Original Article

Effectiveness of Virtual Reality–Based START (Simple Triage and Rapid Treatment) Triage Education on Earthquake Preparedness Among Community Members

Nyayu Nina Putri Calisanie[1], Ramdani Ramdani[2], Sansa Anisa Nur Fatimah[3]

[1,3]STIKep PPNI Jawa Barat, Bandung, West Java, Indonesia
[2]RSUD Dr. Slamet Garut, West Java, Indonesia

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Corresponding author

Nyayu Nina Putri Calisanie*
STIKes PPNI Jawa Barat
Jl. Muhammad No. 438/65 Telp./Fax. (022) 6121914 Bandung
e-mail: nina.calisanie@gmail.com

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Abstract

Background: Indonesia's position along the Pacific Ring of Fire exposes it to frequent seismic events. The recent magnitude 5.6 earthquake in Cianjur highlighted notable deficiencies in community preparedness, especially in areas such as knowledge, disaster education, and emergency response planning. Insufficient public awareness remains a major obstacle to effective disaster risk management.
Objective: This study aimed to determine the impact of Virtual Reality (VR)-based education using the Simple Triage and Rapid Treatment (START) method on enhancing earthquake preparedness among community members.
Methods: A quasi-experimental design with pre- and post-tests and a control group was employed. A total of 112 participants were selected via purposive sampling and divided into intervention and control groups. The intervention group engaged in VR simulations focused on the START triage process as part of their disaster education curriculum. Knowledge improvement was measured using the N-Gain Score to evaluate pre- and post-intervention changes.
Results: The VR-based START triage training led to a 64.47% increase in participants' knowledge, reflecting a moderate level of effectiveness. Compared to the control group, those in the intervention group showed significantly greater improvements in earthquake preparedness.
Conclusion: Incorporating START triage into VR-based educational programs can substantially boost community members' understanding of earthquake preparedness. This interactive and scalable method holds promise for enhancing public disaster education and fostering greater resilience in vulnerable populations.

Keywords: Community Resilience, Disaster Education, Earthquake Preparedness, START Triage, Virtual Reality

INTRODUCTION

The United States, Turkey, Colombia, Iceland, and Greece were reported to have experienced the highest number of earthquakes in 2024 (1). Indonesia ranked 12th, with a total of 5,615 recorded seismic events. Geographically, Indonesia lies between two oceans and two continents and is situated along the Pacific Ring of Fire—a zone characterized by intense tectonic

and volcanic activity, making the country highly susceptible to natural disasters, particularly earthquakes (2). According to the Meteorology, Climatology, and Geophysics Agency (BMKG), a total of 10,789 earthquakes occurred in Indonesia throughout 2023 (3).

Indonesia is an archipelagic nation positioned at the convergence of four major tectonic plates: the Australian, Eurasian, Pacific, and Philippine plates. These plate interactions give rise to subduction zones and active fault lines on both land and seabed. The movement and friction at these boundaries can trigger significant seismic activity. The Center for Volcanology and Geological Hazard Mitigation has identified West Java Province as having the highest number of active faults on the island of Java (4).

Cianjur, a regency in West Java, experienced a notable earthquake with a magnitude of Mw 5.6 (5). Three major fault systems—Cimandiri, Rajamandala, and Nyalindung-Cibeber—run through the region (6). In addition, a newly identified active fault, the Cugenang Fault, was found to cut across nine villages, eight of which are located in Cugenang Subdistrict (7). This fault was confirmed as the epicenter of the devastating earthquake that struck on November 21, 2022. As of December 9, 2022, more than 400 aftershocks had been recorded (8). The quake led to severe infrastructure damage, 334 fatalities, and 593 people suffering serious injuries (9). According to reports in 2024 (10) the Cianjur region was shaken by two more earthquakes in June, as reported by the Regional Disaster Management Agency (BPBD) (11).

These recurring seismic events highlight the urgent need for improved disaster preparedness strategies, particularly those that enable timely, accurate, and efficient responses. In Cianjur, gaps in public readiness are evident, especially in areas related to education and infrastructure. A major contributing factor is the limited awareness and understanding of appropriate actions before, during, and after an earthquake. Inadequate knowledge can exacerbate the impact of such disasters. Strengthening disaster literacy, especially regarding earthquakes, is crucial for improving community resilience and psychological preparedness.

Triage, a method used to prioritize patients based on the severity of their injuries, plays a key role in disaster response (12). During the Cianjur earthquake, media reports highlighted the shortage of medical personnel, which made it difficult to provide timely care to the large number of victims (13). This shortage led to fatigue among healthcare workers and compromised emergency services. Therefore, public knowledge about triage principles is essential to promote community-based disaster readiness and reduce risk during emergencies (14).

