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Exploring the relationship between risk perception and public disaster mitigation behavior in geological hazard emergency management: a research study in Wenchuan county

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Abstract

Modern disaster emergency management emphasizes the collaborative participation of multiple parties. Exploring the relationship between risk perception and mitigation behaviors of the public is essential to develop the effectiveness of public disaster reduction and improve the performance of emergency management. Based on risk perception theory, a research framework on the relationship between risk perception and mitigation behaviors was constructed by selecting two phases of emergency management: pre-disaster preparation and mid-disaster emergency response. The results showed that self-efficacy positively influenced the pre-disaster mitigation behaviors and emergency evacuation behavior. Perceived severity only positively influenced the emergency evacuation behavior in mid-disaster. Additionally, pre-disaster evacuation drills positively influenced the emergency evacuation behavior and the behavior of asking for help from government departments in mid-disaster. The results indicate that pre-disaster mitigation behaviors can have a significant impact on mid-disaster behaviors only if pre-disaster mitigation behaviors provide clear guidance for the emergency phase of the disaster. Therefore, pre-disaster mitigation activities should be carried out strategically with the aim of improving the public's emergency self-help capabilities in disasters, which provides theoretical and practical guidance for improving the

effectiveness of public disaster mitigation and improving the government's disaster emergency management system.

Keywords: Geological disasters, emergency management, risk perception, mitigation behavior

INTRODUCTION

China is one of the countries that suffer most from geological hazards globally. Common geological hazards, such as debris flows, landslides, and avalanches, are usually devastating, and the timing, location, and scale of disasters are uncertain, posing a significant threat to people's lives and property[1]. As shown in Figure 1, the published data from the National Bureau of Statistics of China indicate that the most serious direct losses due to geological disasters in China during 2007-2021 were 10.43 billion yuan in 2013[2]. Overall, the threat of geologic hazards has improved. In recent years, there has been a certain decline in the number of disasters and human casualties compared to around 2010. However, the frequency of disasters and direct economic losses has shown a slight upward trend again after 2018, with annual casualties consistently exceeding one hundred people and annual economic losses of about 300 million yuan. In particular, global climate change has become more drastic, and extreme weather events and disasters have become more frequent in recent years. Therefore, the situation of disaster emergency management in China is still serious, and the disaster emergency management work of the government is severely tested.

In traditional disaster emergency management, the government typically assumes the role of the rescuer, while the public is viewed as victims[3]. However, under the current trend of socialization of disaster risk reduction, there is a growing diversification of stakeholders involved in disaster emergency management. The "14th Five-Year National Comprehensive Disaster Prevention and Reduction Plan"[4] explicitly states the need to "support and guide the participation of social forces in comprehensive risk investigation, hidden danger identification and remediation, emergency rescue, disaster relief donations, livelihood assistance, recovery and reconstruction, psychological counseling and social work, and popular science education". And it is pointed out that the basic principles of disaster prevention and mitigation in China need to "enhance the awareness of disaster prevention and mitigation for all people, improve the level of public safety knowledge and self-help and mutual rescue skills, and effectively reduce casualties and property losses". With the development of theory and practice, it has been gradually recognized that the public is not only the disaster-bearing body but that the adaptive measures it takes are also the key to reducing disaster losses.

The theoretical and practical development of disaster governance in recent years has gradually pointed out that both government governance and public participation are key elements in achieving comprehensive and sustainable disaster risk management[5]. The traditional perspective of disaster risk management places more responsibility on the government. With the practice of the management process in reality, it is found that public participation in disaster risk management plays an important role in improving the overall disaster response capacity of society and reducing disaster losses. One of the important ways is to raise people's awareness of risks and to increase the willingness and participation of the public. Therefore, scholars have gradually shifted the focus of research to how to promote the public's participation in the process of disaster governance initiatives and disaster reduction behavior. Risk perception[6,7], public participation[5], disaster preparedness willingness[8,9], and other perspectives of individual disaster response research have gradually been emphasized.

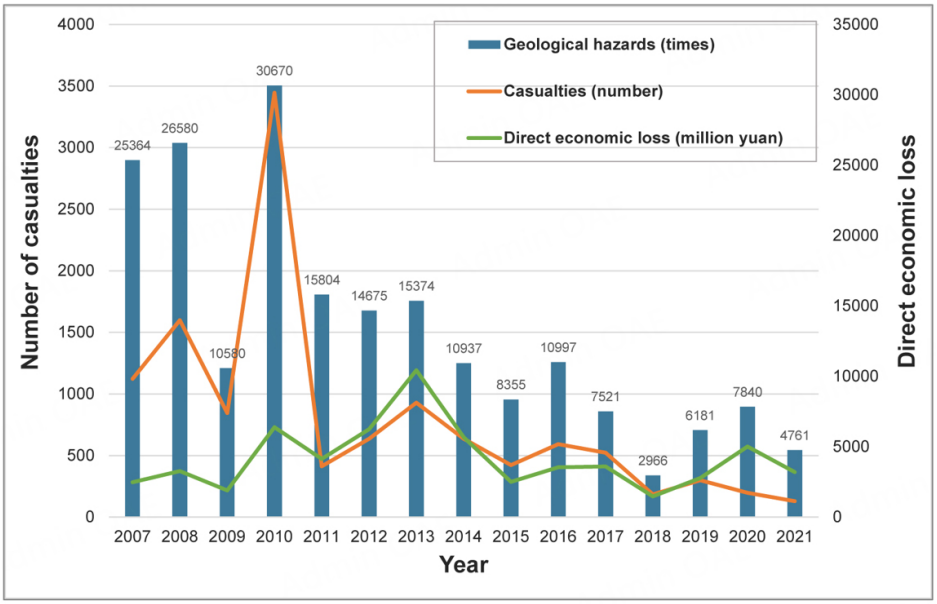

Figure 1. Statistics on the occurrence of geological disasters, casualties, and direct economic losses in China during 2007-2021.

The facilitating effect of risk perception on public behavior in disaster reduction has been validated in several natural disaster areas, such as floods[10,11], earthquakes[12], and hurricanes[13]. Risk perception is a subjective judgment that people make about the characteristics of a specific risk[14], which is also a crucial driving force for public participation in disaster mitigation and emergency management[15-17]. Based on the development process of initiation, movement, and damage caused by geological disasters, emergency management is divided into three stages: pre-disaster prevention and preparation, mid-disaster emergency response, and post-disaster recovery and reconstruction[18]. Existing scholars have mostly focused on the influence of risk perception on public disaster preparedness behaviors in a single stage, such as the pre-disaster preparation stage[15,16,19] and the mid-disaster emergency response stage[20,21]. However, there is a relative lack of research on the mechanism of how risk perception affects public disaster preparedness behaviors throughout the entire process of disaster emergency management. Therefore, employing scientific methods to study the influence of risk perception on public mitigation behaviors in the disaster emergency management holds significant theoretical and practical value. Since post-disaster recovery and reconstruction is a complex system project[22], the public mainly participates in the planning, decision-making, and implementation of reconstruction projects in this stage[18,23,24]. This differs significantly from pre-disaster preparedness and mid-disaster emergency evacuation behaviors, and due to the availability of data, this study only focuses on the first two stages (pre-disaster and mid-disaster) of the disaster emergency management.

