The Impact of Virtual Reality Simulation Training on Earthquake Preparedness Knowledge and Practices Among Rural Volunteers in Indonesia

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Table of Contents

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Abstract

Background: Natural and human-made disasters, particularly earthquakes, threaten global sustainable development, causing significant loss of life, displacement, and economic damage. Indonesia, located in the Pacific Ring of Fire, faces frequent seismic events, highlighting the need for effective disaster preparedness. Traditional training methods often fall short in practical application, prompting the exploration of innovative tools like virtual reality (VR) simulations. VR offers immersive, scenario-based training, improving knowledge retention and response skills. This study evaluates VR's impact on earthquake preparedness among rural Indonesian volunteers, aiming to develop scalable interventions to enhance community resilience and reduce disaster-related risks.

Objective: Earthquakes significantly threaten rural communities in Indonesia, highlighting the critical need for effective training programs for volunteers who serve as primary emergency responders. Virtual Reality (VR) simulation training has recently gained attention as a novel method to enhance disaster preparedness through immersive, interactive learning experiences. This study evaluated the effectiveness of VR simulation training in improving earthquake preparedness knowledge and practical response skills among rural volunteers in Indonesia.

Methods: This quasi-experimental research involved 400 rural volunteers who were equally divided into two groups: an intervention group (n=200) trained using VR simulations and a control group (n=200) receiving standard training. The VR training modules covered earthquake awareness, search and rescue operations, first aid procedures, and evacuation practices. Participants' knowledge and practical skills were evaluated using the Earthquake Preparedness Knowledge Questionnaire (EPKQ) and Earthquake Response Practical Skills Assessment (ERPSA) at baseline, immediately after training, and at a three-month follow-up. Data analysis employed repeated-measures ANOVA and multiple regression

Results: Volunteers trained with VR demonstrated substantial improvements in both knowledge ($F(2,396) = 45.32$, $p < 0.001$) and practical skills ($F(2,396) = 38.76$, $p < 0.001$) compared with the conventional training group. Post-hoc tests confirmed that these improvements remained consistent even after three months. Regression analysis indicated education level (? = 0.32, $p < 0.001$) and age (? = -0.18, $p = 0.02$) significantly influenced VR training outcomes. After controlling for demographic factors, the VR intervention still significantly enhanced earthquake preparedness knowledge (? = 6.23, $p < 0.001$) and practical response abilities (? = 5.45, $p < 0.001$).

Conclusions: VR simulation training significantly boosts earthquake preparedness knowledge and practical response skills among rural Indonesian volunteers, with enduring benefits. These findings support VR's potential as a scalable, effective disaster preparedness tool in resource-constrained environments

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Original Paper

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Conclusions: VR simulation training significantly boosts earthquake preparedness knowledge and practical response skills among rural Indonesian volunteers, with enduring benefits. These findings support VR's potential as a scalable, effective disaster preparedness tool in resource-constrained environments.

Keywords: Virtual reality, disaster preparedness, earthquake training, rural volunteers, simulation-based training

Introduction

Natural and human-made disasters pose significant threats to global sustainable development, as outlined in the United Nations Sustainable Development Goals (SDGs) [1].Earthquakes are one of the most catastrophic natural disasters, accounting for approximately 60% of disaster-related deaths and economic losses worldwide, impacting millions of individuals annually [2]. Earthquakes killed more than 10,000 people and displaced more than 1.5 million in 2022 alone [3]. Indonesia, part of the seismically active Pacific Ring of Fire, is particularly susceptible, with an average of 8,260 seismic events recorded each year, of which approximately 200 cause major damages [4]. These disasters not only cause physical destruction—they can have devastating implications for public health, economic stability, and social cohesion, particularly in resource-limited rural setting [5]. The 2018 Sulawesi earthquake and tsunami, which resulted in the loss of over 4,300 lives and displaced more than 170,000 people,[4] highlight the essential importance of effective disaster preparedness strategies.

