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# Anticipated behavioral response patterns to an earthquake: The role of personal and household characteristics, risk perception, previous experience and preparedness

Stav Shapira[a,b,*], Limor Aharonson-Daniel[a,b], Yaron Bar-Dayan[a,b]

[a] PREPARED Center for Emergency Response Research, Ben Gurion University of the Negev, PO Box 653, Beer Sheva, Israel
[b] Department of Emergency Medicine, Leon and Mathilde Recanati School for Community Health Professions, Faculty of Health Sciences, Ben Gurion University of the Negev, P.O. Box 653, Beer Sheva, Israel

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ABSTRACT

Earthquakes pose a serious threat to human health and well-being. The interaction between human-related factors such as choice of protective behavioral strategy, on one hand, and the built environment, on the other, may exacerbate or mitigate the aftermath of a given quake event. This study surveyed expected behavioral strategies among residents of a high vulnerability risk area in Israel and assessed factors that could influence their behavior. The results demonstrate that residents with low socioeconomic status are more vulnerable. Several personal and socioeconomic characteristics are associated with residents' expected behavior. Levels of earthquake preparedness and dwelling type are significant predictors of choice of a recommended behavioral strategy. The implications of these results and possible ways to improve preparedness are discussed.

## 1. Introduction

The strong earthquake that struck Nepal in April 2015 and claimed the lives of more than 9000 people was just the latest in a series of lethal events over the last decade demonstrating that earthquakes have been the single deadliest natural disaster worldwide [14]. However, independently of the character of the seismic event itself (e.g. its magnitude), these earthquakes seem to have had significantly different impacts in different parts of the world. Countries that implemented strict seismic building codes, strengthened existing structures and took measures to increase the population's preparedness tended to suffer less severe consequences than those that did not (usually developing countries). A recent example supporting this argument is provided by two earthquakes that took place in 2010 and were very similar in micro-seismic parameters, such as magnitude, depth, and distance of the epicenter from large population centers: the magnitude 7.0 New Zealand earthquake resulted in two injured individuals and no fatalities, while the Haiti earthquake (also magnitude 7.0) had a catastrophic aftermath – more than 300,000 fatalities and a similar number of injuries [64]. It is well documented that poor standards of building construction and damage to the built environment are the main causes of injury and death in earthquakes worldwide [27,28,43,45,48]. However, additional factors, such as personal and household characteristics, are recognized as potential contributors to vulnerability [11,56,58]. Population behavior is another such factor. However, the question of how to act during an earthquake is complex and the answers are inconclusive. Currently, there is no unified recommendation regarding appropriate behavior when an earthquake strikes. Two main but divergent behavioral strategies are recommended around the world to persons who find themselves inside buildings: a) shelter inside the structure, usually through "drop, cover and hold"; or b) evacuate the structure to an open area [16]. The reason for this divergence is related to differences in the vulnerability of structures to earthquake hazards (e.g. ground shaking) and in the threats they pose to their occupants. In regions where most of the building stock is seismically designed and can withstand earthquakes (usually in developed countries), the main hazard to occupants is from falling objects (e.g. furniture, electrical or mechanical components, etc.), which can cause injury and even death [40,52,57]; in such cases, the "drop, cover and hold" strategy is preferable since it provides protection from this hazard. However, where the building stock is of poor quality or not reinforced to meet seismic codes, the main threat to occupants is from collapse of the structure [24]. This is common in developing countries, but also characterizes old and historic buildings and neighborhoods in developed countries, and is unfortunately evident in countries where public sector and building industry corruption is widespread [13,3]. In such situations the

* Corresponding author at: The Department of Emergency Medicine, Recanati School for Community Health Professionals, Faculty of Health Sciences, Ben Gurion University of the Negev, P.O. Box 653, Beer Sheva 84105, Israel.
*E-mail address:* stavshap@post.bgu.ac.il (S. Shapira).

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prevailing recommendation is to evacuate immediately to avoid the dangers posed by structural damage, among them being trapped under rubble [4,22,53]. As noted above, currently there is no"one size fits all" recommendation regarding behavior during an earthquake, and the effectiveness of each strategy must be assessed individually by each country or state in light of the characteristics of the local built environment.

