



Enhancing Flood Disaster Knowledge and Preparedness among Health Vocational Students: Evidence from a School-Based Education Program

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ABSTRACT

Flood disasters are frequent hydrometeorological hazards in Indonesia and may disrupt school safety, learning continuity, and students' health. This study examined whether flood disaster preparedness education was followed by improvements in students' knowledge and preparedness and analyzed the association between both variables at Letris Indonesia 2 Health Vocational School, Tangerang. A quantitative pre-experimental study with a one-group pretest–posttest design was conducted among 30 students who completed all stages of the study. The intervention consisted of three 60-minute educational sessions covering flood causes, early warning signs, evacuation procedures, emergency kits, emergency communication, first aid, post-flood sanitation, and disease prevention. Data were collected using validated and reliable questionnaires. Because score differences were not normally distributed, pretest–posttest changes were analyzed using the Wilcoxon signed-rank test, while the association between knowledge and preparedness was examined using Spearman's rho. Students' knowledge increased significantly from a median of 60.00 to 82.00 ($Z = -4.72$, $p < .001$, $r = 0.86$). Preparedness also increased from a median of 52.00 to 78.00 ($Z = -4.78$, $p < .001$, $r = 0.87$). Knowledge was strongly associated with preparedness ($\rho = 0.871$, $p < .001$). Flood disaster preparedness education was associated with short-term improvements in students' knowledge and self-reported preparedness.

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INTRODUCTION

Indonesia is one of the countries with a high level of disaster vulnerability because it is located in an area characterized by complex geographic, geological, hydrometeorological, and socio-ecological conditions. Various types of disasters, such as floods, landslides, earthquakes, volcanic eruptions, droughts, forest and land fires, and extreme weather events, occur repeatedly across different regions of Indonesia. Among these disasters, floods are one of the most frequent hydrometeorological hazards and have widespread impacts on people's lives. Floods not only cause physical damage to settlements and infrastructure but also disrupt economic activities, health services, community mobility, and educational processes. In the context of disaster risk reduction, floods should be understood as events shaped by the interaction of natural hazards, population exposure, environmental vulnerability, community capacity, and suboptimal spatial planning and drainage governance. Therefore, flood risk reduction cannot rely solely on structural approaches, such as the construction

of embankments, drainage systems, or river normalization. It must also be strengthened through community capacity building, including the capacity of school communities.

Floods have significant impacts on the education sector. When flooding occurs, teaching and learning activities may be disrupted because access to schools is obstructed, school facilities are damaged, classrooms are inundated, learning materials are lost, and academic schedules are delayed. In addition, floods can increase health risks among students, including skin diseases, diarrhea, respiratory infections, leptospirosis, and other health problems that commonly emerge during the post-flood period. Disaster situations may also create psychological stress for students, particularly when they experience loss, uncertainty, or disruption to their learning routines. Thus, schools as educational institutions need to have the capacity to anticipate, respond to, and recover from disaster impacts. School preparedness is essential not only to protect the safety of students, teachers, and education personnel but also to ensure educational continuity during emergencies.

The disaster context in Tangerang is relevant to examine because the area is part of an urban region characterized by high population density, rapid residential development, intensive economic activity, and high community mobility. Urban areas such as Tangerang are vulnerable to flooding due to the combined effects of several factors, including high rainfall, land-use change, reduced water catchment areas, dense built environments, drainage conditions, and proximity to rivers or inundation-prone areas. Therefore, discussions of flood preparedness among students in Tangerang should be linked to local risk characteristics rather than only to the general disaster context in Indonesia. Information from official institutions such as the National Disaster Management Agency, inaRISK, the Regional Disaster Management Agency, and Statistics Indonesia can be used to strengthen the understanding of regional vulnerability, population exposure, and the urgency of school-based preparedness. The use of official data makes arguments regarding flood risk more credible and consistent with standards of scientific writing.

Within the framework of disaster risk reduction, schools occupy a strategic position because they function both as educational institutions and as social spaces that can foster a culture of safety, risk awareness, and community preparedness. Schools do not merely serve as places for teaching and learning; they also provide environments that can strengthen the capacity of students, teachers, education personnel, and families to understand and respond to disaster risks in a more organized manner (Ronan & Johnston, 2005; Marzban et al., 2025). The Comprehensive School Safety Framework emphasizes that school safety should be developed through a comprehensive approach that includes three main pillars: safe learning facilities, school safety management and educational continuity, and risk reduction and resilience education (Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector [GADRRRES], 2022). This approach is consistent with the Sendai Framework for Disaster Risk Reduction 2015–2030, which emphasizes the importance of understanding disaster risk, strengthening disaster risk governance, investing in disaster risk reduction, and enhancing preparedness for effective response (United Nations Office for Disaster Risk Reduction [UNDRR], 2015). In the Indonesian context, this perspective is also aligned with the Safe School/Madrasah policy and the Safe Education Unit Program, which emphasize the protection of school communities, institutional capacity building, and the integration of disaster risk reduction education into school activities (Badan Nasional Penanggulangan Bencana [BNPB], 2012; Kementerian Pendidikan dan Kebudayaan, 2017). Accordingly, schools are not only expected to provide safe buildings but also to have emergency procedures, evacuation routes, risk communication systems, preparedness drills, and learning activities that help students understand disaster risks in a contextual manner. Within this framework, students are not positioned solely as vulnerable groups who need protection, but also as agents of change who can disseminate preparedness information to peers, families, and surrounding communities (Ronan & Johnston, 2005; Seddighi et al., 2022; GADRRRES, 2022).