Natural disaster preparedness is an important initiative to prevent loss and damages. It involves understanding health and safety measures, crafting emergency responses, and making sure these measures are put into practice [6]. Communities with strong preparedness measures see fewer deaths and recover more quickly [7]. For example, after Japan's earthquake in 2011, areas with robust disaster plans showed noticeably lower death rates [8]. Likewise, households in the U.S. that had emergency kits were better prepared when Hurricane Harvey struck and fared better with respect to injuries and trauma [9]. In Nepal, communities where disaster education and early warning systems were accessible showed increased resilience to the experience of the 2015 Gorkha earthquake, facing lower mortality rate [10]. In Turkey, research also showed that municipalities with well-developed plans were in a better position to mitigate the impact of the Elazığ earthquake in 2020 [11]. In contrast, Indonesia's rural areas, which often lack adequate disaster training, disproportionately suffered in similar events [12]. Risk reduction programs implemented at the local level have been shown to lessen both fatalities and property damage during earthquakes [13]. A specific goal, such as these steps toward disaster preparedness, would help mitigate risk, enhance response, and build community resilience [14].

Disaster preparedness efforts rely heavily on volunteers, particularly in rural

Indonesia, where they double as first responders and educators [15]. However, their effectiveness is contingent on adequate training—often lackin [16]. A 2020 study from the Philippines showed that trained volunteers dramatically improved response times during Typhoon Vamco, but there was an absence of structured training programs [17]. Despite this, a 2021 study in India found that even motivated volunteers were at a disadvantage when responding to floods due to limited training resources [18]. In Egypt, volunteers were effective in getting prepared for an earthquake but did not have the necessary technical skills [19,20]. A study from Turkey conducted in 2022 showed that regularly trained volunteers are more effective in providing emergency responses [21]. In Indonesia, a 2021 study confirmed the significance of volunteers in mobilizing communities but highlighted shortcomings in their first aid and rescue skillsets due to a lack of training that addressed rural specificities [22].

Traditional means of improving volunteer preparedness, including workshops and drills, often do not engage participants or accurately replicate real-life disaster situations [23]. Although these strategies enhance theoretical understanding, many participants often fall short in translating it into practice during real-life emergency conditions. As with disaster preparedness workshops, which increase awareness but fail to prepare people for the stress and complexity of actual disasters [24]. Earthquake drills and education efforts similarly increase procedural awareness but lack the urgency and unpredictability of real events, thereby limiting their effectiveness for practical skills and confidence [25,26]. Studies are calling for more engaging and immersive forms of training, such as scenario-based simulations, to fill this gap [27,28].

Virtual reality (VR) has been developed as a novel tool for training disaster preparedness through realistic immersive simulations [28,29]. It also improves knowledge retention and practical skills by allowing users to practice disaster scenarios in a controlled setting [30]. Research shows that these virtual reality (VR) simulations significantly enhance disaster preparedness among various groups, from healthcare workers to students. For example, research has demonstrated that VR training improves the ability to respond to earthquakes, navigate decision-making, and increase confidence in performing the task, with VR participants exhibiting more rapid response time than traditional training participants [31]. Likewise, VR simulations for tsunami preparedness have improved participants' situational awareness and their ability to navigate complex environments [32–34]. Although VR has considerable potential, its implementation in low-resource settings such as Indonesia is still limited.

This study works towards filling this gap by evaluating the effect of earthquake preparedness training through VR simulation on knowledge, but also on practices inclination for earthquake preparedness, amongst Indonesian rural volunteers. Utilizing the immersive properties of VR, this research seeks to develop a scalable and effective intervention to improve disaster preparedness in at-risk communities. This new knowledge would be added to academia on novel ideas for disaster preparedness and to be used for the future to help plan safe survival for a community.

Materials and Methods

Study Design

This research utilized a quasi-experimental repeated-measures design to assess the effectiveness of virtual reality (VR) simulation training in enhancing earthquake preparedness knowledge and practical skills among rural volunteers in Indonesia. The study compared two groups: an intervention group that received VR-based training and a control group that participated in traditional disaster preparedness training. Data were collected at three stages: before the intervention (baseline), immediately after the training, and three months post-intervention to evaluate knowledge retention and skill application.

