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Development of Virtual Reality Media for Earthquake Simulation

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Abstract

Background: Indonesia has a high risk of earthquakes, necessitating innovative approaches to disaster mitigation education.
Aims: This study aims to develop Virtual Reality (VR)-based learning media to enhance students' understanding and preparedness, particularly among students, in facing earthquake scenarios.
Methods: The development process comprises four main stages: identifying educational content, designing interactive scenarios, creating 3D assets and interactive elements, and developing the virtual reality application using Unity.
Results: The developed interactive VR media includes a tutorial feature, selectable earthquake location scenario (classroom, library, laboratory), and adjustable earthquake magnitude settings. It enables users to experience immersive and safe earthquake simulations while actively practicing appropriate emergency response procedures.
Conclusion: The application of VR-based learning media offers substantial potential to enhance disaster literacy, increase student engagement, and create more meaningful learning experiences. The implementation of this media in educational settings is expected not only to strengthen a culture of disaster awareness but also to contribute to reducing casualties and losses caused by earthquakes in the future.

A. Introduction

The series of earthquakes with magnitudes of 5–6 that struck Lombok seven years ago left bitter memories, with numerous casualties and significant losses across various sectors (Supendi et al., 2020; Zhao et al., 2024). A similar event occurred on the coast of Palu, where a magnitude 7.0 earthquake triggered a tsunami and liquefaction, resulting in thousands of deaths, injuries, and severe damage to infrastructure and buildings (Carvajal et al., 2019; Jalil et al., 2021). These events serve as a reminder that Indonesia, located on the Pacific Ring of Fire, is highly vulnerable to earthquakes with multidimensional impacts, physical, social, and economic (Kuscahyadi et al., 2018; Reinhardt, 2024; Rindrasih et al., 2024).

From a humanitarian perspective, earthquakes often cause significant loss of life, particularly in densely populated areas with low preparedness levels (Robinson et al., 2021). Many cases show that most earthquake victims are those trapped in collapsing non-seismically-resistant buildings or unaware of proper self-rescue procedures (Chen et al., 2024). Studies by Dollet & Guéguen (2021) and Wang et al. (2023)

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emphasize that the lack of earthquake-resistant building standards and limited public education on evacuation procedures contribute to higher casualty numbers. Therefore, disseminating knowledge and conducting preparedness training are critical components of disaster mitigation systems.

The economic impact of earthquakes is equally severe, encompassing direct and indirect losses that can hinder national and regional economic growth (Ahmed & Li, 2025; Baker & Markhvida, 2023; Manfredi et al., 2021; Sousa et al., 2022). Direct losses include the cost of repairing or replacing damaged buildings and infrastructure, as well as disruptions to critical utilities such as electricity, water, and telecommunications. Indirect losses involve disrupted economic activities, business closures, reduced workforce productivity, and loss of income for individuals and governments. Studies by León et al. (2022) indicate that the ripple effects of these disruptions can impact GDP, increase unemployment, and slow economic recovery in the long term. Developing countries are generally more vulnerable to these economic impacts due to limited emergency response and reconstruction funding.

Given the extensive impacts of earthquakes, mitigation efforts are crucial to reducing potential losses. Mitigation involves not only constructing earthquake-resistant infrastructure but also public education, emergency response training, and early warning systems (Chukwuka et al., 2024; Khaspuria et al., 2024; Mpolomoka et al., 2024; Rahayu et al., 2021). A key component of mitigation efforts is evacuation training procedures, which equip communities with practical knowledge to save themselves during an earthquake (Ibrahim et al., 2025; Mitsuhara, 2024; Shiraki et al., 2017).

While conventional training is widely used for disaster mitigation (L. Wang et al., 2023), its approach often falls short in building genuine preparedness and psychological readiness. This is consistent with findings from previous studies by Ibrahim et al. (2025) and Shiraki et al. (2017), which found that traditional evacuation drills struggle to realistically portray actual emergency situations. As a result, participants often fail to grasp the urgency or complexity of the scenarios they may face.