Disaster preparedness education is an important strategy for strengthening students' capacity to face disaster risks, including floods. Disaster education is not limited to transferring information about disaster types, causes, and impacts. It also aims to develop students' ability to recognize risks, understand warning signs, make appropriate decisions, follow evacuation procedures, and take protective actions before, during, and after disasters occur (Ronan & Johnston,

2005; Seddighi et al., 2022). Systematic reviews have shown that school-based disaster education programs can improve children's knowledge and preparedness, although their effectiveness is strongly influenced by program quality, age-appropriate content, teaching methods, resource availability, and teacher involvement (Seddighi et al., 2022). Therefore, effective disaster preparedness education should be structured, contextual, participatory, and not limited to one-way information delivery. Theoretically, disaster preparedness education can be linked to the concepts of risk awareness, risk perception, self-efficacy, response efficacy, and preparedness behavior. Risk awareness refers to students' awareness of the existence of flood threats and their potential impacts on their lives. Risk perception relates to how students assess the level of danger, vulnerability, and consequences associated with flooding. Self-efficacy refers to students' belief that they are capable of performing the necessary actions during an emergency (Bandura, 1997). Response efficacy refers to the belief that preparedness actions, such as understanding evacuation routes, preparing emergency supplies, participating in simulations, and following safety procedures, can effectively reduce risk. From the perspective of protection motivation theory, protective behavior is influenced by threat appraisal and coping appraisal, including perceived vulnerability, perceived severity, self-efficacy, and response efficacy (Rogers, 1983; Faryabi et al., 2023). Meanwhile, preparedness behavior refers to actual actions or readiness measures undertaken to reduce risk and improve safety during disasters (Paton, 2019; Faryabi et al., 2023).

The relationship among disaster education, knowledge, and preparedness needs to be explained systematically because these three concepts are interrelated but not identical. Knowledge serves as an initial foundation that enables students to understand flood risks, the causes of flooding, early warning signs, health and environmental impacts, and safety procedures that need to be followed. Adequate knowledge can improve students' ability to recognize hazards, understand early warning information, and choose safer actions in emergency situations (Seddighi et al., 2022; Marzban et al., 2025). However, knowledge is not the same as preparedness. Preparedness is a broader concept that includes action planning, the ability to follow evacuation routes, access to early warning information, resource readiness, emergency communication, basic first-aid skills, and psychological readiness to respond to emergencies (UNDRR, 2015; GADRRRES, 2022). Thus, knowledge can be viewed as an important prerequisite for preparedness, but increased knowledge does not automatically lead to disaster-ready behavior if it is not supported by practice, facilities, experience, school support, family support, and the broader social environment. Therefore, effective disaster preparedness education should not only emphasize cognitive aspects but also involve participatory approaches, practice, simulations, response-skill development, and the habituation of safety procedures within the school environment (Ronan & Johnston, 2005; BNPB, 2012; Seddighi et al., 2022). Through this approach, disaster education can serve as an important instrument for connecting risk knowledge with more practical, measurable, and sustainable preparedness.

Previous studies have shown that school-based disaster education programs can improve students' knowledge, attitudes, risk awareness, and preparedness. A systematic review by Seddighi et al. (2022) indicated that school-based education programs can help children and adolescents prepare for natural hazards, particularly when the content is delivered contextually and is appropriate to learners'

characteristics. Ronan and Johnston (2005) also emphasized the importance of schools, families, and communities in building disaster resilience among children and adolescents. Recent evidence on the role of schools in disaster risk management suggests that schools can function as centers of education, coordination, and community capacity building when they have structured safety management systems (Marzban et al., 2025). In addition, studies on the implementation of disaster risk reduction education emphasize that integrating disaster education into curricula and school activities remains an important agenda for strengthening preparedness among younger generations (Tyas et al., 2025).

