

**Technological Innovations for Efficient Disaster Management and Healthcare Response**

**Rika Yuliwulandari<sup>1,2\*</sup>, Zulfan Febriawan<sup>3</sup>, Rifda El Mahroos<sup>3</sup>, Debrina Kusuma Devi<sup>3</sup>,  
Mohammad Idhom<sup>4</sup>, Gideon Setyo Budiwitjaksono<sup>5</sup>, Jaka Purwanta<sup>2</sup>, Yohana Noradika  
Maharani<sup>2</sup>, Jordan Melias Kembaren<sup>3</sup>, Hafiz T.A Khan<sup>6,7</sup>**

<sup>1</sup>Department of Pharmacology, Faculty of Medicine, Universitas Pembangunan Nasional Veteran  
Jawa Timur

<sup>2</sup>Faculty of Mineral Technology, Universitas Pembangunan Nasional “Veteran” Yogyakarta

<sup>3</sup>Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur

<sup>4</sup>Department of Data Science, Faculty of Computer Science, Universitas Pembangunan Nasional  
“Veteran” Jawa Timur

<sup>5</sup>Department of Accounting, Faculty of Economic and Business, Universitas Pembangunan  
Nasional Veteran Jawa Timur

<sup>6</sup>Public Health Group, University of West London, United Kingdom

<sup>7</sup>Oxford Institute of Population Ageing, University of Oxford, United Kingdom

**Corresponding Author**

Rika Yuliwulandari

Faculty of Medicine, East Java Veteran National Development University

Rungkut Madya Street Number 191, Rungkut Kidul, Rungkut District, Surabaya, East Java 60293

E-mail: rika.fk@upnjatim.ac.id

**ABSTRACT**

Disasters pose significant challenges to global health systems. Traditional methods of disaster management often struggle with efficient resource allocation and communication, especially in densely populated metropolitan areas. Technological innovations, such as GIS, UAVs, and VR, offer new opportunities to address these challenges. This study assesses the combined impact of technologies on improving healthcare service delivery and resource management during disasters, particularly in urban environments. A systematic review was conducted using the PRISMA-ScR framework. The research identified and analyzed studies from databases such as PubMed, Scopus, Sage Journals, and Google Scholar, focusing on technology-based disaster management interventions between 2020 and 2024. The review included eight studies that demonstrated significant improvements in disaster preparedness and response through the use of technologies. These technologies enhanced real-time decision-making, reduced response times, and improved the allocation of healthcare resources. However, the studies also highlighted issues with scalability, interoperability, and the lack of real-world testing. The integration of technologies has the potential

to revolutionize disaster management practices. Despite the advancements, further research is needed to address the scalability and operational challenges that limit the full deployment of these technologies in real-world disaster scenarios.

**Keyword :** Disaster technological innovations, disasters information systems, disaster management; healthcare

## Introduction

Natural disasters, such as earthquakes, hurricanes, and floods, have caused widespread destruction, posing significant challenges to global health systems. The frequency and intensity of these events are exacerbated by climate change, leading to an urgent need for more effective disaster management strategies<sup>1</sup>. These challenges demand improvements in preparedness and response to mitigate the impact on human life and infrastructure. In recent years, technological advancements have become integral to disaster management, with innovations such as Geographic Information Systems (GIS) and Virtual Reality (VR) transforming traditional approaches to disaster preparedness, training, and emergency response<sup>2</sup>. The integration of such technologies holds potential for improving real-time decision-making and resource allocation, which are crucial for saving lives during disasters.

The primary issue that arises in current disaster response frameworks is the inefficiency in resource allocation and communication, particularly in metropolitan areas prone to large-scale disasters<sup>3</sup>. This problem is compounded by the lack of real-time data integration and the inability to simulate multi-stakeholder disaster scenarios effectively. Traditional ground-based transportation systems for medical supplies often become inoperative during disasters, leaving critical gaps in healthcare delivery to affected populations. The general solution lies in the application of emerging technologies, such as UAVs for transportation and VR for training, which can address these inefficiencies by enabling quicker, more coordinated responses.

Recent research has proposed solutions that focus on leveraging geospatial information systems to optimize healthcare infrastructure in earthquake-prone metropolitan cities. For example, the development of GIS frameworks that improve resource allocation and emergency response times has shown promising results in cities like Istanbul, Los Angeles, and Tokyo<sup>4</sup>. Another solution involves the deployment of UAVs to transport medical supplies across disaster-affected areas, which has proven effective in controlled environments in Japan but requires further testing in actual disaster conditions. These studies illustrate the potential of technology to address some of the critical challenges in disaster management but also highlight the limitations of existing systems.