Virtual reality (VR) technology offers an immersive, realistic, and interactive way to simulate disaster scenarios (Chen & Chien, 2022). Users can experience time pressure, chaotic environments, and critical scenarios, such as being trapped in a collapsed building or having to make quick decisions while in a state of panic. This approach can significantly enhance participants' understanding, mental readiness, and motor responses compared to conventional training methods. This solution is not only relevant for the general public but also highly effective for SAR personnel, students, and employees in disaster-prone areas.

Based on these issues, this study aims to develop a Virtual Reality (VR)-based learning media as a safe and immersive simulation tool. The resulting product is expected to contribute to innovation in disaster education and enhance students' earthquake preparedness literacy.

B. Research Methods

Figure 1 systematically illustrates the development process of VR media for earthquake mitigation education. This diagram not only highlights the technical components involved but also outlines the logical flow and data sources used in creating VR-based educational content. The following discussion elaborates on the meaning and relationships between the elements in the diagram.

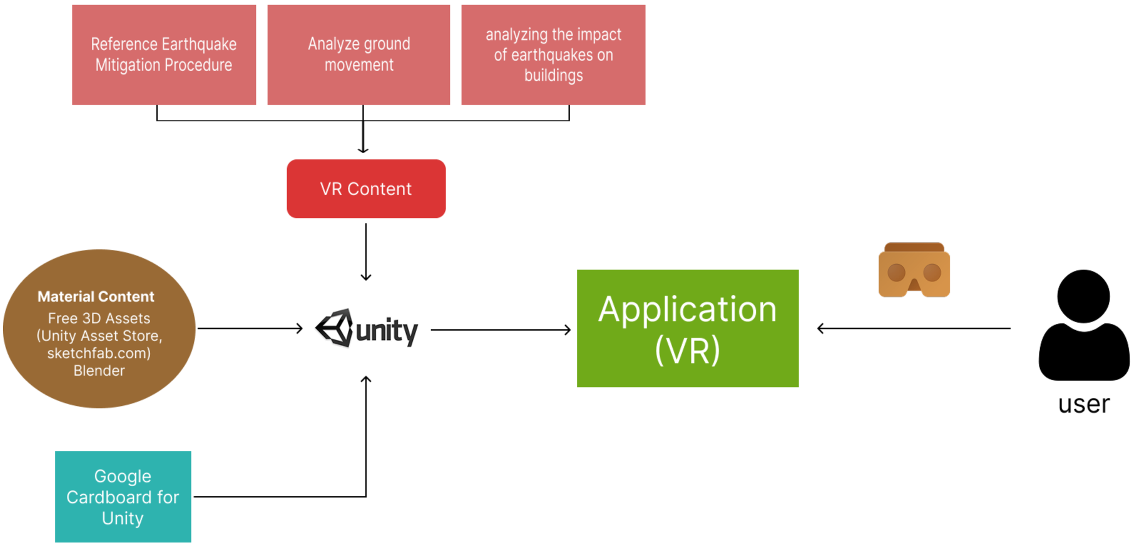


Figure 1. Earthquake VR Development Flow

Initial Stage

The development of VR media begins with identifying and collecting core content. There are three key elements form the foundation for creating VR content:

1. Preparing reference Earthquake Mitigation Procedures

   These are standardized guidelines on earthquake mitigation procedures established by the Regional Disaster Management Agency (BPBD) (Ramdaniati et al., 2024). These references serve as the primary basis for designing educational scenarios displayed in the media.

2. Analyzing Ground Movement

   This stage involves analyzing ground movements during earthquakes, based on data published by the Japan Meteorological Agency (JMA), and their effects on surfaces and building structures. This information is critical for creating realistic simulations in the VR environment.

3. Analyzing the Impact of Earthquakes on Buildings

   This involves studying or modeling the effects of earthquakes on building structures, both in terms of physical damage and potential hazards to humans. This data is essential for creating visual damage scenarios in the simulation, enhancing users' understanding of the real dangers of earthquakes.

These three elements are interconnected and form the narrative and visual foundation of the VR content to be developed.

Designing VR Content

Based on the analysis of the three main elements above, the information is transformed into VR content. This stage involves designing interactive scenarios and structuring simulation scenes to be presented in the media.