The State of Israel is located along the Dead Sea Fault, a locus of intensive seismic activity; over a span of two thousand years, hardly any city in the area has been spared the effects of tremors. The last major and devastating earthquake (Ms = 6.2) struck our region in 1927 - 90 years ago, causing extensive damage and hundreds of fatalities [5]. According to historical records the recurrence time for magnitude 6 earthquakes is ~100 years [18]. Thus, experts believe that strong quakes are certain to occur in the near future, placing the population at risk ([32] and references therein). Numerous studies demonstrated the expected seismic effects in various areas in Israel (i.e. ground shaking amplification, slope failure, and tsunami) that may cause substantial damage to infrastructure and property, and casualties ([32,33] and references therein). The outputs from these investigations were included in Israel's national emergency drills in 2012 [33], and 2017 [60] that were dedicated to manage the impacts of a severe earthquake. The danger is particularly acute because a large proportion of the structures in Israel are not properly earthquake resistant [44]. Therefore, the prime recommended behavior during an earthquake is to evacuate to an open area, or, if that is impossible (e.g. for residents of upper stories), to shelter inside the structure in the nearest staircase (staircases are considered seismically resistant if built post 1980, when a seismic construction code was applied in Israel) or in the apartment's bomb shelter [22].

Human behavior is difficult to predict at all times and even more so during emergencies, which are stressful, chaotic events [63]. Several theoretical frameworks have been proposed in an effort to understand human behavioral response to threats (whether environmental or in other health-related emergencies). The "Protection Motivation Theory" [15,54] and the "Person Relative to Event" approach [41] propose that people engage in self-protective behavior based on their perceived appraisal of the risk and on their evaluation of their resources as sufficient (response-efficacy and self-efficacy) in relation to the threat. The "Protective Action Decision Model" [37] addresses the issue of human behavior in disasters (e.g. natural hazards), but refers more to preparedness-related behavior or response to an ongoing event and often deals with the issue of evacuation from a risk area. This third model suggests that factors such as risk appraisal and perceived efficacy of protective measures and resources influence individual decision-making processes and responses. Risk appraisal encompasses the perceived expectations of individuals regarding the probability and severity of the hazard, its imminence, the extent of personal impact (e.g. physical injury, property damage and disruption to daily routine), and also the rate of concern about the hazard [34]. Risk perceptions were found to be correlated with implementation of seismic adjustments (actions to mitigate potential consequences to people and property) [36] and also with immediate behavioral response patterns during earthquake events [38].

The "Social Attachment Model" [39] deals with immediate response to disastrous events and proposes that individuals are more likely to seek the proximity of a familiar person during a disaster rather than to evacuate, but this tendency was not uniquely attributed to earthquakes. Studies that examined individuals' immediate responses during an earthquake concluded that the decision-making process is conscious, rational and adaptive [17,51]. Escaping buildings during a tremor was found to be a frequent type of response by occupants even in countries where this type of behavior is considered inappropriate; in several unrelated studies up to a third of participants were reported to act in this manner [1,38,49,50].

Previous studies in the field of disaster sociology and epidemiology indicate that disaster vulnerability is affected by personal, household, and also community characteristics. In a meta-analysis that assessed risk factors for earthquake-induced injury and death using data from earthquake events spanning 20 years, increased risk was found among women, the elderly and children, physically disabled individuals, and low socioeconomic status populations [56]. One explanation for this finding is that certain populations have a lower propensity to take preparedness measures or to adopt protective behavior strategies during a disaster (for example, evacuating a collapsing building) [10,69]. However, the evidence in the literature in this regard is inconclusive [21,34,6], and further research is needed. Disaster preparedness (and thus, also vulnerability) may also be affected by sociocultural differences related to people's previous experience, beliefs, and attitudes toward a certain hazardous event [47]. Studies that have conducted cross-cultural comparisons among communities that have previously experienced earthquakes, such as in New Zealand, Japan, and Taiwan, identified common predictors of earthquake preparedness that can be applied in a multinational social resilience policy [29,46,7]. Nevertheless, this issue is less investigated among communities in which earthquakes are less frequent, yet still pose a serious threat to the population, such as in Israel.

Current global trends, such as population growth, increased life expectancy, migration and rapid urbanism, have resulted in a significant increase in the number of persons residing in dense urban centers. Urban settings display unique vulnerabilities to disaster as compared with smaller or rural communities [10]. Residents of a multistory building have only limited escape routes available to them if the structure is damaged in an earthquake; this can multiply the number of casualties and of persons entrapped under rubble, as was demonstrated in numerous events [59]. Seismic building design and structural strengthening methods are constantly being updated and improved, but implementation is very costly. As a result, a substantial percentage of a growing city's building stock (especially in relatively poor or historic parts) may remain highly vulnerable. The convergence of socioeconomic vulnerability and environmental inequality can further exacerbate the negative consequences of a disaster [9]. This explains why impoverished individuals, households or even entire communities are particularly vulnerable [26,62], as demonstrated in the catastrophic earthquake that struck near Port-au-Prince in 2010.