The literature points to significant progress in the use of VR for disaster medicine training, particularly in improving self-efficacy among healthcare professionals. However, most studies have

focused on single-player VR simulations, which do not fully capture the collaborative nature of disaster response. Moreover, while GIS and UAV technologies have advanced in terms of efficiency and accuracy, their implementation in real-life disaster scenarios remains limited due to challenges in scalability, data quality, and system interoperability<sup>3</sup>. These limitations necessitate further investigation into how multi-participant VR and integrated GIS systems can work in tandem to create more robust disaster management protocols.

Despite the promising advancements in technology-enhanced disaster management, gaps remain in the research regarding the scalability and interoperability of these systems across different geographic and healthcare contexts. Moreover, the role of real-time data integration in optimizing multi-stakeholder communication and resource distribution has been underexplored in the current literature. The focus has predominantly been on individual technological solutions rather than a comprehensive, integrated approach that combines VR, GIS, and UAV systems to improve disaster preparedness and response holistically.

This study aims to bridge the research gap by evaluating the combined effectiveness of multi-participant VR training, UAV-based medical transportation, and GIS-based disaster response systems in improving healthcare delivery and resource allocation in disaster-prone metropolitan areas. The novelty of this study lies in its integrated approach, which assesses the interoperability and scalability of these technologies in real-life scenarios. The findings of this research are expected to contribute to the development of more efficient, technology-driven disaster management protocols that can be adopted on a global scale.

## **Material and Methods**

A protocol was developed by the research team that guided the literature search, publication selection, information extraction and descriptive synthesis of results while the Arksey and O'Malley framework guided the methodological development. To ensure methodological quality and transparency, the results are reported according to the Preferred Reporting Items for Systematic Reviews and Meta- Analyses extension for Scoping Reviews (PRISMA-ScR).

### **Search Strategy**

Relevant studies were identified through four scientific databases: PubMed (National Center for Biotechnology Information, National Institutes of Health; Bethesda, Maryland, USA); SCOPUS (Elsevier; Amsterdam; Netherlands); Sage Journals (Thousand Oaks; California; USA) and Google Scholar. The search strategy was approached using a blend of search terms primarily located within titles (Table 1) and conducted within a limited timeframe from 2020 to April 2024. Two reviewers collaborated in developing the strategy and determining suitable outcomes for the search.

### **Table 1. Key search terms**

Key Search Terms
“Disaster” OR “Health” OR “Technology”
“Disaster” OR “Medicine” OR “Technology”
“Health” OR “Information” OR “System” OR “Disaster”
“Disaster” OR “Management” OR “Technology”
“Medication” OR “Technology OR “Disaster”

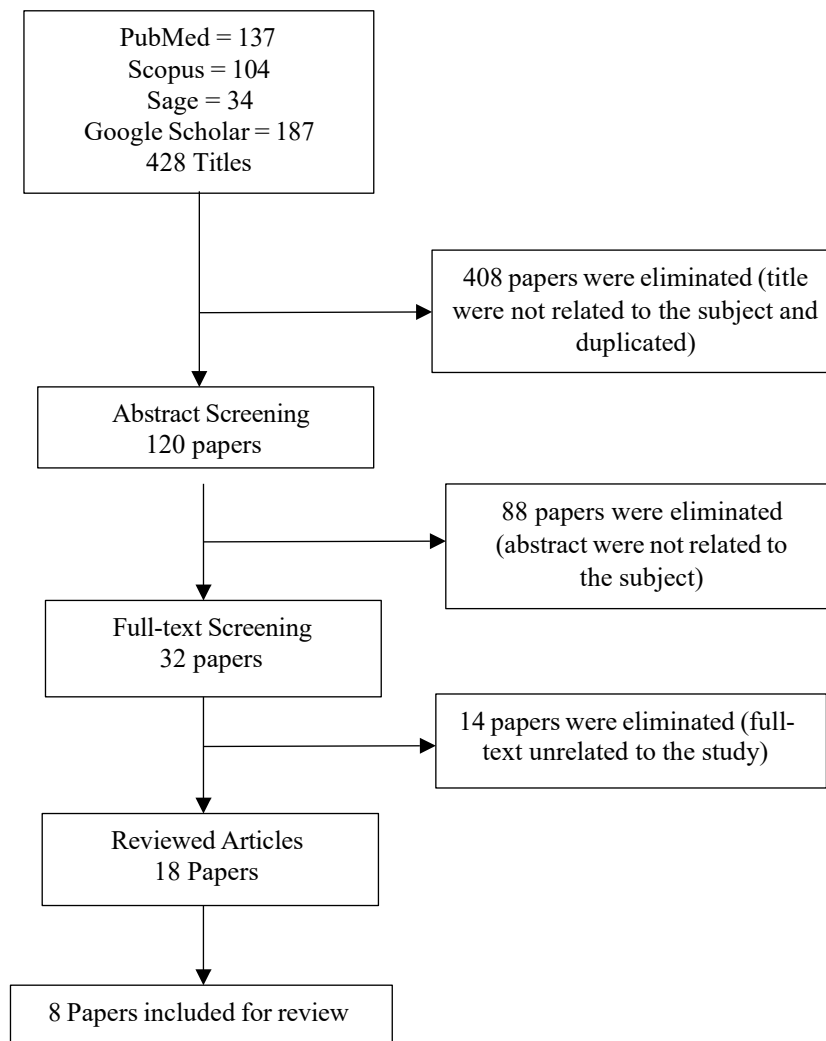
### Eligibility Criteria and Study Selection

