

Disaster Health Literacy, Risk Perception, and Preparedness towards Resilience in a Volcano-Prone Community: A Cross-sectional Study in Yogyakarta, Indonesia



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ABSTRACT

Introduction: Communities residing in proximity to volcanoes face inherent risks from lahars. The eruption of Indonesia's Merapi volcano in 2010 had far-reaching consequences, impacting multiple districts and leading to 386 fatalities and substantial financial losses amounting to approximately US\$403 million. In order to bolster disaster response and mitigation efforts, resilience plays a crucial role by considering hazards, risks, vulnerability, and capacity. This research aimed to examine the relationship between disaster health literacy, risk perception, and preparedness, aiming to enhance resilience within a community susceptible to volcanic activities.

Methods: The study utilized a cross-sectional design involving 258 participants residing in hazard zone III areas near Yogyakarta's Merapi mountain, selected through proportional clustered sampling. Between January and February 2023, the researchers employed several assessment tools, including the Indonesian versions of the communities advancing resilience toolkit (CART-AS), disaster health literacy mitigation and preparedness questionnaire (DHLQ), disaster risk perception questionnaire (DRPQ), and disaster preparedness questionnaire (DPQ).

Results: The collected data underwent analysis utilizing descriptive statistics and the Pearson correlation test. The results unveiled that disaster health literacy ($\beta=0.22$, $p<0.001$), risk perception ($\beta=0.26$, $p<0.001$), and preparedness ($\beta=0.38$, $p<0.001$) were all significant predictors of disaster resilience in a volcano-prone community.

Conclusion: In conclusion, this study underscores the significant interplay between disaster health literacy, risk perception, and preparedness concerning disaster resilience. It emphasizes the significance of fortifying disaster health literacy, fostering accurate risk perception, and promoting preparedness measures to enhance overall disaster resilience. These findings highlight the necessity for targeted interventions and educational programs to augment disaster health literacy, improve risk perception, and enhance preparedness levels within communities, thereby effectively bolstering their resilience and response capabilities.

Keywords: Disaster health literacy; disaster risk perception; disaster preparedness; disaster resilience; volcano-prone community.

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INTRODUCTION

The number of disaster occurrences and the extent of damage caused by disasters continue to increase over time. The overall count of catastrophic incidents in 2022, amounting to 387, is slightly greater than the average recorded between 2002 and 2021, which stood at 370. In terms of fatalities, the total death toll of 30,704 in 2022 was three times higher than the previous year but lower than the average of

60,955 deaths between 2002 and 2021. To provide a more relevant comparison, the number of deaths in 2022 is nearly double the median of 16,011 deaths recorded between 2002 and 2021. Additionally, in 2022, Indonesia ranked first in Asia's highest number of natural disasters, with a total of 20 occurrences.¹

Volcanic eruptions rank among the most devastating calamities, leading to substantial casualties, societal disruptions,

environmental degradation, and economic setbacks. From 2000 to 2017, 90 volcanic activity disasters occurred, claiming the lives of 665 individuals and impacting the lives of 3 million people.² While the precise impact of volcanic activity on morbidity, including physiological and psychological stress, has not been quantified, it is likely that a larger population has been directly or indirectly affected, experiencing acute or chronic effects.³ The presence

of volcanoes close to communities poses inherent dangers in the form of lahars. The eruption of the Merapi volcano in Indonesia in 2010 resulted in extensive outcomes, affecting numerous districts and causing 386 deaths. Furthermore, significant economic damages of around US\$403 million were incurred.^{4,5}

The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priority actions to prevent new and existing disaster risks. These include: (1) Enhancing understanding of disaster risks; (2) Strengthening disaster risk governance to manage disaster risks; (3) Investing in disaster risk reduction for resilience; and (4) Improving disaster preparedness for effective response and “building back better” in recovery, rehabilitation, and reconstruction.⁶

