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Effectiveness of Family-Centred Disaster Risk Mitigation-Based Health Education in Strengthening Household Preparedness among Tsunami-Prone Coastal Communities in Padang, Indonesia

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ABSTRACT

Indonesia is highly vulnerable to earthquakes and tsunamis, particularly along the western coast of Sumatra, where coastal communities experience recurrent disaster threats. This study evaluated the effectiveness of a family-centred disaster risk mitigation-based health education program in improving household preparedness among coastal communities in Padang, West Sumatra. Methods: A quasi-experimental study using a one-group pretest–posttest design was conducted among 60 purposively selected households from approximately 350 eligible households residing in Purus Village. The intervention combined lectures, interactive discussions, and disaster simulation exercises. Family preparedness was assessed using a validated questionnaire measuring disaster knowledge, attitudes, preparedness practices, emergency planning, evacuation readiness, emergency kit ownership, and first-aid capability. Data were analysed using descriptive statistics and paired-samples t-tests in IBM SPSS Statistics version 27, with statistical significance set at $p < 0.05$. Results: The intervention was associated with significant improvements in disaster knowledge, preparedness attitudes, preparedness practices, and overall household preparedness. Participants also demonstrated greater adoption of household emergency planning, evacuation preparedness, emergency supply preparation, and first-aid readiness, indicating successful translation of disaster knowledge into practical preparedness behaviours. Implications: Integrating simulation-based disaster health education into routine preparedness programmes coordinated by local disaster management agencies, primary healthcare centres, and village governments may strengthen household resilience in tsunami-prone coastal communities. Conclusion: Family-centred disaster risk mitigation-based health education represents an effective strategy for improving household preparedness and strengthening community resilience. Future controlled studies with longer follow-up periods are needed to establish causal relationships and evaluate the long-term sustainability of behavioural changes.

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INTRODUCTION

Disaster events continue to pose substantial public health, social, economic, and environmental challenges worldwide. Beyond causing mortality and physical injuries, disasters disrupt health systems, damage critical infrastructure, interrupt essential health services, and generate long-term psychosocial and environmental consequences that collectively threaten sustainable development. Consequently, disaster management has progressively shifted from a response-oriented paradigm toward Disaster Risk Reduction (DRR), emphasizing preparedness, prevention, and resilience as fundamental strategies for minimizing disaster impacts before hazardous events occur. Within this framework, strengthening community preparedness has become an essential public health priority because local populations constitute the first line of response during emergencies and frequently provide immediate assistance before formal emergency services arrive (Sasmito & Prawito, 2023). Indonesia is recognized as one of the most disaster-prone countries in the world due to its location at the convergence of the Indo-Australian, Eurasian, and Pacific tectonic plates within the Pacific Ring of Fire. This geographical setting exposes the country to recurrent earthquakes, tsunamis, volcanic eruptions, and hydrometeorological hazards. Among these hazards, earthquakes and tsunamis remain major public health concerns because of their potential to cause extensive casualties, population displacement, disruption of healthcare delivery, and long-term socioeconomic losses. Coastal communities along the western coast of Sumatra, particularly Padang City, are especially vulnerable because they are directly exposed to seismic activity originating from the Sunda Megathrust. The combination of high population density, extensive coastal settlements, and continuous exposure to earthquake and tsunami hazards substantially increases disaster risk, making preparedness a critical component of community health protection and disaster risk reduction (Buston et al., 2021).

Within disaster-prone communities, the family represents the smallest yet most strategic unit for disaster preparedness because household members are the first to respond immediately after a disaster occurs, long before external assistance becomes available. Families are responsible for making emergency decisions, conducting evacuation, providing first aid, protecting vulnerable members, maintaining sanitation, and ensuring the availability of emergency supplies during crises (Mahathir et al., 2022). Therefore, household preparedness has increasingly been recognized as a fundamental determinant of community resilience. This perspective is supported by the Knowledge–Attitude–Practice (KAP) framework, which explains that adequate knowledge contributes to positive attitudes that subsequently encourage preparedness behaviors, while family resilience theory emphasizes that households equipped with emergency planning, adaptive capacity, and disaster knowledge are better able to anticipate, withstand, and recover from disaster impacts. Consequently, disaster preparedness should not be viewed solely as an individual responsibility but rather as a family-centered public health strategy capable of strengthening resilience at both household and community levels.