VR content is not limited to textual information but is presented as immersive experiences, such as:

1. Experiencing Earthquake Shaking

   This content allows users to experience the shaking and conditions during an earthquake directly. The shaking intensity is adjusted based on the earthquake's magnitude, ranging from mild to severe.

2. Evacuation Simulation to Safe Points

   Users could move freely and simulate self-rescue during an earthquake, including applying the "Drop, Cover, and Hold On" steps as part of proper evacuation procedures.

3. Visualization of Earthquake Damage

During an earthquake, surrounding objects are affected based on the magnitude. The greater the earthquake's strength, the more significant the visualized damage in the simulation.

This approach enabled users to "experience" disaster situations directly, enhancing their understanding of the importance of preparedness and mitigation procedures.

Creating Visual Materials

After designing VR content, supporting visual materials are required. The "Material Content" element indicates in this diagram. The 3D assets used in development are sourced from:

1. Unity Asset Store: A platform providing ready-to-use assets for Unity, including buildings, characters, environments, and animations.
2. Sketchfab.com: A community platform for sharing high-quality 3D assets, including architectural models and disaster response tools.
3. Blender: Open-source software used to create or edit custom 3D assets tailored to the media's needs.

Using accurate and contextually relevant visual assets is crucial for creating a realistic and immersive learning experience.

Development Using Unity

All compiled content, including narratives, interactive logic, and visual assets, is integrated into Unity, a popular game engine for VR media development. Unity was chosen for its compatibility with various platforms, extensive ecosystem, and support for VR devices like Google Cardboard. The development process includes:

1. Setting Up Simulation Environments (Scenes)

   This was the initial stage of media development in Unity, involving the integration of necessary assets such as school buildings, classrooms, libraries, and laboratories.

2. Implementing Interactive Scripts (C#) for Navigation and User Response

   Interactivity in the simulation relies on programming that governs user movement, responses to situations, and object interactions. Scripts were written in C# and cover user navigation using a joystick/gamepad, trigger events (e.g., doors opened when users approach), earthquake intensity selection buttons, and visual effects when falling objects hit users.

3. Integrating Audio and User Interaction with Objects

   Audio effects, such as shaking sounds and interactions with objects in the virtual environment, were included to enhance immersion during earthquakes.

4. Ensuring Alignment with Educational Scenarios

   After the system was built, testing was critical to ensure:

   a) All interactive functions worked as designed.
   b) The simulation ran on smartphones with functional sensors like gyroscopes.
   c) Educational objectives were met, such as users understanding self-rescue steps through interactions.
   d) The testing was conducted in stages, beginning with unit testing to ensure each individual component (scripts, interactions, audio) functioned correctly on its own. This was followed by integration testing to verify that these components interacted with each other as intended.

Output

The result is a VR medium that serves as an educational tool for earthquake mitigation. This media allowed users to experience disaster situations virtually and learn appropriate responses during an earthquake. Key features include: (1) tutorial feature; (2) location scenario selection; and (3) earthquake magnitude selection feature.

Implementation on Google Cardboard

To ensure accessibility for many users, especially students and the general public, Google Cardboard was used as the primary platform. Google Cardboard is an affordable cardboard VR headset compatible with most smartphones. By downloading the media and placing their smartphone in the Cardboard headset, users can immediately experience the VR simulation. This approach is cost-effective and facilitates widespread distribution.

C. Results and Discussion

1. Result

The developed media is a technology-based learning innovation using Virtual Reality (VR) designed to provide an interactive, immersive, and safe earthquake simulation experience. It aims to help users, particularly students, understand basic earthquake concepts, enhance preparedness, and practice appropriate responses during an earthquake through digitally controlled, risk-free simulations.

This VR-based approach offers advantages in delivering disaster-related material by presenting realistic situations that users can experience and learn from. Through this media, users not only gain theoretical knowledge about earthquakes but also experience simulations that depict real conditions in a safe and structured manner.