Screening was conducted in three steps: firstly, two reviewers independently evaluated articles based on the titles. The inclusion and exclusion criteria were set based on the type of database search, article type, publication year, access, language, tier, and subject and can be seen in Table 2. Any papers that did not fulfil the criteria were excluded. Secondly, the abstracts of the selected papers were reviewed. An abstract must contain clear objectives, methods, results and also discuss disaster health technology OR disaster medicine technology OR health information system in disaster OR disaster management technology OR medication technology in disaster. Thirdly, full texts of the chosen papers were evaluated. Studies were included in the review if they met the following criteria: the journal explained disaster health technology, disaster medicine technology, health information system for disaster, disaster management technology, and medication technology for disaster with main findings and weaknesses of both the research and discovered technological weaknesses. Any primary research articles, including randomized controlled trials, cross-sectional studies, and other methods were eligible. Excluded articles covered qualitative studies and article reviews and those that did not discuss technology in relation to disaster, disaster medicine, health and disaster information systems, and medicine.

**Table 2. Inclusion criteria**

Criteria	Scientific Database			
	Scopus	PubMed	Sage Journals	Google Scholar
Article Type	Original Research	Original Research	Original Research	Original Research
Publication Year	2020 - 2024	2020 - 2024	2020 - 2024	2020 - 2024
Access	Access	Access	Access	Access
Language	English	English	English	English
Tier	Q1, Q2, Q3, Q4	-	-	-
Subject	-	-	Education, Social Sciences and Humanities, and Health Sciences	-

### Data Extraction and Synthesis



**Figure 1.** Flow diagram of review article

Data from each selected full-text paper were extracted into a data extraction form developed by the research team. The data included the author and year of publication, type of article, country of study, study aims, study design, description of the intervention, main findings and limitation or gaps. These data were synthesized using a narrative approach based on the study findings and limitations of the study.

## Results

Based on the article search and selection process, eight studies were identified as meeting the inclusion criteria and were further analyzed. These studies varied in terms of methodology, sample population, and intervention approaches used, but collectively addressed topics relevant to the objectives of this review. Most studies employed experimental and observational designs to evaluate the effectiveness of various technology-based interventions in disaster management. All the analyzed articles are summarized in Table 3.

The main findings from the analyzed studies indicate that the use of technology, such as virtual reality and geographic information systems (GIS), has proven effective in enhancing disaster preparedness and healthcare response. Additionally, several studies found that technology-based interventions, such as telerehabilitation programs and online medical management information systems, contributed to reduced response times and improved resource allocation in emergency situations. However, several limitations were identified, including small sample sizes and a lack of testing in real-world field conditions, highlighting the need for further research to confirm these findings.