Previous studies have explored various approaches to triage education. For instance, volunteers from the Muhammadiyah University of Purwokerto's Indonesian Red Cross (PMI) unit were trained using printed pocketbooks. Another study investigated the effect of triage education using lectures and leaflets for families of patients in the Emergency Department of RS Budi Mulia Bitung (15). The findings indicated that this educational intervention significantly improved participants' knowledge. In addition to conventional methods such as printed materials and video conferencing, advances in technology have introduced Virtual Reality (VR) as a powerful tool in educational media (16).

VR technology creates immersive digital environments, allowing users to interact and engage with simulated settings as if they were real. Through VR, individuals can experience highly realistic scenarios within a fully virtual space detached from the physical world. One example of this innovation is the use of Meta Quest-2 VR headsets, which feature high-resolution visuals, user-friendly controls, and ergonomic design. In this study, the VR environment was developed by integrating Simlab Soft software with the Meta Quest-2 device to deliver a realistic and transformative training experience for users (17).

Based on the considerations above, this study aims to examine the effectiveness of disaster triage education using the START (Simple Triage and Rapid Treatment) method delivered through Virtual Reality in enhancing earthquake preparedness among community members.

METHODS

Study Design

This research employed a quantitative approach using a quasi-experimental design with a pretest-posttest control group format. The study involved two groups: an intervention group, which received Virtual Reality (VR)–based triage

education, and a control group, which did not receive the intervention during the study period. The aim was to evaluate the effect of the intervention by comparing knowledge scores before and after the educational session in both groups.

Participat

This study was conducted in Mangun Kerta Village, located in the Cugenang Subdistrict, Cianjur Regency, Indonesia. The data collection process took place over a three-month period, from November 2024 to January 2025. Participants were recruited using a non-probability purposive sampling technique. The inclusion criteria required participants to be residents of Mangun Kerta Village, serve as heads of household, be aged between 20 and 59 years, and possess the ability to read and comprehend written information. Individuals diagnosed with serious or chronic illnesses that could hinder their participation were excluded from the study. The total sample was then divided into two groups: an intervention group, which received Virtual Reality–based triage education, and a control group, which did not receive the intervention during the study period. The number of participants in each group was determined based on eligibility and willingness to participate.

Instrument

Data on earthquake triage knowledge were collected using a structured questionnaire adapted from a previously validated instrument developed by [18]. The questionnaire comprised 10 multiple-choice items assessing participants' understanding of the START (Simple Triage and Rapid Treatment) method. Scoring was categorized as follows:

- High knowledge: scores >75
- Low knowledge: scores <75

Data Collection Procedure

Prior to data collection, approval was obtained from STIKep PPNI West Java and village authorities in Mangun Kerta. The researcher coordinated with local leaders to facilitate participant recruitment and venue arrangements.

- In the intervention group, participants attended a single face-to-face session. They completed a pretest, participated in the VR-based triage education session, and were then given a posttest immediately afterward.
- In the control group, participants completed a pretest and posttest without receiving the VR intervention. However, to ensure ethical fairness and uphold the principle of justice, participants in the control group were provided with an educational module after posttest completion.

Data Analysis

The effectiveness of the intervention was analyzed using the N-Gain Score formula to measure the relative increase in knowledge between pretest and posttest within and between groups. Descriptive and inferential statistics were applied using appropriate statistical software.

Ethical Consideration

Ethical approval was obtained from the Ethics Committee of STIKep PPNI West Java. Written informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality and the voluntary nature of their participation. All procedures adhered to the principles of autonomy, beneficence, non-maleficence, and justice.

RESULTS

Univariate analysis

Table 1. Demographic Data: Age of Participants

Group	Mean ± SD	Median	Mode	Minimum	Maximum
Intervention Group	23.09 ± 12.259	23.00	22	20	30
Control Group	35.04 ± 2.126	34.00	21	20	59

Table 1 presents the descriptive statistics related to the age of participants in both the intervention and control groups. In the intervention group, the mean age was 23.09 years with a standard deviation of ±12.259, indicating a relatively wide distribution of participant ages. The median age was 23 years, and the most frequently occurring age (mode) was 22 years, with the youngest participant being 20 years old and the oldest 30 years. In contrast, the control group had a higher mean age of 35.04 years with a smaller standard deviation of ±2.126, suggesting that the participants were older and more age-homogeneous compared to the intervention group. The median age in this group was 34 years, with a mode of 21 years, and the age range extended from 20 to 59 years. These differences indicate that the control group consisted of generally older and more age-consistent individuals, while the intervention group had a younger and more varied age distribution.

