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Determinants of People's Secondary Hazards Risk Perception: A Case Study in Wenchuan Earthquake Disaster Areas of China

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Few studies have examined people's subjective perceptions of risk after secondary disasters. This study selected 12 towns in the areas where secondary geological hazards (SGH) occurred after the Wenchuan earthquake as the survey research areas and obtained a total of 957 valid samples to assess the risk perceptions of residents and the factors influencing them 10 years after the disaster. Using four indicators (possibility, awareness, apprehension, and impact) to construct the Resident Risk Perception Index (RRPI), the results show that residents in the affected areas have high, moderate, and low-risk perceptions of SGH at 27.59, 48.38, and 24.03% respectively. The study found that people who suffered in the past from geological disasters had a higher risk perception. Perceptions of secondary geological hazard risk varied significantly with age, education, marital status, and experience. It was also found that residents in the 30–40 age group have the highest risk perception, young people in the 20–30 age group have the highest risk awareness, and older people over 60 are more fearful of SGH. The study recommends awareness campaigns and adequate disaster preparedness exercises to improve the risk perception of local people, especially to foster ownership of learning about disasters among residents.

Keywords: secondary geological hazards, risk perception, Wenchuan earthquake disaster areas, disaster experience, risk communication, rural residents

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1 INTRODUCTION

Since the 20th century, major sudden natural disasters such as earthquakes (Tsai and Chen, 2011), tsunamis (Suppasri et al., 2013), volcanic eruptions (Muir et al., 2020), floods (Salvucci and Santos, 2020), and tornados (Silver and Grek-Martin, 2015) have occurred frequently and have become important factors affecting national economies and sustainable development (Park and Reisinger, 2010). Human casualties and damage to material property caused by disasters have increased significantly worldwide (O'Keefe et al., 1976) and the international community has faced unprecedented challenges (Lippi et al., 2010; Thomas et al., 2014). According to the EM-DAT Database (EM-DAT, 2022), there were 1,628 cases of natural disasters worldwide in the last 5 years (1 January 2017–1 January 2022).

The first rule of thumb in dealing with disasters is to avoid harm, and the perception of risk is a prerequisite. However, disaster risk has not been significantly reduced as a result of socio-economic development (IPCC, 2012). Without a proper risk perception assessment, individuals may not understand the importance of mitigating these risks (Bier, 2001). Understanding individual perceptions of risk in disaster-prone areas will assist in developing and implementing risk management measures and planning for the full disaster management cycle (Parsizadeh et al., 2015; Raikes et al., 2019). Regarding the definition of risk perception, some scholars believe that risk perception is people's awareness and understanding of the relevant characteristics of a risky thing and that it is a subjective judgement made by people about the characteristics and severity of a particular risk (Adomah Bempah and Olav Øyhus, 2017; Ullah et al., 2020). It has also been argued that risk perception is a kind of risk cognitive thinking based on an intuitive sensory experience model (Savadori et al., 2004) and is a key factor to encourage protective actions in natural disaster situations (Lindell and Perry, 2000). Psychologically, disaster risk perception is conditioned by factors internal to the individual and is sensitive to shocks and perturbations in the external environment (Gold, 1980). Existing research has envisaged the interaction between society and the environment, where the perceived environment is the primary basis for human decision-making in the process of human-environment interactions (Burton and Kates, 1964; Hewitt and Burton, 1971). Since risk perception comes from people's subjective judgment, there is often a gap between it and the objective real risk. Extensive and intensive coverage of disaster occurrence and damage may enhance people's judgment of the likelihood of a disaster occurring and the severity of its consequences, causing excessive risk perception (Slovic, 2000; Perlaviciute et al., 2017). However, lack of disaster information or asymmetry in information acquisition can lead to low levels of risk perception (Nahayo et al., 2017; Netzel et al., 2021).

The Wenchuan earthquake in 2008 caused widespread concern around the world. According to Chen et al. (2012), 69,227 people died, 374,643 were injured, and 17,923 were missing in this magnitude 8.0 earthquake. Approximately 7,967,000 buildings were completely demolished and 24,543,000 were damaged (The National Almanac of China, 2009), and the affected population was 462,400,002 (Yang et al., 2014). As the earthquake occurred in a mountainous area, more than 15,000 secondary geological hazards (SGH) occurred in a short period, including landslides, landslips, dammed lakes, and debris flows (Yin et al., 2009). The deaths and injuries caused by this earthquake brought more shocking concerns, but the devastating SGH that accompany it cannot be ignored as well. From 2010 to 2018, approximately 244 million people in China were affected by natural disasters, which included 117,299 secondary geological disasters (Xue et al., 2021). These SGH substantially increased the human, social and economic impact of the earthquake (Huang et al., 2012).

Existing studies have done extensive research on human risk perception of original natural hazards, but have mostly focused on developed countries (Lindell et al., 2016; Doyle et al., 2018), while risk perception of secondary hazards has been less studied, and a few scholars have explored the livelihood resilience of farm households in secondary hazard-prone areas (Yang et al., 2021). Therefore, the risk perceptions of residents may differ in researches comparing mountainous and non-mountainous areas and original and secondary hazards. China is a mountainous country, with 70% of its hilly settlements being concentrated residential areas for China's poor population. Frequent geological disasters in mountainous areas hinder the process of poverty alleviation and prosperity in China (Zhou et al., 2021). Data show that the local poverty rate rose from 30% to over 60% after the Wenchuan earthquake (Xinhua News Agency, 2009). The mountain settlements, especially the rural settlements in areas threatened by earthquake hazards (including SGH), are a special group and require special attention (Yong et al., 2020; Qing et al., 2021). In 2020, China attained a complete victory in the fight against poverty and scored decisive achievements in securing a full victory in building a moderately prosperous society in all respects. How to prevent a return to poverty, the risk perception of natural disasters among vulnerable groups deserves our attention even more. In this study, twelve townships in the three severely affected counties of the Wenchuan earthquake were selected as the study area and a questionnaire survey was conducted among the residents of the area with the following objectives:

1) Exploring the general and specific concerns of residents in rural disaster areas regarding SGH.
2) Assessing the perception ability of residents in rural disaster areas to the risk of SGH.
3) Studying the factors influencing the SGH perception among residents in rural disaster areas.
4) Examining the impact of key factors on SGH perceptions in a group of rural disaster area residents.