Nevertheless, the literature also indicates that the implementation of disaster education in schools continues to face several limitations. First, not all schools have structured, institutionalized, and sustainable disaster education programs, despite the growing recognition that schools are strategic settings for disaster risk reduction and resilience education (Ronan & Johnston, 2005; Selby & Kagawa, 2012; GADRRRES, 2022; Marzban et al., 2025). Second, disaster learning is often still informational in nature and has not sufficiently incorporated practical exercises, evacuation simulations, scenario-based learning, or competency-based assessment, even though these approaches are important for translating risk knowledge into preparedness skills and protective actions (BNPB, 2012; Kementerian Pendidikan dan Kebudayaan, 2017; Seddighi et al., 2022; Fazeli et al., 2024; Guo et al., 2025). Third, evaluations of disaster education programs are frequently limited to measuring knowledge gains, whereas preparedness, practical skills, evacuation behavior, first-aid capability, and actual response performance are rarely assessed through observation, drills, or simulation-based methods (Seddighi et al., 2022; Intaramuean et al., 2025; Tyas et al., 2025). Fourth, more intervention studies are needed to examine changes in students' knowledge and preparedness before and after disaster education, particularly in the context of flood hazards and among secondary school students living or studying in flood-prone areas (Sumarno & Setiadi, 2023; Intaramuean et al., 2025). These limitations demonstrate the need for research that not only describes students' level of disaster knowledge but also assesses the extent to which preparedness education can improve students' knowledge, perceived readiness, and practical capacity to face flood risks.

In Indonesia, research on students' disaster knowledge and preparedness has continued to grow, but many studies have focused on relationships among variables or descriptive assessments of preparedness levels rather than intervention-based evaluation (BNPB, 2012; Kementerian Pendidikan dan Kebudayaan, 2017; Sumarno & Setiadi, 2023). Several studies have shown that disaster knowledge is associated with students' attitudes, risk perception, preparedness, and protective behavior; however, intervention studies that specifically evaluate flood disaster preparedness education using a pretest–posttest approach remain relatively limited (Seddighi et al., 2022; Sumarno & Setiadi, 2023; Intaramuean et al., 2025). In addition, few studies have focused on health vocational school students as the target population. This gap is important because health vocational students have characteristics that are highly relevant to flood preparedness, as they study basic health knowledge, first aid, sanitation, health communication, and community health services. These competencies can be directly linked to flood preparedness needs, such as initial assistance, prevention of post-flood diseases, environmental health promotion, emergency communication, and risk education for the community. This

relevance is also supported by evidence that floodwater may contain sewage, hazardous materials, and pathogens that increase the risk of gastrointestinal illness, wound infection, skin problems, leptospirosis, and other post-flood health threats, making health-oriented preparedness education particularly important in flood-prone school settings (Centers for Disease Control and Prevention [CDC], 2024; Acosta-España et al., 2024).

Based on the above discussion, the research gap in this study lies in the limited number of intervention studies evaluating the effectiveness of flood disaster preparedness education among vocational high school students, particularly health vocational students in Tangerang. This gap is not only related to the limited number of studies but also to the need to understand how preparedness education can improve students' knowledge and preparedness within the context of local flood risk. The novelty of this study lies in its focus on health vocational students as a strategic group in strengthening school-based preparedness, its use of the Tangerang flood-risk context as an empirical background, and its evaluation of disaster preparedness education in relation to two main aspects: knowledge and preparedness. By positioning schools as strategic settings for disaster risk reduction, this study is expected to provide empirical contributions to the development of more structured, contextual, and practical disaster education programs.

This study aimed to analyze the effectiveness of disaster preparedness education in improving students' knowledge and preparedness for flood disasters at Letris Indonesia 2 Health Vocational School, Tangerang. Specifically, this study examined changes in students' knowledge and preparedness before and after receiving flood preparedness education and analyzed the relationship between students' knowledge and preparedness in facing flood risks. The findings are expected to strengthen evidence that school-based disaster education is an important strategy for building student preparedness, supporting a school safety culture, and strengthening disaster risk reduction within educational settings.

METHODS

This study used a quantitative design with a pre-experimental approach through a one-group pretest–posttest design. This design was used to evaluate changes in students' knowledge and preparedness for flood disasters before and after the disaster preparedness education intervention. In this design, all respondents were measured at two time points: before the intervention through a pretest and after the intervention through a posttest. Because this study did not include a control group, the findings were interpreted as changes observed after the intervention, while still considering the possibility that external factors may have influenced the results.

The study was conducted at Letris Indonesia 2 Health Vocational School, Tangerang, from September to October 2025. The location was selected because schools are strategic settings for strengthening disaster preparedness, particularly among health vocational students who are closely related to health, first aid, sanitation, and community education. The population in this study consisted of all active students at Letris Indonesia 2 Health Vocational School, Tangerang, during the current academic year. The study sample included 30 students who met the inclusion criteria and completed all stages of the study, from the pretest and educational intervention to the posttest.

Sampling was conducted using stratified random sampling. Respondents were randomly selected in proportion to the number of students in each stratum. The inclusion criteria were active students at Letris Indonesia 2 Health Vocational School, Tangerang, who were willing to participate as respondents, attended the educational intervention, and completed both the pretest and posttest questionnaires. The exclusion criteria included students who did not participate in one of the study stages, did not complete the questionnaire, or provided incomplete responses that could not be analyzed.

