fischhoff et al. 1978; Slovic 1987; Sjöberg 2000; Slovic et al. 2004) regarding determinants influencing risk perception. It was divided into two sections: (a) assessment of individuals' earthquake risk perception and (b) determinants of earthquake risk perception, including demographic and socioeconomic determinants.

3.3.1 Assessment of earthquake risk perception

Based on the various approaches mentioned above, earthquake risk perception was evaluated through four psychometric elements such as (a) risk awareness, (b) perceived worry, (c) perceived likelihood of a devastating event and (d) perceived potential of devastating consequences by a high-magnitude earthquake (>6 Richter scale, Makropoulos et al. 2012). Risk awareness was prompted by the question "How risky you rate your area regarding earthquakes?" and perceived worry was measured through the question "How much you worry about an earthquake event in your area?". Regarding perceived likelihood, it was gauged by the question "How likely is your area to experience a devastated earthquake in the next 10 years?". Finally, perceived potential of devastating consequences by a high-magnitude earthquake was evaluated by the respondents' assessment of the statement "An earthquake of more than 6 Richter scale magnitude will cause major damages to me, my family and my property and will disrupt my daily activities." All psychometric elements were registered in a 5-point Likert-type scale, with options ranging from "Not at All" to "Extremely," and scored from 0 to 4. In order to comprehensively evaluate the determinants of earthquake risk perception, a latent variable, *earthquake risk perception,* was constructed composed by the four aforementioned psychometric elements (involving a theoretical range 0–16); tertiles of the *earthquake risk perception* were also calculated.

[2] The Greek population census is held regularly every 10 years by the Hellenic Statistical Authority (ELSTAT). In Greece, the available population census, at the time this study was conducted, was the 2011 census. Official results of the 2021 census for permanent population were published on March 17, 2023, while the comprehensive results of the census will be available by March 31, 2024.

3.3.2 Determinants of earthquake risk perception

Regarding the demographic and socioeconomic characteristics of the participants, age (in years), sex (men/women), educational level, household structure, mean annual household income (of the past three years) and savings, as well as information from—and trust in—civil protection authorities, were recorded. Concerning participants' houses, the construction period and potential insurance for natural disasters (noninsured, insured and insured due to mortgage protection) were recorded.

Education levels were evaluated according to the following six categories: (a) no formal education (no primary school education), (b) primary education (6 years), (c) secondary education (12 years), (d) vocational education and (e) higher education (under or graduate degree level education). Concerning the evaluation of household structure, participants were classified in relation to: (a) single-person households (unmarried, widowed, divorced or separated), (b) single-parent households headed by father or mother, (c) households of couples without children and (d) households of couples with children (one child, two children or more). Mean household annual income was categorized into four groups such as (a) less than 10.000€, (b) between 10.000 and 20.000€, (c) between 20.000 and 40.000€ and (d) more than 40.000€, in compliance to the Hellenic Ministry of Finance income tax classification standards. Savings were evaluated by the question "To what extent do you save money?", and it was registered in a 5-point Likert-type scale with options ranging from "Not at All" to "Extremely."

Participants' level of information regarding earthquake safety[3] and trust to civil protection authorities was evaluated with the adoption of the 5-point Likert-type scale, with options ranging from "Not at All" to "Extremely." Building construction period was recorded according to the following classification: building constructed (1) before 1960, (2) between 1961 and 1985, (3) 1986–1995, (4) 1996–2000 and (5) after 2000. The selected time intervals were based on the periods of enforcement of the different historical Greek Seismic Codes.[4]

3.4 Statistical analysis

Mean values and their corresponding standard deviations, as well as frequencies (and relative frequencies), were used to present the quantitative and categorical characteristics, respectively. Student's *t* test and analysis of variance were used to evaluate associations between normally distributed continuous variables and groups of participants; post hoc comparisons were adjusted using the Bonferroni rule. Pearson's chi-square test and *r* correlation coefficient was used to evaluate the relationships between continuous and categorical variables, respectively. Linear regression analyses were applied to reveal the determinants of the participants' attitudes and perceptions concerning the risk of an earthquake. Normality of the continuous variables distributions was tested using Q–Q plots; assumption of the linear regression (linearity, independency and homoscedasticity of the residuals) was

[3] Including participation in informational public events and knowledge of preparedness measures through brochures, media and communication platforms.