The types of hazards of interest in this study are geologic hazards that include landslides, debris flows, collapses, and land subsides, as defined by the National Bureau of Statistics of China[2]. Areas affected by earthquakes are generally highly susceptible to subsequent geologic hazards, so the research area selected for this study is Wenchuan County in Sichuan Province, which suffered severe damage during the "5.12" Wenchuan earthquake. The study aims to comprehensively assess the public's risk perception and mitigation behaviors in selected high-risk geological hazard areas. It involves constructing a one-stage model with risk perception as the independent variable and pre-disaster preparedness behaviors as the dependent variables. Additionally, a two-stage model is developed with risk perception and pre-disaster preparedness behaviors as independent variables and mid-disaster mitigation behaviors as the dependent

variables. The study employs binomial logistic regression to examine the influence of four dimensions of risk perception, namely perceived probability, perceived severity, fear, and self-efficacy, on the public's participation in evacuation drills, stockpiling disaster supplies, and participating in disaster prevention and reduction training activities during the pre-disaster stage. Furthermore, it investigates the impact of these dimensions of risk perception on the public's mid-disaster emergency evacuation, family communication, and seeking assistance from government agencies. Assessing the relationship between risk perception and pre-disaster and mid-disaster mitigation behaviors is of great practical value to policy makers in formulating disaster prevention and mitigation policies to promote local people's participation in disaster risk management.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Literature review

Risk perception is mainly measured in three dimensions: perceived probability, perceived severity, and fear[19,25,26]. Perceived probability refers to an individual's evaluation of whether a risk event may have adverse consequences; perceived severity refers to an individual's judgment of how much a risk event will have adverse consequences, and fear implies the negative emotions that an individual feels when facing a potential threat[19,27]. However, solely considering the public's subjective perceptions of a disaster event does not effectively link risk perception with corresponding mitigation behaviors[28]. In recent years, scholars have focused on studying the influence of internal constraints, particularly self-efficacy, on public mitigation behaviors[19]. Self-efficacy is fundamentally a perceived evaluation of dealing with disaster threats, which reflects an individual's belief in their capability to adopt mitigation behaviors and can be broadly categorized within the realm of risk perception[28].

Pre-disaster preparedness involves proactive measures taken in advance, such as participating in evacuation drills, stockpiling disaster supplies, engaging in disaster prevention and mitigation training, and purchasing disaster insurance[9,19]. Emergency response in a mid-disaster stage is the response behavior of the public at the moment of disaster and within a short period of time (30 min) of the disaster. At the moment of disaster occurrence, individuals may choose to evacuate immediately or stay in their current locations[29]. Within the first 30 min of the disaster, typical behaviors include contacting family members, seeking assistance, or returning home[30]. In recent years, numerous studies have emphasized the role of risk perception in disaster risk management[11,12,31], recognizing the driving influence of risk perception on individuals' disaster prevention and mitigation activities. This understanding holds significant importance for integrating "broad social forces" into disaster risk management and improving its effectiveness.

Several scholars have conducted research on the relationship between risk perception and mitigation behaviors. Xu *et al.*, focusing on rural households in remote areas of China, found that risk perception promotes their relocation and purchase of disaster insurance as mitigation behaviors[15,32]. In particular, They[26] emphasized that the perceived severity significantly influences residents' willingness to relocate. In the context of multiple hazards, Xue *et al.* explored the community relocation decision-making process and found that residents' level of risk perception drives the decision-making process under the influence of social relationships[33]. Bourque *et al.* attempted to explain the complex relationship between risk perception and preparedness behaviors[34]. Their empirical study shows that risk perception indirectly affects preparedness through mediating factors such as knowledge and response efficacy. Pan investigated the relationship between risk perception and the adoption of protective behaviors in the mobility-disadvantage group under the threat of geological hazards, and the results showed that this group has an average level of disaster risk perception and a poor awareness of disaster preparedness due to restricted behaviors, which exacerbates overall vulnerability[35].

However, the relationship between risk perception and mitigation behavior is not completely acknowledged. Haynes *et al.* stated that "It is now understood that there is not necessarily a direct link between awareness, perceived risk and desired (by risk managers) preparations or behavioural responses"[36,37]. In the exploration of the relationship between mitigation activities and risk under three hazard types, wildfires, earthquakes, and volcanic activity, risk perception failed to form a statistically significant relationship with protective response. Similarly, Shapira *et al.* found that high levels of risk perception and evacuation behavior were not confirmed in a study of evacuation behavior in earthquake disasters[38]. Cisternas *et al.* also pointed out that the relationship between risk perception and mitigation behavior is complex, and it is not possible to conclude that risk perception is a facilitator of mitigation behavior in any disaster and cultural context[39].

The impact of risk perception on public disaster mitigation has been widely discussed by previous studies, but the results in different contexts still fail to reach a unified consensus. Moreover, this relationship has not been carefully investigated between mitigation behaviors performed during different disaster phases. Previous studies have focused on the relationship between risk perception and mitigation behavior at a particular stage. It is also worth exploring whether there is a link between the behavior between the pre-disaster and mid-disaster stages.

Research hypotheses

Risk perception and pre-disaster mitigation behaviors

Theoretically, the higher the risk perceived by the public, the more likely they are to take risk-reducing measures[10-12,40]. Therefore, risk perception is the subjective basis for the public to adopt mitigation behaviors, and the mechanisms of its different measurement dimensions on the public's mitigation behaviors are not exactly the same. In the stage of pre-disaster preparation, three mitigation behaviors of "participating in evacuation drills", "stockpiling disaster supplies", and "participating in disaster prevention and mitigation training" are selected. Based on the literature review, the more the public perceives the probability and severity of disaster, and the more fearful they are, the more the public will take mitigation behaviors. Therefore, the following hypothesis is proposed:

H1: Perceived probability, perceived severity, fear, and self-efficacy can facilitate the public to adopt mitigation behaviors in the pre-disaster preparation phase.

Risk perception, pre-disaster mitigation behavior, and mid-disaster mitigation behavior

In the stage of disaster emergency response, based on the key disaster response behaviors that have been the focus of previous researchers[5,41,42], three mitigation behaviors were selected: "emergency evacuation", "contacting family members", and "asking for help from government departments". "Emergency evacuation" is the public's instinctive response to self-protection at the moment of disaster, while "contacting family members" and "seeking help from government departments" are among the public measures to effectively reduce losses within 30 minutes of a disaster. Consistent with the pre-disaster preparation phase, the stronger the public perception of probability, severity, and fear, and the more confident they are in taking mitigation measures, the more likely they are to adopt mitigation behaviors during the emergency response phase. Therefore, the following hypothesis is proposed:

H2: Perceived probability, perceived severity, fear, and self-efficacy can facilitate the public to adopt mitigation behaviors during the mid-disaster stage.

The preparedness and emergency response phases are interrelated, and the effectiveness of mitigation behaviors largely depends on the accumulation of disaster knowledge and mitigation skills[43]. The more preparedness actions the public takes before a disaster, the better equipped and confident they are in effectively protecting themselves during unexpected geological hazards. Analyzing the characteristics of pre-disaster and mid-disaster mitigation behaviors, pre-disaster evacuation drills can enrich the public's experience and ability to evacuate in emergencies and help in emergency evacuation during disasters; storing disaster response materials is largely an effective means to sustain life while waiting for rescue, but the relationship with emergency evacuation, contacting family members, and seeking help from government departments is not yet clear; disaster mitigation publicity and training activities can improve the public knowledge base of disaster reduction and promote mitigation behaviors in all three stages. Therefore, the following hypotheses are proposed:

H3a: Participation in evacuation drills can facilitate emergency evacuation during a disaster but has less of an impact on contacting family members and asking for help from government agencies.

H3b: Storing disaster response materials has a positive effect on contacting family members in the mid-disaster stage and weak effects on emergency evacuation and asking for help from government departments.

H3c: Participation in disaster mitigation publicity and training activities can promote the public's behavior of emergency evacuation, contacting family members, and asking for help from government departments during disasters.

Research framework

Based on the previous analysis, a one-stage model of the influence of risk perception on public pre-disaster mitigation behaviors and a two-stage model of the influence of risk perception and pre-disaster mitigation behaviors on public mid-disaster mitigation behaviors are developed in this paper, as shown in Figure 2.

METHODS

Measurements

Based on the research hypothesis, the questionnaire covers two main constructs: risk perception and disaster mitigation behaviors in two stages. The details of the questionnaire's question set are presented in Table 1.

Risk perception

Perceived probability, perceived severity, fear, and self-efficacy were used as the four dimensions to measure risk perception, and each question was measured using a 5-point Likert scale ("1" for strongly disagree and "5" for strongly agree).