The intervention in this study consisted of flood disaster preparedness education delivered to students after the pretest. The education was designed to improve students' understanding of flood risks, preparedness actions, and emergency response procedures in both school and home settings. The educational materials covered the definition and causes of floods, flood risk factors in urban environments, early warning signs, the impacts of floods on health and education, simple mitigation measures, evacuation procedures, evacuation route identification, emergency kit preparation, emergency communication, basic first aid, post-flood sanitation, and prevention of diseases that may occur after flooding. These materials were developed based on a literature review, disaster preparedness guidelines, and principles of school-based disaster risk reduction. The educational intervention was delivered in three sessions, each lasting 60 minutes. The learning methods included interactive lectures, group discussions, educational videos, leaflets or visual materials, preparedness demonstrations, and question-and-answer activities.

The study procedure was carried out in several stages. The first stage involved coordination with the school to obtain permission, determine the schedule, and arrange technical procedures. The second stage involved respondent recruitment based on the inclusion and exclusion criteria. The third stage was the pretest, which measured students' knowledge and preparedness levels before the educational intervention. The fourth stage was the implementation of the flood disaster preparedness education intervention. The fifth stage was the posttest, which measured changes in students' knowledge and preparedness after the education was delivered. The posttest was conducted immediately after the intervention to identify changes that occurred after students received the educational materials.

Data were collected using a structured questionnaire developed by the researchers based on a literature review on flood disaster knowledge and student preparedness. The questionnaire consisted of three main sections. The first section included respondents' characteristics, such as gender, age, grade level, previous flood experience, previous disaster training experience, and sources of disaster-related information. The second section measured students' knowledge of flood disasters, including flood causes, early warning signs, flood impacts, safety procedures, evacuation routes, and actions before, during, and after flooding. The third section measured students' preparedness for flood disasters. Preparedness indicators included not only perceived readiness but also emergency planning, warning systems, resource mobilization, evacuation capacity, emergency communication, and readiness to follow safety procedures. Thus, preparedness measurement was more comprehensive and was not limited to declarative knowledge.

Instrument validity was tested using Pearson Product Moment correlation or corrected item-total correlation to assess the relationship between each item and the total score of each variable. An item was considered valid if the calculated r value was greater than the r table value at a 5% significance

level or met the predetermined item-total correlation criterion. The authors should report the number of items tested, the range of item validity values, the number of retained items, and the number of deleted items, if any items were invalid. Reliability testing was conducted using Cronbach's alpha. An instrument was considered reliable if Cronbach's alpha was ≥ 0.70 . The reliability test showed a Cronbach's alpha of 0.820 for the knowledge variable and 0.785 for the preparedness variable, indicating that both instruments had adequate reliability.

The collected data were examined through editing, coding, data entry, and cleaning before analysis. Data checking was conducted to ensure response completeness, coding accuracy, and consistency of paired pretest and posttest data from the same respondents. Respondents included in the analysis were students who completed all stages of the study, namely the pretest, flood disaster preparedness education, and posttest. Data were analyzed using SPSS version 22. Univariate analysis was used to describe respondent characteristics and the distribution of study variables. Categorical data, such as gender, knowledge category, and preparedness category, were presented as frequencies and percentages. Knowledge was categorized into three groups: good, moderate, and poor. Preparedness was presented using three consistent categories: prepared, moderately prepared, and less prepared.

In addition to categorical analysis, knowledge and preparedness scores were analyzed as numerical data to assess the magnitude of changes before and after the intervention. Normality testing was performed on the difference between posttest and pretest scores for each variable using the Shapiro-Wilk test because the number of respondents was less than 50. Based on the normality test results, the differences in knowledge and preparedness scores did not meet the normality assumption. Therefore, numerical data were presented as medians and interquartile ranges (IQRs), rather than means and standard deviations.

Bivariate analysis to assess differences in knowledge scores before and after the education was conducted using the Wilcoxon signed-rank test. The same test was also used to assess differences in preparedness scores before and after the education. The results were reported as pretest medians, posttest medians, IQRs, Z values, p -values, and effect sizes. The effect size for the Wilcoxon signed-rank test was calculated using the formula $r = Z/\sqrt{N}$, with 0.10 interpreted as a small effect, 0.30 as a moderate effect, and 0.50 or higher as a large effect.

To analyze the association between students' knowledge and preparedness after the education, Spearman's rho correlation test was used. This test was selected because the data did not meet the normality assumption and because the relationship analyzed involved knowledge and preparedness scores that could be treated as ordinal or nonparametric data. Correlation results were reported as Spearman's correlation coefficient, 95% confidence interval, p -value, and interpretation of the strength of the association. A positive correlation coefficient indicated that higher knowledge scores were associated with higher preparedness scores for flood disasters. Statistical significance was set at $p < 0.05$. Very small p -values were reported as $p < 0.001$, rather than $p = 0.000$.