Other factors, such as previous experience with disasters or emergencies (e.g. number of earthquakes experienced, or experience of earthquake losses by a person or his significant others) and implementation of preparedness measures, have also been found to be correlated with population behavior during a disaster; however, results regarding the direction of these correlations have been inconclusive. While some evidence suggests that previous emergency or disaster experience can motivate people to adopt desirable behavioral strategies (e.g. evacuation prior to a hurricane or exiting a building during an earthquake) [67], other reports indicate a contrary effect, sometimes referred to as the experience-adjustment paradox, thought to occur when less-destructive events lead to a "false experience" perception [6]. Either way, the notion of previous personal experience as predictor of behavior has yet to be validated and will have to be further investigated [2,34,35].

Earthquake hazard adjustments, including the implementation of preparedness measures to improve resilience and response capacities, were found to be positively related to hazard awareness. These adjustments range from purchasing insurance, strengthening residential structures, and stockpiling supplies such as food, water and medications, to bracing heavy objects to walls [34]. One can assume that individuals who are highly aware and as a result are better prepared for an earthquake will also be more familiar with immediate response recommendations (e.g. behavioral strategies) and will hopefully act accordingly during the quake. That this is so was confirmed in a study that examined immediate behavioral response patterns of individuals in New Zealand and Japan to two earthquake in 2011; a positive

correlation was found between household emergency preparedness and the appropriate response recommended in these countries [38]. Nonetheless, the specific mechanisms that influence people's actions during a disaster remain unclear and call for further research.

The aim of this study was to evaluate the anticipated behavior patterns of residents in a high seismic risk area in Israel in the face of a strong earthquake. In addition, the study explored the relationship between the behavioral strategy recommended in this region (i.e. evacuating buildings) and factors related to personal and household characteristics – risk perception, previous earthquake and emergency experience, preparedness levels – with the aim of generating information that could be utilized to promote population preparedness and mitigate future consequences.

## 2. Methods

### 2.1. Population and data enrollment

The study was conducted from April 2014 through July 2014 in the city of Tiberias, a major population center located on the western shore of the Sea of Galilee in northern Israel. Its location near the Dead Sea fault places it in an area highly vulnerable to earthquakes [66]. As mentioned above, the last strong and devastating earthquake in Israel occurred decades ago; however, in 2013 a series of relatively small earthquakes (maximum magnitude of 3.6) struck the northern part of the Sea of Galilee. The tremors were well felt in Tiberias and the events were covered by the Israeli media for several days. Although they did not cause damage or casualties, these events raised concern regarding a future and stronger event that might have more serious consequences [55]. Using data obtained from the Israel Central Bureau of Statistics, a random, stratified sample of 420 households distributed over all twelve census tracts of the city was surveyed. Census tracts were stratified to capture the different socioeconomic levels in several areas of the city. The number of households sampled in each census tract was proportional to the total number of households in that tract. The sample included one adult representative (at least 18 years of age) of each household. Previously trained field surveyors distributed the survey door to door according to predefined, randomly selected addresses within each census tract.

Additional information was obtained regarding the socioeconomic index (SEI) rank of each examined household. The SEI is published by the Israel Central Bureau of Statistics and classifies geographical units (census tracts in municipalities) by elements such as average demographics, education, employment and standard of living. The SEI ranges from 1 to 20 (where cluster 1 indicates the lowest socioeconomic rank). The SEI rank of the various Tiberias tracts ranged from 6 to 10 on the above-mentioned scale of 1–20. Each participating household was assigned a SEI score according to his or her residence.

### 2.2. Instruments and key measures

#### 2.2.1. Population survey

A structured, self-administered, anonymous questionnaire was designed to assess: a) demographic and socioeconomic characteristics (personal and household factors), b) expected self-protective behavior during an earthquake, c) earthquake preparedness, d) earthquake risk perceptions, and e) previous experience with earthquakes or other emergencies of the study population. The questionnaire was a modified, independently validated version of a tool used to measure community resilience to emergency scenarios [8,70].