[4] In Greece, the first seismic code was enforced in 1959. In 1984, it was up gradated and supplemented with additional articles and began to be implemented in 1985. In 1995, a new seismic code was implemented (NEAK), while the most recent one, the so-called EAK-2000, with several modifications and clarifications came into force since 2001.

Table 1 Participants' Earthquake Risk Perception score (theoretical range 0–16) by sex and age group

Age group	Men	Women	*P-value*
N	230	276	
20–30	8.5 ± 3.6 (n = 33)*	11.7 ± 3.1 (n = 47)	0.001
30–65	11.6 ± 2.8 (n = 182)	12.1 ± 2.9 (n = 210)	0.111
65 +	10.9 ± 3.4 (n = 15)	10.5 ± 2.9 (n = 19)	0.685
P-value	< 0.001	0.08	
Total	11.7 ± 3.0	11.6 ± 3.0	0.601

*Significantly lower compared to all other age groups, p < *0.01*

Table 2 Participants' characteristics and attitudes in relation to Earthquake Risk Perception score tertiles

	First tertile	Second tertile	Third tertile	p-value
Earthquake Risk Perception score, mean (SD)	8.8 (2.2)	12.5 (0.5)	14.7 (0.8)	< 0.001
Demographic and Socioeconomic				
Age, mean (SD)	42 (14)	44 (11)	45 (12)	0.151
Sex, % men	50%	44%	40%	0.211
Education level, % none/primary or secondary	39%	50%	47%	0.186
Income, % < *10.000€*	21%	28%	32%	0.003
Savings, *% Not at all or slightly*	40%	43%	58%	0.006
Building earthquake insurance, *% Noninsured*	75%	82%	75%	0.470
Building construction period, *%Before1985*	31%	45%	46%	0.015
Attitudes against local authorities				
Trust, *% Not at all or slightly*	56%	56%	61%	0.449
Information, % No	31%	27%	31%	0.134

evaluated using correlograms of the standardized residuals vs. fitted values. All *p*-values (probability of type-I error) were derived from two-sided hypotheses testing. STATA statistical software, v. 15.0, was used for all statistical calculations (College Station, TX, USA).

4 Results

4.1 Earthquake risk perception of the participants

Participants' perceived earthquake risk by age group and sex is presented in Table 1. Overall, the mean risk perception score was moderate in both men and women (i.e., 11.7 and 11.6/16); men at the age group 20–30 years old presented significantly lower earthquake perception score (i.e., 8.5/16 ± 3.6) compared to all other age and sex groups.

Region-specific analysis revealed that mean earthquake risk perception score of participants living in municipality of Nafpaktia was notably lower (9.5/16 ± 3.2), compared to the participants of the other coastal municipalities in the Corinthiakos Gulf (municipality of Corinthos: 12.5 ± 2.5, municipality of Aigialeia: 12.4 ± 2.3, $p < 0.001$).

In Table 2, participants' demographic socioeconomic characteristics and attitudes in relation to Earthquake Risk Perception score tertiles are presented.

As it can be seen in Table 2, participants with lower income, low reported tendency for savings and those living in buildings constructed before 1985 reported higher earthquake risk perception. Additional analyses revealed that previous disaster experience was not significantly associated with earthquake's risk perception ($p=0.772$), mainly because the occurrence of the major catastrophic experiences took place long ago, in 1995 and 1981.

4.2 Determinants of earthquake risk perception

Despite the aforementioned findings, however, residual confounding may exist and mask the true determinants of earthquake risk perception. Thus, to further evaluate the demographic and socioeconomic determinants of earthquake risk perception, a multi-adjusted data analysis was performed (Table 3). Six nested models were estimated, starting from the core *model 1* that was only age, sex adjusted and progressively adjusting potential determinants of earthquake risk perception.