**Table 3.** Results

<b>Title</b>	<b>Type of Research</b>	<b>Background</b>	<b>Objectives</b>	<b>Findings</b>	<b>Novelty</b>	<b>Gaps</b>
Developing Geographic Information Systems in Health Care for Earthquake-Prone Metropolitan Cities: A Methodological Approach  (Tunaligil, 2024)	Methodological Study	Earthquake-prone cities require resilient health infrastructure and effective disaster preparedness to reduce fatalities and improve emergency responses. Historical examples, such as the 1906 San Francisco and 1960 Great Chilean earthquakes, have highlighted the importance of robust systems.	To develop a GIS framework that optimizes health care disaster preparedness and response in metropolitan cities prone to earthquakes, focusing on improving resource allocation, health care accessibility, and response times.	The application of GIS improved emergency preparedness and response in Istanbul, Los Angeles, Tokyo, San Francisco, and Mexico City, with measurable improvements in health care accessibility, resource allocation efficiency, response times, and infrastructure robustness.	This study integrates GIS technology into health care disaster management across several global cities, offering a novel approach to improving public health infrastructure resilience and disaster preparedness. It applies spatial analysis, mapping, and real-time data integration to optimize emergency responses.	Challenges include inconsistent data quality, real-time updates, software integration issues, and the high costs of implementing GIS systems. Additionally, more research is needed to improve the scalability and interoperability of GIS across different health systems.
Design and Development of a Geospatial-Based Information Systems for Disaster Management of Adolescent Reproductive Health in Nusa	System Design and Development (Prototyping Method)	Indonesia is highly vulnerable to natural disasters due to its geographic location. Despite government efforts in disaster management, casualties remain high. A more integrated system involving various sectors is needed, especially for vulnerable groups like adolescents who face	To design and build a geospatial-based information system aimed at improving disaster preparedness and management for adolescent reproductive health in Nusa Tenggara Barat (NTB) Province.	The system (SIGAB KESPRO) was successfully designed using prototyping methodology. It supports target identification, logistics distribution, and reproductive health services for adolescents during disasters. In laboratory trials, all system components functioned	This study integrates geospatial technology with disaster management specifically focused on adolescent reproductive health, which had not been fully explored before in Indonesia. The use of geospatial data	The system has only been tested in a controlled laboratory environment and not in real disaster situations. Further integration with existing data systems and community involvement in using the application needs to be developed.

Tenggara Barat Province in 2020  (Hadi et al., 2021)		reproductive health issues in disaster situations.		well, although further field testing and development are necessary.	enhances the efficiency of managing health services and logistics in disaster-stricken areas.	
An Online Emergency Medical Management Information System using Mobile Computing  (Mitropoulos et al., 2021)	Research Paper	Emergency Medical Services (EMS) are crucial for providing timely and coordinated healthcare to patients in critical conditions. Traditional systems face challenges such as delays in response times and resource allocation, prompting the need for technology-enhanced solutions.	To develop and evaluate eEKAB, an online emergency medical management information system, aiming to reduce EMS response times and optimize resource allocation using mobile computing and GIS technology.	eEKAB significantly reduced EMS procedure times, improved the allocation of human resources, and facilitated better geographical distribution of ambulances. It enhanced communication between EMS teams and enabled quicker incident reporting and response.	The introduction of eEKAB as a pilot system using GIS, mobile apps, and computer-aided dispatch improved the overall EMS system in Greece, representing a technological upgrade over existing solutions.	The system requires improvements in interoperability with private sector EMS centers and enhancements in communication features, such as providing more detailed incident data to responders. Additionally, security measures like a mobile VPN need further refinement.
A Telerehabilitation Programme in Post-Discharge COVID-19 Patients (TERECO): A Randomised Controlled Trial  (Li et al., 2022)	Randomized Controlled Trial (RCT)	Many COVID-19 survivors face ongoing issues such as impaired pulmonary function, decreased exercise capacity, reduced muscle strength, and lowered quality of life. Conventional rehabilitation services are difficult to access due to pandemic restrictions, prompting interest in telerehabilitation alternatives.	To investigate the superiority of a home-based telerehabilitation programme (TERECO) for COVID-19 survivors over no rehabilitation, focusing on exercise capacity, muscle strength, pulmonary function, quality of life, and dyspnea.	The TERECO programme significantly improved the 6-minute walking distance (6MWD), lower limb muscle strength (LMS), and physical quality of life in COVID-19 survivors compared to the control group. Pulmonary function improvements were minimal except for an	This study demonstrated that telerehabilitation can be a feasible and effective method for improving physical fitness and quality of life in COVID-19 survivors post-discharge, offering a low-cost and scalable	The study only included patients with moderate dyspnea and those familiar with smartphone technology, limiting generalizability. Pulmonary function improvements were not substantial, suggesting a need for more targeted interventions. Additionally,