2 LITERATURE REVIEW AND RESEARCH HYPOTHESES

The concept of risk perception is derived from psychology and was first studied in the field of consumer behavior. With the socio-economic development, risk perception has also been gradually applied to the fields such as insurance and disaster science. Scholars have explored extensively the risk perceptions of different groups in response to different hazards, and the results show many differences and similarities (Walshe et al., 2018; Sun and Sun, 2019), but few studies have examined people's subjective perceptions of risk after secondary disasters. This study investigates the correlations and variations between disaster experiences, personal characteristics, risk communication, and disaster risk perception of residents in disaster areas, in the hope of improving the ability of residents in disaster areas to cope with SGH and thus enhance disaster prevention and mitigation.

Many studies have shown that disaster experience is an important factor in shaping risk perception (Bustillos Ardaya et al., 2017; Sun and Han, 2018; Venable et al., 2020). Disaster experience directly or indirectly influences residents' perceptions

of disaster risk (Tian et al., 2014), and individuals with sufficient disaster experience have an immediate understanding of the disaster situations (Hong et al., 2019). Most research results show that residents' disaster experience is positively significantly correlated with their disaster risk perception (Lo and Cheung, 2015; Xu et al., 2019a). Some scholars also argued that experience is not found to be one of the strongest correlates with perceived risk (Champ and Brenkert-Smith, 2016). Faced with the threat of disaster, the likelihood of a disaster (Yang et al., 2020), the geographical location of the disaster (Scolobig et al., 2012), and whether the affected population is evacuated (Bromet et al., 2011) all contribute to the public's different perceptions of risk. Residents of vulnerable areas generally lack the capacity needed to acquire disaster knowledge and skills (Xu et al., 2019b). Residents living in convenient geographic locations have easier access to a variety of market and technology information, so the response capability of these residents may be stronger (Zhang et al., 2012). Based on this, this study proposes hypothesis 1:

H1: Respondents' experience of disasters and the severity of the disaster were positively correlated with disaster risk perception.

In addition, personal characteristics still play an important role in impacting people's risk perception. In particular, gender, age, and educational level are the three most common indicators. However, different studies give different results. Some studies show that the severe disaster had more impact on vulnerable populations such as females, children, and low-income people (Huang et al., 2014). Females show greater fear and worry compared to males (Chen et al., 2020). Risk perception was higher among female respondents than among male respondents (Zhang and Fan, 2013). Young people's perception of disaster risk is higher than that of the elderly (Liu et al., 2018). The awareness, knowledge, and perception are higher among educated people and people having social interaction (Barua et al., 2020). An individual's socioeconomic status will have an underlying impact on disaster awareness and information-seeking behavior. For non-low socioeconomic status population groups, females show higher levels of risk awareness (Teo et al., 2018). However, other studies give conflicting results. For instance, household income and household composition do not seem to impact risk perception measures (Vásquez et al., 2018). Other studies have found that people with religious beliefs can enhance social cohesion and contribute to coping with fear and uncertainty caused by disasters (Sherry and Curtis, 2017). But non-religious people know better the protocols to follow in the event of disasters than the religious population (Ponce-Pacheco et al., 2021). Besides, some studies have made risk perception assessments on race (Senkbeil et al., 2014), public trust (Su et al., 2017), and participation in disaster-related training (Hajito et al., 2015). Economic development, socio-political systems, historical and cultural backgrounds will also influence the public's perception of risk (Zhong and Guo, 2015). Based on this, the following hypothesis 2 is made:

H2: Personal characteristics such as household structure, health status, educational background, and age of the respondents have a significant impact on their capacity to cope with disasters. However, the directions of these relationships are unknown.

On the other hand, a growing number of scholars believe that social media, information exchange, the mastery of disaster knowledge, and other communication factors have a profound impact on risk perception. Media exposure plays an invaluable role in informing residents about disasters (Xu et al., 2020). New media users can clearly understand the severity of disasters (Geng et al., 2021). Social media provides an invaluable source of data and warnings in case of disasters (Zhang et al., 2019), and can effectively facilitate crisis communication and attain situational awareness (Ogie et al., 2018). But at the peak of a disaster, the public prefers to trust information released by the government than the mass media because it is more officially reliable (Zhuang et al., 2020). It has been shown that the greater the access to disaster information, the lower the public's fear level and the greater the overall impact of risk perception (Shen et al., 2020). The lower the perception of disaster risk among those who do not know the causes of disasters (Botzen et al., 2009). Neighbors may have a strong influence on risk perception (Champ and Brenkert-Smith, 2016). For disaster knowledge, some results show that appropriate education can reduce students' fear of disasters (Yoshida et al., 2020). Among the student community, high school students have poor risk perceptions of natural hazards (Khan et al., 2020a) and demonstrate the need to incorporate earthquake risk education into the school curriculum as a first step in reducing the impact of future earthquake hazards (Baytiyeh and Ocal, 2016). residents in rural areas tend to overestimate disaster risks due to a lack of scientific knowledge, which indicates that increases in disaster preparedness can reduce the apprehensions of disasters among the masses (Khan et al., 2020b). Based on this, the following hypothesis 3 is made for this study:

H3: Information exchange and media exposure have a positive impact on disaster risk perception.

3 RESEARCH METHODS AND DATA SOURCES

3.1 Sampling and Data Collection Process

This study selected 12 towns in three counties where SGH occurred after the Wenchuan earthquake as the survey research areas (**Figure 1**) and used two forms of household visits and centralized point visits to conduct questionnaire surveys to obtain data. The survey randomly selects residents between 20 and 80 years old to fill out the questionnaire. During the investigation, if an interviewee with a low education level, illiteracy, or difficulty in answering the questionnaire is encountered, the interviewer helped to fill in the questionnaire according to the interviewee's true