VR development and validation

The VR simulation focused on enhancing earthquake preparedness and response capabilities while providing an immersive and interactive industrial experience. This involved content validation, technical creation, and pilot testing. Content was based on international disaster preparedness standards, including instructions from the World Health Organization (WHO), the Federal Emergency Management Agency (FEMA), and Indonesia's National Disaster Management Authority (BNPB).

Developed in collaboration with disaster response experts, emergency medical professionals, and VR software engineers, the curriculum was designed to be as accurate and realistic as possible. A two-round expert validation was conducted using the Delphi method with a panel of ten disaster response experts. Experts then reviewed the content for accuracy, relevance, and feasibility, which together resulted in iterative refinements. The CVI of the final VR module was 0.92, confirming its validity. Unity 3D was used to develop and program in C# to achieve high-quality graphics and interaction in the VR simulation.

It was tailored for Meta Quest 2 VR headsets, which feature full head tracking, gesture recognition, and real-world movement in the virtual space. Simulation Highlights featured a 360-degree earthquake scenario simulating a high-magnitude event, participants deciding in real-time appropriate responses, interactive drills on triage, first aid, and evacuation, and haptic feedback and spatial audio to enhance sensory immersion and realism (Figure 1).

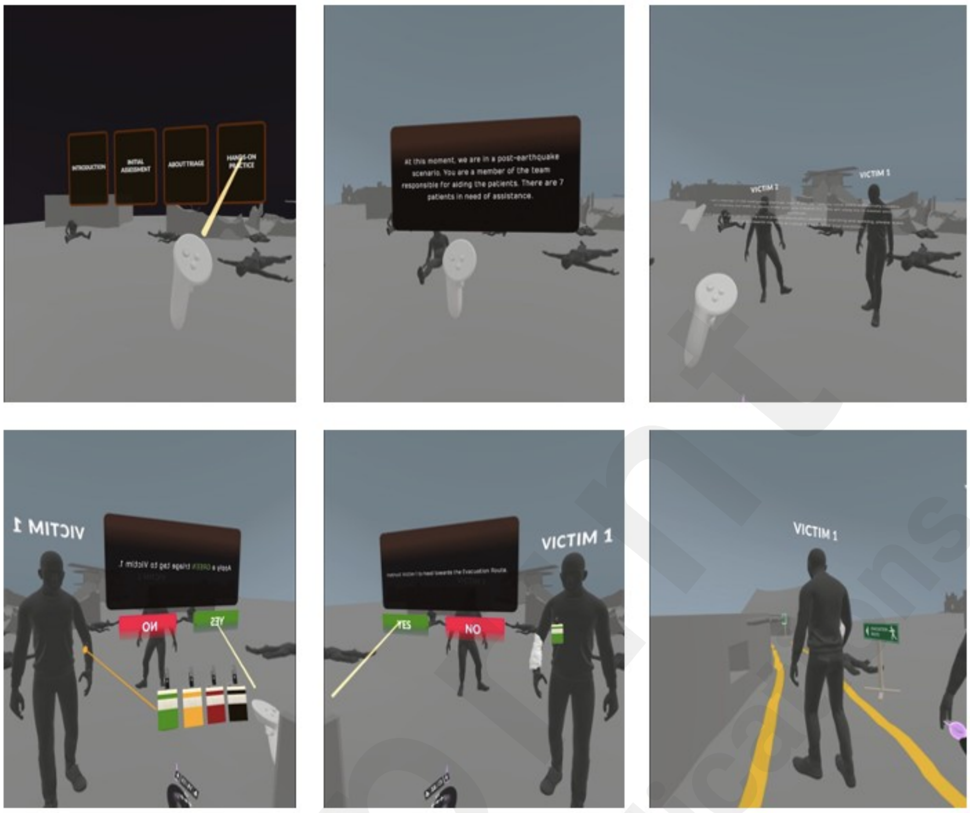

Figure 1. Prototype of virtual reality disaster simulation training

The VR module was beta tested with ten emergency responders, who gave feedback on usability and realism. Adjustments were made to improve navigation, task difficulty, and audio-visual effects. The training program consisted of five 45-minute sessions delivered over two weeks (Table 1).