RESULTS OF STUDY

A total of 30 students from Letris Indonesia 2 Health Vocational School, Tangerang, completed the entire study

process, including the pretest, flood disaster preparedness education, and posttest. All respondents included in the final analysis completed the questionnaires, and no missing data were excluded from the analysis. Thus, the analysis in this section was based on 30 respondents with complete paired data before and after the intervention. If the planned number of respondents differed from the number analyzed, the authors should add a participant flow description, including the number of students invited, the number who agreed to participate, the number who completed the pretest, the number who participated in the intervention, the number who completed the posttest, and the final number included in the analysis. Respondent characteristics were presented to describe the profile of students involved in the study. Based on gender, most respondents were female, with 27 students or 90.0%, while male respondents accounted for 3 students or 10.0%. This distribution indicates that the study respondents were predominantly female.

Table 1. Characteristics of Respondents Based on Gender

Variable	Frequency (F)	Percentage (%)
Male	3	10
Female	27	90
Total	30	100

The measurement of students' knowledge before and after the educational intervention showed an improvement in knowledge categories after the intervention was delivered. Before the education, only 6 students, or 20.0%, had good knowledge. A total of 12 students, or 40.0%, were in the moderate category, and another 12 students, or 40.0%, were in the poor category. After the flood disaster preparedness

education was provided, the number of students with good knowledge increased to 18 students, or 60.0%. Meanwhile, the number of students with moderate knowledge decreased to 8 students, or 26.7%, and the number of students with poor knowledge decreased to 4 students, or 13.3%. These findings indicate that flood disaster preparedness education was followed by a shift in students' knowledge categories toward a better level.

Table 2. Distribution of Students' Knowledge Levels Before and After Flood Disaster Preparedness Education

Knowledge Category	Pretest n (%)	Posttest n (%)
Good	6 (20.0)	18 (60.0)
Moderate	12 (40.0)	8 (26.7)
Poor	12 (40.0)	4 (13.3)
Total	30 (100.0)	30 (100.0)

Based on Table 3, students' knowledge scores increased after they received flood disaster preparedness education. The median knowledge score before the intervention was 60.00, with an interquartile range of 50.00–68.00, whereas after the intervention, the median score increased to 82.00, with an interquartile range of 74.00–90.00. The median difference of 22.00 indicates an increase in students' knowledge after participating in the education. The Wilcoxon signed-rank test showed that this improvement was statistically significant, $Z = -4.72$, $p < 0.001$. The effect size of $r = 0.86$ indicates a large effect, suggesting that flood disaster preparedness education made a strong contribution to improving students' knowledge.

Table 3. Changes in Students' Knowledge Scores Before and After Flood Disaster Preparedness Education

Variable	Pretest Median (IQR)	Posttest Median (IQR)	Median Difference	Z	p-value	Effect Size (r)	Interpretation
Knowledge	60.00 (50.00–68.00)	82.00 (74.00–90.00)	22.00	-4.72	< .001	0.86	Significant improvement

The measurement of students' preparedness also showed improvement after the education was provided. Before the education, only 1 student, or 3.3%, was categorized as prepared, while 8 students, or 26.7%, were categorized as moderately prepared, and 21 students, or 70.0%, were categorized as less prepared. After the education, the number of students in the prepared category increased to 18 students, or 60.0%, while 9 students, or 30.0%, were categorized as moderately prepared, and the number of students in the less prepared category decreased to 3 students, or 10.0%. These results indicate that flood disaster preparedness education was followed by an improvement in students' preparedness.

Table 4. Distribution of Students' Preparedness Levels Before and After Flood Disaster Preparedness Education

Preparedness Category	Pretest n (%)	Posttest n (%)
Prepared	1 (3.3)	18 (60.0)
Moderately Prepared	8 (26.7)	9 (30.0)
Less Prepared	21 (70.0)	3 (10.0)
Total	30 (100.0)	30 (100.0)

Based on Table 5, students' preparedness scores also increased after they received flood disaster preparedness education. The median preparedness score before the intervention was 52.00, with an interquartile range of 44.00–60.00, whereas after the intervention, the median score increased to 78.00, with an interquartile range of 70.00–86.00. The median increase of 26.00 indicates a positive change in students' preparedness after receiving the education. The Wilcoxon signed-rank test showed that the difference in preparedness scores before and after the intervention was statistically significant, $Z = -4.78$, $p < 0.001$. The effect size of $r = 0.87$ indicates a large effect, suggesting that the education provided was strongly associated with improved student preparedness for flood disasters.

Based on Table 6, there was a strong positive association between students' knowledge scores and preparedness scores after the flood disaster preparedness education. The analysis using Spearman's rho showed a correlation coefficient of 0.871, with a 95% CI of 0.744–0.937 and $p < 0.001$. This positive correlation indicates that higher knowledge scores were associated with higher preparedness scores among students in facing flood disasters. Thus, better

knowledge of flood risks, early warning signs, evacuation procedures, and preparedness actions was closely related to students’ readiness to respond to potential disasters. However, this finding should be interpreted with caution

because correlation analysis only indicates an association between variables and does not establish a direct cause-and-effect relationship.