1.1 Tutorial Feature

The tutorial feature is essential for helping users, especially beginners, operate the earthquake VR media (Figure 2). By pressing the “Y” button on the gamepad, users can access an interactive guide displaying visual and narrative instructions. The guide covers navigation in the virtual environment, explanations of controller button functions, and instructions how interacting with objects in the simulation (Figure 3).

This feature ensures users face no technical difficulties accessing and exploring the simulation. The tutorial interface is designed to be informative yet straightforward, with clear images and explanatory text.

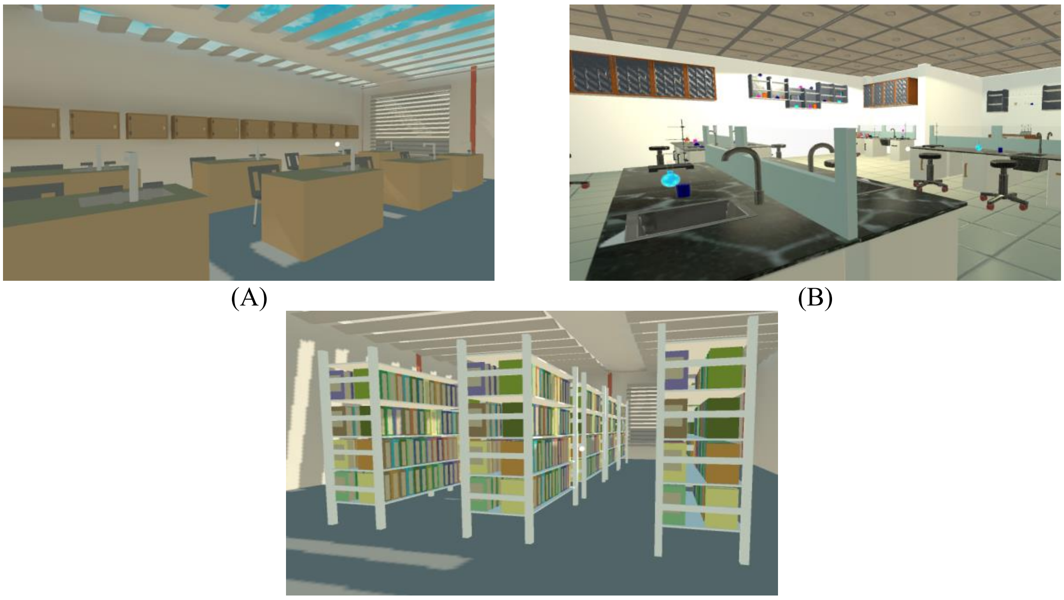
Figure 2. Main Tutorial Feature Interface

Figure 3. Guide Interface in the Tutorial Feature

1.2 Earthquake Location Scenario Selection Feature

This feature offers flexibility for users to choose different earthquake location scenarios. The media provides three primary locations: 1) Classroom, 2) Library, and 3) Laboratory (Figure 4). Each location is designed to reflect real-world conditions, with furniture and potential hazards like tall bookshelves, tables for taking cover, and hanging objects that may fall during an earthquake.

Users can perform actions such as lying down, crouching, jumping, and walking. The media also provides visual feedback: if falling objects hit users, the screen displays a red effect as a warning that such actions could lead to injury in real scenarios (Figure 5). This helps users understand risks and the importance of acting quickly and appropriately during an earthquake.



(A) (B)

(C)

Figure 4. (A) Classroom Interface; (B) Laboratory Interface; (C) Library Interface

