Original Article

doi: 10.31674/mjn.2025.v16isupp2.006

MJN

The Effect of "QuakeGuard" Mobile Application on Resilience among Community Members in Disaster Prone Area in Sukabumi, Indonesia

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ABSTRACT

Background: Traditional disaster preparedness strategies often emphasise structural solutions, but the psychological and social dimensions of resilience have received less attention. Innovative approaches, such as mobile applications like "QuakeGuard," offer promising avenues to address this gap. **Objectives:** This study aimed to assess the effectiveness of the "QuakeGuard" mobile application in strengthening resilience among community members in disaster-prone areas of Sukabumi, Indonesia. **Methods:** A quasi-experimental study design with pre-test and post-test measurements was employed, with data collected at three repeated measurements. A total of 320 participants were recruited through convenience sampling and assigned to either the intervention group (n = 160) or the control group (n = 160). Community resilience was assessed using the Conjoint Community Resiliency Assessment Tool (CCRAT). Data analysis was performed using repeated measures ANOVA, Cohen's d test, and generalised estimating equations (GEE). **Results:** The intervention group demonstrated significant improvements in community resilience over time compared to the control group ($p < 0.05$). The post-test resilience scores for the intervention group (Mean ± SD: 2.93 ± 1.54) were significantly higher than those for the control group (Mean ± SD: 2.56 ± 1.06, $p = 0.012$). GEE analysis showed a significant interaction effect ($\beta = 5.09$, 95% CI: 2.10–8.75, $p = 0.001$). **Conclusion:** The "QuakeGuard" mobile application proved to be an effective tool for enhancing community resilience by providing user-friendly and culturally relevant disaster preparedness resources. Further studies should investigate the long-term effects and scalability of such interventions in diverse communities.

Keywords: Community Resilience; Disaster Preparedness; Disaster Risk Reduction; Indonesia; Mobile Application; QuakeGuard; Sukabumi

INTRODUCTION

Situated within the Pacific Ring of Fire, Indonesia faces heightened vulnerability to geological and hydrometeorological hazards, necessitating proactive disaster management as a national imperative (Fuady, Munadi & Fuady, 2021). Regions like Sukabumi, frequently affected by earthquakes, floods, and landslides, demand comprehensive strategies to strengthen community resilience and disaster preparedness (Fakhruddin *et al*, 2021). Resilience, defined as the capacity to adapt, withstand, and recover from disasters, plays a vital role in reducing the adverse effects of natural hazards while fostering recovery efforts (Patel *et al*., 2017; UNDRR, 2022). Although governmental initiatives for disaster preparedness exist, they often fall short in engaging communities, highlighting the need for innovative, community-cantered approaches (Cretney, 2018).

Traditional disaster preparedness in Indonesia predominantly emphasises structural measures, such as developing infrastructure, often overlooking the psychological and social dimensions essential for fostering resilience (Ayuningtyas *et al*., 2021). However, resilience encompasses not only physical but also cognitive, emotional, and behavioural components that enable individuals and communities to navigate adversity and rebuild effectively (Liu *et al.*, 2018). Despite challenges such as limited resources, low public awareness, and gaps in disaster education, mobile applications tailored to Indonesia's sociocultural context provide a

Received: December 26, 2024 Received in revised form: April 9, 2025 Accepted: April 17, 2025

promising avenue. These digital tools can bridge critical gaps in disaster education and preparedness by delivering accessible, practical, and culturally relevant information, particularly in resource-limited areas like Sukabumi (Hargono *et al.*, 2023).

