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Development and psychometric assessment of the household earthquake preparedness questionnaire: an exploratory sequential mixed-methods study

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Abstract

Introduction Earthquakes may lead to fatalities and property loss often due to lack of preparedness among individuals. This study aimed to develop and assess the psychometric properties of a Household Preparedness for Earthquake Hazards Questionnaire (HPE-Q).

Methods This study utilized a mixed-methods approach comprising of both qualitative and quantitative methods. The qualitative phase concentrated on item generation through semi-structured interviews conducted with Iranian households selected via purposive sampling, alongside a systematic literature review to develop a comprehensive item pool for evaluating household preparedness for earthquake hazards. The quantitative phase focused on item reduction and the assessment of the face, content, and construct validity. To evaluate the reliability of the questionnaire Cronbach's alpha and intraclass correlation coefficients (ICC) were calculated.

Results The initial item pool comprised 88 potential items. Face validity, content validity, and item analysis evaluation was performed and the number of items was reduced to 61. Exploratory Factor Analysis (EFA) further pruned the instrument by eliminating 24 items and Confirmatory Factor Analysis (CFA) mandated the removal of 1 item resulting in a finalized 36-item HPE-Q anchored by 7 main factors: knowledge, self-efficacy, social support, social participation, collective efficacy, protective motivation and behavioral intention. Cronbach's alpha was 0.92 and Interclass Correlation Coefficient (ICC) of the total score was 0.93.

Conclusion Household preparedness for earthquakes is shaped by numerous factors that can either facilitate or impede preparedness and these factors may differ across communities and households. This questionnaire can help identify key aspects of households' preparedness for earthquakes.

Keywords Household, Preparedness, Earthquake, Hazard, Questionnaire

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Introduction

Disasters are sudden and surprising occurrences that cause human injury, life loss or environmental damage [1, 2]. Events such as earthquakes, floods, and volcanic eruptions may strike without warning often resulting in severe human and economic losses [3]. In the past century, Iran has experienced over 250 natural hazards including floods, earthquakes, droughts, and storms impacting 60 million people, causing 158,350 deaths and incurring over US\$53 billion in damages [4, 5].

Iran is characterized by an extremely active seismic setting, leading to the annual occurrence of several of the world's most destructive and deadly earthquakes; furthermore, historical data suggests that a major earthquake capable of inflicting high financial losses strikes the nation, on average, once every seven years.

The implementation of robust disaster preparedness protocols is fundamentally instrumental in mitigating the scope of human casualties and infrastructural damage primarily through its direct capacity to augment a community's systemic resilience and streamline the efficacy of immediate disaster response mechanisms [6]. The Sendai Framework for Disaster Risk Reduction (2015–2030) as a pivotal international document provides a comprehensive framework for reducing risks and strengthening resilience at the national and local levels that directly impact the security and survival of micro-social units including families. By emphasizing the first priority (perception of risk) the framework enables families to become aware of the threats in their environment [7].

Community-based approaches to earthquake disaster management (CBEDM) incorporate social environmental and political dimensions highlighting the local population's resilience and their preferences regarding preventive strategies [8]. The synergistic cooperation between local authorities, non-profit sectors and community stakeholders is fundamental for strengthening communal preparedness and resilience which in turn facilitates greater efficiency in post-disaster recovery [9]. The World Health Organization emphasizes the importance of disaster preparedness for sustainable development and notes that inadequate preparedness in governmental and public sectors contributes to extensive damage from disasters [10].

Key preparedness actions include acquiring knowledge and skills, planning for the impacts, supplying emergency equipment, and implementing protective measures [11]. Empirical data from the Centers for Disease Control and Prevention (CDC) demonstrates that escalating household preparedness directly correlates with enhanced systemic community responsiveness to hazard exposure leading to superior attenuation of immediate impacts and optimization of post-disaster recuperation phases [12]. Evidence suggests that response organizations often

struggle to provide timely healthcare and emergency services (30). Residents familiar with their neighborhoods are typically the first to assist in crises and if properly trained they can significantly help manage disasters and reduce losses [13].