Health education has been widely acknowledged as one of the most effective approaches for improving family disaster preparedness because it enhances disaster knowledge, shapes positive attitudes, and promotes preparedness behaviors before disasters occur. Educational interventions

provide opportunities for communities to recognize hazards, understand early warning systems, formulate emergency plans, and practice appropriate disaster responses through lectures, interactive discussions, and simulation-based learning that integrate cognitive and practical competencies (Lestari et al., 2023; Syahputra et al., 2024). Previous studies have consistently demonstrated beneficial effects of disaster education among emergency nurses, school students, volunteers, and community groups (Al-qbelat et al., 2022; Mhd Noor et al., 2022), while systematic evidence also indicates that educational and behavioral interventions contribute to improved household preparedness (Amberson et al., 2024). Nevertheless, several important research gaps remain. Most previous studies have focused on institutional settings or specific population groups rather than households as the principal unit of preparedness. In addition, preparedness outcomes have predominantly been limited to knowledge or attitude assessments, whereas comprehensive evaluations encompassing preparedness practices, emergency planning, evacuation readiness, first-aid capability, and household logistical preparedness remain relatively scarce (Sarfika et al., 2023). Evidence from highly vulnerable tsunami-prone coastal communities in Padang is also still limited, despite the city's significant exposure to earthquake and tsunami hazards. Furthermore, relatively few studies have integrated disaster risk mitigation principles, health education, and practical simulation into a single family-centered educational intervention while simultaneously evaluating preparedness across cognitive, behavioral, and practical household domains.

Accordingly, the present study addresses these research gaps by implementing a family-centered disaster risk mitigation-based health education intervention integrating lectures, interactive discussions, and disaster simulation among coastal households in Padang. Unlike previous investigations, this study comprehensively evaluates preparedness across disaster knowledge, attitudes, preparedness practices, emergency planning, evacuation readiness, emergency kit ownership, and first-aid capability. The novelty of this study lies in integrating disaster risk mitigation, health education, and simulation into a single family-centered intervention while comprehensively assessing multiple dimensions of household preparedness among families residing in a tsunami-prone coastal area. Therefore, this study aimed to examine pre–post changes in family preparedness following disaster risk mitigation-based health education among coastal households in Padang, West Sumatra.

METHODS

This study employed a quantitative quasi-experimental approach using a one-group pretest–posttest design to evaluate changes in family disaster preparedness following a disaster risk mitigation-based health education intervention. All participants completed baseline (pretest) and post-intervention (posttest) assessments using the same standardized instrument, enabling direct comparison of preparedness levels before and after the intervention. This design was selected because the educational program was implemented as a community-based disaster preparedness intervention in a highly vulnerable coastal area where withholding disaster preparedness education from eligible households was considered impractical and ethically inappropriate. Consequently, a comparison group was not included. Therefore, the study was designed to evaluate temporal changes in preparedness associated with the intervention rather than to establish causal relationships, and this methodological limitation should be considered when interpreting the findings.

The study was conducted between January and March 2026 in Purus Village, Padang City, West Sumatra Province, Indonesia. The study area is located along the western coast of Sumatra and directly faces the Mentawai Segment of the Sunda Megathrust, an active tectonic zone responsible for frequent earthquakes and potential tsunami events. According to the Padang Regional Disaster Management Agency (BPBD) and the national disaster risk mapping system (InaRISK), Purus Village is officially classified as a high-risk earthquake- and tsunami-prone area due to its proximity to active tectonic structures, dense coastal settlements, and previous experience with major seismic events. These geographical and demographic characteristics make the area highly vulnerable to disaster impacts and justify its selection as an appropriate setting for implementing household-based disaster preparedness interventions.

The target population comprised approximately 350 households residing within the tsunami-prone coastal area of Purus Village. The household served as the unit of analysis, with one adult respondent representing each household, preferably the household head or another family member responsible for household decision-making. The required sample size was estimated using G*Power version 3.1 for a paired-samples *t*-test with a two-tailed hypothesis, assuming a significance level (α) of 0.05, statistical power of 80% ($1-\beta = 0.80$), and a medium standardized effect size (Cohen's $dz = 0.50$), resulting in a minimum requirement of 34 households. To improve statistical precision, increase study power, and anticipate potential participant attrition, the sample size was increased to 60 households. All recruited participants completed every stage of the study; therefore, no respondents were excluded from the final analysis.