The emergence of mobile applications has transformed Disaster Risk Reduction (DRR) by offering real-time, user-friendly platforms to enhance preparedness and resilience (Cicek *et al.*, 2023). Studies globally have demonstrated the effectiveness of digital tools in increasing disaster awareness and preparedness. For instance, research in Japan highlighted that mobile applications leveraging gamification and simulation-based learning significantly improved earthquake preparedness and public awareness (Arakawa, Yamada & Sugimori, 2024). Similarly, mobile interventions have effectively educated communities about flood risks, leading to greater evacuation readiness and long-term knowledge retention (Palilling, Nurhidayani & Pineng, 2022). Mobile technologies in disaster management serve multiple functions, such as disseminating early warnings, conducting risk assessments, and delivering educational content, establishing them as integral components of modern DRR strategies (Paul, Bee & Budimir, 2021). Features such as preparedness checklists, educational modules, self-assessment tools, and community support networks within these applications collectively promote proactive behaviours and enhance disaster readiness (Ezeonu *et al*., 2024).

Despite the potential of mobile applications to foster resilience, research on their effectiveness remains limited, particularly in low- and middle-income countries like Indonesia (Syukron, Oktari & Fahmi, 2024). Although digital DRR interventions are gaining momentum, existing studies primarily focus on high-income countries, leaving a significant evidence gap regarding their applicability in low-resource settings (Haque *et al*., 2022; Cvetković *et al.*, 2021). Additionally, much of the research centres on short-term outcomes, such as improved knowledge and awareness, rather than exploring the multifaceted dimensions of resilience, including psychological, social, and infrastructural aspects (Twigg, 2019).

This study addresses these gaps by evaluating the "QuakeGuard" mobile application, designed to enhance community resilience in disaster-prone regions. "QuakeGuard" features an integrated suite of tools, including early warning systems, preparedness checklists, and interactive simulation exercises, aimed at improving disaster readiness among individuals and communities. Its development is grounded in the Health Belief Model (HBM) and Protection Motivation Theory (PMT), which emphasise the roles of perceived risk, self-efficacy, and response efficacy in motivating protective actions (Rogers, 1975; Champion & Skinner, 2008). By addressing barriers to action and fostering collective efficacy, "QuakeGuard" seeks to empower users to take proactive measures in disaster preparedness.

In the Indonesian context, where the use of digital DRR interventions remains underexplored, this study provides critical insights into the potential of mobile applications like "QuakeGuard" to build comprehensive resilience. By examining psychological, social, and infrastructural dimensions, this research contributes valuable evidence to disaster management practices tailored to low-resource communities. The findings of this study have the potential to inform future policies and interventions, promoting sustainable resilience and better preparedness in disaster-prone areas.

METHODOLOGY

Study Design and Setting

This study employed a quasi-experimental design with pre-test and post-test measurements at three time points: baseline (T0), one month after the intervention (T1), and three months after the intervention (T2). Participants were not masked to their group assignments, and researchers were not blinded to the outcome measurement process. The study was conducted in Sukabumi Regency, West Java Province, Indonesia, a region prone to earthquakes due to its geological characteristics. The region's landscape varies from flat plains to steep hills, and its geological formations include Tertiary-era rocks, Quaternary deposits, and recent volcanic debris. These features, along with their softness, contribute to the region's heightened seismic activity (BNPB, 2022).

Sample

Individuals eligible for inclusion were required to be 18 years of age or older, possess proficiency in

reading and writing, have a minimum of six months of experience as a volunteer, and own a smartphone with internet access. Participants were excluded if they expressed unwillingness to participate, had cognitive or mental health disorders, or were pregnant. The sample size was calculated using G*Power software (version 3.1.6) to ensure adequate statistical power. The parameters for the calculation included a significance level (α) of 0.05, an effect size of 0.10, and a power of 0.95. Based on an F-test for two groups, the required sample size was determined to be 260 participants. To account for a potential 20% attrition rate, the final sample size was adjusted to 312, with 156 participants allocated to each group (intervention and control). For participant recruitment, a convenience sampling technique was employed, allowing the selection of individuals based on their accessibility and the feasibility of data collection. This approach was chosen to facilitate efficient recruitment while ensuring the study met its logistical and temporal constraints.