Literature review

Despite geographical variations in risk management practices global data confirms a widespread deficit in household disaster preparedness [14–16]. For instance, research from China in 2021 documented that full disaster preparedness was achieved by only 1.5% of surveyed households [15]. Furthermore, a 2018 New Zealand survey highlighted a general insufficiency in household preparedness revealing that 76.6% of respondents were reluctant to enhance their preparedness for seismic events [17]. A comparable outcome was observed in Taiwan, where residents' proactive intentions regarding initial earthquake precautions did not translate into high levels of actual preparedness [18]. This preparedness status is complexly determined by an array of variables, encompassing individual demographics (such as age, gender, health status, and educational attainment) alongside extensive behavioral, social, cognitive, economic, and cultural determinants [19]. A qualitative study by Cvetković et al. based on more than a thousand face-to-face interviews across eight Serbian municipalities, revealed that the population generally exhibits low levels of household earthquake preparedness. This finding underscores the necessity for community-led programs and strategies aimed at enhancing earthquake safety and preparedness [20]. A 2018 cross-sectional study of more than a thousand Italian households revealed a moderate level of earthquake preparedness. Furthermore, researchers noted that Italians think major earthquakes are unlikely to happen, yet they think they will be severe if they occur [21]. Joëlle et al., published a review about household emergency preparedness and emphasized a major gap in the literature, and the need for evidence-based strategies to address the challenges associated with household preparedness. Specifically, they argue that the construct of social capital and how it can be leveraged to enhance individual and community capacity in emergency situations requires further investigation [22].

Necessity and objectives of the study

Historically disaster risk reduction strategies have overwhelmingly centered on observable individual characteristics that drive preparatory actions. However, contemporary scholarship advocates for a broader perspective recognizing that deeply embedded cultural frameworks and social dynamics significantly mediate an individual's preparedness beliefs, intentions, and ultimate behavioral outcomes [23, 24]. Understanding what

motivates individuals to protect themselves and their property from disasters is more complex than commonly assumed, and a significant barrier to changing behavior is the lack of effective tools in this area [25]. A credible tool can provide insights into the factors influencing desired behaviors, enabling educators to identify key predictors, develop targeted interventions, and determine appropriate educational strategies [26]. Currently, no standardized tool exists to measure the underlying factors affecting household preparedness for earthquakes, and this highlights the need for a tool to evaluate household preparedness. Understanding the situation of household preparedness helps design proper initiatives for increasing disaster preparedness. Therefore, this study aimed to develop and assess the psychometric properties of a household preparedness for earthquake hazards questionnaire. This tool will help identify the factors influencing household preparedness and outline the educational needs for researchers and policymakers. By focusing on these factors, effective educational measures can be developed and implemented to enhance household earthquake preparedness.

Methods

Study design

This research employed a mixed-methods design comprising both qualitative and quantitative methods and was implemented in two sequential phases. In the qualitative phase items were developed through semi-structured interviews conducted with purposively selected Iranian households. Also a systematic review of the literature was performed to construct an initial pool of items measuring household preparedness for earthquake. In the quantitative phase the items were evaluated for face, content, and construct validity. Additionally, the reliability of the questionnaire was examined using test–retest procedures and intra-class correlation coefficients.

Qualitative phase (Item Generation)

Three major steps were undertaken to generate items: (a) conducting interviews with heads of households and later content analysis to identify factors influencing earthquake preparedness, (b) performing a systematic review, and (c) synthesizing findings from steps 1 and 2 to create the item pool.

Step 1: the qualitative study

From December 2021 to May 2022, a qualitative content analysis study [27] was carried in Kerman city. Details of this study and its methods can be found in the publication.

Step 2: the systematic review

A systematic review was conducted following PRISMA guidelines and 18 articles published between 2000 and 2022 were included [28].

Step 3: combining steps 1 and 2 (Synthesis)

The results obtained from the preceding two steps were synthesized to build the measurement items. Redundant topics were eliminated and overlapping items were consolidated. Subsequently new categories and subcategories were established to form the conceptual foundation of the item pool and proceed to a more nuanced evaluation. The resulting comprehensive table comprised themes, categories, subcategories, and codes and yielded an initial assessment instrument consisting of 88 items distilled from an original set of 306. The psychometric characteristics of this questionnaire were examined in terms of face, content, and construct validity, and each item was assigned a response format based on a five-point Likert scale.

Quantitative phase (Item reduction)

Face validity

Face validity was assessed using both qualitative interviews and quantitative ratings. For the quantitative assessment 10 heads of household rated the appropriateness of each item using a five-point Likert scale ranging from one (not important at all) to five (quite important). Suitability was quantified using an Impact Score calculated as:

$$\text{Impactscore} = \text{Frequency (\%)} \times \text{Importance}$$

Items achieving an Impact Score exceeding 1.5 were designated as suitable and retained in the questionnaire. In the qualitative phase semi-structured interviews were conducted specifically on items that scored below the 1.5 threshold. These interviews focused on evaluating the ease of understanding, legibility, grammatical accuracy, and overall writing style. Following the integration of feedback gathered during this qualitative review, the questionnaire underwent necessary revisions [29].