Demographic and socioeconomic characteristics included gender, age, marital status (single, married or common law, divorced or widowed), children under 17 residing in the household (yes or no), education level (elementary, high-school, post high-school, or academic), having a physical disability that might affect mobility during an earthquake, such as difficulty walking or climbing up and down stairs (none, slight, or serious disability), type of residential building (multi-story apartment building or private house), and level of income (much lower than average, lower than average, about average, higher than average, much higher than average). Expected protective strategy during an earthquake was assessed through a multiple-choice question relating to an event that might strike in the future. Several behavior options were presented: a) take cover under a table or heavy furniture, b) sit on floor against an inner wall, c) go into an apartment shelter (if one exists), d) exit outside to an open area, e) go out to the staircase, and f) other/I don't know. These were derived from the IDF Home Front Command recommendations [22]. Israeli residents have been exposed to these guidelines through extensive publicity by the authorities. Earthquake preparedness was assessed using a checklist documenting the implementation or possession of the following four items: a) fastening and bracing heavy objects to walls, b) reinforcing the residential building against seismic hazards, c) preparing an emergency kit with supplies including food and water, drugs and first aid equipment, and d) possession of other necessary equipment (e.g. rope, plastic tape). These items were derived from Center for Disease Control recommendations [71] and are also recommended for the Israeli public by the IDF Home Front Command [23]. The total score in this section ranged from 0 to 4 (where a higher score indicates higher level of preparedness).

Risk perception was assessed by a three-item measure dealing with dimensions associated with environmental hazards [34]. These included judgments regarding the likelihood of a major earthquake occurring in the near future, its perceived effect on the participant and the other household members, and perceived concern about this event. The participants were asked to rate their level of agreement with statements using a 5-point Likert-type scale, ranging from 1 (very low/not at all) to 5 (very high extent). A total risk perception score was calculated as the mean score of these three items ($\alpha = .82$). Participants were asked whether they had previously experienced an earthquake in Israel or abroad (yes or no) or other emergencies (assessed by the number of times that participants were involved in different emergencies such as terrorist attacks, car accidents, etc.) [8,12,70].

The Institutional Review Board (IRB) of the Faculty of Health Sciences at Ben-Gurion University of the Negev approved the study protocol and the final version of the questionnaire.

### 2.3. Procedure

#### 2.3.1. Statistical analysis

Bivariate analyses were conducted using Pearson's and Spearman's correlations and chi-square tests to explore the relationships between the participants' expected self-protective behavior (defined as the dependent variable) and other dimensions assessed in the survey (i.e. personal and household characteristics; earthquake preparedness; risk perception; previous earthquake or other emergency experience; and SEI rank). A hierarchical multivariate logistic regression model was fitted to assess associations of study variables and self-protective behavior, which was dichotomized to 'evacuate the building' (1) and 'other' (0), as evacuating the building during an earthquake is the recommended behavior for Israeli residents, considered most likely to save lives [42]. In the hierarchical logistic regression, eight personal and household characteristics were entered as the first block and the rest of the independent variables (earthquake preparedness, risk perception, previous earthquake or other emergency experience, and SEI rank) as the second block. A forward stepwise (conditional) selection method was used to eliminate variables. All predictors with P-values $< .05$ were considered statistically significant in the model. SPSS software package version 23.0 (SPSS Inc., Chicago, IL) was used to perform the analyses.

**Table 1**
Demographic and socioeconomic characteristics of participants (n = 306).[a]

| | Demographics | | N (Total) | |
|---|---|---|---|---|
| | | | % | n |
| 1 | **Gender** | Female | 58 | 177 |
| | | Male | 37 | 113 |
| 2 | **Age** (years) (Mean + SD) | | 35.2 ± 11.5 (n = 289) | |
| 3 | **Marital status** | Single | 25 | 77 |
| | | Married/Common law | 65 | 198 |
| | | Divorced/Widowed | 8 | 25 |
| 4 | **Children residing in household (under 17 years of age)** | None/not relevant | 50 | 154 |
| | | Yes | 48 | 147 |
| 5 | **Education** | Elementary | 2.5 | 8 |
| | | Secondary (High school) | 29 | 88 |
| | | Post-high school (non-academic) | 36 | 111 |
| | | Academic | 29 | 90 |
| 6 | **Building type** | Apartment building | 59 | 180 |
| | | Private house | 41 | 126 |
| 7 | **Persons with physical disabilities** | No disability | 89 | 272 |
| | | Slight | 8.5 | 25 |
| | | Severe | 1.5 | 4 |
| 8 | **Income level** | Much lower than average | 16 | 49 |
| | | Lower than average | 36.5 | 112 |
| | | Similar to average | 36 | 111 |
| | | Higher than average | 9 | 26 |
| | | Much higher than average | 0.3 | 1 |
| 9 | **Rank in "Socio-Economic Index"** | ≤ 7 | 43 | 132 |
| | | 8 | 11 | 34 |
| | | > 9 | 45 | 137 |

[a] Without missing values; the rate of missing values ranged from 1–5% for the different variables.