Instrument

Community resilience was measured using the Conjoint Community Resiliency Assessment Tool (CCRAT), initially developed by (Leykin *et al*. 2013) and modified from Saravanan (2021). The instrument consists of 10 items rated on a 5-point Likert scale (1 = "Strongly Disagree," 5 = "Strongly Agree"). The original Cronbach's α was 0.85, and in this study, it was 0.93 for the Bahasa Indonesia version.

Procedure

At the baseline (T0), all participants underwent a pre-test assessment that evaluated their knowledge, attitudes, practices related to disaster preparedness, perceived disaster risk, and community resilience. To ensure a thorough understanding of the intervention, all participants received a 45–60 minute training session. This session covered the study procedures, usage of the "QuakeGuard" application, and its features.

Figure 1: QuakeGuard Mobile Application

The SafeGuard mobile application integrates a variety of interactive features designed to enhance disaster preparedness awareness among adolescents. The welcome screen introduces users to the app's purpose, emphasising safety and preparedness. A secure login interface ensures user-specific access and progress tracking. Upon successful login, users are directed to a dashboard featuring navigation options to quizzes, educational videos, emergency announcements, and newest updates. This interface is intentionally designed with contrasting colours and large fonts to support accessibility, including for users with visual limitations. The quiz feature covers multiple domains of disaster risk reduction including earthquake response, flood mitigation, volcanic eruption preparedness, emergency equipment readiness, and first aid knowledge. The quizzes promote active learning and reinforce retention of key information. A dedicated video library provides audiovisual content tailored to adolescent comprehension levels, illustrating disaster scenarios and correct response techniques. Adjacent to the videos, infographics and posters offer visual reinforcement using simplified language and icons, making the material digestible for younger users or those with limited literacy. Moreover, the announcement and emergency response page keep users updated on real-time information and safety tips, promoting immediate engagement during actual events. The search feature allows for keyword-based navigation, while the interactive questionnaire module enables users to reflect on their knowledge and track personal learning progress.

These layered features collectively demonstrate the app's user-cantered design, incorporating principles of accessibility, interactivity, and self-paced learning. For nursing practice, the app exemplifies a valuable tool for community health education and school-based disaster preparedness programs, where nurses can use it to extend their role as educators and advocates for adolescent safety and well-being (Figure 1). To facilitate app use, internet data compensation was provided to all participants.

For the intervention group, the "QuakeGuard" app was central to the program. The app allowed real-time activity tracking through an administrative portal. Participants also attended weekly offline meetings lasting 60-90 minutes, where their progress was evaluated. These sessions provided an opportunity for discussion, clarification of app content, and hands-on activities to reinforce disaster preparedness skills. Upon successful completion of the one-month program, participants in this group received certificates as recognition of their efforts. Meanwhile, the control group received standard health education in the form of informational leaflets outlining key concepts related to earthquakes and disaster preparedness. This approach ensured they received valuable knowledge while serving as a comparison for the app-based intervention.

Follow-up assessments were conducted at T1 (one month after the intervention) and T2 (three months after the intervention). These assessments aimed to measure changes in disaster preparedness knowledge, attitudes, practices, perceived disaster risk, and community resilience over time, providing valuable data to evaluate the effectiveness of the intervention.

Data Analysis

Demographic data and resilience were analysed using descriptive statistics, including frequency distribution, mean, and standard deviation. Bivariate analysis was conducted using repeated measures ANOVA and Cohen's d test. These methods were applied to evaluate the differences in community resilience before and after the intervention, allowing for a detailed assessment of changes over time. To examine the impact of the intervention more comprehensively, multivariate analysis was carried out using general linear mixed models. This approach was particularly suited for assessing changes over time within and between the intervention and control groups. A significance level of $p < 0.05$ was set for all statistical tests. All calculations performed using SPSS version 26.

Ethical Consideration

The research obtained ethical clearance from the Institutional Review Board (IRB) of STIKep PPNI Jawa Barat, Indonesia with reference number III/067/KEPK/STIKep/PPNI/Jabar/III/2024 on 31st March 2024.