Content validity

Content validity was examined using both qualitative and quantitative strategies. In the qualitative evaluation ten health professionals each possessing expertise in emergency and disaster management reviewed the questionnaire. Their feedback encompassed an assessment of question comprehensibility, appropriate word usage, logical item sequencing, proposed scoring system, and the overall appropriateness of the questionnaire dimensions. Based on the expert consensus derived from these suggestions the questionnaire items were subsequently

revised to optimize clarity and conceptual alignment. For quantitative content validity, experts rated each item on a three-point scale: necessary, useful, or not necessary. Then the CVR was calculated using the Lawshe formula [30]:

$$\text{CVR} = (n_e - (N/2)) / (N/2).$$

In this study each item required a score of 0.64 or higher to be acceptable. To determine CVI, 10 experts rated item relevance on a four-point Likert scale. Kappa values were calculated based on the relevance agreement ratio (I-CVI) and chance agreement probability (Pc), with a minimum evaluative requirement of three experts, though ten were included in this study. Items with a Kappa of at least 0.74 were accepted, with ranges of 0.59 – 0.40, 0.74 – 0.60, and > 0.74 classified as poor, good, and excellent, respectively [31]. The CVI, K and Pc formula are listed below and details about them can be found in Polit and Beck 2006 [33].

$$\text{CVI} = \frac{\text{Number of raters giving a rater 3 or 4}}{\text{Total number of raters}}$$

$$k = \frac{\text{Proportion}_{\text{Agreement}} - \text{Proportion}_{\text{Chance agreement}}}{1 - \text{Proportion}_{\text{Chance agreement}}}$$

$$p_c = \left[\frac{N!}{A!(N-A)!} \right] \cdot .5^N$$

Item analysis

Before assessing construct validity household heads completed the HPE-Q, which was used to evaluate internal consistency. Items with an inter-item correlation coefficient between 0.30 and 0.80 were retained, while others were discarded.

Construct validity

Construct validity was examined via EFA and CFA. The EFA utilized maximum likelihood estimation with Promax rotation in SPSS version 22, applied to a sample of 505 household heads. This sample size was justified based on having a minimum of five participants per item, and a 10% margin of error. Data set appropriateness for factor analysis was confirmed through the Kaiser-Meyer-Olkin (KMO) and Bartlett's test, with the established criterion for acceptability set at a KMO value exceeding 0.8 [32].

Factor extraction adhered to standard criteria: retaining factors with Eigenvalues exceeding unity ($\lambda > 1$), ensuring communalities surpassed 0.2, and requiring individual item factor loadings to be greater than 0.3 [33]. The Eigenvalue, representing the variance in an item explained by the factor, was calculated as the

summation of squared factor loadings for all items within that factor. The proportion of total variance explained by each factor was subsequently determined by normalizing its Eigenvalue by the total item count [34]. Following extraction, the structural integrity of the resulting factors was tested via CFA using AMOS software. Model fit was assessed against a comprehensive set of established metrics following the recommendations of Jaccard and Wan (1996). These indices included the Chi-square statistic (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Normed Fit Index (NFI), Adjusted Goodness of Fit Index (AGFI), Tucker-Lewis Index (TLI), and Parsimonious Comparative Fit Index (PCFI), with particular attention given to the χ^2/df ratio [35].

Convergent and discriminant validity

The HPE-Q was assessed for both convergent and discriminant validity. Convergent validity was considered satisfactory with a Composite Reliability (CR) above 0.7 and an Average Variance Extracted (AVE) exceeding 0.5. Discriminant validity was evaluated using the Heterotrait-Monotrait Ratio of Correlations (HTMT) matrix, requiring all values to be less than 0.85 [36].

Reliability

Internal consistency of the instrument was evaluated by calculating the Cronbach's alpha coefficient. For this assessment 66 household representatives affiliated with a health center administered the finalized 36-item electronic questionnaire. Cronbach's alpha was computed for the scale in its entirety and for each underlying factor separately with a coefficient value exceeding 0.7 being established as the threshold for acceptable reliability [37]. Furthermore test-retest reliability was examined utilizing the Intraclass Correlation Coefficient (ICC). This involved an initial administration of the 36-item questionnaire to 40 household representatives followed by a repeated administration to the same people after a two-week interval. The correlation between the initial and subsequent scores was then analyzed.

Results

Findings from the qualitative phase (Item generation)

In the initial qualitative study, data were coded through multiple rounds, resulting in 105 codes grouped into five main categories and 19 subcategories based on social-cognitive theory. The main categories identified were: (A) Cognitive factors (B) Behavioral factors (C) Physical environment, (D) Social environment, and (E) Financial factors. Detailed information, can be seen in the published article [27]. In the second step (systematic review) 18 articles on disaster preparedness behaviors were assessed and 201 items were extracted. The extracted constructs

included self-efficacy, collective efficacy, knowledge, outcome expectations, social support, and normative beliefs. More details are available in the published article [28]. In the third step, combining items from the qualitative and systematic reviews resulted in a preparatory tool with 306 items, which was later reduced to 88 items.