### 2.4. Results

A total of 306 residents completed the questionnaire (73% response rate). The demographic characteristics of the study population are presented in Table 1. The majority of participants were female and married. The mean age was 35 (SD = 11.5) years and 48% had children residing with them. Ten percent of the participants reported having some degree of physical disability. Twenty nine percent of participants had an academic degree, and the income level of most participants was similar to (36%) or less than (36.5%) average income. A similar proportion of participants resided in the lowest (43%) and in the highest (45%) ranked SEI areas of the city. The sample's characteristics resembled the actual characteristics of Tiberias' population, apart from the higher proportion of females in the sample (58%, vs. 50% for the entire city) and a higher proportion of higher-education graduates (academics) (29% vs. 11%) [25].

### 2.5. Expected self-protective behavior during an earthquake

Self-protective behavior was assessed by a multiple-choice question relating to a future event. The majority reported that their preferred strategy would be to evacuate the building in which they found themselves during an earthquake (43%); the second most popular strategy (19%) was entering the shelters in the apartment; 13% reported they would take cover under heavy furniture; 8% reported they would go out to the staircase and 5% that they would sit against an inner wall. Twelve percent of participants indicated they did not know how to act should an earthquake occur. This rate was significantly higher among multi-story apartment building residents vs. private home residents, but was only marginally significant (15.5% vs. 8% respectively, $p = .05$).

### 2.6. Earthquake preparedness, risk perception and previous experience

Most participants (67%) scored 0 or 1 (out of four) in the preparedness measure: only 7% had reinforced their residence for an earthquake hazard, and only 4% had fastened or braced heavy objects to walls. Among the participants who had a 'high' score in the preparedness measure (3–4 items), 56% were high SEI area residents and 35% were low SEI area residents ($p < .05$). Higher preparedness was also significantly associated with higher education levels, higher income, greater experience with previous emergencies, and lower levels of earthquake risk perception.

The mean total risk perception score among participants was 3.5 out of 5, SD = .91, and was negatively correlated with levels of preparedness ($r = -.11$, $p < .05$). Most participants had experienced an earthquake (85%), and a similar rate (78%) had previously experienced at least one other emergency event.

### 2.7. Relation between expected self-protective behavior and study variables

In this study, the preferred self-protective behavior of participants was defined as evacuating buildings. Associations with nominal independent variables (gender, marital status, presence of children in the household, type of residential building and previous earthquake experience) were assessed by conducting chi-square tests: the rate of men reporting an intention to evacuate (47%) was high as compared with women (40%), but the difference was not statistically significant ($p > .05$); the rate of married participants reporting they would evacuate the building if an earthquake occurred (48%) was significantly higher than the rate for single (32.5%) and divorced or widowed participants (29%), ($\chi^2 = 7.11$, $p < .05$); however, this association was rather weak ($\phi_c = .15$). Participants who had children residing with them likewise planned to evacuate at a significantly higher rate (49%) than those who did not (37%), ($\chi^2 = 4.49$, $p < .05$); but in this case too, the association was weak ($\phi = .12$). The rate of residents of private houses reporting an intention to evacuate (60%) was significantly higher when compared with residents of apartment buildings (33%), ($\chi^2 = 18.57$, $p < .001$); the association in this case was moderate ($\phi = .25$). Having previously experiencing an earthquake was not significantly associated with choosing a behavioral strategy, although 45% of those who had undergone the experience planned to flee, versus only 32% among those who had not ($p > .05$).

Table 2 presents the inter-correlation matrix between selection of this behavioral strategy and other ordinal and continuous study variables. Several personal factors (older age, higher educational level) and household factors (SEI rank and income) were positively and significantly associated with choosing the recommended self-protective behavior. Higher preparedness levels were also significantly related to choosing this behavior.

Based on these findings, a multivariate logistic regression model was fitted to predict adoption of the recommended strategy – evacuating buildings (Table 3). The findings indicated that preparedness level was a significant predictor of the intention to evacuate buildings during an earthquake (OR = 1.42, 95% CI: 1.061–1.926, $p < .05$). Residing in private homes (compared with a multi-story apartment building) had a significant positive predictive value on the probability of evacuating outside (OR = 3.18, 95% CI: 1.768–5.719, $p < .001$). All other factors did not reach statistical significance ($p > .05$).