As it can be seen, *model 1* (that included only age and sex) revealed that age was significantly positively associated with earthquake risk perception ($p=0.007$), whereas men had lower risk perception score as compared to women ($p=0.004$), after adjusting for age (Table 3). When education and household structure were added as confounders in the *model 1*, age was still significantly positively associated with earthquake risk perception ($p=0.0012$) with men exhibiting a lower age-adjusted risk perception score as compared to women ($p=0.006$). The positive association with age and men sex remained significant even after household incomes and savings were added (*model 3*, Table 3). However, when trust and earthquake safety information were taken into account, age did not appear to be strongly associated with risk perception of the participants, whereas individuals' information and knowledge regarding earthquakes was notably positive associated with earthquake risk perception ($p<0.01$) (*model 6*, Table 3).

Regarding the other socio-demographic determinants, the lower-middle-income group (10.000–20.000€) was significantly negatively associated to earthquake risk perception as compared to the lowest, as well as the higher ($p=0.003$)-income group. Overall, households with higher-income status had lower earthquake risk perception as compared to those with a low-level income (Table 2). Moreover, savings, education and household structure were not notably associated with earthquake risk perception (p-values >0.05).

Regarding the participants' houses and specifically the building construction period *(model 4)*, earthquake perception score of the participants was negatively associated with those living in post-1996 constructions ($p<0.10$). Finally, building earthquake insurance was not significantly associated with earthquake risk perception.

5 Discussion and conclusions

This study has aimed to contribute to the growing field of research in risk perception of earthquake disasters, by providing evidence on the determinants of risk perception, revealing critical knowledge with respect to vulnerable population groups, in order to strengthen civil protection earthquake policies in one of the most earthquake-prone areas in Europe: The Corinthiakos Gulf in Greece.

The present study revealed that population living in Corinthiakos Gulf presented moderate earthquake risk perception levels, not compatible to the seismicity and disaster experience of the localities. The analysis of the empirical study data revealed that

Table 3 Results (b-coefficient (Standard Error), *p*-value) from nested linear regression models that evaluated determinants of earthquake risk perception of individuals living in a vulnerable area, in Greece ($N=506$)

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Age (per 1 year)	0.02 (0.01); 0.007	0.02 (0.01); 0.0012	0.02 (0.01); 0.029	0.02 (0.01); 0.088	0.02 (0.01); 0.096	0.01 (0.01); 0.110
Sex (men vs. women)	− 0.78 (0.27); 0.004	− 0.74 (0.27); 0.006	− 0.85 (0.28); 0.003	− 0.88 (0.28); 0.002	− 0.89 (0.28); 0.002	− 0.85 (0.28); 0.003
Education level						
Primary, None	–	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
Secondary / Technical	–	1.61 (1.15); 0.163	1.64 (1.17); 0.161	1.84 (1.16); 0.113	1.73 (1.17); 0.140	1.71 (1.16); 0.144
University	–	1.25 (1.15); 0.281	1.30 (1.17); 0.270	1.55 (1.16); 0.185	1.41 (1.18); 0.235	1.34 (1.18); 0.255
Household Structure						
Single-person	–	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
Single-parent	–	1.08 (0.68); 0.115	1.16 (0.71); 0.105	1.15 (0.70); 0.104	1.23 (0.71); 0.084	1.08 (0.71); 0.129
Without children	–	− 0.22 (0.42); 0.604	− 0.20 (0.46); 0.663	− 0.06 (0.46); 0.883	− 0.10 (0.46); 0.815	− 0.13 (0.46); 0.777
With children	–	0.27 (0.30); 0.378	0.25 (0.34); 0.464	0.38 (0.34); 0.273	0.31 (0.35); 0.377	0.31 (0.35); 0.370
Income						
< 10.000€	–	–	*Ref*	*Ref*	*Ref*	*Ref*
10.000–20.000€	–	–	− 1.09 (0.36); 0.003	− 1.05 (0.36); 0.004	− 1.04 (0.36); 0.005	− 1.10 (0.36); 0.003
20.000–40.000€	–	–	0.14 (0.45); 0.755	0.28 (0.45); 0.538	0.37 (0.46); 0.428	0.23 (0.46); 0.614
> 40.000€	–	–	− 1.18 (0.76); 0.120	− 1.18 (0.75); 0.117	− 1.16 (0.75); 0.126	− 1.28 (0.75); 0.091
Savings	–	–				
Not at all	–	–	*Ref*	*Ref*	*Ref*	*Ref*
Slightly	–	–	0.01 (0.45); 0.991	− 0.04 (0.45); 0.927	0.01 (0.46); 0.984	− 0.09 (0,46); 0.837
Somewhat	–	–	− 0.45 (0.45); 0.319	− 0.45 (0.45); 0.538	− 0.37 (0.46); 0.414	− 0.47 (0.45); 0.299
Moderately	–	–	− 0.42 (0.53); 0.426	− 0.42 (0.53); 0.433	− 0.37 (0.53); 0.489	− 0.48 (0.53); 0.371