Participants were recruited using purposive sampling because the intervention specifically targeted households with the highest exposure to earthquake and tsunami hazards. Household selection was conducted in collaboration with village authorities and community health workers based on predetermined eligibility criteria. Eligible households were required to reside within the officially designated tsunami-prone coastal zone of Purus Village, have lived in the study area for at least one year, include at least one adult family member aged 18 years or older who was responsible for household decision-making, be willing to participate in all educational sessions, complete both pretest and posttest assessments, and provide written informed consent. Households were excluded if respondents experienced cognitive or communication impairments that prevented questionnaire completion, failed to attend the entire educational program, withdrew during the study period, or did not complete both assessments. From approximately 350 households identified through village administrative records, eligible households were screened consecutively according to these criteria and invited to participate until the predetermined sample size of 60 households was achieved. This sampling approach ensured that the selected participants represented households with substantial disaster exposure while fulfilling the operational requirements necessary for evaluating the intervention.

The intervention consisted of a standardized disaster risk mitigation-based health education program delivered by trained public health professionals experienced in disaster preparedness education. The educational program integrated three complementary learning methods. The first session consisted of a 90-minute lecture covering earthquake and tsunami hazards, disaster risk mitigation principles, early warning systems, emergency health management, sanitation during disasters, family emergency planning, and preparation of household emergency supplies. The second session involved a 60-minute interactive group discussion that encouraged participants to

share previous disaster experiences, identify household vulnerabilities, discuss local disaster risks, and formulate practical preparedness plans. The third session comprised a 120-minute disaster simulation during which participants practiced evacuation procedures, emergency communication, first-aid techniques, identification of evacuation routes and assembly points, and preparation of household emergency bags. Standardized educational modules, PowerPoint presentations, printed leaflets, flipcharts, educational videos, preparedness checklists, and demonstration equipment were used to ensure consistency in intervention delivery, while participant attendance was monitored throughout all educational sessions.

Family disaster preparedness was measured using a structured self-administered questionnaire adapted from established disaster preparedness instruments and modified to reflect the Indonesian coastal disaster context. The adaptation process included translation, contextual modification, expert review, and pilot testing before implementation. The questionnaire assessed multiple preparedness domains, including disaster knowledge, preparedness attitudes, preparedness practices, emergency planning, evacuation readiness, emergency kit ownership, and first-aid capability. Responses were scored according to predetermined scoring guidelines, with higher scores indicating better preparedness. Content validity was assessed by three experts in disaster management and public health, resulting in a Content Validity Index (CVI) of 0.91. Reliability testing conducted among respondents with similar characteristics outside the study area demonstrated satisfactory internal consistency, with an overall Cronbach's alpha coefficient of 0.89.

Data collection was conducted in three sequential stages. Baseline preparedness was first measured using the pretest questionnaire prior to implementation of the educational intervention. Participants subsequently attended the complete disaster risk mitigation-based health education program consisting of lectures, interactive discussions, and disaster simulation exercises. Fourteen days after completion of the intervention, the same questionnaire was administered as a posttest to evaluate changes in household disaster preparedness. Secondary information regarding disaster vulnerability and community risk characteristics was obtained from the Padang Regional Disaster Management Agency to support characterization of the study setting.

Data were analyzed using IBM SPSS Statistics version 27.0. Descriptive statistics were used to summarize respondent characteristics and preparedness indicators and are presented as frequencies, percentages, means, and standard deviations. Prior to inferential analysis, the normality of the pre–post difference scores was assessed using the Shapiro–Wilk test. Because all difference scores satisfied the assumption of normality ($p > 0.05$), changes in disaster knowledge, preparedness attitudes, preparedness practices, and overall preparedness scores before and after the intervention were analyzed using paired-samples *t*-tests. Mean differences were reported together with 95% confidence intervals (95% CI), *p*-values, and Cohen's *dz* effect sizes to quantify the magnitude of temporal changes associated with the intervention. Changes in preparedness categories and household preparedness components were summarized descriptively using frequencies and percentages to illustrate shifts before and after the intervention. As these variables were not subjected to paired categorical statistical testing in the present study, the observed changes should be interpreted as descriptive evidence supporting the overall pre–post findings rather than as formal statistical comparisons.