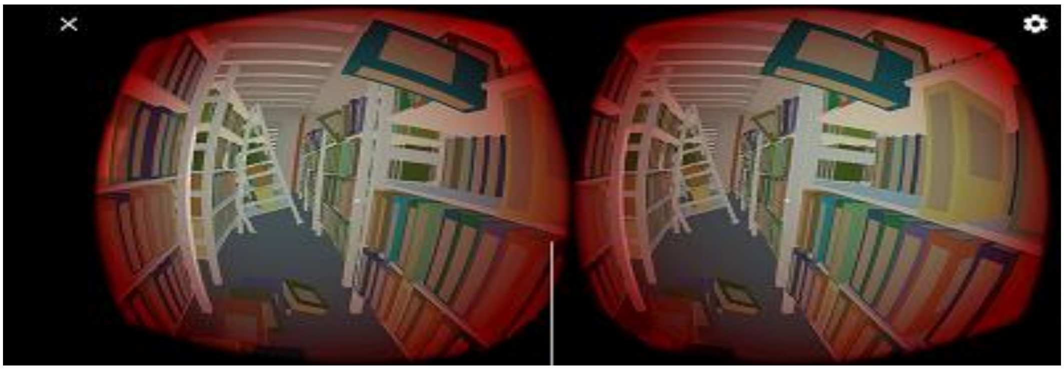


Figure 5. Effect When Hit by an Object

1.3 Earthquake Magnitude Intensity Selection Feature

This feature allows users to select the earthquake intensity to be simulated (Figure 6). Three magnitude intensity categories are provided, as shown in Table 1.

Table 1. Magnitude Intensity Categories

Magnitude Range	Category	Description
3-4	Light	Intended for initial earthquake introduction
5-6	Moderate	Causes some objects to move or fall
7-8	Strong	Creates a more complex emergency situation

Each magnitude level produces different effects in the simulation environment, such as shaking intensity, the number of falling objects, and visualized damage. This feature not only provides a more realistic experience but also helps users understand the relationship between magnitude and environmental impact, reinforcing earthquake concepts taught in disaster education.

Figure 6. Earthquake Magnitude Selection Interface

2. Discussion

Earthquake mitigation efforts are the best way to improve survival rates when a disaster strikes. Many mitigation efforts have been made, both structurally through the construction of earthquake-resistant infrastructure and non-structurally through education and training. In the context of education, traditional approaches like lectures, manual simulations, or informative posters are often insufficient to build adequate preparedness. Therefore, a pedagogical breakthrough is needed to provide meaningful learning to provide more engaging and meaningful disaster education, and one such way is through the use of Virtual Reality (VR) technology.

The VR-based learning media developed in this research represents an innovation that combines educational content with interactivity and immersive experiences. In the VR simulation, users do not simply receive information; they also directly experience earthquake scenarios. This simulation creates a deeper learning experience and can elicit the cognitive, affective, and psychomotor responses needed in a real situation. As stated by Chen & Chien (2022) and Mitsuhara (2024), direct experience through VR can significantly increase information retention and psychological readiness compared to conventional methods.

The features in this media are designed to meet the needs of experiential learning. The option to choose a disaster location scenario allows users to test evacuation responses in various settings, classrooms, laboratories, or libraries, that visually resemble real environments. The presence of falling objects during the earthquake and visual feedback when a user is hit by an object provides a direct understanding of potential dangers and the importance of quick and correct actions during an earthquake. This feature helps build disaster literacy among students, aligning with the research of Ibrahim et al. (2025), which emphasizes the importance of situational training to enhance adaptability and decisiveness.

Another equally important feature is the option to select earthquake magnitude intensity, which reflects the variation in a disaster's impact and complexity. Simulating light to strong tremors shows how the escalation of an earthquake affects the virtual environment, from audio effects and swaying objects to simulated damage. This variation not only visually explains the concept of magnitude but also increases users' awareness of the need for adaptive and comprehensive mitigation procedures.

In the context of sustainable implementation, the choice of Google Cardboard as the primary device shows an inclusive effort to disseminate disaster mitigation literacy. With its affordable price and high compatibility with various smartphones, this media can be accessed by a wider range of people, including schools in areas with technological limitations. This aspect makes the media not only innovative but also socially valuable in expanding the reach of mitigation education.

However, this research has several limitations. First, the scope is limited to the development process of the VR-based earthquake simulation media without conducting an extensive effectiveness test on its impact on student preparedness. Second, the media still uses Google Cardboard, which has limitations in providing an optimal immersive experience compared to other high-performance VR devices like Oculus Rift or HTC Vive. This may reduce the level of immersion and realism experienced by users in understanding the simulation of emergency situations.