Table 3 (continued)

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Extremely	–	–	0.76 (1.03); 0.462	0.54 (1.02); 0.595	0.67 (1.03); 0.516	0.50 (1.03); 0.627
Building Earthquake Insurance						
Noninsured	–	–	–	*Ref*	*Ref*	*Ref*
Insured	–	–	–	0.36 (0.44); 0.412	0.35 (0.45); 0.426	0.27 (0.44); 0.543
Insured due to mortgage protection	–	–	–	0.02 (0.47); 0.953	0.04 (0.47); 0.932	− 0.02 (0.47); 0.953
Building Construction period						
Before 1960	–	–	–	*Ref*	*Ref*	*Ref*
1961–1985	–	–	–	− 0.15 (0.55); 0.780	− 0.13 (0.56); 0.810	− 0.13 (0.55); 0.815
1986–1995	–	–	–	− 0.96 (0.59); 0.105	− 0.95 (0.60); 0.114	− 0.95 (0.60); 0.111
1996–2000	–	–	–	− 1.10 (0.60); 0.070	− 1.09 (0.61); 0.072	− 1.03 (0.60); 0.088
After 2000	–	–	–	− 1.59 (0.58); 0.007	− 1.60 (0.59); 0.007	− 1.49 (0.58); 0.012
Trust						
Not at all	–	–	–	–	*Ref*	*Ref*
Slightly	–	–	–	–	− 0.46 (0.36); 0.209	-0.52 (0.36); 0.154
Somewhat	–	–	–	–	− 0.18 (0.38); 0.636	− 0.26 (0.37); 0.485
Moderately	–	–	–	–	0.12 (0.47); 0.787	− 0.10 (0.47); 0.982
Extremely	–	–	–	–	− 1.45 (1.40); 0.300	− 1.27 (1.39); 0.362
Information (Yes/No)	–	–	–	–	–	0.72 (0.30); 0.017

previous disaster experience was not associated with earthquake's risk perception, potentially because the occurrence of the major catastrophic experiences took place long ago, in 1995 and 1981. Even more, inhabitants in the municipality of Nafpaktia (a highly seismic area) reported, notably, the lowest score of the entire study area. This may well be explained by the fact that the Nafpaktia community did not experience any recent major catastrophic earthquake. Contrary to Nafpaktia, in 1981, the municipality of Corinth experienced a devastating earthquake (Ms = 6.7R, 6.4R, 6.3R) causing great damages and human losses (Papazachos et al. 1984; Bernard et al. 1997). The same applies to the municipality of Aigialeia that in 1995 was also hit by a 6.2R catastrophic earthquake. However, the low earthquake risk perception in Nafpaktia still requires further study, taking into account the repeatedly recorded seismic events affecting this area during the last decade (Mesimeri et al. 2018; Kaviris et al. 2021).

Regarding the demographic and socioeconomic determinants of earthquake risk perception, the study revealed that older participants had higher earthquake risk perception attitudes, irrespective of their sex, education, and economic status, whereas younger people lack risk perception, and this was more evident among younger men. Moreover, stratified analysis by income revealed that higher household income status was associated with reduced earthquake risk perception. Furthermore, inhabitants living in newly constructed buildings tend to present a lower earthquake risk perception status. Additionally, the study indicated that participants' education level, household structure, savings and trust in civil protection authorities along with building's insurance for earthquakes were not significantly associated with earthquake risk perception. Finally, safety information-knowledge of individuals had a positive correlation with earthquake risk perception, irrespective of the age, sex, education, household structure, economic status and trust in civil protection authorities. The presented findings highlight a profile of an individual in Greece with moderate-to-low earthquake risk perception and define a set of people at high risk of facing the harmful consequences of future earthquakes.