RESULTS

At baseline, 355 participants were approached for enrolment, as shown in Figure 2. Of these, 320 participants agreed to participate, resulting in a response rate of 90.14%. Approximately 2.8% (10 participants)

refused to participate, and an additional 25 participants did not complete the pre-test measurement—15 from the intervention group and 10 from the control group.

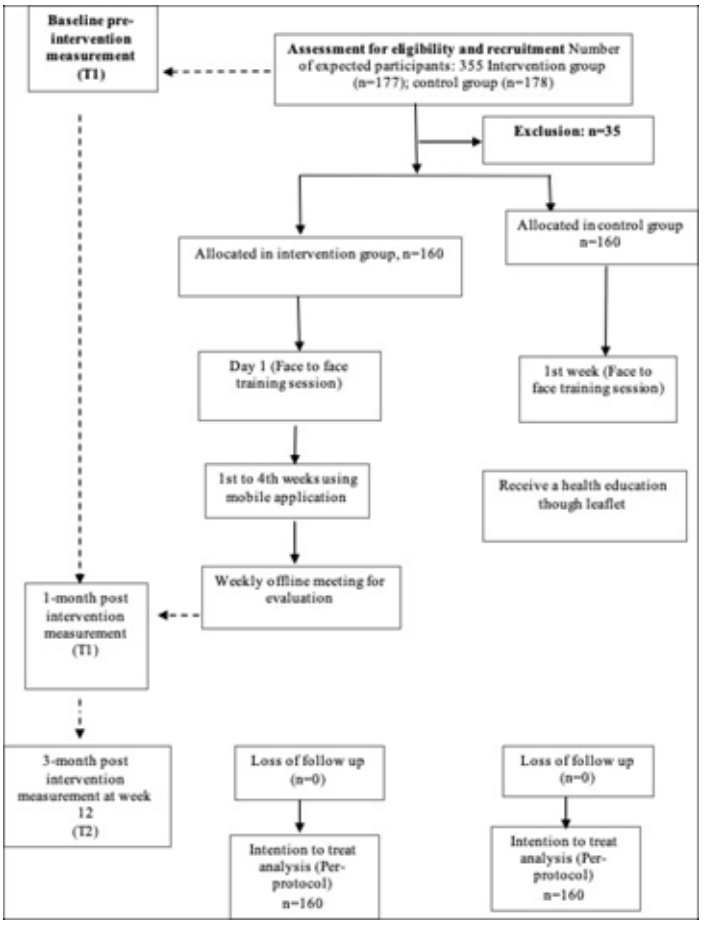

Figure 2: Study Flow Chart

There were no statistically significant differences between the intervention and control groups in terms of age, gender, education level, marital status, or employment status ($p > 0.05$), indicating that the groups were comparable at baseline.

Table 1: Baseline Demographic Comparison between Intervention and Control Groups (n = 320)

Variable	Intervention Group (N = 160)	Control Group (N = 160)	*p*-value
Age (Mean ± SD)	35.50 ± 5.72	33.65 ± 4.94	0.187[b]
Gender			0.118[a]
Male (%)	54 (33.75%)	60 (37.5%)	
Female (%)	106 (66.25%)	100 (62.5%)	
Education Level			0.357[a]
Above Senior High School (%)	47 (29.37%)	55 (34.37%)	
Below Senior High School (%)	113 (70.63%)	105 (65.63%)	
Marital Status			0.312[a]
Married (%)	114 (71.25%)	101 (63.13%)	
Single (%)	46 (28.75%)	59 (36.87%)	
Employment Status			0.214[a]
Employed (%)	93 (58.12%)	100 (62.5%)	
Unemployed (%)	67 (41.88%)	60 (37.5%)	

Note: $p < 0.05$; a = p-value from Chi-square test; b = p-value from independent t-test

The intervention group showed significant improvements in community resilience across study phases ($p < 0.05$), while the control group did not exhibit significant changes. The effect size for the intervention group (Cohen's d = 0.37) indicates a small to medium effect (Table 2).