Disaster mitigation behaviors

"Evacuation drill activities", "storage of disaster response materials", and "disaster mitigation publicity and training" are used as pre-disaster mitigation behaviors, while "emergency evacuation", "contacting family members", and "asking for help from government departments" are considered as mid-disaster mitigation behaviors. The adoption of mitigation behaviors by the public is treated as a binary variable. If individuals engage in mitigation behaviors, they are assigned a value of 1; if they do not adopt such behaviors, they are assigned a value of 0. In particular, for the mitigation behavior of "asking for help from government departments", as long as the respondents ask for help from any of the "community (village) committee", "township government", or "public security department", this item is assigned a value of 1. If the

Table 1. Definition, assignment criteria, and statistical results of question items in the questionnaire

Variable category	Item	Definition and criteria	Mean	SD
Risk perception	Perceived probability	I live in an area with the potential for geological hazards (1-5)	3.81	1.10
		I live in a house that is located in a geological hazard-prone area (1-5)	3.39	1.29
	Perceived severity	When a geological hazard occurs, some essential supplies (electricity, telephone, water) are interrupted (1-5)	4.33	0.75
		When a geological hazard occurs, my house will be severely damaged (1-5)	3.96	0.99
		When a geological hazard occurs, my assets (crops, livestock, cars, *etc.*) will be severely damaged (1-5)	4.06	0.92
		When a geological hazard occurs, my life as well as the lives of my family members, will be in danger (1-5)	3.84	0.96
	Fear	I get fearful when I think about geological hazards (1-5)	3.96	0.97
		I would be concerned about the impact of a geological hazard on me as well as my family (1-5)	4.11	0.91
		When a geological hazard hits, I feel like the world is in chaos (1-5)	3.62	1.09
	Self-efficacy	I can keep emergency materials (food, water, emergency power, *etc.*) at home (1-5)	3.44	1.04
		I can become familiar with safe hiding spots and evacuation routes in the event of a geological hazard (1-5)	3.99	0.93
		I can reinforce my house to cope with geological hazards (1-5)	3.35	1.08
Pre-disaster mitigation behaviors	Evacuation drill activities	I have participated in evacuation drills (No = 0, Yes = 1)	0.81	0.40
	Storage of disaster response materials	I am already at home storing disaster response materials (No = 0, Yes = 1)	0.83	0.37
	Disaster mitigation publicity and training	I have participated in disaster mitigation publicity and training activities (No = 0, Yes = 1)	0.73	0.44
Mid-disaster mitigation behaviors	Emergency evacuation	When a geological hazard strikes, I will follow a safe evacuation route for emergency evacuation. (No = 0, Yes = 1)	0.91	0.29
	Contacting family members	Within 30 min of a geological hazard, I would contact my family to ask for their help or ensure their safety (No = 0, Yes = 1)	0.36	0.48
	Asking for help from government departments	Within 30 min of a geological hazard, I will ask for help from the community (village) committee (No = 0, Yes = 1)	0.48	0.50
		Within 30 min of a geological hazard, I will ask for help from the township government (No = 0, Yes = 1)	0.38	0.49
		Within 30 min of a geological hazard, I will ask for help from the public security department. (No = 0, Yes = 1)	0.12	0.32
Demographic characteristics	Gender	Male = 0, Female = 1	0.49	0.50
	Age	Under 18 years old = 1, 18-30 years old = 2, 31-45 years old = 3, 46-60 years old = 4, 60 years old and above = 5	3.25	1.11
	Education	Elementary school and below = 1, middle school = 2, high school and junior college = 3, college and undergraduate = 4, graduate and above = 5	2.11	1.10
	Monthly household income	1,000 yuan or less = 1, 1,001-2,500 yuan = 2, 2,501-4,000 yuan= 3, 4,001-5,500 yuan = 4, 5,501 yuan or more = 5	2.58	1.16
	Number of times affected by disasters	No = 0, 1-2 times=1, 3-4 times = 2, 5 - 6 times = 3, more than 6 times = 4	2.97	1.12

SD: Standard deviation.

respondents do not ask for help from any organization, the value is 0.

Demographic characteristics

Gender, age, education, monthly household income, and the number of disasters were used as demographic variables.

Data collection

This study used a combination of questionnaire research and semi-structured interviews to collect data in

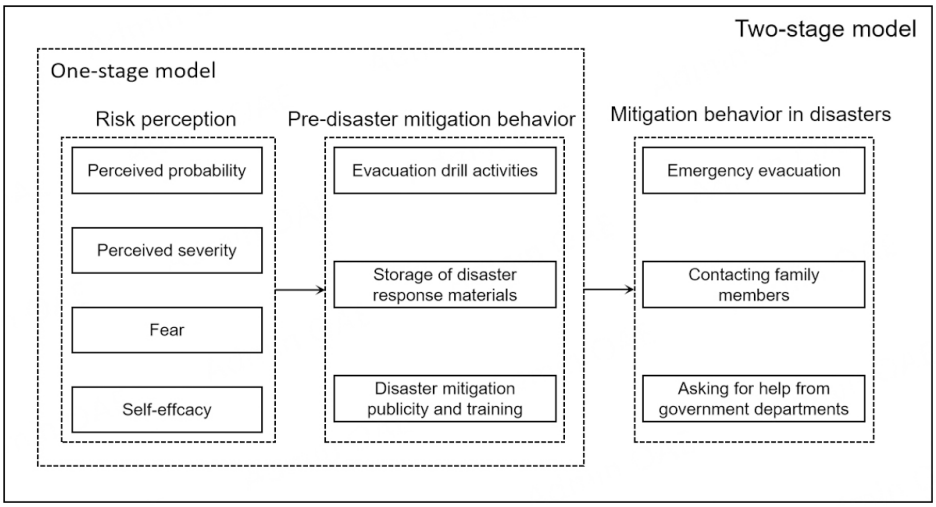

Figure 2. A theoretical framework for risk perception and public mitigation behavior in disaster emergency management.

October 2021 in Yingxiu Township, Miansi Township, Shuimo Township, and Caopo Township, which are typical geohazard-prone areas in Wenchuan County. Before the questionnaire research, the questionnaire was modified and adjusted several times according to the pretest results to form the final questionnaire. In order to ensure the reliability of the data, local residents living in Wenchuan County all year round were selected as the research subjects. Two hundred twenty-two questionnaires were collected, and after eliminating invalid questionnaires such as incomplete questionnaires, 206 valid questionnaires were obtained, with an effective rate of 92.79%.

The basic demographic information of the respondents is shown in Table 2. The number of males and females in the study sample was almost the same. Respondents covered the full range of age groups, with the middle-aged cohort of 31-60 year olds making up the majority of the sample (125, 60.7%). The educational level of the respondents was relatively low, with 67.4% having received only basic quality education and failing to receive senior high school education. The overall monthly household income is low, with the portion in the range of CNY 2,501-4,000 accounting for the largest proportion of respondents (31.1%). In addition, 92.7% of the respondents had experienced disasters due to the high prevalence of geologic hazards in the study area. Overall, the respondents' situation can basically correspond to the actual situation in the local area, which can well reflect the characteristics of the local population, and the sample data can be considered as representative to a certain extent.

Data analysis methods

Binary logit regression

A binary logit regression model of the relationship between risk perception and public mitigation behaviors pre- and mid-disaster was developed and modeled as follows[44,45]. Odds ratios (OR) describe the direction of the likelihood that the public will adopt mitigation behaviors when one of the predictors increases by one unit while the other variables remain the same[46]. If OR is greater than 1, it indicates that the increase in this predictor is positively correlated with an increase in the chance of public decisions to adopt, and if OR is less than 1, the situation is the opposite[47].

$$Y = Logit\ (P) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_j x_j \quad (1)$$

$$Odds\ ratio = \frac{P}{1-P} \quad (2)$$

Table 2. Demographic characteristics of respondents (*N* = 206)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	106	51.5%
	Female	100	48.5%
Age	< 18 years old	13	6.3%
	18-30 years old	40	19.4%
	31-45 years old	64	31.1%
	46-60 years old	61	29.6%
	> 60 years old	28	13.6%
Education level	Primary or below	79	38.3%
	Junior high school	60	29.1%
	Senior high school	34	16.5%
	Bachelor degree	32	15.5%
	Postgraduate degree	1	0.5%
Income level per month	< 1,000 CNY	43	20.9%
	1,001-2,500 CNY	57	27.7%
	2,501-4,000 CNY	64	31.1%
	4,001-5,500 CNY	28	13.6%
	> 5,501 CNY	14	6.8%
Disaster experiences	None	15	7.3%
	Once or twice	58	28.2%
	3-4 times	80	38.8%
	5-6 times	24	11.7%
	> 6 times	29	14.1%

In equation (1), Y is the dependent variable, β_0 is the constant term, β_j is the regression coefficient of the j^{th} independent variable, and x_j is the j^{th} independent variable; in equation (2), OR is the chance ratio of event occurrence, P is the probability of event occurrence, and 1 - P is the probability of event non-occurrence.