Evidence from recent studies on socio-demographic determinants of earthquake risk perception shows important linkages with the results of this study. Specifically, in terms of age, the high earthquake risk perception among older people that observed here is in line with the results of other studies too (Beck et al. 2012; Tian et al. 2014; Bronfman et al. 2016). This can be explained by the fact that older people living in highly risky areas, like the Corinthiakos Gulf, have already experienced significant damages and losses and survived several earthquakes in the recent period. These people may feel more exposed and threatened than the younger participants, which consequently may have resulted in the high risk perception of earthquakes.

Sex has traditionally been regarded as an important demographic determinant of earthquake risk perception. Results from the present study revealed that men were significantly associated with lower risk perception. This result is in accordance with the outcomes of similar studies (Kung and Chen 2012; Tian et al. 2014; Bronfman et al. 2016; Fernandez et al. 2018). Davidson and Freudenburg (1996) explained this sex difference in risk perception through social roles and everyday activities. Women perform more the role of nurturer and care provider, which is associated with concern about health and safety issues, and consequently about risks. Another explanation was provided by Fynn et al. (1994), who concluded that sex differences in risk perception may relate to sociopolitical factors, such as unequal power relations and different level of trust in authorities and institutions. According to the *European Forum for Disaster Risk Reduction Roadmap 2021–2030* (EFDRR 2021), one of the main enabling approaches for achieving the priorities of the Sendai Framework for Disaster Risk Reduction

2015–2030 is an all-of-society inclusive approach which would support and engage at-risk groups in strategic planning. In particular, it is highly recommended to strengthen sex-responsive and age-sensitive policies, strategies and frameworks at all levels promoting the engagement of different socioeconomic parts of society and a shared understanding of risk. Furthermore, the European Consensus on Humanitarian aid, which was signed by the Council, the European Parliament, and the European Commission in 2007, highlights that natural hazards or human-induced crises are not sex and age neutral and stresses the need to integrate sex and age considerations in policy design. Thus, civil protection authorities should design sex- and age-oriented policies and customized measures to the specific population groups revealed in the study.

During the past years, several researchers have also demonstrated that individuals' earthquake risk perception can be influenced by their income status. Results of the present study revealed that risk perception was negatively associated with income. Households with higher income status had lower earthquake risk perception as compared to those with a low-level income. Similar results have been reported by other researchers, such as Slovic (2000), Tian et al. (2014), Lo and Cheung (2015). One possible explanation is that individuals with higher income have the resources' capacity to cope with the damages a high-magnitude earthquake can cause and, hence, may have a (false) sense of security, feeling a higher degree of control over earthquakes and that their lives are less threatened.

Contrary to previous findings which have highlighted that low education (Armas 2006, 2008; Tian et al. 2014) and household structure, i.e., widowed/divorced (Xue et al. 2021), are significant determinants of earthquake risk perception, the present study did not reveal such association. The same finding regarding both education and household structure holds for similar analyses made by Qureshi et al. (2021) and Tekeli-Yeşil et al. (2011). An explanation that could be given is that the sense of security that capture risk perception is not provided via formal education, in Greece, which is in fact true. There is a considerable lack of information about natural hazards and how to protect against them in school programs. In Greece, a policy implemented—for consecutive years—by the Earthquake Planning and Protection Organization (E.P.P.O.)-Civil Protection provides sporadic lectures regarding earthquakes in some, but not in all schools. Nonetheless, this form of education has not yet become an integral component in risk perception building and, in many respects, though highly useful, still highlights the need for school-based programs, modules and further improvements that will enhance risk perception of young people regarding earthquakes. The lack of association with household structure may be attributed to the fact that the percentage of singles, divorced or widowed participants was relatively low in our sample (i.e., 29%), making the analysis underpowered.