2.1 Implications

The development of Virtual Reality (VR)-based learning media for earthquake simulations has important implications in the context of disaster education. This media provides a more realistic learning experience so that students not only understand the concept of earthquakes theoretically, but also experience emergency situations safely and in a controlled manner. This immersive experience can improve understanding of self-rescue procedures, such as "Drop, Cover, and Hold On," and increase preparedness in facing risky conditions. In addition, the use of VR provides an effective learning alternative for schools that cannot carry out physical simulations due to facility limitations or safety risks. The implementation of VR media can also encourage digital transformation in disaster education, strengthening a disaster-aware culture in the school environment.

2.2 Research contribution

This research makes a significant contribution to the development of technology-based disaster learning media. First, this research produced a VR media prototype that was systematically developed based on official earthquake mitigation procedures and the results of earthquake impact analysis on buildings. Second, this research shows that VR can be used to represent various location scenarios (classrooms, laboratories, and libraries) so that users can learn the appropriate responses in different environments. Third, the magnitude intensity selection feature provides additional educational value because users can observe the relationship between earthquake strength and the level of danger in the surrounding area. Fourth, this study introduces an innovative, affordable, and easy-to-implement approach to disaster education using Google Cardboard, which has the potential to be widely used in schools, including those with limited resources. Thus, this study contributes to the fields of pedagogy, educational technology, and disaster literacy.

2.3 Limitations

This study has several limitations that need to be considered. First, the study only focuses on the development of VR media without conducting extensive effectiveness tests on improving student preparedness. Therefore, the impact of the media on behavioral changes or psychological readiness cannot yet be empirically concluded. Second, the VR media developed still uses Google Cardboard and smartphones, so the level of immersion, visual comfort, and interactivity is limited compared to high-end VR devices such as Oculus Rift or HTC Vive. Third, the simulated earthquake scenarios are still limited to three locations, so the variety of disaster environments is not fully represented. Fourth, the use of VR requires a smartphone with a gyroscope sensor, which not all students may have. This limitation may affect accessibility and user experience in the widespread application of the media.

2.4 Suggestions

Based on the results found, several suggestions can be made for further research and development. First, further research in the form of large-scale trials is needed to assess the effectiveness of the media in increasing students' preparedness and understanding. This can be done through pre-tests and post-tests, behavioral tests, and observation of responses during simulations. Second, further development could consider the use of more sophisticated VR devices to improve immersion and the quality of user interaction. Third, the variety of earthquake scenarios needs to be expanded, for example, scenarios in public spaces, residential homes, or urban environments, so that users can learn safety responses in various conditions. Fourth, the integration of system-based evaluation features, such as measuring response speed or accuracy of actions, can increase the educational value of the media. Finally, collaboration with disaster management agencies such as BPBD or BNPB is recommended to ensure that the media is in line with national mitigation education standards and can be applied in real-world disaster training programs.

D. Conclusion

Overall, the development of this media shows that VR technology can be an effective educational tool for delivering disaster mitigation content. The transformation of information from text and images into a direct experience in a virtual environment has been proven to increase users' understanding of risks and the procedures that must be followed. This media also encourages active user engagement in the learning process, which is an essential element in 21st-century learning.

Therefore, this media not only offers technological innovation in learning but also provides a positive social impact by building a disaster-aware culture in society. Its implementation in schools and community training programs is expected to increase public preparedness to face earthquakes and reduce the risk of casualties and losses in the future.

For future research, it is suggested that the development of this media be expanded to include more varied earthquake scenarios that align with local geographical and infrastructural conditions. In addition, improving the quality of immersion through the use of more advanced VR devices should also be considered so that the learning experience becomes more realistic and impactful. Evaluating the effectiveness of the media through longitudinal studies and controlled experiments is also important to ensure its significant contribution to improving disaster preparedness.

E. Acknowledgment

We express our deepest gratitude to all parties who have supported the completion of this research on the development of Virtual Reality media for earthquake simulation. We sincerely thank the Universitas Pendidikan Indonesia and Universitas Sultan Ageng Tirtayasa for providing the facilities and resources necessary for this study.