Table 5. Changes in Students’ Preparedness Scores Before and After Flood Disaster Preparedness Education

Variable	Pretest (IQR)	Median	Posttest (IQR)	Median	Median Difference	Z	p-value	Effect Size (r)	Interpretation
Preparedness score	52.00 (44.00–60.00)		78.00 (70.00–86.00)		26.00	-4.78	< .001	0.87	Significant improvement

Table 6. Association Between Students’ Knowledge and Preparedness Scores After Flood Disaster Preparedness Education

Variables Analyzed	Correlation Coefficient	95% CI	p-value	Interpretation
Knowledge and preparedness	0.871	0.744–0.937	< .001	Strong positive association

Overall, the analysis showed that flood disaster preparedness education was followed by significant improvements in students’ knowledge and preparedness. In addition, knowledge had a strong positive association with preparedness. These findings indicate that improving knowledge through disaster education is an important component in building students’ preparedness. Nevertheless, because this study used a one-group pretest–posttest design without a control group, conclusions regarding the effectiveness of the education should be stated cautiously as improvements observed after the intervention, rather than as causal evidence that is completely free from the influence of external factors.

DISCUSSION

The findings of this study indicate that flood disaster preparedness education was followed by improvements in students’ knowledge and preparedness at Letris Indonesia 2 Health Vocational School, Tangerang. The discussion is organized according to the main findings: first, the improvement in students’ knowledge after the intervention; second, the improvement in students’ preparedness; and third, the association between knowledge and preparedness after the intervention. This structure is important because knowledge and preparedness are related but conceptually distinct constructs. Knowledge reflects students’ cognitive understanding of flood risks and safety procedures, whereas preparedness reflects readiness to plan, respond, mobilize resources, and follow emergency procedures. However, because this study used a one-group pretest–posttest design without a control group, the findings should be interpreted as improvements observed after the educational intervention rather than definitive causal evidence that all changes were caused solely by the intervention.

The first major finding shows that students’ knowledge increased after receiving flood disaster preparedness education. Before the intervention, a considerable proportion of students were still categorized as having moderate or poor knowledge, whereas after the intervention, the proportion of students with good knowledge increased. This finding suggests that structured disaster education can improve students’ understanding of flood causes, early warning signs, health and environmental impacts, evacuation procedures, emergency communication, and actions before, during, and

after floods. This result is consistent with Ronan and Johnston (2005), who emphasized that schools, youth, and families are important actors in strengthening community resilience. It also supports the systematic review by Seddighi et al. (2022), which found that school-based education programs can help prepare children for natural hazards, although program quality, teaching methods, age appropriateness, and resource availability remain important determinants of effectiveness. Similar conclusions were also reported by Guo et al. (2025), who highlighted that disaster preparedness education requires the use of appropriate educational models, risk communication strategies, and innovative learning approaches to improve preparedness outcomes.

The increase in knowledge can be explained through the educational mechanism used in the intervention. Disaster preparedness education provides students with organized information that helps them recognize hazards, understand risk factors, and identify appropriate protective actions. Through interactive lectures, discussion, visual materials, videos, demonstrations, and question-and-answer activities, students can connect abstract disaster concepts with practical situations that may occur in their school or home environment. Disaster education is more likely to be meaningful when it is contextualized to local risks, such as flood-prone urban areas, drainage problems, high rainfall, and exposure to flood-related health problems. Intaramuean et al. (2025) found that flood education programs incorporating discussions, workshops, slide presentations, interactive teaching, and local flood information improved students’ flood knowledge and preparedness. Therefore, the improvement in students’ knowledge in the present study may reflect the role of structured and contextual learning in strengthening risk awareness and understanding of flood preparedness.

The second major finding shows that students’ preparedness also improved after the educational intervention. Before the intervention, most students were categorized as less prepared, while after the intervention, the number of students categorized as prepared increased substantially. This finding suggests that the intervention was not only associated with cognitive improvement but also with better self-reported readiness to face flood disasters. Preparedness is broader than knowledge because it includes emergency planning, access to warning information, resource mobilization, evacuation capacity, communication readiness, and confidence in following safety procedures. In line with the Comprehensive School Safety Framework, school safety

should not be limited to safe buildings but should also include school disaster management, continuity of education, and risk reduction and resilience education (Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector [GADRRRES], 2022). This finding is also consistent with the Sendai Framework for Disaster Risk Reduction 2015–2030, which emphasizes understanding disaster risk, strengthening disaster risk governance, investing in risk reduction, and enhancing preparedness for effective response (United Nations Office for Disaster Risk Reduction [UNDRR], 2015).

The improvement in preparedness can be further understood through the concepts of self-efficacy and response efficacy. Self-efficacy refers to students' belief that they are capable of performing protective actions, whereas response efficacy refers to the belief that those actions are useful in reducing risk. When students understand evacuation routes, emergency kits, early warning signs, first aid principles, post-flood sanitation, and emergency communication procedures, they may feel more capable of responding to flood-related risks. Bandura (1997) emphasized that perceived self-efficacy influences how individuals think, feel, and act in challenging situations. In the context of disaster preparedness, Protection Motivation Theory explains that protective behavior is shaped by threat appraisal and coping appraisal, including perceived severity, perceived vulnerability, self-efficacy, and response efficacy (Rogers, 1983; Faryabi et al., 2023). Paton (2019) also argued that disaster preparedness is influenced by psychological, social, and contextual factors, not merely by the availability of information. Thus, education can improve preparedness when it strengthens students' perception of risk and their confidence in taking appropriate actions.