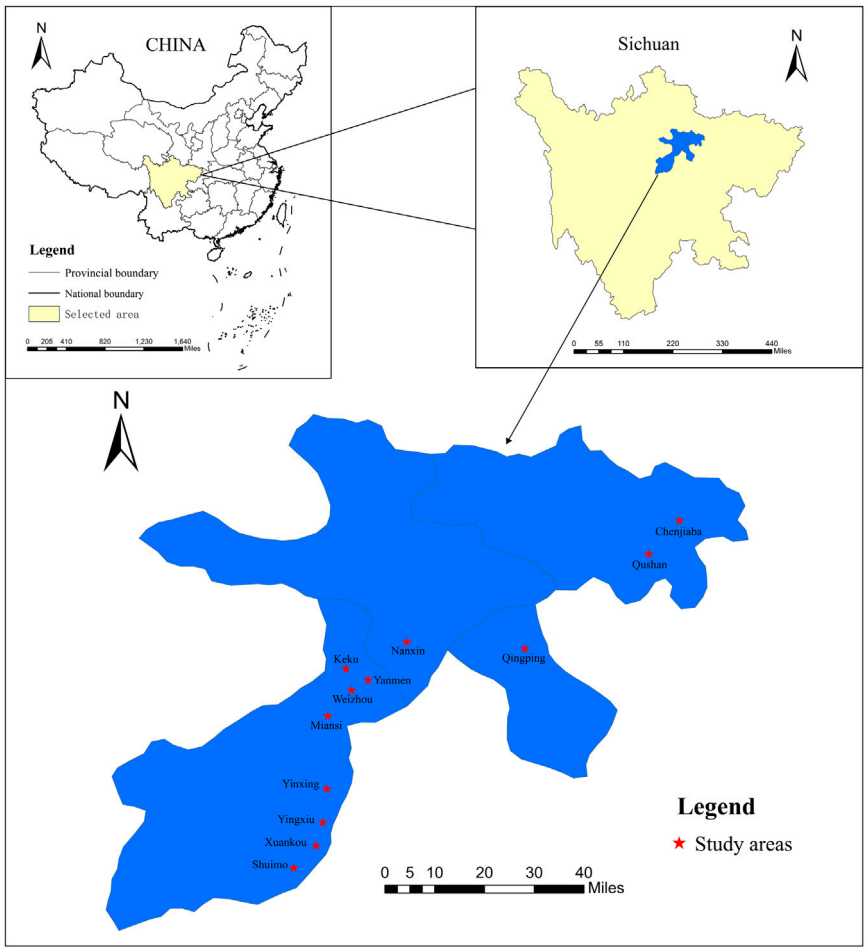

FIGURE 1 | The location of sample towns and townships.

meaning. A total of 1,000 questionnaires were distributed and 957 valid questionnaires were returned, with a validity rate of 95.7%. The specific number of valid questionnaires for each township is shown in **Figure 2**. **Figure 3** illustrates part of the interviews conducted by the research team during the field research in Beichuan and Wenchuan counties. Among them, **Figure 3A** shows the large mudslide in Chenjiaba, **Figure 3B** shows the landslide prevention actions in Chenjiaba, and **Figure 3C** and **Figure 3D** show the field research and the site where the questionnaire was done.

3.2 Research Variables

3.2.1 Risk Perception Measure

Disaster risk perception refers to the process in which individuals make subjective judgments on the characteristics and severity of disaster risks (Peng et al., 2017). By combing the existing literature (Xu et al., 2018; Qing et al., 2021), this study intended to measure the level of disaster risk perception of residents in disaster areas from four dimensions: "possibility," "awareness," "apprehension," "impact". The "possibility" indicator reflects an individual's assessment of the likelihood of a disaster occurring (Kellens et al., 2013; Lawrence et al., 2014; Xu et al., 2016). The "awareness" indicator reflects whether an individual is aware of the SGH (Grothmann and Reusswig, 2006; Ho et al., 2008). The "apprehension" indicator describes the extent to which an individual is afraid of a disaster (Li et al., 2016; Armas et al., 2017). The "impact" indicator indicates the extent to which people in the disaster area perceive the damage to their personal property and person caused by the disaster (Keown, 2010; Sun and Xue, 2020). The evaluation method of each indicator adopts a Likert scale (1–5 options) and single-choice form, allowing respondents to choose corresponding options based on their subjective judgments. The risk perception measures are shown in **Table 1**. The mean values of the four dimensions are 2.86, 2.13, 2.10, and 1.87, respectively, and the level of risk perception is basically at the middle level. They were more likely to agree that SGH causes personal and property damage (mean = 1.87), and their perception of concern for changes in the surrounding geological environment was the least different (standard deviation = 0.85).

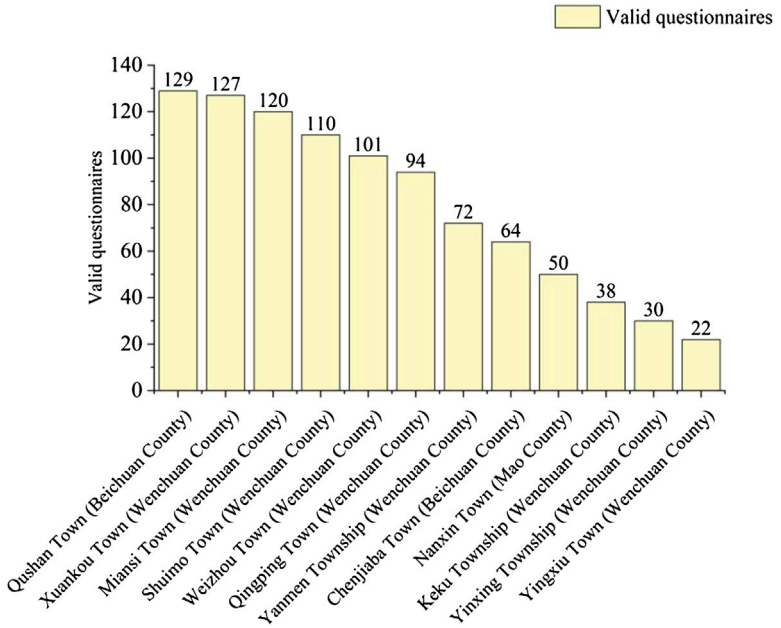

FIGURE 2 | Valid questionnaires in different regions and towns.

3.2.2 Selection of Independent Variables

This study classified the influences into disaster experience, individual characteristics, and risk communication factors. According to the characteristics of the Wenchuan earthquake-stricken area, we adopted gender, age, marital status, education level, family monthly income, and health status as control variables to measure personal characteristics. In this study, the frequency, impact, and damage caused by SGH were included in the indicator system, and five variables were selected to measure risk communication (**Table 2**).