Table 2. Demographic Data: Gender of Participants

Group	Gender	Frequency	Percentage
Intervention Group	Male	10	17.9%
	Female	46	82.1%
Control Group	Male	17	30.4%
	Female	39	69.6%

Table 2 illustrates the gender distribution of participants across the intervention and control groups. In the intervention group, the majority of respondents were female, comprising 82.1% (46 individuals), while males accounted for 17.9% (10 individuals). Similarly, in the control group, females also made up the majority at 69.6% (39 individuals), whereas males represented 30.4% (17 individuals). Overall, both groups were predominantly composed of female participants, with a slightly higher proportion of males in the control group compared to the intervention group.

Table 3. Demographic Data: Education Level of Participants

Group	Education Level	Frequency	Percentage
Intervention Group	Elementary School (SD)	2	3.6%
	Junior High School (SMP)	16	28.6%
	Senior High School (SMA)	38	67.9%
Control Group	Elementary School (SD)	9	16.1%
	Junior High School (SMP)	7	12.5%
	Senior High School (SMA)	33	58.9%
	Bachelor's Degree (S1)	7	12.5%

Table 3 presents the educational backgrounds of participants in both the intervention and control groups. In the intervention group, the majority of participants had completed senior high school (67.9%), followed by junior high school (28.6%), and a small number had only elementary education (3.6%). In the control group, most participants also completed senior high school (58.9%), while others had elementary education (16.1%), junior high school (12.5%), or a bachelor's degree (12.5%). These results indicate that both groups had relatively strong representation from individuals with senior high school education, but the control group had a broader range of educational attainment, including some college-educated participants.

Table 4. Demographic Data: Occupation of Participants

Group	Occupation	Frequency	Percentage
Intervention Group	Housewife	32	57.1%
	Unemployed	21	37.5%
	Others	3	5.4%
Control Group	Housewife	10	17.9%
	Unemployed	11	19.6%
	Farming	9	16.1%
	Gardening	7	12.5%
	Others	19	33.9%

Table 4 summarizes the occupational status of participants in the intervention and control groups. In the intervention group, the majority were housewives (57.1%), followed by unemployed individuals (37.5%), and a small proportion categorized as others (5.4%), which may include informal or miscellaneous work. In the control group, occupations were more diverse. The largest proportion fell into the "others" category (33.9%), which included students and office workers, followed by housewives (17.9%), unemployed individuals (19.6%), farmers (16.1%), and gardeners (12.5%). This variation suggests that the control group had more occupational diversity compared to the intervention group, which was more concentrated in domestic roles.

Table 5. Disaster Preparedness Scores Before and After START Triage Education in Intervention and Control Groups

Group	Test	High Knowledge	Low Knowledge	Mean Score
Intervention Group	Pre-test	7	49	32.14
	Post-test	44	12	80.00
Control Group	Pre-test	5	51	52.14
	Post-test	7	49	54.29

Table 5 presents the comparison of disaster preparedness knowledge scores before and after the START triage educational intervention. In the intervention group, only 7 participants were categorized as having high knowledge in the pre-test, while 49 participants had low knowledge, resulting in a mean score of 32.14. After receiving Virtual Reality–based triage education, the post-test results showed a substantial improvement, with 44 participants achieving high knowledge and only 12 remaining at a low knowledge level, increasing the mean score to 80.00. In contrast, the control group showed minimal change. The pre-test revealed 5 participants with high knowledge and 51 with low knowledge, with a mean score of 52.14. The post-test showed a slight increase to 7 participants in the high knowledge category and 49 in the low category, with the mean score rising slightly to 54.29. These findings suggest that the VR-based START triage education significantly improved disaster preparedness knowledge in the intervention group, while the control group showed only marginal improvement without the intervention.

Normality Testing

Normality testing aims to determine whether the data in a sample are normally distributed. In this context, if the Asymp. Sig. (2-tailed) value is less than 0.05, the data do not follow a normal distribution. Conversely, if the value exceeds 0.05, the data are considered to be normally distributed.

Table 6. Normality Test Results

Variable	Kolmogorov-Smirnov	Asymp. Sig. (2-tailed)	Interpretation
Intervention Group	0.421	0.000	Not normally distributed
Control Group	0.464	0.000	Not normally distributed

According to the results presented in Table 6 using the Kolmogorov-Smirnov method, both the intervention and control groups yielded Asymp. Sig. values below 0.05, indicating that the data distributions in both groups deviate from normality.