				increase in maximum voluntary ventilation (MVV).	alternative to traditional rehabilitation.	the impact on mental health was minimal, indicating the need for more comprehensive programmes.
The Impact of the Coronavirus Disease 2019 (COVID-19) Pandemic on the Use of Emergency Medical Services System in Bangkok, Thailand  (Huabbangyang et al., 2022)	Retrospective Cross-sectional Study	COVID-19 has significantly impacted global public health systems, particularly emergency medical services (EMS), but limited studies have examined the pandemic's effect on EMS in Bangkok, Thailand.	To compare the number of EMS patients and the operational periods of EMS in Bangkok during the severe COVID-19 pandemic period (2020) with the prepandemic period (2019).	There was a 9.36% increase in EMS patients during the pandemic period, with significantly longer EMS operation times (response, on-scene, transportation, and total prehospital time) compared to the control period.	The study provides critical insights into how a pandemic affects the use and operation of EMS systems in a developing country, highlighting specific operational challenges.	The study is limited to EMS data from Bangkok, and results may not be generalizable to other regions. Incomplete data due to the retrospective nature also limited comprehensive analysis.
A Longitudinal Examination of Interpersonal Violence Exposure, Concern for Loved Ones During a Disaster, and Web-Based Intervention Effects on Posttraumatic Stress Disorder Among Adolescent Victims of the Spring 2011 Tornadoes  (Gilmore et al., 2021)	Longitudinal Study, Secondary Data Analysis of a Randomized Clinical Trial (RCT)	Adolescents exposed to natural disasters often face mental health challenges, especially those with a history of interpersonal violence (IPV). The study seeks to understand how IPV history and concern for loved ones during a disaster affect PTSD symptoms and response to web-based interventions like Bounce Back Now (BBN).	To examine the moderating effects of IPV history and concern for loved ones on the efficacy of BBN intervention in reducing PTSD symptoms among adolescents exposed to disasters.	Adolescents with a history of IPV had more severe PTSD symptoms. The BBN intervention was particularly effective for adolescents whose caregivers expressed concern for loved ones during the disaster. However, IPV history did not significantly moderate the effect of BBN on PTSD outcomes.	This study highlights the significance of caregiver concern during a disaster as a moderating factor in the efficacy of web-based interventions for PTSD. It also emphasizes the need to consider interpersonal trauma history when designing post-disaster interventions.	The study suggests the need for more in-depth assessments of concern for loved ones, including multi-item measures. It also indicates the need for interventions tailored to IPV-specific experiences. Additionally, the intervention took place 9 months after the disaster, and results might differ if implemented sooner.

## Discussion

Disaster management is a multifaceted process requiring the seamless integration of healthcare services, logistics, and technological innovation. Recent advances in technology have reshaped the way emergency services are deployed, medical supplies are transported, and mental health recovery is facilitated post-disaster. Tools such as Geographic Information Systems (GIS), Unmanned Aerial Vehicles (UAVs), and web-based interventions have revolutionized disaster response efforts<sup>5-7</sup>. These technologies not only enhance response times but also enable more efficient resource allocation and targeted healthcare interventions, leading to better outcomes for affected populations<sup>8,9</sup>.

Healthcare services, particularly Emergency Medical Services (EMS), play a vital role in disaster responses, ensuring that patients receive immediate medical attention and are transported to healthcare facilities for further care<sup>10</sup>. The COVID-19 pandemic brought the role of EMS to the forefront, highlighting both the challenges and opportunities for technological integration in healthcare<sup>11</sup>. This discussion examines the role of various technological and healthcare innovations in disaster management, providing insights into how these advancements have enhanced both physical and mental health recovery and improved disaster preparedness.

### The Role of Emergency Medical Services (EMS) in Disaster Management

Emergency Medical Services (EMS) serve as the first line of medical intervention during disasters, providing critical care before patients reach healthcare facilities. During the COVID-19 pandemic, EMS faced unprecedented challenges as the number of patients increased dramatically. The demand for EMS services in Bangkok rose by 9.36% during the pandemic, resulting in extended response times and increased pressure on healthcare systems<sup>12</sup>. The added requirement for COVID-19 screenings and the use of personal protective equipment (PPE) also contributed to operational delays. Despite these challenges, EMS remained an indispensable part of the disaster response, ensuring that patients continued to receive life-saving care in a timely manner.

The introduction of mobile-based EMS management systems, such as eEKAB, has further enhanced the capabilities of EMS in disaster settings. eEKAB reduced the time required to respond to emergencies by streamlining the dispatch process and improving communication between ambulance drivers and healthcare facilities<sup>3</sup>. These systems enable more efficient resource allocation, ensuring that the nearest available ambulance is deployed to the scene, ultimately improving patient outcomes. The integration of mobile technology into EMS not only modernizes emergency response but also alleviates the strain on healthcare infrastructure during crises.