Marginal effect

OR can reveal the direction of the relationship but does not reflect the magnitude of the probability[48]. Marginal effects indicate the amount of change in the dependent variable when there is a small change in the value of the independent variable, and this can be used to describe the degree to which each independent variable affects the dependent variable[49]. Therefore, this paper further explored the effect of independent variables on the adoption of mitigation behaviors by the public by calculating the mean marginal effect results of logistic regression. The specific formula is as follows[48,50]:

$$MU_j = \frac{\Delta y}{\Delta x} = \frac{\exp(\beta_0+\beta_1 x_1+\cdots+\beta_j x_j)}{1+\exp(\beta_0+\beta_1 x_1+\cdots+\beta_j x_j)} - \frac{\exp(\beta_0+\beta_1 x_1+\cdots+\beta_{j-1} x_{j-1})}{1+\exp(\beta_0+\beta_1 x_1+\cdots+\beta_{j-1} x_{j-1})} \quad (3)$$

In Equation (3), MU_j is the marginal effect of the j^{th} variable, and β_0 and β_j are the constant term in Equation (1) and the regression coefficient of the j^{th} variable, respectively.

RESULTS

Descriptive statistical analysis

Risk perception

The mean and its dimensions are shown in Figure 3. The results show that the current average risk perception score of the local public in the study area is 3.78, which is at a slightly above-average level. It is

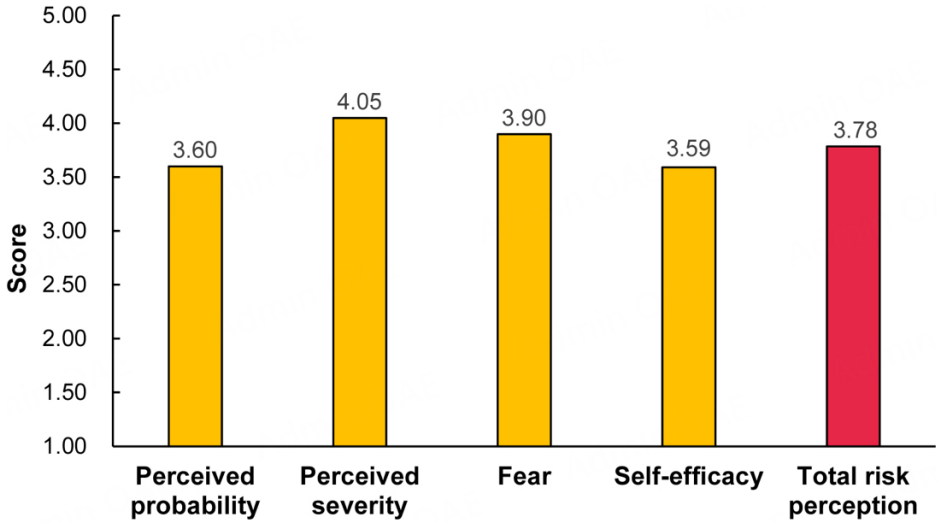

Figure 3. Descriptive analysis of the public perception of geological hazard risk in the study area of Wenchuan County.

somewhat different from the risk perception of the public shortly after the Wenchuan earthquake in 2008 (M = 7.87, measured on an 11-point scale)[20]. Among the four dimensions of risk perception, public perceived severity (Mean = 4.05) is high, i.e., they have a high assessment of the possible serious consequences of geological hazards. Fear (Mean = 3.90), perceived probability (Mean = 3.60), and self-efficacy (Mean = 3.59) are at average levels.

Disaster mitigation behaviors

As shown in Figure 4, in the pre-disaster preparation stage, the percentages of residents who had participated in evacuation drill activities, stored disaster response materials, and participated in disaster mitigation publicity and training activities were 81%, 83%, and 73%, respectively. In the emergency response (mid-disaster) stage, 91% of residents would evacuate urgently according to the safe evacuation route at the moment of the disaster, indicating that most residents have a strong sense of self-protection; within 30 min of the disaster, 36% of residents would contact their families for help or to ensure their safety. Among the government departments that the study focused on, the department that residents are most willing to turn to is the community (village) committee (48%), followed by the township government (38%), and finally, the public security department (12%).

Logit regression and marginal effect results

Logit regression and marginal effects results for the one-stage model

The one-stage model uses risk perception as the independent variable, demographic characteristics as the control variable, and whether the public adopts mitigation behaviors before a disaster as the dependent variable. The regression and marginal effect results are detailed in Table 3 and Figure 5.

Firstly, we examine the impact of risk perception on pre-disaster mitigation behavior, as shown in Table 3. Perceived probability negatively affected the public's behaviors of storing disaster response materials (OR < 1, $P < 0.05$) and participating in disaster mitigation publicity and training activities (OR < 1, $P < 0.1$). Keeping other factors at the mean, each 1-unit increase in perceived probability was associated with a 3.9% and 6.5% decrease in the probability of the public storing disaster response materials and participating in disaster mitigation publicity and training activities, respectively (marginal effects, Figure 5). However, the results of the data analysis showed that perceived severity and fear had no significant effect on the public's pre-disaster mitigation behaviors.

Table 3. Logit regression results of the one-stage model

Variable	Pre-disaster stage (odds ratio)		
	Evacuation drill activities	Storage of disaster response materials	Disaster mitigation publicity and training
Perceived probability	0.926	0.574**	0.683*
Perceived severity	0.775	1.024	0.642
Fear	1.027	1.549	1.541
Self-efficacy	2.234***	5.123***	2.479***
Gender	0.421**	1.183	0.472**
Age	0.759	0.653*	0.657**
Education level	1.076	0.909	1.101
Income level per month	1.453*	1.378	1.537**
Number of disasters experienced	1.340	3.098***	1.207
Observations	206	206	206
LR chi2(χ^2)	29.47	57.82	41.82
Prob > chi2(χ^2)	0.0005	0.0000	0.0000
Pseudo R^2	0.1453	0.3133	0.1749

Note: Standard errors in parentheses, significance levels are *P < 0.1; **P < 0.05; ***P < 0.01.

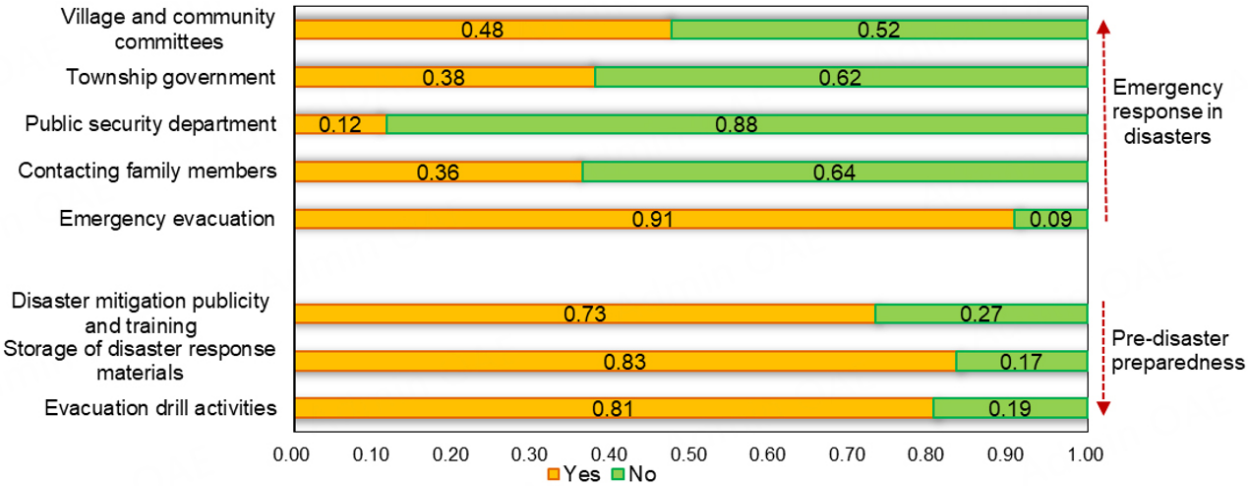

Figure 4. Descriptive analysis of public disaster mitigation behavior in the pre-disaster and mid-disaster stages in the study area.