Bivariate Analysis

Comparison of Scores Before and After START Triage Education in Intervention and Control Groups

Table 7. Wilcoxon Test Results

	Post-Control – Pre-Control	Post-Intervention – Pre-Intervention
Asymp. Sig. (2-tailed)	0.347	0.000

As shown in Table 7, the Asymp. Sig. value for the intervention group is 0.000. Since this value is less than 0.05, the alternative hypothesis (Ha) is accepted. This suggests that there was a statistically significant difference between pre-test and post-test scores following the virtual reality-based triage education.

Effectiveness of START Triage Education Using Virtual Reality

Table 8. N-Gain Score Results

	N	Mean (%)	Standard Deviation	Effectiveness Category
N-Gain Percentage	56	64.47	27.74	Moderately effective

The N-Gain analysis for the intervention group in Table 8 shows an average score of 64.47%. This result places the virtual reality-based triage education within the category of "moderately effective," indicating a meaningful improvement in participant knowledge or skills.

Relationship Between Demographic Factors and Preparedness Scores

Table 9. Spearman Correlation Test

Demographic Variable	Correlation Coefficient	Sig. (2-tailed)
Age	0.114	0.405
Gender	0.137	0.313
Education	0.099	0.467
Occupation	-0.145	0.285

As presented in Table 9, all demographic variables show Sig. (2-tailed) values above 0.05. This implies that there is no statistically significant correlation between demographic characteristics and participants' preparedness levels.

DISCUSSION

Demographic Data

Age

The study found that the average age of participants in the intervention group was 23.09 years, while in the control group, it was 35.04 years. The most frequently occurring age in the intervention group was 22 years, compared to 21 years in the control group. Participants in the intervention group ranged from 20 to 30 years old, whereas in the control group, ages ranged from 20 to 59 years. The results revealed no statistically significant correlation between age and preparedness scores. This finding aligns with previous research (18), which concluded that age alone does not determine preparedness levels, as other factors—such as knowledge, availability of resources, and training opportunities—play a more crucial role. Preparedness is not necessarily age-dependent; individuals of various ages can benefit from virtual reality (VR)-based educational interventions that enhance their ability to respond effectively to emergency situations. This technology facilitates interactive and adaptive learning experiences, allowing users to build preparedness skills tailored to their individual abilities and learning needs, regardless of age.

Gender

In the intervention group, 10 participants (17.9%) were male, and 46 (82.1%) were female. In the control group, 17 participants (30.4%) were male, and 39 (69.6%) were female.

Biological sex, typically classified as male or female, may influence cognitive and behavioral responses (19). However, the analysis showed no significant relationship between gender and preparedness levels. This is consistent with findings from previous studies (18), which noted that while physiological differences exist between sexes, these do not constitute a primary factor in determining one's preparedness. Moreover, gender did not significantly influence knowledge improvement after the intervention. This suggests that VR-based educational tools can be accessed and understood effectively by users of any gender, demonstrating their inclusivity and broad applicability in diverse populations.

Educational Background

Among the intervention group, 2 participants (3.6%) had completed elementary school, 16 (28.6%) had middle school education, and 38 (67.9%) had completed high school. In the control group, 9 (16.1%) had elementary education, 7 (12.5%) had middle school education, 33 (58.9%) had completed high school, and 7 (12.5%) held a bachelor's degree. Education serves as a vehicle for cultural transmission across generations, equipping individuals with knowledge and values through structured learning (20). Despite this, the study found no significant correlation between educational attainment and preparedness levels. This supports findings by (18), which indicated that education level alone is not sufficient to shape preparedness and that tailored training or educational programs are needed to build such competencies. The VR-based intervention proved effective across different educational levels, suggesting that such technology can transcend educational disparities and deliver meaningful learning experiences to all participants, regardless of formal academic background.

Occupational Status

Participants in the intervention group included 32 housewives (57.1%), 21 unemployed individuals (37.5%), and 3 individuals with other occupations (5.4%). In the control group, 10 were housewives (17.9%), 11 were unemployed (19.6%), 9 were farmers (16.1%), 7 worked as gardeners (12.5%), and 19 had various other jobs (33.9%). Occupation is a socio-economic activity where individuals invest time and effort with the expectation of financial compensation and social contribution (21). The current study found no significant correlation between occupation and preparedness scores. This contrasts with earlier findings (22) that suggested a connection between employment and preparedness. Regardless of job type, participants in this study were able to understand and benefit from the VR-based education, demonstrating that the learning experience is accessible and effective for individuals across different occupational backgrounds.