In addition to improving efficiency, mobile-based systems such as eEKAB allow for better coordination of resources across multiple regions. This is especially important in large-scale disasters where resources may be scarce, and the ability to allocate them based on real-time data is critical.

The system's user-friendly interface also makes it easier for EMS personnel to adapt to new operational protocols, leading to faster adoption and integration into existing EMS frameworks. This demonstrates the potential for mobile technology to not only enhance response times but also optimize the overall management of emergency services during disasters.

### **The Geospatial-Based Disaster Management System**

Geospatial-based disaster management systems, such as the SIGAB KESPRO system developed by researcher<sup>13</sup>, play a crucial role in improving disaster preparedness and response, particularly in managing healthcare services for vulnerable populations. The system was designed to enhance adolescent reproductive health services in West Nusa Tenggara (NTB) during emergencies by utilizing real-time mapping and data collection. This approach allows for more efficient logistics management, ensuring that healthcare services are distributed equitably to areas with the greatest need.

In addition to streamlining resource allocation, geospatial systems enable disaster response teams to identify and prioritize high-risk areas based on real-time data. This improves the speed and accuracy of health service delivery during emergencies, reducing the time it takes for aid to reach affected populations. Researcher emphasized that by integrating geospatial data with healthcare management, the SIGAB KESPRO system was able to address critical gaps in adolescent reproductive health services, an area often overlooked in disaster situations<sup>13</sup>. This underscores the importance of tailored healthcare interventions in disaster management, particularly for vulnerable groups.

The SIGAB KESPRO system also offers significant potential for scalability and adaptability in different disaster contexts. The geospatial framework used in the system can be expanded to include other health services or adapted for use in different regions. This flexibility makes geospatial-based systems a valuable tool in improving the efficiency and effectiveness of disaster management across various settings. Future advancements in this technology could further enhance its capabilities, allowing for even more precise targeting of resources and services in disaster-stricken areas.

### **Geographic Information Systems (GIS) in Earthquake Preparedness**

Geographic Information Systems (GIS) have become indispensable in disaster preparedness, particularly in earthquake-prone cities where timely and accurate information is essential for effective responses<sup>14</sup>. Other researchers highlights the importance of GIS in cities such as Istanbul, Los Angeles, and Tokyo, where the technology is used to map critical infrastructure, identify gaps in healthcare coverage, and optimize resource allocation<sup>4</sup>. GIS enables authorities to visualize spatial data in real-time, facilitating better decision-making and reducing emergency response times during earthquakes and other natural disasters.

One of the key benefits of GIS is its ability to integrate data from multiple sources, providing a comprehensive overview of the disaster area. This allows disaster management teams to make informed decisions about resource allocation, evacuation routes, and healthcare service delivery. In earthquake-prone cities, GIS has been shown to reduce emergency response times by up to 20% and improve the efficiency of healthcare resource distribution by 30%, as noted by researcher<sup>4</sup>. The ability to continuously monitor earthquake activity and infrastructure damage in real-time further enhances the responsiveness of healthcare systems, ensuring that affected populations receive timely medical care.

The future of GIS in disaster management lies in its continued integration with other emerging technologies, such as UAVs and mobile-based systems, to create a more cohesive and responsive disaster management framework. As GIS technology continues to evolve, it is likely that its role in disaster preparedness and response will become even more critical, offering new ways to anticipate, manage, and mitigate the effects of natural disasters on vulnerable populations.

### **The Role of Bounce Back Now (BBN) in Disaster Mental Health Recovery**

Bounce Back Now (BBN) is a web-based mental health intervention designed to provide support for individuals recovering from traumatic events, such as natural disasters. Other researchers demonstrated that BBN was particularly effective in reducing PTSD symptoms in adolescents affected by the 2011 tornadoes in the United States<sup>15</sup>. The intervention provided self-guided modules on topics such as PTSD, depression, and substance use, allowing participants to access mental health support remotely. Adolescents whose caregivers expressed concern for their safety during the disaster experienced the most significant benefits from the program, highlighting the importance of interpersonal support in trauma recovery.