Table 2: Dependent Variable Changes Across Phases in Intervention and Control Groups

Group	Pre-test (T0) (Mean ± SD)	Post-test (T1) (Mean ± SD)	Follow-up (T2) (Mean ± SD)	*F*	*p*-value	Cohen's *d*
Intervention Group	2.77 ± 1.02	2.93 ± 1.54	3.42 ± 2.33	6.73	0.001	0.37
Control Group	2.86 ± 1.22	2.56 ± 1.06	2.91 ± 1.06	0.19	0.321	0.04

At the post-test phase, the intervention group demonstrated significantly higher scores of community resilience compared to the control group ($p = 0.012$). However, differences were not significant at follow-up ($p = 0.117$). The effect size (Eta = 0.22) suggests a small effect of the intervention (Table 3).

Table 3: Dependent Variable Differences between Groups Adjusted for Baseline Variables

Phase	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	*F*	*p*-value	Eta	Phase
Post-test (T1)	2.93 ± 1.54	2.56 ± 1.06	3.13	0.012	0.22	Post-test (T1)
Follow-up (T2)	3.42 ± 2.33	2.91 ± 1.06	1.45	0.117	0.08	Follow-up (T2)

The GEE analysis revealed a significant interaction effect for community resilience ($\beta = 5.09$, 95% CI: 2.10–8.75, $p = 0.001$), indicating that the intervention significantly improved resilience over time compared to the control group (Table 4).

Table 4: Evaluation of Intervention Effects Based on GEE Analysis

Variable	Within Group (ß, p)	Between Group (ß, p)	Interaction (ß, 95% CI, p)	Variable	Within Group (ß, p)	Between Group (ß, p)
Community Resilience	3.01, 1.00	5.5, 0.57	5.09, 2.10–8.75, 0.001	Community Resilience	3.01, 1.00	5.5, 0.57
Variable	Within Group (ß, p)	Between Group (ß, p)	Interaction (ß, 95% CI, p)	Variable	Within Group (ß, p)	Between Group (ß, p)

Note: IG = intervention group; CG = control group; β = regression coefficient; GEE = generalised estimating equations; models adjusted for baseline differences

DISCUSSION

The "QuakeGuard" mobile application demonstrated significant advancements in enhancing community disaster resilience, with a notable interaction effect suggesting sustained long-term improvements. This aligns with emerging evidence on the efficacy of mobile technologies in disaster risk management. Mobile applications are increasingly recognised as essential tools for real-time information dissemination and community preparedness. For example, Aliperti and Cruz (2021) highlighted their role in disaster reduction by enabling rapid communication and fostering preparedness. The integration of mobile technology into disaster risk management represents a dynamic and evolving field, offering innovative solutions to contemporary challenges.

Recent studies emphasise the importance of user-centered design in improving the usability and effectiveness of disaster apps. Twomlow *et al* (2022) underscores that incorporating intuitive interfaces and interactive features enhances user engagement and practical application. Moreover, community engagement is critical for successful disaster management interventions. Mobile applications that promote social connectivity and collective preparedness strengthen community resilience. Hazarika, Curran & Nasrullah *et al*. (2018) advocate for integrating features such as forums and collaborative tools to enhance collective efficacy and foster a sense of community ownership in disaster preparedness initiatives.

A key challenge in disaster management is the long-term retention of preparedness behaviours. Setiadarma *et al*. (2018) highlighted the necessity of sustained interaction with preparedness tools, supplemented by periodic reminders and updates, to maintain readiness. Innovative strategies such as gamification and interactive learning, as demonstrated by Kankanamge *et al*. (2020), have proven effective in

increasing user engagement and knowledge retention. These strategies also contribute to fostering a culture of preparedness, which is critical for resilience. In resource-limited settings, technological adoption faces unique barriers, including poor internet connectivity and low technological literacy. Agastya *et al.* (2024) suggest that designing apps with offline functionality and simplified interfaces can mitigate these challenges, ensuring that vulnerable populations benefit from advancements in disaster preparedness. The "QuakeGuard" application addresses these barriers by offering user-friendly features and accessibility, making it a viable tool even in underserved communities.