Self-efficacy showed a significant positive effect on all three pre-disaster mitigation behaviors. Keeping other factors at their mean values, for each 1-unit increase in self-efficacy, the probability of the public participating in evacuation drill activities, storage of disaster response materials, and participation in disaster mitigation publicity and training activities increased by 10.3%, 11.5%, and 15.4%, respectively.

Secondly, the results showed that individuals with different demographic characteristics also exhibit significant differences in pre-disaster mitigation behaviors. Gender negatively affected the public's behavior in participating in evacuation drills (OR < 1, P < 0.05) and publicity and training activities (OR < 1, P < 0.05), keeping other factors at their mean values, males were 11.1% and 12.8% more likely to participate in evacuation drills and publicity and training activities than females, respectively. Age negatively affected the public's behaviors of storing disaster response materials (OR < 1, P < 0.1) and participating in disaster

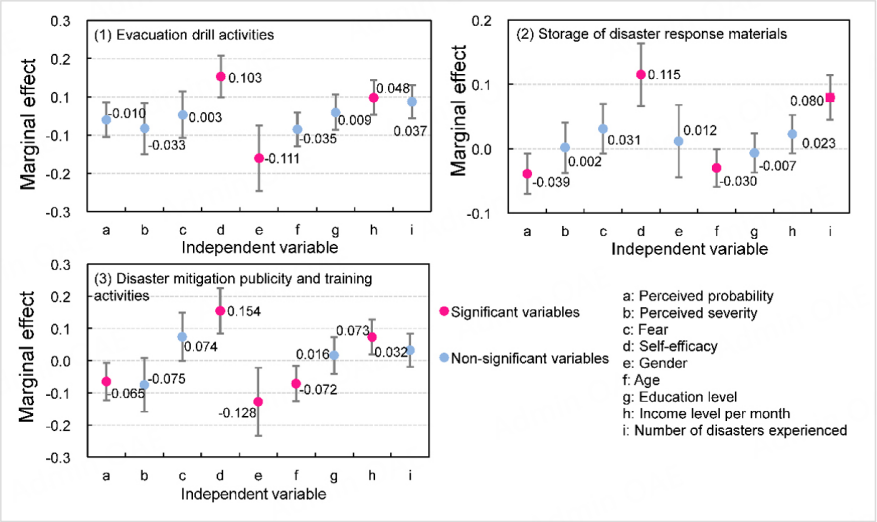

Figure 5. Marginal effects of the one-stage model. Gray lines in the figure represent 90% confidence intervals. The marginal effect values for each factor are labeled, where the points labeled in red are the factors that are significant in this stage of the binary logistic regression model.

mitigation publicity and training activities (OR < 1, $P < 0.05$). Keeping other factors at the mean, each 1-unit increase in age was associated with a 3% and 7.2% decrease in the probability of the public storage of disaster response materials and participation in disaster mitigation publicity and training activities, respectively. However, educational level had no significant effect on the public's pre-disaster mitigation behavior. The level of monthly household income positively influenced the public's behaviors in participating in evacuation drill activities (OR > 1, $P < 0.1$) and publicity and training activities (OR > 1, $P < 0.05$).

Keeping other factors at the mean, each unit increase in income increased the probability of public participation in evacuation drills and publicity and training activities by 4.8% and 7.3%. The number of disaster experiences positively (OR > 1, $P < 0.01$) influenced the public's behavior in the storage of disaster response materials. Keeping other factors at the mean, the probability of the public storage of disaster response materials increased by 8% for every 1 unit increase in the number of disaster experiences.

In terms of demographic characteristics, these categories of the public are able to exert greater mitigation energy in the pre-disaster preparation stage: males, younger age, higher income, and more disaster experiences.

Logit regression and marginal effects results for the two-stage model

The two-stage model uses risk perception and pre-disaster mitigation behavior as independent variables, demographic characteristics as control variables, and whether the public adopts mitigation behavior in mid-disaster as dependent variables, and the regression and marginal effect results are detailed in Table 4 and Figure 6.

The results of the analysis for mitigation behavior in the mid-disaster stage showed that risk perception still has a significant influence in this process. Perceived probability negatively influenced the behaviors of a public emergency evacuation (OR < 1, $P < 0.05$) and asking for help from government departments (OR < 1, $P < 0.05$). Keeping other factors at the mean, the probability of public emergency evacuation and asking for

Table 4. Logit regression results of the two-stage model

Variable	Mid-disaster stage (odds ratio)		
	Emergency evacuation	Contacting family members	Asking for help from government departments
Perceived probability	0.330**	1.339	0.629**
Perceive severity	3.845*	0.997	0.749
Fear	0.466	0.853	1.348
Self-efficacy	97.828***	0.980	1.099
Evacuation drill activities	12.482**	0.547	2.920**
Storage of disaster response materials	0.381	1.741	0.735
Disaster mitigation publicity and training activities	0.139	0.567	1.578
Gender	0.152**	1.204	0.771
Age	1.030	0.958	0.904
Education level	0.876	0.834	1.039
Income level per month	0.709	1.098	1.071
Number of disasters experienced	3.132**	0.724**	1.130
Observations	206	206	206
LR chi2 (χ^2)	72.52	14.80	25.69
Prob>chi2 (χ^2)	0.0000	0.2528	0.0119
Pseudo R^2	0.5721	0.0548	0.1084

Note: Standard errors in parentheses, significance levels are *P < 0.1; **P < 0.05; ***P < 0.01

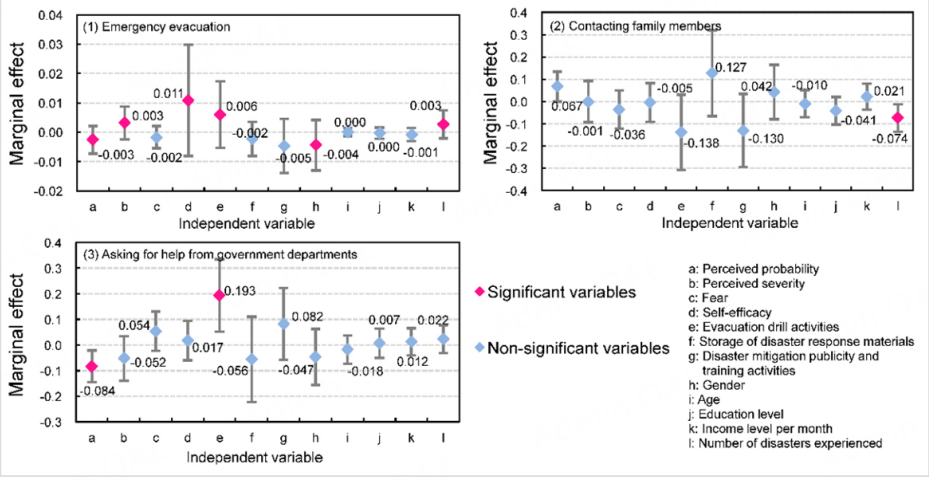

Figure 6. Marginal effects of the two-stage model. Gray lines in the figure represent 90% confidence intervals. The marginal effect values for each factor are labeled, where the points labeled in red are the factors that are significant in this stage of the binary logistic regression model.

help from government departments decreased by 0.3% and 8.4%, respectively, for each 1-unit increase in perceived probability, consistent with the pre-disaster results. Perceived severity positively influenced emergency evacuation behavior, and keeping other factors at the mean, the probability of public emergency evacuation increased by 0.3% for each unit increase in perceived severity. Fear had no significant effect on the three mitigation behaviors of the public in the mid-disaster stage, which is consistent with the pre-disaster results. Self-efficacy positively and significantly influenced emergency evacuation behavior (OR > 1, P < 0.01). Keeping other factors at their mean values, the likelihood of public emergency evacuation

increased by 1.1% for each unit increase in self-efficacy.