In Indonesia, significant progress has been made in various regulations and institutions related to disaster risk reduction (DRR), with the enactment of the Disaster Management Law No. 24 of 2007, Spatial Planning Law No. 26 of 2007, and the Presidential Regulation (PERPRES) on the National Disaster Management Agency, No. 1 of 2019. The National Disaster Management Agency (BNPB) was established to enhance coordination and responsibilities for DRR among government agencies, non-governmental organizations (NGOs), international partners, and other stakeholders. Indonesia has developed internationally recognized best practices in community-based emergency response and post-disaster recovery. However, challenges remain, including coordination, human resources and technical capacity, systematic consideration of risk in development, infrastructure resilience, and the establishment of sustainable and efficient financing mechanisms related to risk reduction, preparedness, and recovery.⁷

Enhancing disaster resilience can help improve responses to disaster risks as it requires a holistic consideration of hazards, exposure, risk, vulnerability, and capacity. Programs aimed at enhancing disaster resilience have the potential to save lives while also safeguarding infrastructure, livelihoods, social systems, and the environment.⁸ Resilience, as

a multidimensional concept, has been recognized for its ability to contribute to identifying effective and efficient options for reducing and managing current and future risks.⁹ Enhancing risk perception and disaster literacy can improve disaster preparedness, ultimately enhancing community disaster resilience.^{3,10-12}

Understanding individuals’ risk perceptions is crucial for understanding their responses and interpretations of hazard events. Exploring risk perception helps comprehend how and why individuals react to hazards and interpret such events.¹³⁻¹⁶ Cultural factors, including collectivism-individualism, uncertainty avoidance, and power distance, significantly shape risk perception and impact individuals’ and governments’ responses to natural hazards.¹⁷⁻²¹

Community disaster preparedness is strongly dependent on disaster literacy and awareness. Communities must possess disaster literacy, enabling them to comprehend their region’s geographical vulnerabilities to disasters. Disaster education is significant in cultivating a resilient generation, especially among the younger population.²² By enhancing disaster literacy, individuals become more aware of the potential risks and are better equipped to mitigate losses caused by disasters.²³

According to the problem addressed by this research, there is a need to understand the relationship between disaster health literacy, risk perception, and preparedness within a community vulnerable to volcanic activities. Exploring the interconnections among these factors is crucial for identifying areas that can be enhanced and ultimately strengthening the community’s resilience against volcanic hazards. Moreover, this study aimed to investigate the relationship between disaster health literacy, risk perception, and preparedness to bolster resilience within a community susceptible to volcanic activities.

METHODS

Design, setting and sample

From January to February 2023, a cross-sectional study was conducted in hazard zone III of volcano-prone areas, Umbulharjo Village, Cangkringan District, Sleman Regency, Yogyakarta

Special Region, Indonesia. The criteria for participant inclusion were as follows: being a minimum of 18 years old, having experienced the eruption of Mount Merapi in 2010, having basic literacy skills in reading and writing, and expressing willingness to participate as respondents in the study.

The estimated sample size was determined using the Raosoft sample size calculator (<http://www.raosoft.com/samplesize.html>), with a total population of 5,312 individuals residing in nine hamlets, with a margin of error of 5% and a confidence level of 90%, which resulted in the total minimum sample size of 258. Sample proportions were calculated to determine the sample size for each hamlet. Consecutive sampling was utilized to select participants who met the research criteria within a specific time frame, ensuring the required number of respondents was met.

Data collection

The researchers conducted the study after obtaining the required research permit and approval. The researcher visited the residents of Umbulharjo Village, which comprises 9 sub-villages. Through door-to-door visits, the researchers approached households individually until the desired number of participants was reached. Once suitable participants were identified, their informed consent was obtained by completing a consent form. Following this, the participants were asked to complete a questionnaire, typically taking 5-10 minutes to finish.