F. Author Contribution Statement

The development of Virtual Reality media for earthquake simulation was a collaborative effort involving all authors. MBU and AA served as the primary developers, leading the creation of the Virtual Reality media. Prasetyaningsih reviewed earthquake-related content and designed the primary scenarios for the VR media. LSR, RH, along with WA, acted as advisors, evaluating the developed media to ensure its quality and effectiveness.

All authors contributed to the refinement of the project and approved the final version of the work, ensuring its accuracy and integrity.

References

Ahmed, H., & Li, Y. (2025). Performance-based seismic retrofitting and resilience assessment for RC buildings considering direct and indirect losses. *Advances in Structural Engineering*. https://doi.org/10.1177/13694332251325919

Baker, J., & Markhvida, M. (2023). Modeling future economic costs and interdependent industry recovery after earthquakes. *Earthquake Spectra*, *39*, 914–937. https://doi.org/10.1177/87552930231162385

Carvajal, M., Araya-Cornejo, C., Sepúlveda, I., Melnick, D., & Haase, J. S. (2019). Nearly instantaneous tsunamis following the MW 7.5 2018 Palu earthquake. *Geophysical Research Letters*, *46*(10), 5117–5126. https://doi.org/10.1029/2019gl082578

Chen, S., & Chien, W. (2022). Immersive Virtual Reality Serious Games With DL-Assisted Learning in High-Rise Fire Evacuation on Fire Safety Training and Research. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.786314

Chen, T., Ceballos, D., Lin, K., Liu, G., Lin, T., & Yeh, C. (2024). Migration as a hidden risk factor in seismic fatality: a spatial modeling of the Chi{-}Chi earthquake and suburban syndrome. *Natural Hazards and Earth System Sciences*. https://doi.org/10.5194/nhess-24-4457-2024

Chukwuka, O., Paraskevadakis, D., Wang, J., & Ren, J. (2024). Managing risk in emergency supply chains–An empirical study. *International Journal of Logistics Research and Applications*. https://doi.org/10.1080/13675567.2024.2359645

Dollet, C., & Guéguen, P. (2021). Global occurrence models for human and economic losses due to earthquakes (1967--2018) considering exposed GDP and population. *Natural Hazards*, *110*, 349–372. https://doi.org/10.1007/s11069-021-04950-z

Ibrahim, S., Mahnaz, W., Arif, S., & Kiran, S. (2025). Understanding the Need for Situational Handling During Natural Hazards: An Attitudinal Study Among School Students. *Indus Journal of Social Sciences*. https://doi.org/10.59075/ijss.v3i2.958

Jalil, A., Fathani, T. F., Satyarno, I., & Wilopo, W. (2021). Liquefaction in Palu: The cause of massive mudflows. *Geoenvironmental Disasters*, *8*(1). https://doi.org/10.1186/s40677-021-00194-y

Khaspuria, G., Soni, P., Dadhich, K., & Ranjan, A. (2024). Natural Disaster Mitigation Strategies: A Comprehensive Review. *Journal of Scientific Research and Reports*. https://doi.org/10.9734/jsrr/2024/v30i82221

Kuscahyadi, F., Meilano, I., Hanifa, N. R., & Virtriana, R. (2018). Earthquake risk assessment of hospital in Indonesia. *Aip Conference Proceedings*, *1987*. https://doi.org/10.1063/1.5047380

León, J., Ordaz, M., Haddad, E., & Araújo, I. (2022). Risk caused by the propagation of earthquake losses through the economy. *Nature Communications*, *13*. https://doi.org/10.1038/s41467-022-30504-3

Manfredi, G., Prota, A., Di Ludovico, M., De Martino, G., & Dolce, M. (2021). Relationships between empirical damage and direct/indirect costs for the assessment of seismic loss scenarios. *Bulletin of Earthquake Engineering*, *20*, 229–254. https://doi.org/10.1007/s10518-021-01235-5

Mitsuhara, H. (2024). Metaverse-Based Evacuation Training: design, implementation, and experiment focusing on earthquake evacuation. *Multimodal Technologies and Interaction*, *8*(12), 112. https://doi.org/10.3390/mti8120112