Ethical approval for this study was obtained from the Nusa Cendana University Ethics Committee (Approval No. 421/KEPK/2026) prior to data collection. All participants received

written and verbal information regarding the study objectives, procedures, potential benefits, possible risks, confidentiality, and voluntary participation before providing written informed consent. Participant anonymity was ensured through the use of unique identification codes, all research data were stored securely with access restricted to the research team, and participants were informed of their right to withdraw from the study at any stage without consequences.

RESULTS

1. Respondent Characteristics (Univariate Analysis)

Table 1. Distribution of Respondent Characteristics (n = 60)

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	38	63.3
	Female	22	36.7
Age	20–35 years	18	30.0
	36–50 years	27	45.0
	>50 years	15	25.0
Education	Elementary School	12	20.0
	Junior High School	18	30.0
	Senior High School	22	36.7
	College	8	13.3
Length of Stay	<5 years	10	16.7
	≥5 years	50	83.3

The study participants generally represented households with substantial exposure to earthquake and tsunami hazards. Most respondents were mature adults who had lived in the study area for many years, indicating considerable familiarity with local disaster risks and community conditions. In addition, the educational background of most participants suggested adequate literacy to understand and actively engage in the disaster risk mitigation-based educational activities. Overall, these characteristics indicate that the study population was appropriate for evaluating household preparedness within a high-risk coastal community.

2. Level of Preparedness Before and After Intervention

Table 2. Changes in Family Preparedness Scores Before and After the Disaster Risk Mitigation-Based Health Education Intervention (n = 60)

Preparedness Domain	Pretest Mean ± SD	Posttest Mean ± SD	Mean Difference (95% CI)	t (59)	p-value	Cohen's dz
Knowledge	55.20 ± 10.15	78.45 ± 8.72	23.25 (20.31–26.19)	14.32	<0.001	1.85
Attitude	60.10 ± 9.80	82.30 ± 7.95	22.20 (19.48–24.92)	13.95	<0.001	1.80
Practice	50.75 ± 11.20	76.85 ± 9.10	26.10 (22.96–29.24)	15.08	<0.001	1.95
Overall preparedness	**55.35 ± 8.95**	**79.20 ± 7.88**	**23.85 (20.82–26.88)**	**15.72**	**<0.001**	**2.03**

The findings demonstrate that the educational intervention was consistently associated with improvements across all measured dimensions of household disaster preparedness. Positive changes were observed not only in cognitive outcomes but also in attitudes and preparedness practices, indicating that participants were able to translate newly acquired knowledge into more adaptive preparedness behaviours. The large effect sizes further suggest that these improvements were meaningful from both statistical and practical perspectives, supporting the value of integrating disaster risk mitigation principles into community-based health education programs. Nevertheless, because the study employed a one-group pretest–posttest design, these findings should be interpreted as temporal improvements associated with the intervention rather than definitive evidence of causal effectiveness.

3. Distribution of Preparedness Categories

Table 3. Family Preparedness Categories Before and After the Intervention

Preparedness Category	Pretest n (%)	Posttest n (%)
Low	32 (53.3)	5 (8.3)
Moderate	20 (33.3)	18 (30.0)
High	8 (13.3)	37 (61.7)

The distribution of preparedness levels shifted substantially toward higher categories following implementation of the intervention. This pattern indicates that the observed improvements were experienced by a broad proportion of participating households rather than being limited to a small number of respondents. The overall movement toward better preparedness suggests that the educational program successfully strengthened household readiness across different levels of baseline preparedness, reflecting improved family capacity to anticipate and respond to disaster situations.