Initial assessment instrument consisting of 88 items distilled from an original set of 306.

Findings from the quantitative phase (face, content, and construct validity)

Face validity

In this stage 3 items number 46, 66, and 77 received an item impact score of less than 1.5. These 3 items were retained to be re-evaluated by the participants, and interviews were conducted face-to-face with the same 10 participants who had rated the questionnaire in the previous stage. The items were examined for ambiguity and difficulty level. The phrases were revised based on the participants' feedback and in consultation with the research team incorporating their suggestions. In this stage in addition to items number 46, 66, and 77, several other items were also edited for better understanding by potential participants.

Content validity

During the qualitative assessment of content validity 1 item was merged with others and 6 were reassigned to different subgroups. Consequently 87 items were retained for the quantitative evaluation of content validity. For this purpose, two indices Content Validity Ratio (CVR) and Content Validity Index (CVI) were calculated. In the CVR analysis 12 items were eliminated because their CVR scores fell below the critical threshold of 0.62. In the CVI assessment 8 items were excluded for obtaining a K score lower than 0.74 (considered the cutoff point) reducing the number of questionnaire items to 67. The average CVI values of the instrument was calculated with 0.90 serving as the acceptable reference value [30]. In the present study the mean CVI score for all items was 0.97 exceeding the standard criterion. Subsequently 6 additional items were discarded during the internal consistency analysis and because their inter-item correlation coefficients were below 0.30. This resulted in a final questionnaire comprising 61 items.

Construct validity

For the assessment of construct validity data were collected from a total of 505 heads of household who completed the 61-item HPE-Q. The sample was allocated for the assessment with 250 participants designated for EFA and 255 for CFA. The demographic profile of the participants indicated a mean age of (40.15 ± 8.58) years. The majority of the sample comprised female respondents

(72.5%) who were married (83.9%) and employed (63.1%). Furthermore, the majority of participants possessed academic education (67.3%) and (32%) reported prior experience with a destructive earthquake.

Exploratory factor analysis

EFA was performed through maximum likelihood estimation and Promax rotation on the data obtained from 250 individuals. Initial assessment of suitability for factor analysis confirmed the presence of strong correlations evidenced by a Kaiser-Meyer-Olkin (KMO) measure of 0.92 and a statistically significant Bartlett's Test of Sphericity ($P < 0.001$) and test value of 10178.489. During the analysis 24 items were excluded due to communalities falling below the established threshold of 0.2. Following the parallel analysis criterion, 7 main factors were successfully extracted and subsequently named: Social Participation (6 items), Behavioral Intention (6 items), Knowledge (7 items), Self-Efficacy (8 items), Social Support (4 items), Collective Efficacy (3 items), and Motivation for Protective Actions (3 items). The eigenvalues for these 7 factors were reported as 8.03, 7.70, 6.38, 5.43, 4.56, 4.64 and 7.02 respectively. Collectively, these seven factors accounted for 53.70% of the total variance within the HPE-Q scores, and are showed in Table 1.

Internal consistency for the 7 derived factors was assessed with Cronbach's alpha and values for all factors were greater than 0.7. The overall Cronbach's alpha for the entire 61-item scale was 0.927. The findings pertaining to convergent and discriminant validity are presented in Table 2.

The analysis of convergent and discriminant validity yielded appropriate metrics for the whole questionnaire including Composite Reliability ($CR = 0.899$), Average Variance Extracted ($AVE = 0.568$), Maximum Shared Variance ($MSV = 0.000$), $MaxR(H) = 0.928$ and $HTMT = 0.753$, supported adequate convergent and discriminant validity. Further confirmation regarding the discriminant validity for the 7 factors of the scale are presented in Table 3.

Confirmatory factor analysis

The seven-factor structure of HPE-Q was assessed through CFA, as shown in Fig. 1. At this stage the factor loadings obtained for each of the questions were evaluated. The factor loading for item number 11 was less than 0.4, so this item was removed. All model fit indices were acceptable ($IFI = 0.901$, $CFI = 0.900$, $PRATIO = 0.925$, $PNFI = 0.750$, $PCFI = 0.833$, $RMSEA = 0.060$, $CMIN/DF = 1.885$) and the goodness of fit of the model was confirmed. The number of items reached 36 at the end of this step.