Table 1. VR training module

Session	Content
Session 1: Initial Assessment and Orientation	• Pre-test to assess baseline knowledge and skills. • Introduction to the VR system and interaction mechanics.
Session 2: Earthquake Awareness and Triage Simulation	• Immersive earthquake scenario with collapsing structures and injured victims. • Training on the START protocol for triage and victim prioritization. • Interactive decision-making exercises.
Session 3: Search and Rescue Simulation	• Navigation through a damaged environment to locate trapped individuals. • Training on safe movement in unstable structures and debris clearance. • Teamwork and communication exercises with virtual team members.
Session 4: First Aid and	• Hands-on practice of CPR, wound care, and

Medical Assistance	fracture immobilization. • Scenario-based responses to victims with varying injury severity. • Performance feedback after each task.
Session 5: Safe Evacuation and Post-Earthquake Response	• Practice of evacuation procedures and identification of safe routes. • Training on post-earthquake hazards like aftershocks and fires. • Final assessment and feedback on overall progress.

he control group received typical training, including lecture sessions, demonstrations, and group discussions without VR integration. To ensure the VR training program effectively improved learning outcomes, the following validation measures were implemented: Pre- and post-training assessments: Participants completed the questionnaires at baseline, immediately post-intervention, and at three-month follow-up. A post-training evaluation survey was administered, measuring user satisfaction, perceived realism, and ease of use. The VR system recorded decision accuracy, response time, and task completion rates for each participant, allowing for quantitative analysis of skill improvements.

Sample

Eligible participants were rural volunteers aged 18 or older with no prior formal earthquake preparedness training. Additional inclusion criteria included normal or corrected vision and a commitment to attend all training sessions. Exclusion criteria included a history of motion sickness, medical conditions limiting physical activity, or incomplete participation.

The study enrolled 400 participants, evenly split between the intervention (n=200) and control (n=200) groups. The sample size was determined using G*Power analysis, with an effect size of 0.5,[35] power of 0.95, and alpha level of 0.05. Participants were recruited via convenience sampling from earthquake-prone rural areas in Indonesia to ensure demographic diversity.

Instruments

The questionnaire is designed to assess the knowledge, perception, and practice regarding earthquake preparedness among Nepalese immigrants residing in Japan[36]. The questionnaire is divided into three sections Earthquake preparedness general knowledge and practice (23 items) uses a 3-point Likert scale: Yes (1 point), No (1 point), Don’t know/Not applicable (0 points). Example items: “Do you think your building is more vulnerable to earthquake damage?”, “Do you know the evacuation center near your home?”, “Have you prepared an emergency bag?”. The total score ranges from 0 to 23, with higher scores indicating better preparedness. Effectiveness of the educational intervention (15 items) uses a True/False format: Correct answer (1 point) and Incorrect answer (0 points). Example items: “In an earthquake, you should move to an open area”, “You should not use objects with fire hazards during the earthquake.” The total score ranges from 0 to 15, with higher scores indicating better understanding of the intervention. Cronbach's Alpha = 0.92, indicating high internal consistency [31]. This instrument has been

Socio-demographic characteristics includes questions on age, sex, education level, type of housing, work status, formal education, and perception of online earthquake preparedness education.

The instrument was translated into Bahasa Indonesia following the World Health Organization (WHO) guidelines for translation and adaptation of instruments [37]. This process involved forward translation by two bilingual experts, reconciliation of translations, backward translation by an independent translator, and review by a panel of disaster preparedness experts to ensure conceptual equivalence. The Bahasa Indonesia version was pilot-tested with 30 participants from a similar population to assess clarity, cultural relevance, and reliability. The result from pilot test showed that Cronbach's alpha was 0.86, indicating that the instrument had a good reliability in Indonesian context.

Procedure

The study was approved by the STIKep PPNI Jawa Barat Institutional Review Board (III/098/KEPK/STIKep/PPNI/Jabar/III/2024) prior to the start of the study on March 4th, 2024. Local disaster response agencies and community organizations reached out to rural volunteer groups. All study participants provided informed consent prior to enrolment. Participants then filled out the pre-test. Participants were assigned to either the VR-based training group or the conventional training group. Immediately after training completion, both groups completed post-tests to evaluate immediate learning outcomes. Three months post-intervention, a follow-up assessment was conducted to measure knowledge retention and practical skill retention. A structured feedback questionnaire was administered to assess participants' experiences with the training.