3.3 Risk Perception Index

The risk perception level was measured through a three-digit Likert scale. 1 represents the option of "strongly agree" or "agree" on the four-dimensional Likert scale, 2 represents the option of "neutral", and 3 represents the option of "disagree" or "strongly disagree". A resident risk perception index (RRPI) was constructed and used to assess the resident risk perception to geohazards. The RRPI can be expressed by

$$RRPI = \sum_{i=1}^{n} s_{ij} \times w_i \, (n = 4) \tag{1}$$

Where s_i and w_i are the standardized data and the weight value of the index i, respectively. s_{ij} is the average value of the j_{th} option of the indicator i_{th}. The RRPI was a relative measure of geohazards risk perception for each resident, and in this study, the lower the value of RRPI, the higher the level of geohazards risk perception. Here, each indicator should be considered to have the same contribution ($w_i = 1$) to the population's perception of geohazard risk (Cutter et al., 2003; Liu et al., 2018).

4 RESULTS

4.1 Socioeconomic Characteristics

From the valid sample, the ratio of men to women is 43.68–56.32, of which 91.75% are married and 4.18% are unmarried. The age distribution of the total sample was predominantly 40 years old, accounting for 77.95%. The respondents in good health or general health accounted for 63.43%, and very poor health accounted for 11.60%. Among the interviewees, ethnic minorities account for 57.37%, and the Han nationality accounts for 42.63%. The proportion of interviewees from urban and rural areas is 24.66–75.34. Respondents have a low monthly income. Among the urban household registration respondents, 67.82% of the residents had a monthly income of less than 4,000 yuan, and among the rural household registration respondents, the figure was 82.18%. The majority of the respondents were from low-income groups. The overall level of education of the respondents was low, with 3.87% of the respondents reported to be illiterate. The majority of respondents had a middle school education level (nearly half), followed by a primary education level (32.08%).

4.2 Descriptive Statistics of Risk Perception Indicators

The four dimensions risk perception level was measured through a five-digit Likert scale. When respondents were asked if major SGH would occur in the future, 30.41% of respondents perceived "agree", followed by "disagree" (28.63%), and "neutral" (25.29%). When asked if they are always aware of geological changes in their surroundings, more than half of the respondents "agree"

FIGURE 3 | Data collection process. [**(A)**: The large mudslide in Chenjiaba. **(B)**: The landslide prevention actions in Chenjiaba. **(C,D)**: The field research.] Note: Panel 3A is provided by Associate Professor Ming Chang, State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology.

TABLE 1 | Risk perception measurement.

Dimension	Item[a]	Mean	SD[b]
Possibility	R1: I think there will be major SGH in the future	2.86	1.09
Awareness	R2: I will always pay attention to the surrounding geological changes	2.13	0.85
Apprehension	R3: I am afraid of SGH	2.10	1.14
Impact	R4: I think SGH will cause personal and property losses	1.87	0.88

[a]*1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree.*
[b]*SD = standard deviation.*

(57.68%) and a further 19.75% "strongly agree". Among the 957 respondents, nearly half (42.53%) expressed great fear of SGH (strongly agree), and 22.36% chose "agree". The majority of respondents strongly agreed (44.93%) or agreed (24.56%) that SGH can cause damage to personal property or security. More people (43.26% "disagree" and 5.85% "strongly disagree") do not think that there will be a larger earthquake in the future compared to a secondary geological hazard. A larger proportion of people strongly agreed that earthquakes cause damage to personal property and safety (52.98%) as well as being very fearful of earthquakes (53.40%).

4.3 Measurement of Resident Risk Perception Index

The scores of RRPI were initially calculated using an additive model (**Eq. 1**). The RRPI scores were divided into three grades using the mean value (MV) and standard deviation (SD) of RRPI

TABLE 2 | Influences on rural residents' disaster risk perception.

Category	Item	Mean	SD[a]
Disaster experience	C1: The number of large-scale SGH since the Wenchuan earthquake[b]	3.77	1.31
	C2: The greatest impact caused by SGH[c]	2.32	1.26
	C3: Loss caused by disaster[d]	2.83	1.17
Individual characteristics	C4: Gender (1 = male, 2 = female)	1.56	0.50
	C5: Age[e]	2.54	1.29
	C6: Marital status (1 = unmarried, 2 = married, 3 = divorced, 4 = widowed)	2.03	0.42
	C7: Education level (1 = bachelor degree or above, 2 = middle school, 3 = primary school, 4 = uneducated)	2.24	0.80
	C8: Family monthly income[f]	4.15	1.00
	C9: Health status compared with peers (1 = much better–5 = much worse)	2.93	0.80
Risk communication	C10: Whether the location has a special prevention team of SGH (1 = yes, 2 = no, 3 = don't know)	1.57	0.76
	C11: The number of local publicities for SGH (1 = a great many–5 = none)	2.90	1.01
	C12: The number of local disaster prevention drills organized by the masses (1 = a great many–5 = none)	4.30	1.12
	C13: Understanding of SGH (1 = totally know–5 = totally unknown)	2.57	0.87
	C14: Will you take the initiative to learn the knowledge related to SGH (1 = yes, 2 = no)	1.53	0.50

[a]*SD = standard deviation.*
[b]*1 = ten times a year and above, 2 = seven to nine times a year, 3 = four to six times a year, 4 = one to three times a year, 5 = none.*
[c]*1 = Very large, 2 = large, 3 = general, 4 = small, 5 = no direct impact.*
[d]*1 = more than 40,000 Yuan, 2 = 30,000 to 40,000 Yuan, 3 = 20,000 to 30,000 Yuan, 4 = less than 20,000 Yuan, 5 = none.*
[e]*1 = 61–80 years old, 2 = 51–60 years old, 3 = 41–50 years old, 4 = 31–40 years old, 5 = 20–30 years old.*
[f]*1 = more than 10,000 Yuan, 2 = 7,001 to 10,000 Yuan, 3 = 4,001 to 7,000 Yuan, 4 = 3,001 to 4,000 Yuan, 5 = less than 3,000 Yuan.*