Table 1 Exploratory factors extracted from the questionnaire of HPE-Q. Total cumulative variance: 53.70%

Factor name	Item	Factor load	Communalities	Percentage of variance	Eigenvalue
Social Participation	Q42. How much planning has been done in your neighborhood for informing and warning residents about emergency evacuation?	0.898	0.796	28.88	8.03
	Q39. How much have the roles of neighborhood members been defined based on their expertise and skills to enhance household preparedness for earthquakes?	0.892	0.742		
	Q40. How much equipment, such as generators and similar items for emergency situations, has been procured through the participation of neighborhood households?	0.890	0.751		
	Q41. How much have safe and secure locations equipped with sanitary facilities for emergency housing been designated in your neighborhood before an earthquake, and are residents aware of them?	0.821	0.687		
	Q38. How many training sessions on household preparedness for earthquakes are conducted by trained residents in your neighborhood?	0.794	0.657		
	Q43. How well do the residents of your neighborhood collaborate with local and municipal authorities to implement programs and actions for household preparedness against earthquakes?	0.612	0.460		
	Behavioral intention	Q61. I intend to identify safe exit routes for emergency evacuation from buildings during an earthquake.	0.914		
Q62. I intend to identify safe places in my home for taking shelter during an earthquake.		0.744	0.632		
Q60. I intend to plan for assisting vulnerable groups (the elderly, children, patients, and disabled individuals present in the home) during an earthquake.		0.605	0.564		
Q63. I intend to prepare a list of acquaintances and relatives living in another city, along with their phone numbers, to seek help from them during an earthquake.		0.550	0.496		
Q64. I intend to procure emergency equipment such as fire extinguishers for my home.		0.530	0.376		
Q59. I intend for at least one family member to participate in first aid training courses (CPR, controlling bleeding, clearing airways, transporting injured individuals, etc.).		0.419	0.347		
Knowledge		Q6. How aware are you of how to secure and stabilize household items and furniture to reduce earthquake-related injuries?	0.917	0.716	4.16
	Q5. How aware are you of how to arrange household items and furniture to minimize earthquake-related injuries?	0.864	0.655		
	Q7. How knowledgeable are you about the necessary items and equipment for an emergency kit (such as water, non-perishable food, medication) for an earthquake?	0.706	0.497		
	Q3. How aware are you of how to protect yourself during an earthquake (such as how to cover your head and face, taking shelter in a safe place, and similar actions)?	0.571	0.451		
	Q1. How knowledgeable are you about the causes of incidents such as fires, explosions, and gas leaks following an earthquake?	0.471	0.296		
	Q9. How aware are you of the needs and how to care for vulnerable groups (the elderly, disabled individuals, children, pregnant women, and patients) during an earthquake?	0.437	0.436		
	Q8. How much do you know about the location of the nearest public shelter (temporary accommodation)?	0.413	0.412		

Table 1 (continued)

Factor name	Item	Factor load	Communalities	Percentage of variance	Eigenvalue
Self-Efficacy	Q13. I can cut off the electricity, water, and gas in my home after an earthquake occurs.	0.766	0.475	2.68	5.43
	Q12. If a fire breaks out after the earthquake, I can use a fire extinguisher to put it out.	0.555	0.346		
	Q15. During an earthquake, I can guide my family members to take shelter in a safe place.	0.552	0.414		
	Q11. I know the location of the shut-off points for gas, electricity, and water in my home.	0.541	0.302		
	Q16. I have the ability to maintain my mental and emotional calm and control my feelings and emotions during and after an earthquake.	0.528	0.328		
	Q14. I have the ability to provide first aid to rescue individuals affected by the earthquake.	0.482	0.409		
	Q17. I can obtain the necessary information and training regarding household preparedness actions for earthquakes through social media and the media.	0.458	0.284		
	Q18. I can secure household items in advance to prevent them from falling during an earthquake.	0.399	0.355		
Social Support	Q36. To enhance household skills, practical in-person classes (such as first aid, fire extinguishing, etc.) are organized by responsible organizations.	0.730	0.532	2.98	4.556
	Q35. Safe and designated locations for gathering and temporary accommodation for families have been identified and communicated in advance by responsible organizations.	0.714	0.621		
	Q34. Banks provide resilient housing facilities (loans) for residential buildings or the purchase of emergency equipment for families.	0.663	0.468		
	Q37. To increase household preparedness for earthquakes, responsible organizations, including health centers and the Red Crescent, provide necessary training through media and virtual social networks.	0.625	0.418		
Collective Efficacy	Q66. In our neighborhood, a volunteer team has been formed to assist with household preparedness actions against earthquakes and rescue operations during an earthquake.	0.844	0.796	2.88	4.64
	Q65. In our neighborhood, one person has been designated as the coordinator for household preparedness actions against earthquakes.	0.768	0.798		
	Q67. In our neighborhood, drills have been conducted in various areas such as emergency evacuation from homes, sheltering in safe places, assisting and providing aid to neighborhood members, and similar activities.	0.666	0.742		
Motivation For Protective Actions	Q56. I would like to prepare an emergency kit at home (water, dry food, medicine, hygiene supplies).	0.776	0.722	1.50	7.02
	Q57. I would like to designate a meeting place for my family members to gather after an earthquake so they do not become confused and scattered.	0.675	0.664		
	Q55. I would like to secure household items and furniture to prevent them from falling during an earthquake.	0.433	0.458		

Finding of the HPE-Q reliability

Internal consistency of the questions in HPE-Q was calculated and the Cronbach’s alpha was 0.92. Interclass correlation coefficient (ICC) of the questionnaire was 0.93.