Moreover, the current study revealed that households living in relatively new buildings (i.e., constructed after 1996) have lower earthquake risk perception. The low perception of earthquake risk of households living in relatively new buildings has been also highlighted by Tian et al., (2014) and Eraybar et al., (2010), while other studies do not prove a statistically significant link between age of buildings and earthquake risk perception (Armas 2006; Tekeli-Yeşil et al. 2011). This finding can be explained by the fact that households' earthquake risk perception is confined by the decision to acquire new-safe building in compliance with the seismic codes, while at the same time, households may well exhibit reduced risk perception for dealing with potential damages and losses. Hence, through several media channels, local authorities should convey the message to their intended population strata that living in newly constructed buildings do not definitely ensure a high security from earthquakes' future damages and losses and capacity to cope and recover from such events.

Building earthquake insurance and trust[5] to the civil protection authorities has been considered by many (Dwyer et al. 2004; Athavale and Avila 2011; Xu et al. 2019) as key determinants of earthquake risk perception. The findings, however, of the current study did not reveal any association of them with risk perception. It is hard to provide a logical explanation for this finding; however, the low trust in the building insurance system in Greece, and the small number of buildings that are insured, may be some of the reasons that this factor was not associated with earthquake risk perception in the studied population.

An additional finding of the study has been the positive correlation observed between safety knowledge-information (provided to the inhabitants by the authorities) with risk perception. Safety knowledge-information has appeared to be exerting an all-embracing positive influence to the local population, irrespective of age, sex, education, household structure, economic status and trust in civil protection authorities. Evidence from previous studies confirms the linkage between risk perception and natural hazards' knowledge and engagement in risk management (Mileti and Fitzpatrick 1992; Tekeli-Yeşil, et al. 2011). Indeed, with the increasing number of disasters observed the past years in various countries, i.e., forest fires, floods, earthquakes and recent pandemics, whether natural or man-made catastrophes, greater information, understanding and cooperation seem to be essential to strengthen civil protection and risk management. Following the proposed recommendations of the *Third Meeting of the Civil Protection Directors-General* of the Union for the Mediterranean (held in Barcelona, February 2019), issues like "Volunteers in Civil Protection" and "Engaging citizens in disaster risk management" were further studied and discussed in detail, by the European Commission, Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO). Key conclusions of these studies were that to inform and engage citizens is a key component in natural disaster management. Citizens should be active actors in civil protection and usually are the first responders. Consequently, civil protection authorities of Corinthiakos Gulf should plan and develop activities designed to raise the awareness and prepare the population to prevent disaster and respond properly in case of an earthquake emergency. Social activities, like social media and volunteers, have an important role to increase risk perception and engage the citizens.

Taking into consideration also the aforementioned findings of the study regarding demographic and socioeconomic determinants of risk perception, civil protection authorities should focus on designing targeted communication and informational strategies providing tailored informational brochures and materials regarding earthquakes in Corinthiakos Gulf, in order to engage and motivate the revealed population groups with low earthquake risk perception taking steps and increasing their knowledge. Furthermore, key activities, such as informational events, preparedness discussions and drills, along with participatory design of earthquake management policies and communication strategies should also focus on these specific population groups so as to encourage their participation and engagement in disaster risk management.

The *Global Assessment Report (GAR) on Disaster Risk Reduction 2022* (UNDRR, 2022) argued that policymakers continue to undervalue the role of risk perceptions in shaping decision-making. A key recommendation of the report was that designing and reframing risk approaches to factor in how human minds make decisions about risk is a key action to accelerate risk reduction. Hence, civil protection authorities of Corinthiakos Gulf should

[5] The issue of trust in relation to risk perception studies requires far more systematic attention; see Han et al. (2022).

concentrate their actions in understanding individuals' earthquake risk perception and identifying their key determinants. The revealed determinants in this study can have practical implications for policymakers in the area, as they could serve as fruitful insights for improving earthquake policies and communication strategies and, by doing so, beneficially change behaviors and attitudes toward earthquakes.

5.1 Limitations

The sample of the present study was not national as it is a place-based study, and participants were recruited only from the area of Corinthiakos Gulf and, therefore, cannot represent the total Greek population living in urban regions. In addition, our sampling was not designed based on societal characteristics of the referent population (i.e., socioeconomic status, educational level, household structure, etc.) because of lack of such information, but it was only based on demographic characteristics (i.e., age, sex distribution of the studied referent population). Thus, representativeness of the studied sample regarding the aforementioned societal characteristics may be a concern.

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Declarations

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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