The findings are also supported by more recent literature on individual preparedness and behavioral training. Fazeli et al. (2024) noted that preparedness should not be viewed as a short-term transfer of information, but as a long-term process that promotes relevant skills, safety culture, and collaboration between individuals, schools, communities, and government institutions. This perspective is relevant to the present study because the observed improvement in preparedness may represent an initial gain following education, while sustained preparedness would require repeated learning, drills, school policy support, and institutionalized safety procedures. Guo et al. (2025) similarly emphasized that disaster preparedness education can be strengthened through behavior change theories, risk communication models, simulations, and innovative learning approaches. Therefore, while the findings are encouraging, a single educational intervention should be considered an entry point for building preparedness rather than a complete disaster risk reduction program.

The third major finding shows a strong positive association between students' knowledge and preparedness after the intervention. This indicates that students with higher knowledge scores tended to have higher preparedness scores. This result supports the assumption that knowledge is an important foundation for preparedness. Students who understand the causes of floods, warning signs, evacuation procedures, emergency supplies, and post-flood health risks are more likely to report better preparedness. Similar findings were reported by Sumarno and Setiadi (2023) in a study of junior high school students in Bekasi, Indonesia, which showed that knowledge, attitude, and behavior were related to flood preparedness. However, the same study also indicated that knowledge, attitude, and action explained only a portion of preparedness, suggesting that other factors also contribute to disaster readiness. This supports the argument that knowledge is necessary but not sufficient; preparedness also depends on prior disaster experience, family support,

school facilities, warning systems, drills, and the broader social environment.

The strong correlation between knowledge and preparedness in this study needs to be interpreted critically. Although the coefficient suggests a very strong positive association, the relationship may partly reflect common method bias because both knowledge and preparedness were measured using self-report questionnaires administered to the same respondents. Kock et al. (2021) explained that common method bias may occur when independent and dependent variables are collected using the same response method, and this can inflate or distort observed relationships. Podsakoff et al. (2003) also noted that common rater effects, social desirability, consistency motives, and similar measurement contexts can influence survey responses. In this study, students who answered positively on knowledge items may also have answered positively on preparedness items, especially if the instruments contained overlapping content. Therefore, although the correlation is meaningful, it should not be interpreted as evidence that knowledge directly causes preparedness. It is more appropriate to state that higher knowledge is strongly associated with higher self-reported preparedness.

The claim of effectiveness should also be presented carefully. The results show significant improvements in knowledge and preparedness after the intervention, but the absence of a control group limits the ability to rule out alternative explanations. Changes may have been influenced by discussion among students, exposure to information from social media, prior flood experience, family conversations, teacher influence, or other school activities conducted during the same period. Moreover, the posttest was conducted shortly after the intervention, meaning that the results primarily reflect short-term changes. This is important because immediate posttest gains may not necessarily indicate long-term retention or actual behavioral readiness. Intaramuean et al. (2025) also highlighted the importance of follow-up measurement in flood preparedness education because maintaining risk perception and preparedness over time remains challenging. Therefore, the results should be framed as evidence that disaster preparedness education was associated with short-term improvement in students' knowledge and preparedness.

The context of a health vocational school adds an important dimension to the interpretation of the findings. Students at a health vocational school are exposed to basic health knowledge, first aid, sanitation, health communication, and community health promotion. These competencies are highly relevant to flood preparedness because flood disasters are often followed by health risks such as diarrhea, skin infections, respiratory infections, leptospirosis, water contamination, and sanitation problems. Therefore, flood preparedness education for health vocational students can be linked to practical competencies, including basic first aid, post-flood hygiene promotion, emergency communication, and health education for families and communities. This is consistent with school-based disaster risk reduction literature, which views students not only as vulnerable groups but also as potential agents of change who can disseminate preparedness information to peers, families, and communities (Ronan & Johnston, 2005; Seddighi et al., 2022; GADRRRES, 2022; Marzban et al., 2025). However, because this study did not directly measure first aid skills, evacuation performance, or actual disaster response behavior through simulation or observation, the discussion should be limited to self-reported preparedness rather than actual response competence.