The relationship between the public's pre-disaster mitigation behavior and mid-disaster mitigation behavior was partially confirmed. Evacuation drills positively influenced the public's behavior in emergency evacuation (OR > 1, $P < 0.05$) and asking for help from government departments (OR > 1, $P < 0.05$). The probability of public emergency evacuation and asking for help from government departments increased by 0.6% and 19.3%, respectively, for every 1 unit increase in evacuation preparedness, keeping other factors at the mean. However, storage of disaster response materials and participation in disaster mitigation publicity and training activities had no significant effect on the public's behavior in emergency evacuation, contacting family members, and asking for help from government departments in mid-disaster.

Individual characteristics remain a partial influence on participation in mid-disaster mitigation behaviors. Gender negatively influenced emergency evacuation behavior (OR < 1, $P < 0.05$). Keeping other factors at the mean, males were 0.4% more likely than females to perform an emergency evacuation in the event of a disaster. Age, education level, and income level of the household per month had no significant effects on all three mitigation behaviors of the public in mid-disaster. The number of disaster experiences positively influenced emergency evacuation behavior (OR > 1, $P < 0.05$). However, the number of disaster experiences negatively influenced the behavior of contacting family members (OR < 1, $P < 0.05$). Keeping other factors at the mean, the probability of public emergency evacuation increased by 0.3%, and the probability of contacting family members decreased by 7.4% for each 1-unit increase in the number of disasters.

Overall, men and the public with more disaster experiences were more proactive in responding to unexpected geological hazards.

DISCUSSIONS

Theoretical implications

Impact of perceived probability

In terms of pre-disaster mitigation behaviors, the results showed that increased perceived probability reduced the frequency of public storage of disaster response materials and participation in disaster mitigation publicity and training activities, which was inconsistent with the study results of Hu *et al.*[19]. On the one hand, the relationship between risk perception and disaster mitigation behavior has certainly divided scholars in studies of different regions and types of disasters. The results of many studies show weak or even contradictory conclusions between risk perception and disaster response behavior to general common sense[10,51]. In the context of China's reality, this result may be due to the fact that local government departments take the majority of the responsibility for disaster mitigation. This shift in disaster response responsibility leads to anomalous results between public perceptions of severity and preparedness behavior. Individuals have a higher perceived probability (more likely to suffer disasters) but believe that this must result in more behavior by the local government to protect their lives and property. On the other hand, this result may be due to the limited sample size in the data-driven empirical research paradigm, and the accuracy of the results can be verified by continuing to conduct similar studies to enrich the sample collection method and expand the sample size. In terms of mitigation behaviors in mid-disaster, the results showed that the individuals with high perceived probability were less likely to adopt emergency evacuation and ask for help from government departments in the event of a geological disaster, which was probably consistent with the pre-disaster results. This may be due to the fact that Wenchuan County is in a multi-hazard environment affected by landslides, debris flows, and flash floods. The frequent occurrence of geological hazards tends to lead to negative emotions such as numbness and apathy among the public, and this unhealthy psychology may further influence the public not to adopt active mitigation behaviors.

Impact of perceived severity

In terms of pre-disaster mitigation behaviors, the findings showed no correlation between perceived severity and the three pre-disaster mitigation behaviors, which is consistent with the findings of Hu *et al.*[19]. In terms of mid-disaster mitigation behaviors, the individuals with high perceived severity were more likely to evacuate in an emergency when a disaster hit, which is consistent with the findings of Wang *et al.*, while perceived severity was not correlated with people' behaviors of contacting family members and seeking help from government departments when a disaster hit[52]. Many studies show that the effects of a specific disaster fade over the next two years[53,54]. Although serious disasters, such as the 2008 Wenchuan earthquake and the "8.20" debris flow, had a huge impact on local residents, such mega-disaster events occur infrequently, and their impact is gradually decreasing. Most residents believe that such a terrible geological disaster as the 2008 Wenchuan earthquake will not happen again in their lifetime[16]. However, although the negative impact of episodic mega-geological hazards on the public is gradually diminishing and does not correlate with public pre-disaster mitigation behaviors, emergency escape and evacuation remain the instinctive response of most people when they perceive a high level of disaster severity.

Impact of fear

The results of the study showed no significant correlation between fear and the public's pre-disaster and mid-disaster mitigation behaviors. The possible reason is that after the Wenchuan earthquake in 2008, local geological disaster prevention and mitigation activities were actively and orderly carried out, and local residents were mobilized to regularly participate in disaster mitigation education activities, such as studying disaster mitigation manuals, and so on. Thus, it can be seen that with the continuous improvement of emergency management systems, the public's fear of geological disasters will be reduced, and their fear of knowing the impact on pre-disaster mitigation behaviors will gradually fade. In addition, the frequency of local mega-geological hazards in Wenchuan is not high, and the frequent occurrences are some small geological hazards, which cause relatively small impacts due to the continuous improvement of mitigation construction. Therefore, the public may not take comparatively adequate mitigation actions when these small geological hazards occur.

Impact of self-efficacy

In terms of pre-disaster mitigation behaviors, the findings indicated that self-efficacy was a key factor in promoting the three pre-disaster mitigation behaviors, which is consistent with previous research findings[19,55,56]. In terms of the mitigation behaviors in the mid-disaster, the study results showed that the public with high self-efficacy is much more likely to evacuate, which indicated that the public's positive evaluation of their ability to evacuate safely is the most important basis for emergency evacuation in the mid-disaster. This showed that the public's self-efficacy is a positive evaluation of their ability to take mitigation actions, and enhancing the public's self-efficacy is one of the most important measures to improve the pre-disaster mitigation construction and enhance the efficiency of emergency management.

The influence of pre-disaster mitigation behaviors on mid-disaster mitigation behaviors

The results of the study showed that having participated in evacuation drills facilitated emergency evacuation and mitigation behavior by asking for help from government agencies during a disaster. Participation in evacuation drills and other related activities can help the public to store relatively good evacuation experience and other disaster knowledge and can further effectively guide the public to evacuate and ask for help from government departments to effectively protect their own lives in case of geological hazards.

In addition, the relationship between two pre-disaster activities-storing disaster preparedness materials and participating in disaster mitigation publicity and training activities-and the three study-selected disaster mitigation behaviors in the mid-disaster stage was not confirmed. The possible reason is that these two pre-disaster mitigation behaviors do not effectively guide the response process in the mid-disaster stage, so the link between them cannot be established. However, the unsubstantiated relationship between participation in publicity and training activities and response to disasters was unexpected. This may potentially indicate a lack of systematic publicity for the public to seek help within a short period of time after a disaster. The publicity and training activities are usually carried out in the form of distributing brochures and producing posters, which cannot confirm the effectiveness of public participation. This also confirms that the former has an impact on the latter only when the pre-disaster mitigation behavior is an effective preparation for the mitigation behavior in the mid-disaster stage.

Policy implications

Based on the results of the study, some suggestions are made to improve the construction of disaster emergency management systems at the public level.

(1) Previous analysis illustrates that the frequent occurrence of geological hazards tends to influence the public to develop negative emotions such as numbness and burnout, and these negative emotions may lead them not to adopt mitigation behaviors. Therefore, decision makers are advised to focus on the mental health of the public in geological hazard-prone areas and do the work of pre-disaster encouragement and mobilization and post-disaster reassurance to effectively guide and help them to establish a positive and optimistic mindset to face potential geological hazards.

(2) The community (village) committees are the most trusted government department by the local people in the mid-disaster stage. Communities (villages) are the smallest administrative units in China and play an important role in building disaster reduction for all people. Therefore, it is recommended that decision makers strengthen community-based mitigation activities, such as community lectures and publicity activities, to enrich public disaster knowledge, enhance public self-rescue capabilities, and help the public establish a higher sense of self-efficacy.