Knowledge Scores Before and After VR-Based START Triage Education

The comparison of knowledge levels before and after the intervention showed a marked improvement among participants who received VR-based education. Initially, only seven individuals in the intervention group demonstrated high knowledge, while the majority (49) showed limited understanding. Following the intervention, the number of participants with high knowledge rose to 44, leaving only 12 in the low-knowledge category. This shift illustrates a significant enhancement in understanding of triage concepts. In contrast, the control group displayed minimal improvement: from five participants with high knowledge at baseline to only seven after traditional educational exposure. These results underscore the effectiveness of the VR approach in delivering emergency preparedness education. They align with previous findings (23) indicating that immersive technologies outperform conventional methods in terms of knowledge retention and skill acquisition.

Score Differences Pre- and Post-VR-Based Education

Statistical evaluation demonstrated a meaningful improvement in preparedness scores post-intervention, with a p-value of 0.000, which is well below the significance threshold of 0.05. This supports the alternative hypothesis, confirming that the VR-based triage education significantly improved participant knowledge. The findings echo those of Maulana et al. (25), who also reported superior learning outcomes with VR compared to traditional presentation tools like PowerPoint. The contrast in score changes between the intervention and control groups validates the utility of VR for educating individuals on emergency response strategies.

Effectiveness of the VR-Based Intervention

Participants in the intervention group achieved an average preparedness score of 64.47%, indicating moderate success in achieving learning objectives. The immersive features of VR allowed participants to interact with emergency scenarios in a realistic virtual environment, enhancing both engagement and comprehension. This multi-sensory experience promoted emotional and cognitive involvement, which are key for effective learning (26, 27). By simulating real-life emergencies, the VR tool enabled learners to develop critical thinking and decision-making skills relevant to triage situations. The outcome is consistent with previous studies (23), which documented substantial learning gains from VR use, as

reflected by a moderate N-Gain score in the intervention group (0.42) versus a low score in the control group (0.16). These results reaffirm the value of VR in educational settings, particularly for complex, scenario-based content (30).

Study Limitations

While the study demonstrated the efficacy of VR-based triage education, several limitations should be acknowledged. First, the sample was limited in size and drawn from a specific demographic, which may restrict the generalizability of findings. Second, although the intervention showed positive results, the follow-up period was short, limiting the ability to assess long-term knowledge retention or behavioral change. Third, technological familiarity and comfort levels with VR tools may have varied among participants, potentially influencing their learning outcomes. Additionally, factors such as motivation, prior experience with emergencies, and learning preferences were not controlled, which could have affected individual performance. Future studies should consider larger, more diverse populations, include long-term assessments, and control for digital literacy to provide a more comprehensive understanding of VR's effectiveness in educational interventions.

CONCLUSION

The findings of this study demonstrate that virtual reality-based education using the START (Simple Triage and Rapid Treatment) method is moderately effective in improving earthquake disaster preparedness among community members, as indicated by an N-Gain Score of 64.47%.

No significant correlations were found between preparedness levels and demographic variables, suggesting that the intervention was equally accessible and beneficial across different age groups, genders, educational backgrounds, and occupations. Overall, the use of virtual reality in disaster preparedness education shows promising potential in enhancing community readiness for emergency situations. Future research is recommended to explore the effectiveness of more advanced technologies, such as mixed reality, in further strengthening disaster preparedness efforts.

Implication for Practice:

Nurses, public health educators, and disaster response teams can integrate VR simulations into community-based training initiatives to promote more engaging and effective preparedness strategies. By providing participants with hands-on, scenario-based learning experiences, practitioners can help bridge the gap between theoretical knowledge and real-life application. Additionally, embedding VR training modules into routine community outreach or school-based disaster programs may increase awareness, confidence, and responsiveness among the general public during emergencies. Future studies are encouraged to explore the use of emerging technologies—such as mixed reality (MR) and augmented reality (AR)—to further optimize learning outcomes and reinforce long-term preparedness behaviors across various populations.

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Author Contributions

NNPC : conceptualized the study, developed the methodology, and supervised the research process, writing of the original draft and subsequent manuscript revisions
RR : conducted data collection and formal analysis.
SANF : contributed to the writing of the original draft and subsequent manuscript revisions
All authors reviewed and approved the final manuscript.

Conflict of Interest Disclosure

The authors declare that there are no conflicts of interest relevant to the content of this article.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. All data have been anonymized to protect participant confidentiality.

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