Data Analysis

Data were analysed using SPSS version 25. Descriptive statistics were used to summarize participant characteristics and baseline measures. Participant characteristics and baseline measures were summarized descriptively. Changes in earthquake preparedness knowledge and practices from baseline to follow-up (6 months post-intervention) were compared between the intervention and control groups using repeated-measures ANOVA. Bonferroni post-hoc analysis was performed to determine at which particular time points significant differences were observed. A multiple regression analysis to assess the impact of demographic factors (age, gender, education level) on the effectiveness of the VR intervention. A mixed-effects model was used to control for possible confounders, as this model can account for random effects associated with participant differences, and fixed effects associated with the intervention. The goodness-of-fit of the model was evaluated using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). A p-value of <0.05 was considered statistically significant.

Result

Demographic Characteristics

This study enrolled 400 participants, evenly distributed between the intervention (n=200) and control (n=200) groups. At the baseline assessment, both groups demonstrated similar demographic characteristics (Table 1). The predominant age range among participants was 18–30 years (intervention: 45.0%, control: 42.5%), with a nearly equal gender distribution (intervention: 52.0% female, control: 50.5% female). A majority of participants had completed secondary education (intervention: 70.5%, control: 68.0%) and lived in single-family homes (intervention: 65.0%, control: 67.5%). Employment rates were high across both groups (intervention: 75.0%, control: 72.5%), and a significant portion had previously received formal education on disaster preparedness (intervention: 60.0%, control: 58.0%). Furthermore, a large proportion of participants viewed online earthquake preparedness education as beneficial (intervention: 85.0%, control: 82.5%). No statistically significant differences were found between the two groups concerning age, gender, education, housing type, employment status, prior disaster education, or perception of online earthquake preparedness training ($p > 0.05$).

Table 1. Demographic Characteristics of Participants (n=400)

Characteristic	Intervention Group (n=200)	Control Group (n=200)	p-value
Age (years)			0.45
18–30	90 (45.0%)	85 (42.5%)	
31–40	40 (20.0%)	45 (22.5%)	
41–50	50 (25.0%)	55 (27.5%)	
>50	20 (10.0%)	15 (7.5%)	
Sex			0.78
Male	96 (48.0%)	99 (49.5%)	
Female	104 (52.0%)	101 (50.5%)	
Education Level			0.62
Primary	30 (15.0%)	35 (17.5%)	
Secondary	141 (70.5%)	136 (68.0%)	
Tertiary	29 (14.5%)	29 (14.5%)	
Type of Housing			0.58
Single-family	130 (65.0%)	135 (67.5%)	
Multi-family	70 (35.0%)	65 (32.5%)	
Work Status			0.67
Employed	150 (75.0%)	145 (72.5%)	
Unemployed	50 (25.0%)	55 (27.5%)	
Formal Education			0.71
Yes	120 (60.0%)	116 (58.0%)	
No	80 (40.0%)	84 (42.0%)	
Perception of Online Education			0.52

Characteristic	Intervention Group (n=200)	Control Group (n=200)	p-value
Useful	170 (85.0%)	165 (82.5%)	
Not Useful	30 (15.0%)	35 (17.5%)	

Changes in Earthquake Preparedness Knowledge and Practices

A repeated-measures ANOVA analysis was employed to examine variations in earthquake preparedness knowledge and response skills between the intervention and control groups over time. Findings indicated a significant interaction between group and time for knowledge ($F(2, 396) = 45.32$, $p < 0.001$) and practical skills ($F(2, 396) = 38.76$, $p < 0.001$), underscoring the effectiveness of the VR intervention in enhancing preparedness outcomes (Table 2).