4. Ownership of Family Preparedness Components

Table 4. Changes in Household Preparedness Components Before and After the Intervention (n = 60)

Preparedness Component	Pre (%)	Post (%)	Absolute Change (pp)	Relative Increase (%)
Household emergency plan	25.0	70.0	+45.0	180.0
Knowledge of evacuation routes	40.0	85.0	+45.0	112.5
Emergency preparedness bag	20.0	65.0	+45.0	225.0
First-aid knowledge	35.0	80.0	+45.0	128.6

Descriptive findings indicate that the educational intervention contributed to improvements across all practical components of household disaster preparedness. Participants demonstrated greater readiness to implement concrete preparedness measures, including developing emergency plans, recognizing evacuation procedures, preparing emergency supplies, and strengthening first-aid capacity. These findings suggest that the intervention extended beyond improving disaster knowledge by encouraging the adoption of practical preparedness behaviours that are directly applicable during emergency situations. Collectively, the improvements observed across multiple preparedness components indicate that the intervention supported a more comprehensive

strengthening of household disaster preparedness and family resilience in tsunami-prone coastal communities.

5. Summary of Findings

Overall, the study demonstrated consistent improvements in family disaster preparedness after implementation of the disaster risk mitigation-based health education program. Significant pre–post increases were observed in knowledge, attitudes, preparedness practices, and overall preparedness scores, with large effect sizes across all continuous outcomes. Descriptive analyses also indicated substantial improvements in preparedness categories and household preparedness components, including emergency planning, evacuation knowledge, emergency supply preparedness, and first-aid knowledge. Taken together, these findings suggest meaningful temporal improvements in multiple dimensions of household disaster preparedness following participation in the intervention while recognizing that the study design does not permit definitive causal inference.

DISCUSSION

1. Changes in Family Preparedness Following the Educational Intervention

The present findings indicate that disaster risk mitigation-based health education was associated with meaningful improvements across multiple dimensions of family disaster preparedness. Rather than reflecting isolated gains in disaster knowledge, the intervention appears to have facilitated broader behavioural adaptation, suggesting that participants were able to integrate disaster-related information into practical household preparedness. This pattern supports the concept that effective preparedness education should promote not only cognitive understanding but also behavioural readiness and household decision-making capacity.

These findings are consistent with the Knowledge–Attitude–Practice (KAP) framework, which proposes that behavioural change develops progressively through improvements in knowledge, followed by the formation of favourable attitudes that eventually encourage the adoption of appropriate practices. Within the present intervention, lectures primarily strengthened participants' understanding of disaster risks and mitigation principles, whereas interactive discussions encouraged reflection on household vulnerabilities and facilitated positive attitudes toward preparedness. Consequently, the educational process appears to have supported behavioural change through sequential reinforcement of cognitive and affective domains before practical preparedness behaviours emerged.

The observed improvement in preparedness practices can also be interpreted using Social Cognitive Theory. According to this theory, behavioural change is strongly influenced by observational learning, behavioural rehearsal, self-efficacy, and mastery experiences rather than knowledge acquisition alone. The practical disaster simulation incorporated into the intervention likely contributed substantially to behavioural improvement because participants actively practiced evacuation procedures, emergency communication, first-aid techniques, and emergency planning under conditions resembling actual disaster situations. Such experiential learning enables individuals to transform abstract information into procedural knowledge while increasing confidence in performing appropriate actions during emergencies. Consequently, simulation may have produced greater improvements in preparedness practices than cognitive domains because it

directly strengthened behavioural competence and self-efficacy through repeated practice rather than passive information transfer alone.

This interpretation is consistent with previous educational research demonstrating that simulation-based learning generally produces greater improvements in practical preparedness than lecture-based education alone. Al-qbelat et al. (2022) similarly reported that disaster education integrating practical activities significantly enhanced disaster preparedness competencies among emergency nurses, while Noor et al. (2022) found that community-based educational interventions incorporating behavioural components effectively improved disaster preparedness. Furthermore, the systematic review conducted by Amberson et al. (2024) concluded that educational interventions combining knowledge transfer with practical learning activities consistently produce stronger improvements in household preparedness than information-based approaches alone. Collectively, these findings support the present results and suggest that simulation serves as an important mechanism for translating disaster knowledge into observable preparedness behaviours.

Several participant characteristics may also have contributed to the observed improvements. Most respondents had resided in the study area for many years and therefore had prolonged exposure to earthquake and tsunami risks. Such long-term exposure may have increased participants' awareness of local hazards and facilitated the integration of newly acquired disaster knowledge with previous personal experiences. Likewise, the predominance of respondents with secondary educational attainment may have supported comprehension of educational materials and active participation during lectures, discussions, and simulation exercises. These characteristics may have enhanced participants' ability to absorb disaster-related information and apply it within household preparedness planning, although these factors were not examined analytically in the present study and therefore should be interpreted cautiously.