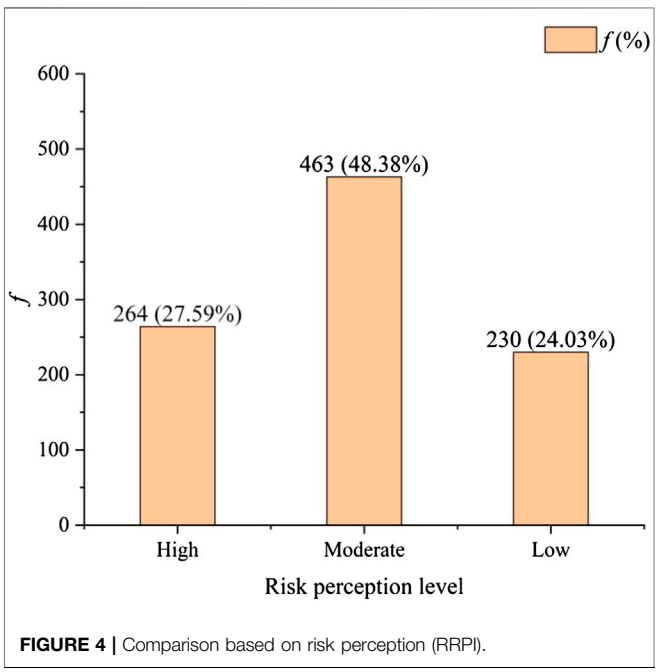

FIGURE 4 | Comparison based on risk perception (RRPI).

scores. If the RRPI score was greater than 1 SD from the MV [(RRPI score) > (MV + 1 SD)], the geohazards risk perception of residents was in a low category, if the RRPI score was lower than 1 SD from the MV [(RRPI score) < (MV − 1 SD)], the geohazards risk perception of residents was in the high category and other RRPI scores [(MV − 1 SD) ≤ (RRPI score) ≤ (MV + 1 SD)] were in the moderate category (Liu and Li, 2016). In this study, the SD, MV, maximum and minimum values of RRPI scores were 1.82, 6.08, 12, and 4, respectively. Therefore, the ranges of the high, moderate, and low categories of risk perception for residents were (4, 4.26), (4.26, 7.90), and (7.90, 12), respectively.

The results show (**Figure 4**) that nearly half of the respondents (48.38%) have moderate disaster risk perception, only 27.59% have a high perception of geohazard risk, and still, nearly a quarter of the respondents have low-risk perception. Furthermore, among the four dimensions affecting risk perception, the mean scores of possibilities, awareness, apprehension, and impact were 1.92, 1.32, 1.52, and 1.32, respectively.

4.4 Influencing Factors of Risk Perception

As can be seen from **Figure 5**, the disaster experience has had a considerable impact on the risk perceptions of residents in the affected areas. Overall, residents who have experienced more large-scale SGH since the Wenchuan earthquake have a higher risk perception, and those who experience ten or more large-scale SGH per year have the highest risk perception. For the question on the impact of SGH, more affected residents had a higher perception of risk than those who were less affected, with the largest number of residents (39.39%) being very affected. The highest risk perceptions were found among those who answered "large impact". The majority of residents (44.20%) suffered a financial loss of RMB 20,000 to 30,000 in SGH, with those who did not suffer a financial loss having the highest perception of risk.

Differences in personal characteristics can likewise lead to differences in the risk perceptions of residents in the affected areas (**Figure 6**). This study found that men were more aware than women and that women were more fearful and apprehensive than men. Overall, risk perceptions were higher among females than males in the study area. In terms of age, middle-aged people in their 40 and 50s have the highest risk perception, older people

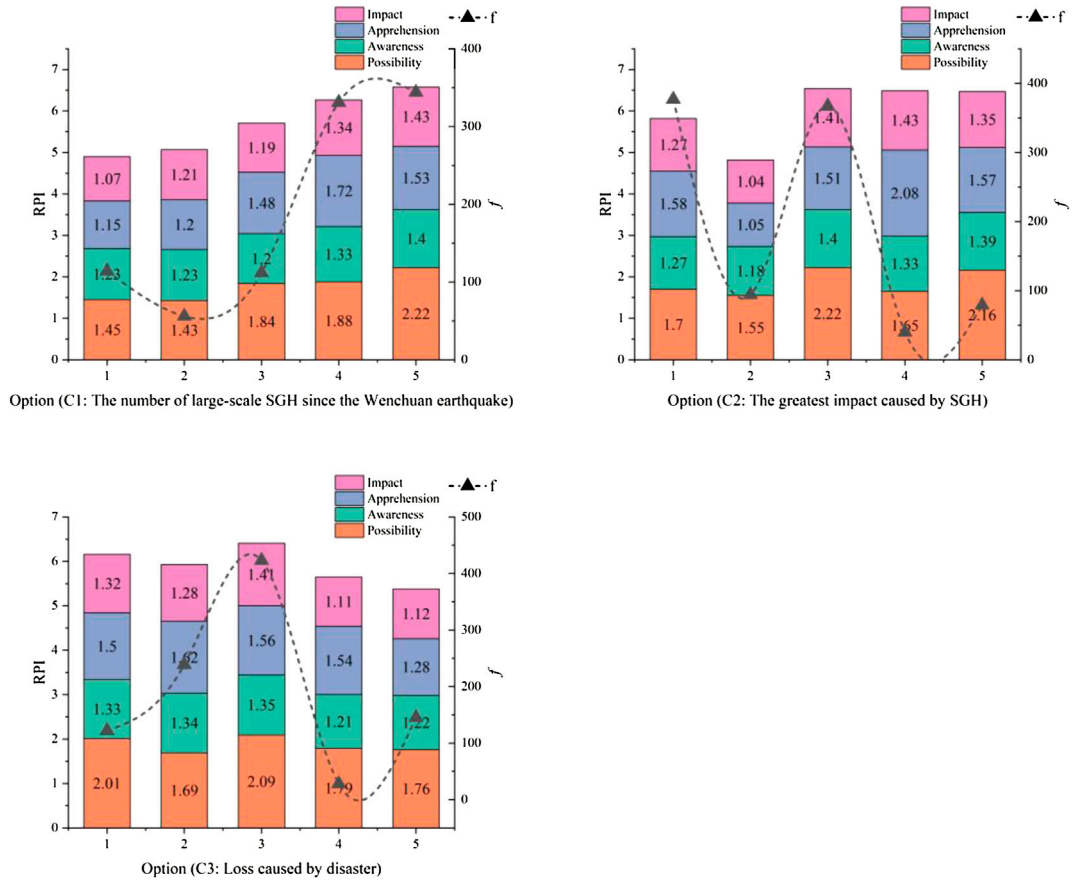

FIGURE 5 | The impact of disaster experience on risk perception.

over 60 have the highest perception of apprehension, and younger people in their 20 and 30s have the highest perception of awareness. Of all groups, the perceived risk is highest for those who are widowed, followed by those who are married. In terms of education, the majority of respondents had a primary (32.08%) or secondary (47.54%) level of education, and we found that the perception of disaster risk was highest among respondents with primary school education. In terms of economic level, households with higher incomes were more risk-perceptive than those with lower incomes, and the lowest income group of all respondents was similarly more risk-perceptive. Respondents whose health status differs significantly compared to their peers are more risk perceptive.