Scoring

The final HPE-Q had thirty-six items in seven main domains. The scoring method for the HPE-Q for earthquake hazard was based on a Likert scale ranging from 1 to 5.

The domain of behavioral intention was assessed on a 5-point Likert scale as follows: very unlikely (1), unlikely (2), moderately likely (3), likely (4), very likely (5). The knowledge, social participation, and motivation for protective actions are assessed as very low (1), low (2), somewhat (3), high (4), very high (5). Self-efficacy was assessed as: not at all sure (1), unsure (2), no opinion (3), sure (4), completely sure (5). Social support and collective efficacy were assessed as: strongly disagree (1), disagree (2), no opinion (3), agree (4), strongly agree (5). Considering that

Table 2 The convergent validity, discriminant validity, and internal consistency of HPE-Q

Factors	CR	AVE	MSV	MaxR (H)	Cronbach's alpha
Self-Efficacy	0.765	0.320	0.624	0.774	0.863
Social Participation	0.915	0.783	0.648	0.928	0.859
Motivation For Protective Actions	0.818	0.602	0.688	0.838	0.839
Behavioral intention	0.877	0.547	0.688	0.892	0.845
Collective Efficacy	0.927	0.679	0.648	0.938	0.898
Knowledge	0.852	0.457	0.624	0.867	0.879
Social Support	0.783	0.479	0.359	0.804	0.862

the tool consists of 36 items, the minimum score for the entire tool, was 36 and the maximum was 180.

Discussion

In the present study, the items of the tool were designed through a qualitative study [27] by conducting individual in-person interviews with households in the city of Kerman and reviewing structured articles, tools, texts, and related resources [28]. The initial tool, consisting of 88 items, entered the quantitative phase for validation. During the process of assessing the content and construct validity, the initial tool was reduced from 88 items to 36 items. Ultimately, the measurement tool for factors influencing household preparedness for earthquakes was presented with 7 constructs and 36 items, which demonstrated satisfactory validity and reliability. The constructs of this tool included knowledge (7 items), self-efficacy (7 items), social support (4 items), social participation (6 items), collective efficacy (3 items), protective motivation (3 items), and behavioral intention (6 items).

In the present study, the first subscale of HPE-Q was social participation. Community participation essentially involves the involvement of people in all processes of the disaster risk management cycle. This is a process in which people at risk or affected by disasters spontaneously or as guided participate in decision-making, planning, and implementation processes. This finding aligns with the results of studies [38, 39] that indicate the

active participation of community members in the preparedness process is crucial, and people can engage in analyzing community data, setting priorities, planning intervention activities, and making decisions regarding their community's priorities. Participatory approaches to disaster preparedness allow planners to employ methods that are well-aligned with the culture of local communities, contributing to the creation of safer and more resilient communities. Therefore, it is essential for planners to strive towards empowering the community and encouraging public participation in social activities.

The second subscale of HPE-Q was behavioral intention. Intention reflects the strength of an individual's will and determination to take actions for household preparedness against earthquakes. In a study conducted by Zarmakhzabieh et al. in Malaysia, behavioral intention was directly related to preventive actions and household preparedness for earthquakes [40]. According to the results of the study by Gomasin and Subrevilla in the Philippines, the intention to take preparedness actions was the most significant factor influencing protective behavior against natural hazards, and the greater the household's intention regarding preparedness actions for earthquakes, the more likely they are to take such actions [41].

The third subscale of HPE-Q was knowledge, taking preparedness actions requires knowledge of risk reduction measures, familiarity with appropriate action guidelines in the event of a hazard, and the ability to engage in self-protection activities before a hazard occurs [42]. Knowledge refers to the understanding of disasters and the comprehension of preparedness measures against disasters. It also includes understanding appropriate actions to save one's life during a hazard and preparing necessary equipment before a hazard occurs, which community members, including households, should have [43]. These outcomes closely corroborate the conclusions of Jahangiri et al., particularly their emphasis on the significant role of public earthquake knowledge as a primary determinant of enhanced preparedness behavior [28].