## 3. Discussion and conclusions

The results of this study provide some insights into the self-protective behaviors that are likely to be adopted during an earthquake by persons who, although they live in an area that is highly vulnerable to seismic hazards, have not recently experienced such an event. The findings demonstrate that the anticipated behavior of most participants complies with the guidelines on how to act during an earthquake in

**Table 2**
Means and correlation matrix between study variables.

| Variables | M (SD) | Expected behavior | SEI | Age | Disability | Education | Income | Preparedness | Emergency experience | Risk perception |
|---|---|---|---|---|---|---|---|---|---|---|
| Expected behavior | – | – | .13* | .11 | − .05 | .16** | .12* | .22** | .08 | − .02 |
| SEI | 7.89 (1.42) | .13* | – | .07 | − .05 | .12* | .17** | .13* | .06 | .02 |
| Age | 35.2 (11.5) | .14* | .04 | – | .20* | − .08 | .05 | .04 | .20* | − .07 |
| Disability | .1 (.35) | − .06 | − .05 | .19** | – | − .08 | − .16** | − .07 | .05 | .12* |
| Education | 2.95 (.84) | .15** | .11* | − .10 | − .05 | – | − .23** | .16** | .01 | .03 |
| Income | 2.39 (.86) | .13* | .16** | .04 | − .12* | .23* | – | .24* | .12* | − .08 |
| Preparedness | 1.11 (.96) | .20** | .13* | .02 | − .09 | .14* | .23* | – | .16** | − .11* |
| Emergency experience | 2.15 (.79) | .08 | .04 | .24* | .05 | .01 | .11* | .14* | – | .08 |
| Risk perception | 3.46 (.91) | − .01 | .01 | − .03 | .12* | .05 | − .08 | − .11* | .07 | – |

Note: The correlations above the diagonal are Spearman's, and correlations below the diagonal are Pearson's.
* $p < .05$.
** $p < .001$.

Israel (i.e. evacuating buildings as a preferred strategy). Ostensibly this is an encouraging finding, but an in-depth examination of the results reveals a number of additional findings that need to be addressed. In terms of personal and household characteristics, the strategy of evacuating buildings was mainly associated with participants who were older, were married with children, had a higher education, and resided in private homes in areas with a higher socioeconomic index. This corresponds in part to the results of Alexander and Magni [2], who reported that people who fled outside during the L'Aquila earthquake in Italy (2009) were older than those who implemented other behavioral strategies. The same study also reported that participants with a higher education had a greater tendency to implement active behavior strategies during the tremor, though the authors were referring to a number of behavioral patterns and not just to evacuating outside. The association we found between the presence of children under 17 residing in the household and the intention to evacuate the building during an earthquake is in keeping with the findings of Goltz et al. [17], who report that the presence of a family member was associated with actual response activities during the Whittier Narrows earthquake in California (1987). However, in that tremor the findings related to the strategy of "drop, cover and hold" and not to evacuating buildings. Our finding also appears to be inconsistent with the "Social Attachment Model", which suggests that people would prefer to stay close to their family members rather than evacuate during a disaster [39]. However, because parents feel responsible for the safety and wellbeing of their young children, they are more likely to be aware of the guidelines for proper action during an earthquake. Protecting young children (before protecting self) is also a common explanation to the fact that women were found to be at higher risk of injury and death in many previous earthquake-related studies (for example see [2]; and references reviewed in [56]). The current results also indicated gender-related differences in the intention to choose a behavioral strategy, with men being more likely to report evacuation than women; however, these did not reach statistical significance. A possible explanation for this may lie in the higher proportion of women in the sample compared with their rate in the actual population, which may lead to a certain bias. Further research is needed to determine this issue in the current context.

In a recent study that examined immediate behavioral response patterns of individuals during the Christchurch (New Zealand) and Hitachi (Japan) earthquakes (2011), none of the personal characteristics discussed above were significantly correlated with the choice of a strategy of evacuating buildings; however, a negative association was reported by Lindell et al. [38] between choosing this strategy and participants' educational levels. We note that in all these cases, evacuating buildings during an earthquake was not considered an appropriate behavioral response; instead, "drop, cover and hold" was recommended as the proper immediate action. Given the cultural differences and disparities in perceptions, experience and preparedness, the basis for comparison here is somewhat tenuous.