In terms of risk communication (**Figure 7**), respondents with a dedicated geohazard prevention team in their place of residence have a higher risk perception, and they generally have a higher risk awareness and a higher sensitivity to hazards. Over half of the respondents (59.87%) have such a disaster prevention team in their local area. From the government's point of view, if the local government publicizes SGH enough times, it will make the residents have a high perception of risk. If the government organizes enough disaster prevention drills for the public, it will likewise help improve the public's risk perception. Unfortunately, however, the majority of respondents (67.50%) indicated that they had not conducted such an exercise. From an individual perspective, if residents have more knowledge or information about the relevant SGH, they have a better understanding of the risk and have a higher risk perception. Interestingly, the study also found that residents who actively learn about SGH have a higher perception of risk, at 46.67%.

5 DISCUSSION

The Wenchuan earthquake had a huge impact on people's daily lives and psychology, with far-reaching effects. What's more, it made residents worry and fear about the SGH that accompanied the earthquake. Exploring the risk perception of SGH among residents in affected areas can help improve their resilience, which is important for avoiding or mitigating secondary damage in the affected areas. However, few studies have focused on residents' perceptions of SGH. The marginal contribution of this study is that the empirical study is used to analyze the relationship between disaster experience, personal and household characteristics, risk communication, and the perceived risk level of SGH. The results of the current study have some similarities and differences with existing studies. On the other hand, the subjects selected for this study are rural

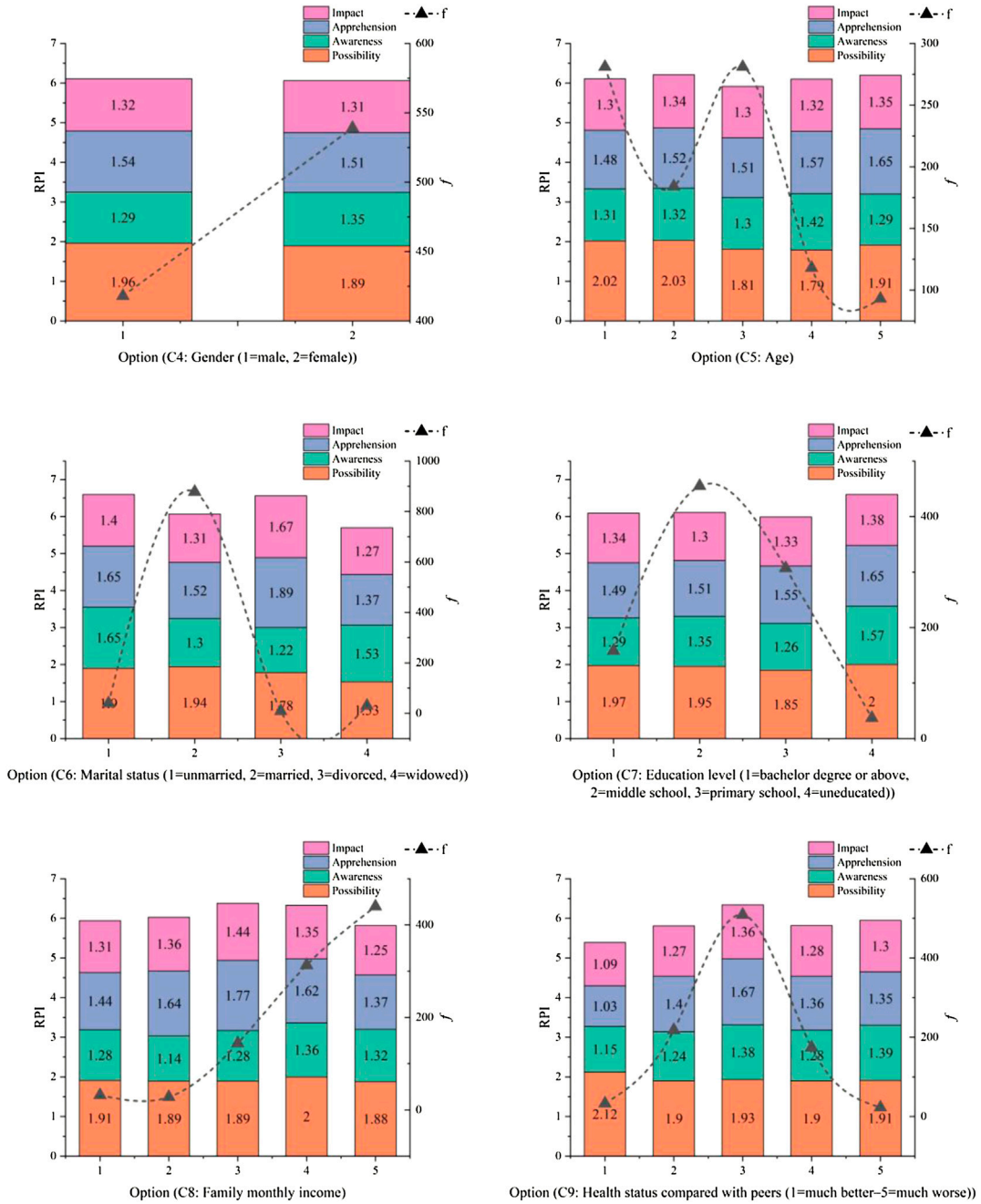

FIGURE 6 | The impact of individual characteristics on risk perception.

residents who are frequently threatened by secondary hazards and are vulnerable due to their resource endowments, which have received less attention in previous studies. In areas where mega-earthquakes have occurred, it is common sense that residents should have a high perception of SGH, but this is not the case. During the long-term study and follow-up of the affected areas, the research team found that despite the experience of the mega-earthquake, only 27.59% of respondents in the study area had a high perception of SGH, and still almost a quarter of residents (24.03%) had a low perception of risk. When confronted with the same hazards and environmental changes, some inhabitants are more psychologically vulnerable due to their inability to perceive risks and adapt to changes in time and are helpless to deal with the SGH that arises, while others are the opposite. One of the main reasons for this is that different individuals have different sensitivities to hazards and environmental changes, and different factors influence risk perception. Perceptions are differentiated and such discrepancy is an important factor in shaping different