Table 3 The results of HTMT of HPE-Q

Factors	Self-Efficacy	Social Participation	Motivation For Protective Actions	Behavioral intention	Collective Efficacy	Knowledge	Social Support
Self-Efficacy	0.566						
Social Participation	0.465***	0.885					
Motivation For Protective Actions	0.520***	0.695***	0.776				
Behavioral intention	0.633***	0.735***	0.830***	0.740			
Collective Efficacy	0.354***	0.805***	0.640***	0.677***	0.824		
Knowledge	0.790***	0.382***	0.558***	0.599***	0.332***	0.676	
Social Support	0.388***	0.526***	0.487***	0.444***	0.599***	0.457***	0.692

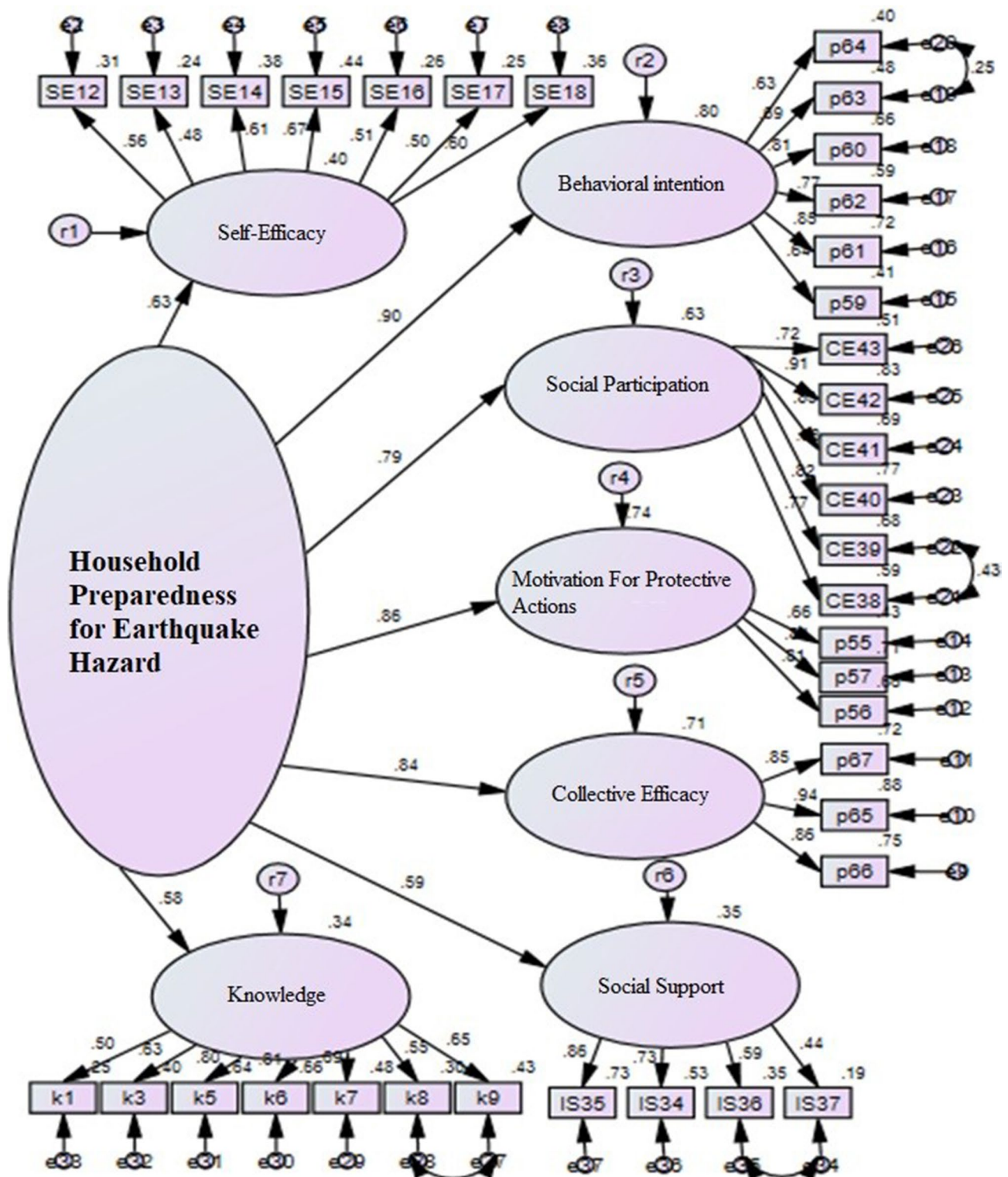


Fig. 1 The CFA model of HPE-Q

In the present study self-efficacy was the fourth sub-scale of HPE-Q. Self-efficacy is an individual’s assessment of their abilities or competencies to perform a task, achieve a goal, and produce something [44]. This

finding aligns with a study by Wei et al. in Taiwan [45], in which the researchers designed a tool to assess knowledge and self-efficacy in first aid during household incidents among parents of children under four years old,

stating that self-efficacy is a core and essential component of many health behavior theories and models [46]. In fact, self-efficacy is a factor in determining individual well-being and reducing vulnerability. In other words, self-efficacy is crucial for behavior formation and change; the higher the self-efficacy, the greater the likelihood of behavior formation and change. In disaster-related research, self-efficacy evaluates an individual's ability to initiate or complete preventive actions, protective measures, preparedness, usefulness, and effectiveness of responses.