Mpolomoka, D., Chansa, C., Ngulube, L., & Chitondo, L. (2024). Disaster management and mitigation strategies in Zambia: A systematic review. *World Journal of Advanced Research and Reviews*. https://doi.org/10.30574/wjarr.2024.21.3.0995

Rahayu, L., Wijaya, O., Rozaki, Z., & Rahmawati, N. (2021). Farmers' Disaster Mitigation Strategies in Indonesia. *Reviews in Agricultural Science*. https://doi.org/10.7831/ras.9.0_178

Ramdaniati, S. N., Handayani, E., Himmawan, L. S., & Adnan, A. (2024). Mitigasi Bencana Gempa Bumi dalam Meningkatkan Kesiapsiagaan Siswa SD Negeri Gombong 4 Desa Tanjung Jaya. *AS{-}SYIFA Jurnal Pengabdian Dan Pemberdayaan Kesehatan Masyarakat*, *5*(1), 30–36. https://doi.org/10.24853/assyifa.5.1.30-36

Reinhardt, R. (2024). The complexity of disaster impacts: An example on foreign investment in Indonesia. *Revue D Economie Du Developpement*, *33*(3), 89–94. https://doi.org/10.3917/edd.373.0089

Rindrasih, E., Ratminto, N., Effendi, K. C., & Silviani, D. (2024). Expert perspectives on disaster risk reduction strategies in the tourist area of Borobudur-Yogyakarta-Prambanan in Indonesia. *Progress in Disaster Science*, *24*, 100379. https://doi.org/10.1016/j.pdisas.2024.100379

Robinson, D., Dou, Y., Zhang, Q., Xu, F., Shi, P., He, C., Huang, Q., Yan, J., Daniell, J., Zhao, B., & Bai, X. (2021). A Global Analysis of the Relationship Between Urbanization and Fatalities in Earthquake-Prone Areas. *International Journal of Disaster Risk Science*, *12*, 805–820. https://doi.org/10.1007/s13753-021-00385-z

Shiraki, W., Isouchi, C., Inomo, H., Takahashi, M., & Takahashi, K. (2017). Experience-Based Training in Earthquake Evacuation for School Teachers. *Journal of Disaster Research*, *12*, 782–791. https://doi.org/10.20965/JDR.2017.P0782

Sousa, R., Rodrigues, H., & Silva, V. (2022). The importance of indirect losses in the seismic risk assessment of industrial buildings – An application to precast RC buildings in Portugal. *International Journal of Disaster Risk Reduction*. https://doi.org/10.1016/j.ijdrr.2022.102949

Supendi, P., Nugraha, A. D., Widiyantoro, S., Pesicek, J. D., Thurber, C. H., Abdullah, C. I., Daryono, D., Wiyono, S. H., Shiddiqi, H. A., & Rosalia, S. (2020). Relocated aftershocks and background seismicity in eastern Indonesia shed light on the 2018 Lombok and Palu earthquake sequences. *Geophysical Journal International*, *221*(3), 1845–1855. https://doi.org/10.1093/gji/ggaa118

Wang, L., Gao, L., Chen, Y., Li, R., He, H., & Feng, X. (2023). Earthquake disaster preparedness training programme for hearing-impaired children: a randomized quasi-experimental trial. *International Journal of Disaster Risk Reduction*, *92*, 103716. https://doi.org/10.1016/j.ijdrr.2023.103716

Wang, W., Li, Y., Zhang, Z., Xin, D., He, Z., Zhang, W., & Chen, X. (2023). Rapid estimation of disaster losses for the M6.8 Luding earthquake on September 5, 2022. *Science China Earth Sciences*, *66*(6), 1334–1344. https://doi.org/10.1007/s11430-022-1078-6

Zhao, S., Miller, M., Cummins, P., & McClusky, S. (2024). Co-seismic and post-seismic deformation associated with the 2018 Lombok, Indonesia, earthquake sequence, inferred from InSAR and seismic data analysis. *Remote Sensing of Environment*. https://doi.org/10.1016/j.rse.2024.114063

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