Study measurements

The researchers employed five different tools for data collection. These tools comprised a socio-demographic questionnaire that gathered information on age, gender, occupation status, and educational level. Additionally, Indonesian versions of the Communities Advancing Resilience Toolkit (CART-AS), the Disaster Health Literacy Mitigation and Preparedness Questionnaire (DHLQ), the Disaster Risk Perception Questionnaire (DRPQ), and the Disaster Preparedness Questionnaire (DPQ) were utilized. The researchers obtained permission from the developer of the Indonesian versions of these questionnaires to incorporate them

into the study.

The Indonesian version of CART-AS was used to investigate disaster resilience among individuals in the volcano-prone area²⁴. The CART-AS is an instrument consisting of 27 questionnaire items. It comprises five domains: a) connection and caring, b) resources, c) transformative potential, d) information and communication, and e) disaster management. Each question utilizes a Likert scale ranging from 1 to 5 (strongly disagree to agree), with higher scores indicating better disaster resilience. The results of the factor analysis indicated that the model exhibited a good fit, as evidenced by the chi-square/df value for this instrument of 1.37, CFI value of 0.99, GFI value of 0.90, RMSEA value of 0.037, and SRMR value of 0.03.

The Indonesian version of DHLQ was used to investigate individuals' knowledge levels regarding disaster health literacy in two phases, including mitigation and preparedness among individuals in the volcano-prone area²⁵. Each phase is divided into four domains: obtaining, reading, understanding, and using information. The questionnaire consists of 68 items with "Yes" or "No" response options. The reliability test results for the disaster health literacy instrument in the mitigation phase yielded a Cronbach's Alpha value of 0.925. In contrast, in the preparedness phase, Cronbach's Alpha value was found to be 0.897.

The Indonesian version of DRPQ was used to investigate disaster risk perception among individuals in the volcano-prone area²⁶. The disaster risk perception questionnaire used consists of eight items. Each question utilizes a Likert scale with scores ranging from 1 to 4 (strongly disagree, disagree, agree, strongly agree), where higher scores indicate a better perception of disaster risk. The DRPQ Indonesian version demonstrated acceptable reliability with a score of 0.67.

The Indonesian version of DPQ was used to investigate disaster preparedness among individuals in the volcano-prone area²⁷. The disaster preparedness questionnaire consists of 31 items using the Guttman scale. There are 23 items for favorable statements and 8 items for unfavorable statements. In this study,

respondents are expected to answer clearly "Yes" or "No". A score of 1 is assigned to favorable statements, while 0 is assigned to unfavorable statements. The DPQ Indonesian version demonstrated acceptable reliability with a score of 0.89. A higher score indicates better disaster preparedness.

Statistical analysis

The collected data were analyzed using IBM SPSS Statistics (IBM Corp., Armonk, N.Y., USA). Descriptive statistics, such as frequencies, percentages, means, and standard deviations (SD), were utilized to present information on age, gender, occupation status, and educational level. The Kolmogorov-Smirnov test confirmed the normality assumption for continuous variables, indicating a normal data distribution. The assumptions for multiple linear regression analysis were assessed, including linearity, independence of errors, homoscedasticity, and multicollinearity. The results indicated that the variance inflation factor (VIF) values were below the threshold of 5, indicating no significant multicollinearity. The scatterplot of the dependent variable against each independent variable showed a relatively linear pattern without any noticeable correlation or discernible pattern. Pearson correlations were used to examine the associations between the research variables, and statistical significance was determined if the two-sided P value was less than 0.05. Finally, a multiple linear regression analysis was conducted to identify the factors influencing perceived stress.

Ethical considerations

The study received ethical approval from the Research Ethics Committee of the STIKES Surya Global Yogyakarta (Approval number: 1.14/KEPK/SSG/II/2023). All participants provided informed consent. The study involved informing participants about the objectives and procedures, their rights to confidentiality, and the option to withdraw at any point. After receiving this information, participants willingly agreed to participate by signing a consent form. This ensured that all participants were fully informed about the study's nature and voluntarily chose to participate.