Evidence from other disasters suggests that personal characteristics are associated with both human responses and disaster-related losses. When several large hurricanes struck the Gulf Coast of the United States, the demographic and economic traits of the affected population were associated with their behavior prior to and during the events, mostly regarding the decision to evacuate. Studies that were conducted following hurricane Ivan (2004) and hurricane Ike (2008) indicated that factors such as type of residency, home ownership status, education and income levels were related to the evacuation decision making

**Table 3**
Multivariate logistic regression model results for predicting who would evacuate buildings during an earthquake.

| Variable | B | S.E. | Wald | P | OR | (95% CI) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| **Gender** (male) | .326 | .290 | 1.267 | .260 | 1.386 | .785 | 2.446 |
| **Age** | .011 | .015 | .536 | .464 | 1.011 | .982 | 1.041 |
| **Family status** (divorced/widowed) | | | 3.470 | .176 | | | |
| Single | .487 | .645 | .572 | .450 | 1.628 | .460 | 5.759 |
| Married/Common law | .887 | .554 | 2.563 | .109 | 2.428 | .820 | 7.193 |
| **Children residing in household** (yes) | .330 | .302 | 1.189 | .276 | 1.390 | .769 | 2.515 |
| **Education** | .101 | .178 | .321 | .571 | 1.106 | .781 | 1.567 |
| **Income** | .053 | .168 | .099 | .753 | 1.054 | .758 | 1.466 |
| **Type of Residential building** (private house) | 1.157 | .299 | 14.917 | .000** | 3.180 | 1.768 | 5.719 |
| **Having a physical disability** | − .297 | .427 | .483 | .487 | .743 | .321 | 1.717 |
| **Preparedness** | .357 | .152 | 5.510 | .019* | 1.429 | 1.061 | 1.926 |
| **Constant** | − 4.683 | 1.161 | 16.261 | .000 | .009 | | |

Nagelkerke $R^2 = .19$, chi-square$_{(14)} = 40.086$, $p < .001$, $n = 257$.
* $p < .05$.
** $p < .001$.

process of affected residents [19,20]. Although these associations were at times minor or indirect, they are supported by a recent study that performed a statistical meta-analysis of a large number of hurricane evacuation studies (both actual and expected responses) conducted over nearly 25 years [21]. Correspondingly, personal characteristics, in combination with other environmental factors such as disaster-prone topography and poor quality housing, were also associated with increased vulnerability in those events that resulted in a high casualty burden [9]. To sum up, it seems well established that population characteristics affect the choice of behavioral pattern in hurricane scenarios, but the same cannot be said with certainty regarding earthquakes. This could be due to differences in the nature of the two types of events (i.e. rapid onset in earthquakes vs. slower development in hurricanes), or to the fact that hurricane studies have focused exclusively on the US population. Further research is required to settle this issue; however, agencies responsible for promoting earthquake preparedness among the population should consider such diversity when planning future disaster risk reduction strategies.

In our study, higher levels of earthquake preparedness (i.e. implementation of measures aimed at home-hazard mitigation) were significantly associated with the declaration that building evacuation would be the self-protective behavior of choice during an earthquake. Preparedness was also a significant predictor of such a choice. Preparing for an earthquake may require considerable resources. The financial cost of reinforcing structures against seismic tremors is clearly high; however, some measures can be carried out for a relatively modest outlay, e.g. preparing an emergency kit, stockpiling supplies, or bracing heavy objects to walls. Such preparations presuppose awareness of risk reduction measures, acquaintance with guidelines regarding how to act during the event, and also an ability to engage in self-protective activities prior to the event; all of these are dependent on the socioeconomic status of the targeted population [61]. One possible explanation for the results of the present enquiry, therefore, is that participants with greater resources (in terms of income and education, for example) were more aware of what actions should be taken during an earthquake. This conjecture finds support in a study that examined the immediate behavioral responses to an earthquake of individuals in New Zealand and Japan. It was found that participants with a higher income were better informed about earthquakes and were also more likely to implement the protective strategy recommended in these regions (drop, cover and hold) [38]. Further evidence from the literature suggests that people who perceive their resources as adequate for coping with a threat are more confident and self-efficacious and are more likely to proactively seek information regarding disaster preparedness and response [31]. While implementation of preparedness measures increased the probability of selection of the recommended self-protective behavior, on the whole preparedness levels were rather low, particularly among residents of in the low SEI areas of Tiberias. This suggests that enhancing readiness, especially among specific target populations, could have a strong mitigating effect on the outcomes of future events.

Previous emergency and earthquake experience and levels of risk perception were not significantly associated with the declared intention to evacuate buildings during a quake. The lack of a significant effect of previous experience on decision-making and behavioral response was also seen in studies that examined actual response patterns to earthquakes in the US [17] and in New Zealand and Japan [38], and also in studies relating to hurricane events [21]. The fact that the last strong earthquake in Israel occurred in 1927 and that recent earthquakes in the region were relatively weak and did not result in substantial loss may explain why the participants' previous earthquake experiences were not associated with recommended self-protective behaviors. This notion is consistent with the concept of "false experience" described by Baker [6], and has also been discussed in a thorough literature review focused on factors related to household adjustments to earthquakes [34].