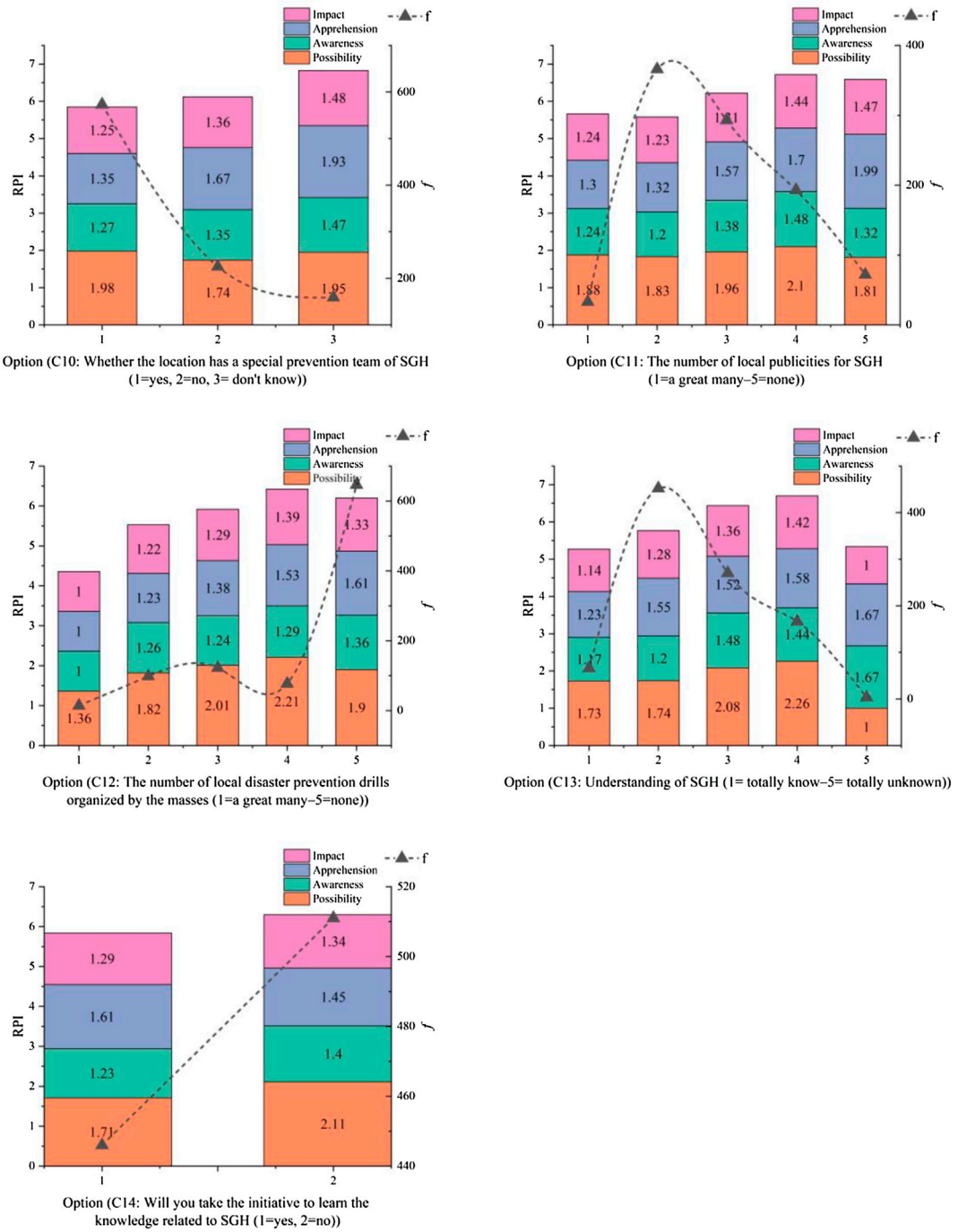

FIGURE 7 | The impact of risk communication on risk perception.

disaster prevention and mitigation decisions. It follows that understanding people's perceptions of disasters is the primary basis for a deeper understanding of their adaptation to disasters.

This study finds that residents' risk perceptions are strongly influenced and varied by disaster experiences, individual characteristics, and risk communication factors in 12 study areas where SGH had occurred. Consistent with Hypothesis 1, the number of SGH experienced by residents since the Wenchuan earthquake was positively correlated with residents' risk perception ability, that is, the more the number of SGH experienced, the higher the risk perception ability, which is similar to previous studies (McClure et al., 2015; Xu et al., 2016; Cui and Han, 2019; Xu et al., 2020). Disasters cause loss of life and property as well as inconvenience to residents, so they

are more able to imagine the emotional distress and personal loss caused by such a disaster (Siegrist and Gutscher, 2008). However, this does not mean that governments can relax their vigilance in low-risk areas, as Tian et al. (2014) argue that people who suffer more from disasters tend to be less sensitive to them, which means that governments should equally strengthen disaster awareness and risk communication in risk-prone and low-risk areas. In addition, this study finds that most of the study participants are middle-aged and the elderly and live in mountainous areas, and are unwilling to relocate due to old-fashioned thinking. When the disaster came, most of them suffered economic losses (84.8%). However, residents who did not suffer property damage had the highest risk perception. Perhaps this is because most people are more familiar and knowledgeable about SGH after experiencing financial losses, and show less apprehension and awareness of SGH. As mentioned by Mileti and Darlington (1995), whereas 80% of respondents in an earthquake risk zone believed an earthquake would occur where they lived in the next 5 years, most judged that they would not suffer injuries or loss to their property. At this point, people in the risk zones believe they will suffer less harm in a disaster than other citizens, showing relative optimism and less fear (Helweg-Larsen 1999). Similarly, Alam (2020b) study shows that even though many residents are located in high-risk areas and have observed damage caused by landslides in their immediate area, they still consider that their area is safe for living and they are at low risk. Therefore, psychosocial aspects of the community should also be included in the risk management system.