From a practical perspective, the findings suggest that disaster preparedness education should be integrated into school programs in a more systematic and sustainable manner. One-time education may improve short-term knowledge, but building a disaster-aware culture requires repeated exposure, practical exercises, teacher involvement, school policy support, and collaboration with local disaster management agencies. The Comprehensive School Safety Framework emphasizes the need for safe learning facilities, school safety management, continuity of education, and risk reduction and resilience education (GADRRRES, 2022). Similarly, the Indonesian Safe School/Madrasah policy and the Safe Education Unit program emphasize the importance of protecting school communities, strengthening institutional capacity, and integrating disaster risk reduction into school activities (Badan Nasional Penanggulangan Bencana [BNPB], 2012; Kementerian Pendidikan dan Kebudayaan, 2017). Therefore, schools can strengthen preparedness through regular education sessions, flood hazard mapping, evacuation route identification, emergency drills, school disaster management teams, emergency kits, and cooperation with BPBD, health centers, and local communities.

The sustainability of the program is essential. Disaster preparedness should not be treated as a single educational event but as a continuous learning process. Regular simulations, scenario-based learning, evacuation drills, peer education, and integration into classroom and extracurricular activities may help maintain students' preparedness over time. Tyas et al. (2025) noted that disaster risk reduction education still faces challenges related to curriculum integration, pedagogical alignment, and implementation gaps. Fazeli et al. (2024) also emphasized that preparedness training requires long-term systematic planning and stakeholder engagement. In the school setting, teachers play a central role in maintaining the continuity of disaster education because they can connect preparedness materials with students' daily experiences and school safety procedures. Therefore, the findings of this study can be used as a basis for developing more sustained, participatory, and practice-oriented disaster preparedness programs in health vocational schools.

This study has several limitations. First, it was conducted in a single school, which limits the generalizability of the findings to other schools or regions. Second, the sample size was relatively small, so the findings should be interpreted with caution. Third, the one-group pretest–posttest design without a control group limits causal inference. Fourth, the data were collected through self-report questionnaires, which may be affected by response bias, social desirability bias, and common method bias (Podsakoff et al., 2003; Kock et al., 2021). Fifth, the posttest was conducted shortly after the intervention, so the study cannot determine whether the improvements were sustained over time. Sixth, the study did not include direct behavioral assessment, evacuation simulation, first aid performance assessment, or observation of actual preparedness behavior. Consequently, the conclusions should be restricted to improvements in knowledge and self-reported preparedness.

Future studies should use stronger designs, such as quasi-experimental designs with control groups, or cluster-based comparisons between classes. Studies with larger samples and multiple schools are also needed to improve generalizability. Follow-up measurements should be included to examine knowledge retention and sustained preparedness. In addition, future research should combine questionnaires with direct observation, evacuation drills, simulation-based assessment, first aid skill evaluation, and school preparedness

audits. Such approaches would provide stronger evidence regarding whether disaster preparedness education improves not only what students know and report, but also how they act in simulated or real emergency situations.

CONCLUSIONS AND RECOMMENDATION

This study showed that flood disaster preparedness education was followed by significant improvements in students' knowledge and preparedness at Letris Indonesia 2 Health Vocational School, Tangerang. Students' knowledge and preparedness scores increased after the educational intervention, indicating that structured disaster preparedness education may strengthen students' understanding of flood risks, early warning signs, evacuation procedures, emergency communication, and basic preparedness actions. The study also found a strong positive association between knowledge and preparedness, suggesting that students with higher disaster-related knowledge tended to report better preparedness for flood disasters.

However, because this study used a one-group pretest–posttest design without a control group, the findings should be interpreted cautiously as short-term improvements observed after the intervention, rather than definitive causal evidence. The results support the importance of integrating disaster preparedness education into school-based learning activities, particularly in flood-prone areas. Schools are encouraged to implement disaster education continuously through classroom learning, evacuation drills, simulations, emergency planning, and collaboration with local disaster management and health institutions. Future studies should involve larger samples, multiple schools, control groups, follow-up measurements, and direct assessment of preparedness behavior to provide stronger evidence regarding the long-term effectiveness of disaster preparedness education.

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Conflicts of interest/Competing interests

The authors declare that they have no conflicts of interest related to this study.

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles for research involving human participants. All participants provided informed consent prior to data collection. Participation was voluntary, and confidentiality and anonymity of respondents were strictly maintained throughout the study.

Consent for publication

Not applicable. The manuscript does not contain any individual person's data in any form (including images, videos, or personal details).

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Artificial Intelligence-Assisted Technology

The authors declare that no artificial intelligence-assisted technology was used in the design, data collection, analysis, or interpretation of the study results.

Authors' contributions:

Rina Wijayanti developed the initial research idea, formulated the study objectives, designed the research framework, coordinated the data collection process, conducted the initial data analysis, and prepared the first draft of the manuscript. Dina Raidanti provided methodological guidance throughout the study, reviewed the appropriateness of the research design and instruments, contributed to the interpretation of the findings, and critically revised the manuscript to strengthen its scientific clarity and coherence. Wahidin was responsible for the statistical analysis, checked the consistency and accuracy of the data interpretation, verified the presentation of the results, and contributed to improving the manuscript's analytical and technical quality. Septia Dwi Lestari supervised the overall research process, reviewed the final version of the manuscript, provided substantive input on the discussion and conclusion, and approved the manuscript for submission.

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ADDITIONAL INFORMATION

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