(3) Decision makers should consider the linkage mechanisms among the pre-disaster, mid-disaster, and post-disaster phases in the disaster emergency management and strategically develop various pre-disaster preparedness activities with the aim of improving the public's ability to save and mitigate themselves during disasters while improving post-disaster rescue and resettlement to reduce casualties and losses comprehensively.

(4) The results also show that men, younger individuals, those with higher incomes, and those with more disaster experience can play a greater role in disaster reduction. However, the mitigation energy of other groups cannot be ignored. Therefore, it is recommended that decision makers continue to play the important role of men while encouraging women to actively participate in disaster reduction, focus on helping vulnerable groups such as low-income and elderly people to participate in disaster reduction, encourage communities (villages) to set up a grassroots relief team composed of the public with rich disaster experience to carry out disaster knowledge and science popularization activities, relief during disasters and post-disaster resettlement, *etc.*, and bring into play their power in the disaster emergency management.

Limitations and future research

This study has made some valuable progress and findings, which are essential for improving emergency management systems. However, it has some limitations.

Firstly, the sample data of this study were obtained from Wenchuan County, a geological hazard-prone area in southwest China. Although this area is representative, further expansion of the study area and data collection is needed in the future to improve the representativeness and generalizability of the findings in a larger area.

Secondly, this study analyzed the relationship between risk perception and public mitigation behaviors at multiple stages, which has some theoretical and practical guidance for improving public disaster reduction effectiveness. However, this study only analyzed the pre-disaster preparation and mid-disaster emergency response phases and neglected to analyze the post-disaster recovery and reconstruction phases. In the future, the linkage mechanism of the three phases of pre-disaster preparation, mid-disaster emergency response, and post-disaster recovery and reconstruction should be studied from the perspective of the whole life cycle of emergency management.

Finally, although one of the study's focuses was on the public's mitigation behaviors in the pre-disaster and mid-disaster phases, the study used the public's own reported behaviors as a substitute for this section due to the difficulty of obtaining on-site information at the time of the occurrence of the disaster during the study design and research process. It would greatly enhance the value of future research if first-hand, on-site disaster data could be obtained at the time of the disaster.

CONCLUSIONS

Giving full play to the mitigation capacity of the public is a key task to realize multi-level participation in disaster emergency management. Based on the comprehensive measurement of public risk perception and mitigation level in Wenchuan, a one-stage model of risk perception and pre-disaster mitigation behaviors was established, and a two-stage model including pre-disaster mitigation behaviors and mid-disaster mitigation behaviors was developed, and then the mechanism of risk perception on public mitigation behavior in pre-disaster and mid-disaster and the linkage between the two stages in pre-disaster and mid-disaster were analyzed. The following conclusions can be drawn:

(1) The residents of Wenchuan County have an average level of overall risk perception, a high awareness of disaster preparedness, and a strong sense of self-protection in disasters.

(2) There are both similarities and differences in the mechanisms of risk perceptions in the pre-disaster and mid-disaster phases. The similarities are that perceived probability inhibits public mitigation behaviors in both pre-disaster and mid-disaster, and fear has no effect on mitigation behaviors in both phases. The differences are as follows. Perceived severity only facilitates emergency evacuation behavior in the mid-disaster stage. Self-efficacy was more significant in facilitating pre-disaster mitigation behaviors. Self-efficacy only positively affects emergency evacuation behavior in mid-disaster.

(3) There is a certain linkage between the pre-disaster and mid-disaster phases, but only when the pre-disaster mitigation behaviors are effective preparations for the mid-disaster mitigation behaviors do the linkage effect between the two phases become apparent.

(4) In terms of demographics, men, individuals with higher household incomes, younger age groups, and those with more disaster experience showed a stronger sense of responsibility and engagement in disaster mitigation.

DECLARATIONS

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Authors' contributions

Methodology, data processing and analyses, writing, and refining the manuscript: Cai J, Hu S
Data processing and analysis: Sun F, Tang L
Supervision and refining the manuscript: Fan G
Conceptualization, methodology, funding acquisition, supervision, and refining the manuscript: Xing H

Availability of data and materials

Not applicable.

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Conflicts of interest

All authors declare that they are bound by confidentiality agreements that prevent them from disclosing their conflicts of interest in this work.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

REFERENCES

1. Jin J, Chen P, Chen M, Cui Y, Zhang H, Ning S. A bibliometric analysis of the progress of research on natural disaster risk prevention and control based on knowledge graphs. *Disaster Sci* 2019;2:145-52. (In Chinese). DOI
2. National bureau of statistics of China, China statistical yearbook, China Statistics Press. Available from: https://data.stats.gov.cn/search.htm?s=%E5%9C%B0%E8%B4%A8%E7%81%BE%E5%AE%B3 [Last accessed on 30 Oct 2023].
3. Liu Y, Kong Z, Zhang J. Model construction and analysis of the whole process of disaster emergency management. *Disaster Sci* 2019;34:198-202. (In Chinese). DOI
4. Central People's Government of the People's Republic of China. "Fourteenth five-year plan national comprehensive disaster prevention and mitigation plan". Available from: https://www.gov.cn/zhengce/zhengceku/2022-07/22/content_5702154.htm [Last accessed on 30 Oct 2023].
5. Pearce L. Disaster management and community planning, and public participation: how to achieve sustainable hazard mitigation. *Nat Hazards* 2003;28:211-28. DOI
6. Gravina T, Figliozzi E, Mari N, Schinosa FDT. Landslide risk perception in Frosinone (Lazio, Central Italy). *Landslides*