This study finds that most of the indicators of personal and household characteristics have a significant effect on the risk perception rating, which is partially consistent with Hypothesis 2. Among them, women have a higher risk perception of SGH than men, which is consistent with the findings of Kung and Chen (2012). However, the results in this study show little variation by gender, possibly because almost everyone in this small study area has experienced SGH, and this general phenomenon has resulted in a similar sensitivity to risk between men and women. Some scholars also hold contradictory views, such as Zhou et al. (2012), who argue that women have weaker perceived risk. Zhong and Guo (2015) state that there is no significant difference in risk perception by gender. This may be due to the different regions, dimensions, items, variables, and different types of hazards. In contrast, other individual characteristics have a greater impact on risk perception. In terms of age, some scholars believed that age is positively correlated with risk perception (Lindell and Hwang, 2008), although negative outcomes have also been found (Kellens et al., 2013). we found that middle-aged people in their 40 and 50s have the highest perception of risk. Education is also an important factor in perceived disaster risk, and the majority of respondents in this study had primary or secondary education, where educated respondents had significantly higher risk perceptions than uneducated ones, and our findings are consistent with those of Rahman (2019). A particular finding of this study is that respondents with primary education almost always live and work locally, are very familiar with their surroundings, and almost always live halfway up the mountain, whereas most respondents with secondary and post-secondary education chose to go out for work (Xu et al., 2020; Zhuang et al., 2020), are less familiar with the local geological environment than residents at home and have home addresses mostly near river valleys. Respondents with primary education, therefore, had the highest perception of risk. However, it has also been argued that well-educated people will believe that disasters are acts of God and will go beyond our imagination to prevent them, which can make such groups lack awareness of impending disasters (Bhandari et al., 2021). The perception of the disaster was more pronounced among the widowed, who had already lost their partner in the disaster, followed by the married, who had more complex financial and interpersonal relationships and in most cases would take into account the family situation, similar to the results of existing studies (Sun and Han, 2018; Xue et al., 2021). For low-income residents, who are less well off, show more fear and concern about SGH and are more in agreement that SGH can cause loss of life and property, which is consistent with existing research findings (Xue et al., 2021).

Risk communication is considered to be an essential factor in assessing disaster risk perception and can help citizens understand disaster risks associated with environmental hazards and promote community engagement (Moreno et al., 2016). Consistent with Hypothesis 3, this study finds that the dissemination of disaster knowledge can further enhance residents' awareness of worry, preparedness, and responsibility, which in turn improves their risk perception. Specific emergency drills and disaster prevention education can raise residents' awareness of disaster prevention and mitigation, improve emergency avoidance, self-protection, and self-rescue capabilities. Xu et al. (2020) and Zhuang et al. (2020) find that residents of disaster threatened areas in China mainly obtain disaster information through traditional media channels (mainly television and mobile phones), with relatives and friends also being important sources of information. Kao et al. (2017) also mention that pre-disaster preparedness in daily life ensures that an appropriate emergency response is executed in the event of a disaster. Emergency drill training allows the public to gain experience and familiarize themselves with how to find the correct escape routes and evacuation sites, enhancing their ability to deal with natural disaster emergencies and thus their disaster risk perception. These findings are similar to existing studies (Huang et al., 2020; Wei et al., 2020). This study finds that the way residents obtain and interpret relevant information significantly affects disaster risk perceptions, that is, risk perception is higher for those who actively learn SGH or know more about SGH (Only three people had no knowledge of SGH at all and were excluded from the analysis because of the small sample size), and knowing more disaster information can help residents overcome psychological panic when facing risk events. Research by Alcántara-Ayala and Moreno (2016) suggests that without access to information, people tend to underestimate the possibility of disasters and do not realize

the need to understand the risks and take protective measures.

This study aims to protect human life and property via disaster risk reduction to achieve sustainable development of human society. The results of the study can provide theoretical references for disaster risk management in the vast SHG-prone areas in China. As mentioned by Alam (2020a), research on risk hazards will contribute to the development and implementation of effective people-centered disaster risk reduction strategies and disaster governance. There are still some limitations in this study. Due to time constraints, this study was unable to dynamically monitor the risk perceptions of residents in the extremely hard-hit areas of the Wenchuan earthquake, and we will continue to track the risk perceptions of rural residents for SGH in the future to explore the differences in the changes of residents' perceptions of disaster risks under various impact conditions. In addition, this study is aimed at rural residents living in mountainous areas and may include consideration of urban residents in the future.

6 CONCLUSION AND POLICY IMPLICATIONS

We believe that assessing the perception of SGH among residents in the Wenchuan earthquake-affected areas can provide local governments with decision-making options regarding future disaster prevention and mitigation in rural areas, as well as for keeping residents in the affected areas out of the plight of returning to poverty. This study constructed a resident risk perception index using four indicators (possibility, awareness, apprehension, and impact) and found that:

1) In SGH-prone areas, residents have a higher risk perception of SGH (high-risk perception rate of 27.59%) compared to original hazards like earthquakes (high-risk perception rate of 17.66%), and nearly half have a moderate risk perception of SGH (48.38%).
2) Residents have less fear of SGH than earthquakes and believe that SGH has less of an impact than earthquakes. Most people do not believe that earthquakes will occur in the future, but are more likely to experience SGH.
3) Disaster experience is positively correlated with risk perception ability. In addition to gender, personal and household characteristics had a significant effect on risk perception ability. In addition, risk communication and information exchange have a positive impact on disaster risk perception.

Reducing the risk of SGH in rural areas helps to promote sustainable development in rural areas. This study also has certain policy implications. First, the government should pay more attention to vulnerable groups, especially the uneducated elderly, and should use various channels to inform the public of all types of disasters promptly and ensure the accuracy, timeliness, and transparency of information delivery. Second, the authorities should enhance health education on disaster risks, especially SGH, to improve residents' risk response capabilities, as most people indicated that they do not actively learn or understand information on SGH. Third, the authorities should regularly conduct disaster prevention exercises for relevant types of disasters to effectively raise the awareness, knowledge, and skills of residents, as the more experienced people, are in disasters, the higher their risk perception is. Fourth, the authorities need to establish a disaster risk early warning management system to detect and identify signs of disaster risk at an early stage and set up a working group on geohazard prevention and control to conduct regular and irregular hazard screening.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Chengdu University of Technology. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

HH: Funding acquisition, Investigation, Project administration, and Resources. RW: Conceptualization, Data curation, Methodology, Visualization, and Roles/Writing—original draft; YX: Conceptualization, Data curation, Methodology, Visualization, and Roles/Writing—original draft. YL: Formal analysis, Writing—review and editing. Q-FZ: Software, Supervision, and Validation. XX: Software, Supervision, and Validation.

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