The finding that risk perceptions did not affect expected behavior is inconsistent with the significant correlation reported between the risk perceptions of individuals in New Zealand and Japan and their immediate response to earthquakes, in terms of immediate evacuation from a building [38]. However, a precise comparison between the results cannot be drawn as the recommended protective action in those regions is "drop, cover and hold" and not evacuating a building. The present result is also inconsistent with theoretical models such as the "Protection Motivation Theory", the "Person Relative to Event" and the "Protective Action Decision Model", all of which suggest that risk appraisal does influence individual decision-making processes and responses [15,37,41,54]. The absence of association observed here may perhaps be explained in terms of the theory of "risk perception paradox," in which individuals who have previously experienced a disaster and also have high risk perception levels seldom take preparedness actions or implement appropriate behavioral responses, whether due to lack of resources or the projection of responsibility to others [65]. Another possible explanation may stem from the design of the present study: cross-sectional studies do not allow measurement of change over time, a parameter that is very relevant in the specific context of risk perception and behavior. Weinstein & Nicolich [68] noted that high levels of risk perception can cause people to change their actions, and that this in turn could diminish their risk perception to match their new behavior. This could alter the correlation between the variables, but as mentioned can be detected only by examining multiple surveys.

The fact that a fairly considerable percentage of the survey participants (12%) reported that they did not know what to do during an earthquake indicates that educational efforts aimed at earthquake preparedness and response need to be improved, but also that the number of casualties could theoretically be reduced. Uncertainty regarding proper action was greater among apartment building residents, and they were less likely to evacuate the building. Not surprisingly, residence in a private house was a significant predictor of evacuating a building, as escaping a collapsing building may not be an option for residents of upper stories. This point needs to be considered and better addressed when instructing urban populations regarding appropriate measures during an earthquake. Taken together with the other results of our study, these findings could help focus mitigation strategies where they are most needed. Specifically, the results indicate that preparedness efforts in Tiberias should be targeted at low SEI areas and more especially at occupants of multi-story apartment buildings. Public health agencies and other community or national organizations can use this information to assess and optimize preparedness plans, namely by raising awareness regarding protective behavioral strategies prior to and during earthquakes and by directing these efforts at the more vulnerable populations.

The main limitation of this current study is that it focuses on a behavioral strategy (escape from buildings) that is not universally recommended, and hence its findings are not always generalizable. However, immediate evacuation is accepted as an appropriate strategy for vulnerable or mixed building stock [16], and most earthquake-induced casualties occur in regions with the same type of structures (usually developing countries) [56]. This suggests that our findings could contribute to disaster risk reduction efforts in at least some parts of the world.

Further limitations are related to the measurement of some of the study variables. Earthquake preparedness was measured according to the IDF Home Front Command guidelines, and may lack additional elements mentioned in the literature that may provide a more comprehensive view of this complex concept. Such elements include: hazard and guidelines awareness; views and beliefs regarding preparedness measures' effectiveness and costs; and regarding who is responsible for coping with earthquakes [34]. The measure of previous experience does not take into account factors related to the number of events experienced or their size/intensity [7]. This may have an effect on an

individuals' risk perception, and subsequently their willingness to take preparedness measures or choose a specific behavioral strategy. These limitations may lead to a certain bias in the nature and strength of the association between these variables. In principle the results of this research should be interpreted with some caution, as they are based on anticipated rather than on actual behavior. However, the rate of participants reporting that they would evacuate the building during an earthquake was similar to the rate documented in real events in Italy [49,50] and in Japan [38]. In addition, there was significant correspondence between expected and actual behavior during other disasters, such as hurricanes [21,30]. Despite these limitations, the current results help enlarge our understanding of individuals' decision-making and immediate response during earthquakes by offering insights regarding factors and mechanisms that may be involved in this complex process. Since the scenario of a strong earthquake is perhaps the most devastating threat facing the Israeli population and is both foreseeable and probable, future research should focus on extending this study to additional regions and populations of the country. In addition, most of the studies dealing with behavior during earthquakes originate in developed countries (e.g. USA, Japan, New Zealand, and Italy); in future the investigation should be expanded to include data from developing countries. The availability of a broader database will make it possible to assess the generalizability of the current findings and will assist decision makers in optimizing risk reduction efforts.

Earthquakes are unpredictable events and can have dire consequences. The impact of such events on the environment and on the exposed population can be evaluated, even if the probability of a particular event occurring cannot be known. Focusing on ways to prepare the population by raising awareness and disseminating instructions regarding proper actions to take prior to and during the event could help mitigate potential losses during a future disaster and ultimately save lives.

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