2017;14:1419-29. DOI
7. Calvello M, Papa MN, Pratschke J, Nacchia Crescenzo M. Landslide risk perception: a case study in Southern Italy. *Landslides* 2016;13:349-60. DOI
8. Gao X, Roder G, Jiao Y, Ding Y, Liu Z, Tarolli P. Farmers' landslide risk perceptions and willingness for restoration and conservation of world heritage site of Honghe Hani Rice Terraces, China. *Landslides* 2020;17:1915-24. DOI
9. Khan G, Qureshi JA, Khan A, et al. The role of sense of place, risk perception, and level of disaster preparedness in disaster vulnerable mountainous areas of Gilgit-Baltistan, Pakistan. *Environ Sci Pollut Res Int* 2020;27:44342-54. DOI
10. Terpstra T. Flood preparedness: thoughts, feelings and intentions of the Dutch public. *Uni Twente* ;2010:163. Available from: https://research.utwente.nl/en/publications/flood-preparedness-thoughts-feelings-and-intentions-of-the-dutch- [Last accessed on 10 Nov 2023].
11. Ardaya A, Evers M, Ribbe L. What influences disaster risk perception? Intervention measures, flood and landslide risk perception of the population living in flood risk areas in Rio de Janeiro state, Brazil*Int J Disaster Risk Reduct* 2017;25:227-37. DOI
12. Mızrak S, Özdemir A, Aslan R. Adaptation of hurricane risk perception scale to earthquake risk perception and determining the factors affecting women's earthquake risk perception. *Nat Hazards* 2021;109:2241-59. DOI
13. Adjei E, Benedict BC, Murray-tuite P, Lee S, Ukkusuri S, Ge Y. Effects of risk perception and perceived certainty on evacuate/stay decisions. *Int J Disaster Risk Reduct* 2022;80:103247. DOI
14. Slovic P. Perception of risk. *Science* 1987;236:280-5. DOI PubMed
15. Xu D, Peng L, Liu S, Su C, Wang X, Chen T. Influences of sense of place on farming households' relocation willingness in areas threatened by geological disasters: evidence from China. *Int J Disaster Risk Sci* 2017;8:16-32. DOI
16. Xu D, Liu Y, Deng X, et al. Earthquake disaster risk perception process model for rural households: a pilot study from southwestern China. *Int J Environ Res Public Health* 2019;16:4512. DOI PubMed PMC
17. AlQahtany AM, Abubakar IR. Public perception and attitudes to disaster risks in a coastal metropolis of Saudi Arabia. *Int J Disaster Risk Reduct* 2020;44:101422. DOI PubMed PMC
18. Lin Y, Meng J, Wang M. Self-help, shared-help, and public-help: Japan's disaster emergency management model. *China Administration* 2022;5:136-43. (In Chinese). DOI
19. Hu S, Yu M, Que T, Fan G, Xing H. Individual willingness to prepare for disasters in a geological hazard risk area: an empirical study based on the protection motivation theory. *Nat Hazards* 2022;110:2087-111. DOI
20. Li H, Fan C, Jia J, Wang S, Hao L. Public risk perception and emergency management in sudden disasters: the case of the May 12 Wenchuan earthquake. *Managing World* 2009;6:52-60. (In Chinese).Available from: http://www.doc88.com/p-2069508907679.html[Last accessed on 30 Oct 2023]
21. Li Q, Peng Y, Gu X. Simulation of public emergency response behavior in a sudden disaster situation. In: The 15th Annual China Management Conference. 2020 Nov 6-8; Chengdu, China. DOI
22. Xu J, Lu Y. A comprehensive and integrated model for post-earthquake reconstruction system engineering. *Syst Eng Theory Pract* 2008;7:1-16. (In Chinese) Available from: http://www.cnki.com.cn/Article/CJFDTotal-XTLL200807001.htm [Last accessed on 30 Oct 2023].
23. Chen B, Li H, Wu Y. A review of the theory of post-Wenchuan earthquake reconstruction. *Urban Deve Res* 2011;18:105-11. (In Chinese) Available from: http://www.doc88.com/p-7059820915196.html [Last accessed on 30 Oct 2023].
24. Duan Z, Chen T, Yang Q. Behavioral framework and path analysis of public participation in post-disaster infrastructure reconstruction. *J Tianjin Uni* 2013;15:54-60. (In Chinese) Available from: http://www.cnki.com.cn/Article/CJFDTOTAL-TDXS201301011.htm [Last accessed on 30 Oct 2023].
25. Palm R. Urban earthquake hazards: the impacts of culture on perceived risk and response in the USA and Japan. *Appl Geogr* 1998;18:35-46. DOI
26. Xu D, Zhou W, Deng X, Ma Z, Yong Z, Qin C. Information credibility, disaster risk perception and evacuation willingness of rural households in China. *Nat Hazards* 2020;103:2865-82. DOI
27. Zaalberg R, Midden C, Meijnders A, McCalley T. Prevention, adaptation, and threat denial: flooding experiences in the Netherlands. *Risk Anal* 2009;29:1759-78. DOI PubMed
28. Xue K, Guo S, Liu Y, Liu S, Xu D. Social Networks, Trust, and disaster-risk perceptions of rural residents in a multi-disaster environment: evidence from Sichuan, China. *Int J Environ Res Public Health* 2021;18:2106. DOI PubMed PMC
29. Durage SW, Kattan L, Wirasinghe SC, Ruwanpura JY. Evacuation behaviour of households and drivers during a tornado: Analysis based on a stated preference survey in Calgary, Canada. *Nat Hazards* 2014;71:1495-517. DOI
30. Li H, Fan C, Jia J. Individual behavioral response patterns and influencing factors during earthquake disasters: the case of Lushan earthquake. *J Beijing Uni Tech* 2017;19:114-20. DOI
31. Bronfman NC, Cisternas PC, Repetto PB, Castañeda JV, Guic E. Understanding the relationship between direct experience and risk perception of natural hazards. *Risk Anal* 2020;40:2057-70. DOI PubMed
32. Xu D, Liu E, Wang X, Tang H, Liu S. Rural households' livelihood capital, risk perception, and willingness to purchase earthquake disaster insurance: evidence from southwestern China. *Int J Environ Res Public Health* 2018;15:1319. DOI PubMed PMC
33. Xue K, Cao S, Liu Y, Xu D, Liu S. Disaster-risk communication, perceptions and relocation decisions of rural residents in a multi-disaster environment: Evidence from Sichuan, China. *Habitat Int* 2022;127:102646. DOI
34. Bourque LB, Regan R, Kelley MM, Wood MM, Kano M, Mileti DS. An examination of the effect of perceived risk on preparedness behavior. *Environ Behav* 2013;45:615-49. DOI
35. Pan A. Study on mobility-disadvantage group' risk perception and coping behaviors of abrupt geological hazards in coastal rural area of China. *Environ Res* 2016;148:574-81. DOI

36. Haynes K, Barclay J, Pidgeon N. Whose reality counts? Factors affecting the perception of volcanic risk *J Volcanol Geotherm Res* 2008;172:259-72. DOI
37. Perry RW, Lindell MK. Volcanic risk perception and adjustment in a multi-hazard environment. *J Volcano Geotherm Res* 2008;172:170-8. DOI
38. Shapira S, Aharonson-daniel L, Bar-dayan Y. Anticipated behavioral response patterns to an earthquake: The role of personal and household characteristics, risk perception, previous experience and preparedness. *Int J Disaster Risk Reduc* 2018;31:1-8. DOI
39. Cisternas PC, Cifuentes LA, Bronfman NC, Repetto PB. The influence of risk awareness and government trust on risk perception and preparedness for natural hazards. *Risk Anal* Forthcoming 2023. DOI PubMed
40. Bubeck P, Botzen WJ, Aerts JC. A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Anal* 2012;32:1481-95. DOI PubMed
41. Krasko V, Rebennack S. Two-stage stochastic mixed-integer nonlinear programming model for post-wildfire debris flow hazard management: mitigation and emergency evacuation. *Eur J Oper Res* 2017;263:265-82. DOI
42. Corwin KA, Brand BD, Hubbard ML, Johnston DM. Household preparedness motivation in lahar hazard zones: assessing the adoption of preparedness behaviors among laypeople and response professionals in communities downstream from Mount Baker and Glacier Peak (USA) volcanoes. *J Appl Volcanol* 2017;6:3. DOI
43. Cvetković VM. The relationship between educational level and citizen preparedness to respond to natural disasters. *J Geogr Inst Jovan Cvijic Sasa* 2016;66:237-53. DOI
44. Cox DR. The Regression analysis of binary sequences. *J Royal Stat Soc Ser B* 1958;20:215-32. DOI
45. Niu L. A review of the application of logistic regression in educational research: common issues, implications, and suggestions. *Educ Rev* 2020;72:41-67. DOI
46. Frontczak M, Schiavon S, Goins J, Arens E, Zhang H, Wargocki P. Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. *Indoor Air* 2012;22:119-31. DOI PubMed
47. Diriye AW, Jama OM, Diriye JW, Abdi AM. Public preference for sustainable land use policies - empirical results from multinomial logit model analysis. *Land Use Policy* 2022;114:105975. DOI
48. Que T, Wu Y, Hu S, Cai J, Jiang N, Xing H. Factors influencing public participation in community disaster mitigation activities: a comparison of model and nonmodel disaster mitigation communities. *Int J Environ Res Public Health* 2022;19:12278. DOI PubMed PMC
49. Norton EC, Dowd BE, Maciejewski ML. Marginal effects-quantifying the effect of changes in risk factors in logistic regression models. *JAMA* 2019;321:1304-5. DOI PubMed
50. Menard S. Six approaches to calculating standardized logistic regression coefficients. *Am Stat* 2004;58:218-23. DOI
51. Wachinger G, Renn O, Begg C, Kuhlicke C. The risk perception paradox -implications for governance and communication of natural hazards. *Risk Anal* 2013;33:1049-65. DOI PubMed
52. Wang X, Yang Z, Su C. Mindfulness to emergency evacuation: the mediating role of risk perception and self-efficacy. *Chn Prod Saf Sci Technol* 2022;18:210-5. (In Chinese). DOI
53. Sims JH, Baumann DD. Educational programs and human response to natural hazards. *Environ Behav* 1983;15:165-89. DOI
54. Weinstein ND. Effects of personal experience on self-protective behavior. *Psychol Bull* 1989;105:31-50. DOI PubMed
55. Cai J, Hu S, Que T, Li H, Xing H, Li H. Influences of social environment and psychological cognition on individuals' behavioral intentions to reduce disaster risk in geological hazard-prone areas: an application of social cognitive theory. *Int J Disaster Risk Red* 2023;86:103546. DOI
56. Yu J, Sim T, Qi W, Zhu Z. Communication with local officials, self-efficacy, and individual disaster preparedness: a case study of rural northwestern China. *Sustainability* 2020;12:5354. DOI