The scalability and accessibility of BBN make it an essential tool for disaster mental health recovery, particularly in remote or underserved areas where traditional mental health services may be limited. By providing evidence-based mental health interventions in a digital format, BBN ensures that individuals can receive timely support even when access to in-person services is restricted. This is especially important in the aftermath of disasters, where the demand for mental health services often exceeds the available resources. BBN's ability to deliver tailored interventions remotely makes it a valuable asset in disaster recovery efforts.

However, while BBN was effective in addressing PTSD symptoms, Researchers noted that there were no significant interactions between BBN and a history of interpersonal violence (IPV)<sup>15</sup>. This suggests that while BBN is effective for general trauma recovery, it may need to be adapted to better address the needs of individuals with more complex trauma histories. Future iterations of BBN could incorporate more targeted interventions for those with a history of IPV or other forms of interpersonal trauma, ensuring that the program meets the diverse needs of disaster-affected

populations.

### **Telerehabilitation**

Telerehabilitation programs, such as TERECO, have emerged as vital tools in the recovery of COVID-19 survivors, offering remote support for physical rehabilitation and recovery. TERECO significantly improved physical capacity and lower limb muscle strength in post- COVID-19 patients, particularly in areas related to mobility and daily functioning<sup>16</sup>. The program's remote format allowed patients to engage in supervised rehabilitation sessions without the need for in-person visits, reducing the risk of infection and overcoming logistical barriers associated with traditional rehabilitation services.

The success of telerehabilitation programs like TERECO highlights the importance of integrating digital health solutions into post-pandemic healthcare systems. By offering accessible, remote rehabilitation services, programs like TERECO ensure that patients continue to receive the care they need, even in situations where physical access to healthcare facilities is limited. This is particularly relevant in the context of global health emergencies, where healthcare systems may be overwhelmed, and the need for scalable solutions is critical.

However, researcher noted that while TERECO was effective in improving physical recovery, it had limited impact on lung function and mental health<sup>16</sup>. This suggests that while telerehabilitation is a valuable tool for physical recovery, additional interventions may be needed to address the full spectrum of post-COVID-19 recovery needs. Future telerehabilitation programs could incorporate more comprehensive approaches that address both physical and mental health outcomes, ensuring a holistic approach to patient recovery.

### **Conclusion**

The studies reviewed highlight the transformative impact of technological advancements on disaster management and healthcare systems. Emergency Medical Services (EMS), supported by mobile-based management systems like eEKAB, have become more efficient and responsive, particularly during the COVID-19 pandemic. UAVs and Geographic Information Systems (GIS) have revolutionized how medical supplies are transported and how disaster response is coordinated, ensuring that essential resources reach those in need, even in challenging environments. Furthermore, web-based interventions like Bounce Back Now (BBN) and telerehabilitation programs such as TERECO have provided accessible solutions for mental and physical health recovery, particularly in remote or underserved areas. The integration of Virtual Reality (VR) into disaster medicine education has enhanced the preparedness of healthcare professionals, equipping them with the skills and confidence needed to respond to real-life emergencies. These technological innovations represent scalable, efficient solutions for improving disaster management and healthcare delivery,

underscoring the need for continued investment in digital tools to support communities during and after crises.

## References

1. World Health. Climate Change and Health [Internet]. World Health Organization. 2020. Available from: <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>
2. Jung Y. Virtual Reality Simulation for Disaster Preparedness Training in Hospitals: Integrated Review. *J Med Internet Res* [Internet]. 2022 Jan 28;24(1):e30600. Available from: <https://www.jmir.org/2022/1/e30600>
3. Mitropoulos S, Mitsis C, Valacheas P, Douligieris C. An online emergency medical management information system using mobile computing. *Appl Comput Informatics* [Internet]. 2025 Jan 30;21(1/2):65–77. Available from: <http://www.emerald.com/aci/article/21/1-2/65-77/1241895>
4. Tunaligil V. Developing a Geographic Information System for health institutes in earthquake-Prone metropolitan cities: A Methodological Approach. *Med Sci Discov* [Internet]. 2024 Sep 4;11(9):260–8. Available from: <https://medscidiscovery.com/index.php/msd/article/view/1191>
5. Rodríguez-Espíndola O, Albores P, Brewster C. GIS and Optimisation: Potential Benefits for Emergency Facility Location in Humanitarian Logistics. *Geosciences* [Internet]. 2016 Mar 29;6(2):18. Available from: <https://www.mdpi.com/2076-3263/6/2/18>
6. Rudiastuti AW, Suryanegara E, Wirawan A, Purwanto B, Gill SN, Prihanto Y, et al. Design and Implementation of a User-Centered Web-App using Open Source Platform: Indonesia Disaster Data (InDITA). *JOIV Int J Informatics Vis* [Internet]. 2020 Dec 18;4(4):243–9. Available from: <https://joiv3.remorac.com/ojs31/index.php/joiv/article/view/460>
7. Abid SK, Sulaiman N, Chan SW, Nazir U, Abid M, Han H, et al. Toward an Integrated Disaster Management Approach: How Artificial Intelligence Can Boost Disaster Management. *Sustainability* [Internet]. 2021 Nov 13;13(22):12560. Available from: <https://www.mdpi.com/2071-1050/13/22/12560>
8. Twumasi NYD, Shao Z, Orhan A. Remote Sensing and GIS Methods in Urban Disaster Monitoring and Management – An Overview. *Int J Trend Sci Res Dev* [Internet]. 2019 Jun 30;Volume-3(Issue-4):918–26. Available from: <https://www.ijtsrd.com/engineering/civil-engineering/23976/remote-sensing-and-gis-methods-in-urban-disaster-monitoring-and-management—an-overview/nana-yaw-danquah-twumasi>
9. Nabukonde A, Barakagira A, Akwango D. The Use of Geographical Information System (GIS) and Remote Sensing (RS) Technologies in Generation of Information Used to Mitigate