Table 2. Repeated-Measures ANOVA for Earthquake Preparedness Knowledge and Practices

Variable	Time Point	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	F-value	p-value
Knowledge	Baseline	12.34 ± 2.45	12.10 ± 2.30	45.32	<0.001
	Post-intervention	18.56 ± 1.89	13.45 ± 2.10		
	Follow-up	17.89 ± 2.01	12.89 ± 2.15		
Practices	Baseline	10.23 ± 1.98	10.10 ± 1.85	38.76	<0.001
	Post-intervention	15.67 ± 1.45	11.23 ± 1.56		
	Follow-up	14.89 ± 1.50	10.89 ± 1.60		

Post-Hoc Analyses with Bonferroni Corrections

To pinpoint specific points of improvement, post-hoc analyses using Bonferroni corrections were conducted. In the intervention group, significant progress in knowledge and skills was observed from baseline to immediately after the intervention ($p < 0.001$) and from baseline to follow-up ($p < 0.001$). However, no statistically significant differences were noted between post-intervention and follow-up assessments ($p > 0.05$), suggesting that the benefits of VR training were maintained over time. Conversely, the control group showed no meaningful changes across any time points ($p > 0.05$) (Table 3).

Table 3. Post-Hoc Analyses with Bonferroni Corrections

Variable	Comparison	Intervention Group (p-value)	Control Group (p-value)
Knowledge	Baseline vs. Post-intervention	<0.001	0.12
	Baseline vs. Follow-up	<0.001	0.15
	Post-intervention vs. Follow-	0.06	0.89

Variable	Comparison	Intervention Group (p-value)	Control Group (p-value)
	up		
Practices	Baseline vs. Post-intervention	<0.001	0.10
	Baseline vs. Follow-up	<0.001	0.13
	Post-intervention vs. Follow-up	0.08	0.92

Multiple Regression Analysis

Regression Analysis A multiple regression analysis was performed to explore the impact of demographic variables (age, gender, and education level) on the effectiveness of VR training. Results revealed that education level ($\beta = 0.32, p < 0.001$) and age ($\beta = -0.18, p = 0.02$) were significant predictors of improvements in earthquake preparedness knowledge and practical response, while gender had no significant influence ($\beta = 0.05, p = 0.45$) (Table 4).

Table 4. Multiple Regression Analysis for Predictors of VR Intervention Effectiveness

Predictor	β-coefficient	Standard Error	p-value
Age	-0.18	0.08	0.02
Gender (Female)	0.05	0.07	0.45
Education Level	0.32	0.06	<0.001

Mixed-Effects Model

To control for potential confounding factors, a mixed-effects model was applied, incorporating random effects for participant variability and fixed effects for the intervention. This model demonstrated a strong fit, with an Akaike Information Criterion (AIC) of 1256.34 and a Bayesian Information Criterion (BIC) of 1289.45. Findings reaffirmed the substantial impact of VR training on earthquake preparedness knowledge ($\beta = 6.23, p < 0.001$) and practical response skills ($\beta = 5.45, p < 0.001$), even after adjusting for demographic variables (Table 5).

Table 5. Mixed-Effects Model for VR Intervention Impact

Outcome	Fixed Effect (β)	Standard Error	p-value
Knowledge	6.23	0.45	<0.001
Practices	5.45	0.38	<0.001

Discussion

The results highlight the impact of VR simulation in improving earthquake preparedness knowledge and practices of rural volunteers in Indonesia, effects that were sustained over three months. Overall, these results point towards the promise of VR-based training as a scalable, low-cost, and effective approach for improving disaster preparedness given the unique needs of rural communities. These results align with previous studies that have highlighted the effectiveness of immersive technologies in disaster preparedness training. These findings are consistent with earlier research which has shown the impact of immersive technologies for training in disaster preparedness. For example, a scoping review by Alshowair et al [38]. determined that VR exercises are more effective than traditional tabletop exercises in disaster preparedness training due to the realistic and immersive environment that enhances knowledge retention and practical skills [39]. The consistency of these findings underscores the potential of VR as a scalable and effective tool for disaster preparedness training.

Research study showed that VR training of first responder emergency medical providers led to further improvement and lasting effects [38]. In a similar, study found that VR interventions improved knowledge retention and hands-on skills in disaster situations, especially in resource-limited environments[25]. These consistent results highlight the potential of VR to be a scalable and effective technology for disaster preparedness training [38]. Using it effectively and efficiently has become critical to progress, and now VR technology is turn the tide technology into a game-changer in disaster preparedness training, with the emergence of immersive and interactive simulations to improve learning outcomes [28]. A recent research showing great gains in the earthquake preparedness of rural volunteers in Indonesia highlights the potential of VR in this area. A scoping review, however, demonstrated that VR exercises were more realistic than conventional tabletop exercises and resulted in improved knowledge retention and practical skills. Although classical disaster drills may be resource-consuming, VR is a low-cost solution that can be adapted with different frameworks [28].