RESULTS

Socio-demographics characteristics

A total of 258 individuals participated in this research, comprising 130 (30.3%) males and 128 (49.6%) females. Most participants (38.7%) fell within the age range of 24-30 years old. The largest occupational group among the respondents was farmers, accounting for 31.0% of the participants, while 38.7% had completed their senior high school education (Table 1).

Disaster resilience among participants

Table 2 shows that the average resilience score is 112.57, with a minimum value of 97 and a maximum value of 128. The domain of connection and concern has an average score of 34.30, with a minimum value of 27 and a maximum value of 40. The resource domain has an average score of 15.98, with a minimum value of 12 and a maximum value of 20. The information and communication domain has an average score of 16.24, with a minimum value of 10 and a maximum value of 20. The transformative potential domain has an average score of 24.98, with a minimum value of 20 and a maximum value of 29. The disaster management domain has an average score of 21.07, with a minimum value of 15 and a maximum value of 25.

Disaster resilience predictors

The relationship between study factors such as disaster health literacy, disaster risk perception, and disaster preparedness toward disaster resilience is shown in Table 3. The correlation between disaster resilience and disaster health literacy ($r=0.84$, $p<0.01$), risk perception ($r=0.45$, $p<0.01$), and preparedness ($r=0.19$, $p<0.01$) was significant. Furthermore, Table 4 also shows the linear regression of the study variables. Disaster health literacy ($\beta=0.22$, $p<0.001$), risk perception ($\beta=0.26$, $p<0.001$), and preparedness ($\beta=0.38$, $p<0.001$) were all significant predictors of disaster resilience in a volcano-prone community.

In terms of the CART-AS domain analysis, the first domain (connection and caring) was found to be influenced by several factors. Specifically, disaster health literacy ($\beta=0.23$, $p<0.001$), risk perception ($\beta=0.45$, $p<0.001$), and preparedness

Table 1. Participant characteristics (n=258)

Variables	f (%)
Age	
17-23	10 (3.8)
24-30	100 (38.7)
31-37	58 (22.4)
38-44	40 (15.5)
45-50	50 (19.3)
Gender	
Male	130 (50.3)
Female	128 (49.6)
Occupation status	
Farmer	80 (31.0)
Household wife	79 (30.6)
Self-employee	48 (18.6)
Private employee	51 (19.7)
Academic level	
Elementary school	68 (26.3)
Junior high school	60 (23.2)
Senior high school	100 (38.7)
Diploma	30 (11.6)

Table 2. Mean, standard deviation, minimum-maximum (min-max) of disaster resilience

Indicators	Mean	SD	Min-Max
Overall score	112.57	6.89	97-128
Domain 1 (connection and caring)	34.30	3.10	27-40
Domain 2 (resources)	15.98	1.50	12-20
Domain 3 (transformative potential)	16.24	1.43	10-20
Domain 4 (information and communication)	24.98	1.94	20-29
Domain 5 (disaster management)	21.07	1.92	15-25

($\beta=0.26$, $p<0.001$) were identified as significant predictors. This implies that individuals with higher levels of disaster health literacy, greater risk perception, and better preparedness tend to have higher scores in connection and caring.

Regarding the second domain (resources), this study discovered that disaster health literacy ($\beta=0.16$, $p=0.01$), risk perception ($\beta=0.15$, $p=0.03$), and preparedness ($\beta=0.50$, $p<0.001$) were significant predictors. This suggests that individuals with greater disaster health literacy, higher risk perception, and better preparedness are more likely to have higher scores in the resources domain.

Similarly, the third domain (transformative potential) was influenced by several factors, including disaster health literacy ($\beta=0.15$, $p=0.03$), risk perception ($\beta=0.26$, $p=0.00$), and preparedness ($\beta=0.11$, $p=0.04$). This indicates that individuals with higher disaster health literacy, who perceive greater risks and

demonstrate better preparedness, are likelier to exhibit higher scores in the transformative potential domain.