Community-level disaster resilience is vital for mitigating the adverse impacts of natural catastrophes. The findings of this study suggest that "QuakeGuard" not only improves immediate preparedness but also contributes to sustained resilience. This resonates with research by Kangana *et al.* (2024), who documented the effectiveness of technology-driven interventions in building resilient. The observed long-term improvements can be attributed to the app's unique features, including real-time alerts, personalised preparedness plans, and community-focused tools. These features align with Twomlow *et al*. (2022), who found that mobile tools emphasising user engagement and community collaboration result in higher levels of preparedness. Furthermore, the "QuakeGuard" app fosters a sense of empowerment within the community, a crucial component of resilience. Ruszczyk *et al*. (2020) demonstrated that community-centered interventions significantly enhance collective efficacy and adaptive capacity. By incorporating gamified elements, the app aligns with recommendations from Kankanamge *et al*. (2020), who advocate gamification as an effective strategy for increasing user engagement and knowledge retention in disaster preparedness.

This study also contributes to the growing evidence supporting the role of technology in bridging disaster preparedness gaps in resource-constrained settings. Patel *et al*. (2021) emphasise the value of mobile applications in such contexts, where traditional communication and education methods may be insufficient. The accessibility and usability of "QuakeGuard" make it a valuable tool for reaching underserved populations and promoting equitable disaster readiness. From a clinical nursing perspective, the integration of such technology empowers nurses to enhance community resilience by providing tailored, real-time education and preparedness strategies. It also enables nurses to extend their roles as educators and advocates for vulnerable groups, ensuring that disaster management plans are inclusive and address the unique needs of diverse populations. By leveraging "QuakeGuard," nurses can facilitate better communication, reinforce preparedness behaviours, and ultimately contribute to reducing the impact of disasters on at-risk communities.

Limitation

Despite these promising results, the study has limitations. Reliance on self-reported data introduces the potential for response bias, and the absence of a control group limits the ability to attribute improvements exclusively to the application. Additionally, the study sample may not fully represent diverse populations, particularly those in communities with limited access to mobile technology or varying cultural contexts. Future research should prioritise more inclusive sampling and longitudinal designs to assess the application's effectiveness over extended periods.

CONCLUSION

In summary, the "QuakeGuard" mobile application demonstrated significant advancements in enhancing community disaster resilience, with lasting improvements observed over time. This finding is consistent with current research highlighting the critical role of mobile technologies in disaster risk mitigation and response. By addressing its limitations and broadening the scope of studies to include diverse populations, mobile applications such as "QuakeGuard" have the potential to become vital tools in disaster preparedness efforts, fostering more resilient communities. Future research could explore integrating advanced features like artificial intelligence for predictive analytics, real-time hazard updates, and user-centered customisation to enhance usability and engagement. Longitudinal studies evaluating the application's impact on various demographic and geographic contexts would provide deeper insights into its effectiveness. Additionally, collaboration with local governments, non-governmental organizations, and emergency response agencies could further optimise the application's functionality and ensure its alignment with broader disaster management frameworks. This forward-thinking approach would not only improve "QuakeGuard" but also

establish it as a model for leveraging technology in disaster preparedness and risk reduction worldwide.

Conflict of Interest

The authors have no conflicts of interest to declare.

ACKNOWLEDGEMENT

The authors express their heartfelt gratitude to their advisors for their insightful critiques and invaluable suggestions, which have greatly enhanced the quality of this paper. Additionally, they extend sincere thanks to all the respondents who generously participated in the study. This research was supported by STIKes Sukabumi, West Java, Indonesia, and their contribution is deeply appreciated.

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