In the present study, the fifth subscale of HPE-Q was social support. Social support interventions include the provision of humanitarian services, public services, and support from close ones [47]. Social support interventions are primarily implemented for vulnerable households, especially those that are economically disadvantaged [48]. This finding is consistent with a study by Panziri et al. in Italy, who also emphasized that social support interventions reduce families' inability to achieve preparedness for disasters. These interventions include emotional and financial support, resource sharing, education, dissemination of information through social networks, family outreach, friends, colleagues, neighbors, and non-governmental organizations [49]. The lack of social support for the preparedness of impoverished households against disasters leads to severe physical and mental health consequences following an incident. Additionally, creating social networks and providing social support services at the community level enhances residents' preparedness and resilience against disasters.

The sixth identified factor for HPE-Q was collective efficacy. Collective efficacy refers to the belief in a group's ability to coordinate actions to achieve a specific outcome. It also pertains to beliefs about a group's capability to perform certain actions that lead to desirable outcomes [50]. Various studies have shown that collective efficacy significantly influences beliefs, intentions, and behaviors related to disaster preparedness. In communities where people believe in their collective abilities to prepare for hazards and where risk-reduction behaviors align with local cultural practices, there tends to be less damage following hazards [39, 51]. Compared to self-efficacy, beliefs in collective efficacy are associated with group tasks, shared efforts, and the common thoughts of group members, as well as group progress. High collective efficacy leads to ambitious yet attainable goals, increased effort, and exceptional perseverance, while low collective efficacy results in reduced effort and lower performance [23].

In this present study the seventh identified factor for HPE-Q was protective motivation. Protective motivation triggers or sustains protective behavior. For protective motivation to be felt, the perceived sensitivity and

severity must outweigh maladaptive responses (failure to protect oneself), and perceived self-efficacy and perceived response efficacy must surpass the costs of adaptive responses (self-protection). Results from various studies indicate that the greater individuals' motivation for preventive actions against hazards, the more their intention and engagement in protective and preventive behaviors increase.

In this study, all equivalent indices of model fitness were evaluated and confirmatory factor results showed the acceptable fitness of the model. According to CFA, the questionnaire with 7 dimensions and 36 questions is a suitable tool with acceptable validity and reliability for assessing household preparedness for earthquake hazards. Our proposed methodology for validating the questionnaire, in terms of statistical rigor and Structural Equation Modeling (SEM), aligns with advanced frameworks used in other fields (such as occupational risk assessment). This comparison demonstrates that our instrument is not only psychometrically valid but also, in terms of data analysis, meets the high standards of current structural equation modeling [52].

This study had several limitations. The HPE-Q was created as a self-report tool and evaluated only within Iranian households in Kerman province. Further research is necessary to assess the HPE-Q psychometric properties at a national level and in other communities.

Conclusion

Household preparedness for earthquakes is essential for reducing vulnerability, ensuring effective response during disasters, minimizing damage and casualties, and enabling timely recovery. Various factors influence preparedness, which can either facilitate or hinder actions against earthquakes. These factors may differ across communities and even among households in the same area. Therefore, it is crucial to identify these factors before planning household training and to base interventions on them. The absence of a standardized tool for measuring factors related to earthquake preparedness is a significant barrier to accurately identifying these influences.

The HPE-Q designed to measure factors influencing household preparedness for earthquakes is valid, reliable, and practical. It can become a potential standard for assessing preparedness factors. As simply educating and raising awareness is insufficient for sustaining behavior change, this tool can help to identify household preparedness factors and develop targeted interventions based on these predictors. This approach will help allocate resources effectively, to focus efforts on elements that can improve household preparedness.

Supplementary Information

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Supplementary Material 1

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Author contributions

HF conceived the concept and design of the study. FR conducted the survey, and MN, PJ and NK were involved in data analysis and manuscript writing. HS and AI supervised the study and critically reviewed the manuscript. All authors read and reviewed the final manuscript.

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Data availability

The data can be made available upon reasonable request.

Declarations

Ethical approval

The Ethics Committee of Kerman University of Medical Sciences approved the study proposal under the code of ethics of IR.KMU.REC.1400.719. All methods were performed in accordance with the relevant guidelines and regulations; this study did not include animals. Informed written consent was obtained from all participants. Confidentiality and anonymity of the participants were ensured by coding the questionnaires. Study participants were informed clearly about their freedom to opt out of the study at any point of time without justifying for doing so.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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