The fourth domain (information and communication) was also found to be influenced by the same factors: disaster health literacy ($\beta=0.21$, $p=0.00$), risk perception ($\beta=0.15$, $p=0.01$), and preparedness ($\beta=0.33$, $p<0.001$). This means that individuals with higher levels of disaster health literacy, increased risk perception, and improved preparedness are more likely to score higher in the information and communication domain.

Lastly, the fifth domain (disaster management) was significantly predicted by disaster health literacy ($\beta=0.12$, $p=0.04$), risk perception ($\beta=0.15$, $p=0.01$), and preparedness ($\beta=0.45$, $p<0.001$). This indicates that individuals with higher disaster health literacy, greater risk perception, and better preparedness tend to have higher scores in the disaster management domain.

As presented in Table 3, these findings highlight the influence of various factors, such as disaster health literacy, risk perception, and preparedness, on the different domains of disaster resilience. They suggest that these factors play important roles in shaping individuals' scores in each domain, emphasizing the interconnectedness between individual factors and disaster resilience.

DISCUSSION

This study aimed to investigate the relationship between disaster health literacy, risk perception, and preparedness to bolster resilience within a community susceptible to volcanic activities. The findings of this study revealed that the average total resilience score was 112.57, which approached the maximum score of 128, indicating a high level of overall resilience. The connection and caring domain had an average score of 34.30, approaching the maximum score of 40, indicating a high level of connection and caring. The resource domain had an average score of 15.98, nearing the maximum score of 20, indicating a high level of available resources. The information and communication domain had an average score of 16.24, nearing the maximum score of 20, indicating a high level of information and communication. The transformative potential domain had an average score of 24.98, nearing the maximum score of 29, indicating a high level of transformative potential. The disaster management domain had an average score of 21.07, approaching the maximum score of 25, indicating a high level of disaster management. With the average scores of all domains approaching their respective maximum values, it can be concluded that the scores for each domain related to disaster resilience among the community in the disaster-prone area of Gunung Merapi, Sleman, Yogyakarta, were high.

Furthermore, the findings of this study indicate a significant relationship between disaster risk perception and community disaster resilience in the disaster-prone area of Gunung Merapi. This aligns with the research conducted by Sadeghloo et al., which revealed a connection between disaster risk perception and disaster

Table 3. Descriptive statistics and correlations among study variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Disaster resilience total	1										
2. Disaster resilience domain 1	0.76**	1									
3. Disaster resilience domain 2	0.64**	0.66**	1								
4. Disaster resilience domain 3	0.52**	0.63**	0.54**	1							
5. Disaster resilience domain 4	0.88**	0.42**	0.45**	0.77**	1						
6. Disaster resilience domain 5	0.76**	0.54**	0.94**	0.71**	0.56**	1					
7. Disaster health literacy	0.84**	0.74**	0.55**	0.67**	0.68**	0.69**	1				
8. Disaster health literacy (mitigation)	0.29*	0.45**	0.35**	0.22**	0.24*	0.22**	0.23**	1			
9. Disaster health literacy (preparedness)	0.52**	0.68**	0.64**	0.58**	0.45**	0.40**	0.52**	0.43**	1		
10. Disaster risk perception	0.45**	0.63**	0.40**	0.76**	0.29**	0.31**	0.29**	0.83**	0.55**	1	
11. Disaster preparedness	0.19*	0.14*	0.24*	0.31**	0.29**	0.14*	0.17*	0.29**	0.31**	0.21**	1

Note: Pearson correlation was tested, *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed).