From the perspective of Family Resilience Theory, preparedness extends beyond individual competencies and reflects the adaptive capacity of households as integrated social systems. Families that possess shared knowledge, coordinated emergency plans, and clearly defined responsibilities are generally better prepared to anticipate, respond to, and recover from disaster events. Therefore, the observed improvements likely represent strengthened collective household resilience rather than improvements confined to individual family members. This finding reinforces the importance of positioning the family as the primary target of community-based disaster preparedness programs.

2. Changes in Household Preparedness Categories

The shift toward higher preparedness categories suggests that the intervention generated improvements across a broad proportion of participating households rather than benefiting only a limited number of respondents. This finding indicates that the educational program was capable of strengthening preparedness among households with varying baseline levels of readiness, thereby supporting more equitable improvements within the community.

The observed transition is consistent with the sequential behavioural process described by the KAP framework. As disaster knowledge increased and attitudes toward preparedness became more favourable, participants appeared more willing to adopt preparedness behaviours within their households. Consequently, improvements in preparedness categories may reflect cumulative behavioural adaptation rather than isolated improvements in a single preparedness domain.

Contextual characteristics of the study population may also have influenced these findings. Participants living in a disaster-prone coastal environment are routinely exposed to information regarding earthquake and tsunami risks through community experience, local government activities, and previous disaster events. Such contextual exposure may have increased the perceived relevance of the educational program, thereby encouraging greater engagement throughout the intervention. Individuals who perceive disaster risks as personally relevant are generally more likely to adopt preparedness behaviours because educational messages are interpreted within the context of their everyday experiences.

These findings are consistent with previous quasi-experimental studies demonstrating that disaster preparedness education contributes to movement toward higher preparedness classifications among communities, volunteers, and school populations (Al-qbelat et al., 2022; Noor et al., 2022). The present study extends this evidence by demonstrating similar patterns within household populations residing in highly vulnerable tsunami-prone coastal communities.

3. Improvements in Household Preparedness Components

Improvements across household preparedness components suggest that the intervention influenced not only participants' knowledge but also their ability to implement concrete preparedness measures within the family environment. Household emergency planning, evacuation readiness, emergency supply preparation, and first-aid capability represent practical competencies that directly determine household capacity to respond during the critical period before external emergency assistance becomes available.

The comprehensive improvements observed across these components are likely attributable to the integrated structure of the educational program. Lectures provided conceptual understanding, interactive discussions facilitated collaborative problem-solving and family planning, whereas disaster simulations enabled participants to practice preparedness behaviours repeatedly within realistic scenarios. This combination created opportunities for participants to translate conceptual knowledge into practical household actions, thereby strengthening preparedness across multiple operational domains simultaneously.

The findings also align with Social Cognitive Theory, which emphasizes that repeated behavioural rehearsal and mastery experiences enhance self-efficacy and increase the likelihood that newly acquired behaviours will be maintained. Participants who repeatedly practiced evacuation procedures, emergency communication, and first-aid techniques during simulation were more likely to develop confidence in implementing these actions during actual emergencies. Consequently, improvements in practical preparedness components may reflect increased behavioural capability rather than simple acquisition of disaster-related information.

These findings are consistent with the systematic review by Amberson et al. (2024), which concluded that community-based educational interventions integrating practical learning activities frequently improve household preparedness behaviours, including emergency planning, disaster logistics, and preparedness practices. Therefore, the present findings further support recommendations that disaster education programs should incorporate experiential learning alongside conventional health education to maximize behavioural outcomes.

4. Practical Implications, Study Limitations, and Future Directions

The present findings suggest that integrating disaster risk mitigation into family-centred health education represents a promising strategy for strengthening household preparedness within disaster-prone coastal communities. From a public health perspective, preparedness education should be integrated into routine community health promotion activities delivered through primary healthcare centres, village health posts, schools, and community organisations. Incorporating practical simulation alongside health education may enhance behavioural readiness by providing opportunities for households to rehearse emergency responses before disasters occur.