VR can only work for disaster preparedness if the content used in VR has quality and relevance [40]. Key considerations involve integrating a variety of disaster scenarios, such as earthquakes, floods, and fires, ensuring holistic training. For example, a virtual reality flood simulator was created to improve flood disaster preparedness by offering immersive simulations that met official guidelines [41]. Simulations that are tailored to local environments and cultural contexts enhance the relevance and realism of the training [42]. In Indonesia, VR simulations have been employed to educate communities about disaster mitigation by blending high-tech solutions with local community scenario use cases. Success metrics such as anecdotes, success stories, and writing have requested the success of engaging users, using interactive elements, and offering real-time feedback. Using interactive simulations proved essential in increasing the user engagement and preparedness in disaster training, aligning with the VOICE-based disaster resilience training [43].

Although the VR simulation training showed promising results, areas for improvement also emerged: integrating VR simulations into broader disaster preparedness programs could give participants a more comprehensive view of responding to emergencies [44]. In Indonesia, the Asia Pacific Disaster Resilience Centre (APDRC) has also worked to implement VR-based disaster simulation as part of wider training initiatives across multiple countries. Importing VR scenarios that reflect the specific contexts and techniques in the place can make the training more relevant and impactful. This can better prepare volunteers for real-world situations by developing simulations that reflect the actual geographical and architectural know-how of rural Indonesian communities. Access to relevant hardware and software, particularly for resource-limited environments, is critical. Investigating cost-efficient alternatives, such as mobile-based VR applications, can facilitate a wider audience in the training program. While a follow-up study may have been out of the intent of this paper, conducting them after a couple of weeks or months can reveal the long-term retention of knowledge and skills learned through VR training and if refresher courses are needed to be implemented.

Implications and Limitations

The notable differences in earthquake preparedness knowledge and practices seen in the intervention group have important clinical and public health implications. While traditional methods of training can be difficult to implement in rural and underserved communities, VR simulation training can be an inexpensive and convenient way to improve disaster preparedness. Despite not assessing for retention, the results at 3 months highlight continued knowledge improvement (retaining the knowledge), supporting the theory that VR training is favorable for such long-term behavior change that is needed in disaster relief scenarios. Additionally, the result that education level and age were significant predictors of intervention effectiveness underscored the importance of providing customized training programs that target demographic differences in desired outcomes. Older adults may need some extra care or altered training protocols to realize the same benefits as younger attenders.

This study, however, has several limitations despite its strengths. First, participants were not randomly assigned to groups, which limits our ability to draw causal inferences using this quasi-experimental design. Data were gathered at a single point in time, and there is a potential risk of bias in responses which could affect the results. Second, the study was conducted within a limited geographic and cultural context, limiting the external validity of the results. Third, self-reported measures of knowledge and practices could potentially introduce bias in the response. Objective measures, including observational assessments, should be included in future research as well, to further validate the findings. Moreover, the follow-up of three months may be too short to test the long retention of the intervention effects. Clinical trials with longer follow-up periods are needed to assess the durability of these gains.

Conclusion

These results suggest that VR simulation training is beneficial and effectively improves earthquake preparedness knowledge and practices among the rural volunteers in Indonesia. The overall improvements documented in the intervention group, which remained in follow-up, suggest a VR-based training approach that emphasizes preparation and, importantly, opportunities for team practice has the potential to improve disaster preparedness in low-resource settings. The results highlight the need to take demographic variables, such as education level and age, into account in the design and implementation of disaster preparedness programs. Further studies are needed to examine the scale-up of VR training and determine the most effective ways of conducting it for a range of populations in a variety of settings.

Data Sharing Statement

All data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of STIKep PPNI Jawa Barat.

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Disclosure

All authors declare no conflicts of interest in this work.

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