- Risks from Landslide Disasters: An Application Review. Arch Curr Res Int [Internet]. 2023 Mar 8;23(2):43–9. Available from: <https://www.journalacri.com/index.php/ACRI/article/view/558>
10. Sulaiman N, Mohamad Abdullah N, Nazir U, Ismail M, Abdul Latib SKK, Mahmud NPN. Geographical Information System (GIS) and Remote Sensing (RS) Applications in Disaster Risk Reduction (DRR) in Malaysia. Int J Integr Eng [Internet]. 2022 Sep 6;14(5). Available from: <https://publisher.uthm.edu.my/ojs/index.php/ijie/article/view/8292/5188>
  11. Birnbaum ML, Daily EK, O'Rourke AP, Kushner J. Research and Evaluations of the Health Aspects of Disasters, Part VI: Interventional Research and the Disaster Logic Model. Prehosp Disaster Med [Internet]. 2016 Apr 2;31(2):181–94. Available from: [https://www.cambridge.org/core/product/identifier/S1049023X16000017/type/journal\\_article](https://www.cambridge.org/core/product/identifier/S1049023X16000017/type/journal_article)
  12. Huabangyang T, Trakulsrichai S, Yuksen C, Sricharoen P. The Impact of the Coronavirus Disease 2019 (Covid-19) Pandemic on the Use of Emergency Medical Services System in Bangkok, Thailand. Open Access Emerg Med [Internet]. 2022 Aug;Volume 14:429–40. Available from: <https://www.dovepress.com/the-impact-of-the-coronavirus-disease-2019-covid-19-pandemic-on-the-us-peer-reviewed-fulltext-article-OAEM>
  13. Sapuan Hadi M, Hastono SP, Prabawa A. Design and Development of a Geospatial-Based Information Systems for Disaster Management of Adolescent Reproductive Health in Nusa Tenggara Barat Province In 2020. IOP Conf Ser Earth Environ Sci [Internet]. 2021 Apr 1;755(1):012073. Available from: <https://iopscience.iop.org/article/10.1088/1755-1315/755/1/012073>
  14. Westlund S. The Use of Geospatial Technology in Disaster Management. Int J Appl Geospatial Res [Internet]. 2010 Jul 1;1(3):17–30. Available from: <https://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/jagr.2010070102>
  15. Gilmore AK, Price M, Bountress KE, Zuromski KL, Ruggiero K, Resnick H. A Longitudinal Examination of Interpersonal Violence Exposure, Concern for Loved Ones During a Disaster, and Web-Based Intervention Effects on Posttraumatic Stress Disorder Among Adolescent Victims of the Spring 2011 Tornadoes. J Interpers Violence [Internet]. 2021 May 23;36(9–10):NP4611–25. Available from: <https://journals.sagepub.com/doi/10.1177/0886260518791236>
  16. Li J, Xia W, Zhan C, Liu S, Yin Z, Wang J, et al. A telerehabilitation programme in post-discharge COVID-19 patients (TERECO): a randomised controlled trial. Thorax [Internet]. 2022 Jul;77(7):697–706. Available from: <https://thorax.bmj.com/lookup/doi/10.1136/thoraxjnl-2021-217382>