Nevertheless, several methodological limitations should be acknowledged. The one-group pretest–posttest design does not permit definitive causal inference because improvements may also have been influenced by external factors occurring during the study period. Furthermore, purposive sampling within a single tsunami-prone coastal community may limit generalisability to populations with different geographical, cultural, or hazard characteristics. Participant characteristics, including previous disaster experience, educational attainment, and duration of residence, may also have influenced preparedness outcomes; however, these variables were not analysed as potential effect modifiers. Finally, preparedness was evaluated shortly after completion of the intervention, preventing assessment of the long-term sustainability of behavioural changes.

Future studies should employ controlled or randomized study designs with larger and more diverse household populations, incorporate longer follow-up periods to evaluate behavioural retention, and examine the influence of participant characteristics, including disaster experience, educational level, and residential history, on intervention effectiveness. Such investigations would strengthen the evidence base regarding disaster risk mitigation-based health education and support the development of more targeted family-centred disaster preparedness programmes.

CONCLUSIONS

This study demonstrated that a family-centred disaster risk mitigation-based health education program was associated with meaningful improvements in multiple dimensions of household disaster preparedness among families residing in tsunami-prone coastal communities in Padang, West Sumatra. The intervention contributed not only to enhanced disaster knowledge and preparedness attitudes but also to strengthened practical preparedness, including emergency planning, evacuation readiness, emergency supply preparation, and first-aid capability. These findings indicate that integrating lectures, interactive discussions, and simulation-based learning provides a comprehensive educational approach capable of supporting behavioural readiness and strengthening household resilience in disaster-prone coastal settings.

From a public health perspective, the findings underscore the strategic role of family-centred disaster preparedness education as an integral component of community disaster risk reduction. Because households constitute the first level of response before formal emergency assistance becomes available, strengthening family preparedness has the potential to reduce disaster-related health risks, facilitate more effective evacuation, and improve community resilience. Consequently, disaster preparedness education should be viewed not merely as an educational activity but as an essential investment in community health protection and disaster risk management within coastal populations vulnerable to earthquakes and tsunamis.

Nevertheless, the strength of the evidence generated by this study should be interpreted in light of several methodological limitations. The use of a one-group pretest–posttest design without a comparison group limits the ability to attribute the observed improvements exclusively to the educational intervention, as external events, repeated testing, or participants' previous disaster experiences may also have contributed to the changes. In addition, the purposive recruitment of households from a single tsunami-prone coastal community may limit the generalisability of the findings to other geographical settings with different demographic or hazard characteristics. Furthermore, preparedness outcomes were evaluated only during the short-term period following the intervention; therefore, the sustainability of behavioural changes over time remains uncertain. Accordingly, the present findings should be interpreted as evidence of significant temporal improvements associated with the intervention rather than definitive proof of causal effectiveness.

The findings provide several practical implications for disaster risk reduction policy and implementation. Disaster risk mitigation-based health education should be integrated into routine community preparedness programmes coordinated jointly by the **Padang Regional Disaster Management Agency (BPBD Kota Padang)**, **Primary Healthcare Centres (Puskesmas)**, and village governments in collaboration with community organisations. Rather than being conducted as a one-time educational activity, preparedness programmes should be implemented on a regular basis, at least twice annually, particularly in tsunami-prone coastal villages. Educational content should prioritise family emergency planning, identification of evacuation routes and assembly points, preparation of household emergency kits, basic first-aid skills, sanitation during disasters, and simulation-based evacuation exercises to strengthen practical preparedness. Involving local health cadres, community leaders, schools, and disaster preparedness volunteers may further enhance programme sustainability and community participation.

Future research should employ controlled quasi-experimental or randomized study designs to strengthen causal inference regarding intervention effectiveness. Studies involving larger household populations across multiple tsunami-prone coastal areas in Padang and other regions of western Sumatra are required to improve external validity and identify contextual differences in preparedness outcomes. Future investigations should also incorporate medium- and long-term follow-up assessments to evaluate the sustainability of behavioural change and examine the influence of contextual factors, including previous disaster experience, educational attainment, duration of residence, household socioeconomic conditions, and participation in previous disaster preparedness programmes, on intervention effectiveness. Such evidence will support the development of more targeted, evidence-informed, and sustainable family-centred disaster preparedness policies for coastal communities facing recurrent earthquake and tsunami risks.

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