Table 4. Multiple linear regression analysis of disaster resilience predictors

Variable	Disaster resilience total		Domain 1 (connection and caring)		Domain 2 (resources)		Domain 3 (transformative potential)		Domain 4 (information and communication)		Domain 5 (disaster management)	
	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value
Disaster health literacy	0.22	<0.001	0.23	<0.001	0.16	0.01	0.15	0.03	0.21	0.00	0.12	0.04
Disaster risk perception	0.26	<0.001	0.45	<0.001	0.15	0.03	0.26	0.00	0.15	0.01	0.15	0.01
Disaster preparedness	0.38	<0.001	0.26	<0.001	0.40	<0.001	0.11	0.04	0.33	<0.001	0.45	<0.001

resilience.²⁸ In their study, Sadeghloo et al. explained that one factor supporting this relationship is the cognitive dimension of risk perception, as higher scores indicate a better understanding, awareness, and knowledge of risks.²⁸ Recognizing the causes of a crisis and understanding its real impacts can effectively enhance preparedness and resilience, ultimately reducing the number of affected casualties. Risk perception increases community preparedness for natural hazards, accelerating resilience and aiding in risk mitigation and faster recovery.

Research by Bodas et al. found a positive and significant correlation between disaster risk perception and disaster resilience.²⁹ They also revealed that resilience positively predicts disaster preparedness.²⁹ A vital component of individual resilience is household adaptation to emergencies. Households engaged in preparedness activities are more resilient due to increased awareness and actual adaptation, which contribute to the survival and recovery of family members after a disaster. One important factor influencing individual preparedness for disaster resilience is risk perception. In the context of disaster preparedness, risk perception involves awareness, beliefs, attitudes towards the possibility and severity of events, perceived threat disruption, and additional attitude factors that reflect how an individual perceives a given risk. Antronico et al. found that enhancing communication and information and involving individuals in targeted actions to improve preparedness in response to potential hazards can increase risk perception, enhancing resilience.³⁰ Qing et al. stated that risk perception acts as a mediator between the preparedness measures individuals implement to manage various hazards and their level of resilience.³¹

This study also demonstrates that the levels of disaster health literacy in the mitigation and preparedness phases among the community in the disaster-prone area of Gunung Merapi in Sleman, Yogyakarta, have an average total score of 30 for disaster health literacy in the mitigation phase and 29 for disaster health literacy in the preparedness phase. The scores in both phases are close to their maximum values of 36 and 32. Thus, it can be concluded that the scores related to disaster health literacy in the mitigation and preparedness phases among the community in the Gunung Merapi disaster-prone area in Sleman, Yogyakarta, are high.

High levels of disaster health literacy indicate that the community must possess cognitive abilities and social skills that determine motivation and capacity to access, read, understand, and use information daily.³² Factors influencing disaster health literacy include education, occupation, income, age, language, access to health information, social support, self-efficacy, and culture.^{32,33} This study differs from the research conducted by Nurdiansyah et al. regarding the differences in health literacy levels between rural and urban areas, indicating that rural communities have lower health literacy than urban areas.³⁴ In contrast, in the current study, most

respondents lived in rural areas with low socioeconomic status. They worked as farmers or livestock breeders, yet they had high levels of disaster health literacy.

This study's high disaster health literacy level can be attributed to education and training. Literacy can be enhanced through education and training, accompanied by developing the ability to think critically, explain phenomena, and utilize scientific evidence.³⁵ Disaster preparedness training has been frequently conducted in the research location, contributing to improved literacy levels. Formal and non-formal education is derived from literacy, which serves as the foundation at all educational levels and is a requirement for everyone, both in urban and rural areas, for adults, children, women, and men.³⁶ Education and training are inseparable components in the human resource development system, involving planning, placement, and human resource development processes.³⁷

CONCLUSION

To summarize, this research emphasizes the important relationship between disaster health literacy, risk perception, and preparedness in the context of disaster resilience. It highlights the importance of strengthening disaster health literacy, promoting accurate risk perception, and implementing preparedness measures to enhance overall disaster resilience. These findings underscore the need for specific interventions and educational initiatives to improve disaster health literacy, enhance risk perception, and increase community preparedness levels. By doing so, these communities' resilience and response capabilities can be effectively reinforced.

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CONFLICT OF INTERESTS

There is no conflict of interest to declare.

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