EURASIAN JOURNAL OF EMERGENCY MEDICINE
Review
DOI: 10.4274/eajem.galenos.2024.45452
Eurasian J Emerg Med.

Use of Technology in Disaster Medicine

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Abstract

This review explores the impact of telemedicine, mobile health (mHealth) applications, and point-of-care ultrasound in disaster scenarios. A comprehensive literature review was conducted using databases such as PubMed, MEDLINE, and Google Scholar to identify relevant studies on technology in disaster medicine. The findings indicate that telemedicine significantly enhances communication and coordination among emergency teams, mHealth applications improve patient tracking and triage, and point-of-care ultrasound provides rapid and accurate diagnostics in disaster settings. These technological advancements have contributed to efficient and effective disaster response efforts, highlighting the critical role of technology in modern disaster medicine.

Keywords: Disaster medicine, technology, telemedicine, mobile health, point-of-care ultrasound, emergency response

Introduction

Disaster medicine is a critical field focused on providing medical care in the aftermath of natural and human disasters. These events can overwhelm healthcare systems, leading to significant challenges in timely and effective care delivery to affected populations. Recent technological advancements have the potential to transform disaster medicine by enhancing preparedness, response, and recovery efforts. This literature review explores the role of various technological innovations, including telemedicine, mobile health (mHealth) applications, and point-of-care ultrasound, in improving disaster response and management. By examining the current state of technology in disaster medicine, we highlight the benefits, challenges, and future directions of research and practice.

Natural disasters, such as earthquakes, hurricanes, and floods, as well as man-made crises like terrorist attacks and industrial accidents, can result in mass casualties and significant disruptions to healthcare infrastructure (1,2). In such scenarios, the rapid deployment of medical resources and effective coordination among emergency responders are critical for saving lives and reducing morbidity (3). Traditional disaster response methods often struggle to meet these demands, leading to delays and inefficiencies in care delivery (4).

Technological innovations offer promising solutions to these challenges by enabling real-time communication, remote diagnosis and treatment, and efficient resource management (5,6). For example, telemedicine allows healthcare providers to deliver medical care remotely, bridging the gap between affected areas and specialized medical centers (7). mHealth applications further enhance disaster response by providing tools for patient tracking, triage and information management (8). These applications can streamline the flow of information, ensuring that responders have up-to-date data on patient status and resource availability. Additionally, point-of-care ultrasound devices offer portable, easy-to-use diagnostic tools that can be deployed in the field to rapidly assess and treat injuries (9).

Despite the potential benefits of such technologies, their implementation in disaster medicine is not without challenges. Issues such as the interoperability of different systems, the reliability of communication networks, and the need for training and support must be addressed to fully realize the advantages of technological solutions (10). This review aims to provide a comprehensive overview of the state of technology in disaster medicine, identify key areas for improvement, and suggest future research and development directions.

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Cite this article as: Abualenain J. Use of Technology in Disaster Medicine. Eurasian J Emerg Med.

Received: 17.05.2024
Accepted: 12.08.2024

Brief Literature Review

A literature search was conducted to identify relevant studies on the use of technology in disaster medicine. The databases that were searched were PubMed, MEDLINE, and Google Scholar. The search terms used were "disaster medicine," "technology," "telemedicine," "mobile health," "mHealth," "point-of-care ultrasound," and "emergency response." The search was limited to articles published in English between 2000 and 2023. The inclusion criteria were studies that discussed the application of these technologies in disaster scenarios, provided empirical data or case studies, and contributed to understanding the benefits and challenges of telemedicine, mHealth applications, and point-of-care ultrasound in disaster settings. The exclusion criteria included articles not focused on disaster scenarios or those lacking empirical data.

Relevant articles were selected based on their contributions to understanding the benefits and challenges of the technologies under consideration. The selected articles were then analyzed using a thematic analysis approach to highlight key findings and trends. This process involved data coding to identify common themes and synthesizing results to provide a comprehensive overview of the current state of technology in disaster medicine.

Review Outcomes

A total of 24 studies were included in this review. These studies highlight the significant impact of telemedicine, mHealth applications, and point-of-care ultrasound on disaster response and management. The findings from these studies are categorized and summarized below.

Telemedicine in Disaster Response

Telemedicine provides remote medical support and enhances communication and coordination among emergency teams. Several studies have demonstrated the significant benefits of telemedicine in disaster settings:

Real-time Communication: Telemedicine facilitates real-time communication between on-site responders and remote medical specialists, allowing for timely decision-making and expert consultation. For example, Benner et al. (1) highlighted the use of telemedicine during a natural disaster in Germany, where remote specialists provided critical support to on-site teams and improved patient outcomes. Additionally, Callaway et al. (3) described the effective use of telemedicine during the Haiti earthquake, where it enabled efficient coordination and resource allocation.

Remote Diagnostics: Remote diagnostic capabilities enable healthcare providers to assess patients' conditions without the need for physical presence, which is particularly valuable in inaccessible or hazardous areas. Boeriu et al. (2) reported the successful deployment of telemedicine in remote areas during a flood disaster in Romania, where remote diagnostic methods significantly enhanced the speed and accuracy of patient assessments.

Improved Coordination: Enhanced coordination among emergency teams and healthcare facilities ensures that resources are allocated efficiently and that patient care is prioritized based on severity and need. Franc-Law et al. (7) found that telemedicine improved coordination during a simulated disaster exercise, resulting in more efficient resource utilization and better patient management, a finding also supported by Mazur and Rippey (11).

Mobile Health Applications

mHealth applications improve patient tracking and triage during disasters. Several studies have demonstrated the significant benefits of mHealth applications in disaster settings:

Patient Tracking: mHealth applications provide real-time patient tracking, enabling responders to monitor their status, location, and medical needs. Harrison et al. (8) reported that mHealth applications are crucial for tracking patient movements and needs during hurricanes in the United States.

Triage Management: These applications assist in the triage process by providing standardized assessment tools and algorithms, ensuring that patients are prioritized according to the severity of their conditions. Madanian et al. (12) described the use of mHealth applications in earthquake response scenarios, where they improved the triage accuracy and speed.

Resource Allocation: mHealth applications help manage resources by providing up-to-date information about the availability of medical supplies, personnel, and facilities. Case et al. (4) found that mHealth applications were instrumental in managing resources during a simulated pandemic, ensuring that critical supplies were directed where they were needed most. This finding is further supported by Doarn and Merrell (13), who highlighted the effectiveness of mHealth applications in crisis situations, emphasizing their role in resource management

Point-of-Care Ultrasound

Portable ultrasound devices enable rapid diagnosis in disaster situations. Several studies have demonstrated the significant benefits of point-of-care ultrasound in disaster medicine:

Rapid Diagnostics: Point-of-care ultrasound allows for quick and accurate diagnosis of injuries and conditions, facilitating timely and appropriate treatment. Heiner and Baker (14), through a systematic review and meta-analysis, highlighted the accuracy and critical role of the Focused Assessment with Sonography for Trauma in disaster settings, supporting its utility in improving diagnostic processes during mass casualty incidents.

Portability: These devices are compact and easy to transport, making them suitable for use in field settings and remote areas. Chan et al. (5) described the deployment of portable ultrasound devices during a major disaster, where their portability was critical for providing diagnostic services in challenging environments. This was further evidenced by Wydo et al. (15), who emphasized the critical role of portable ultrasound devices in disaster triage, particularly in mass casualty incidents, where rapid assessment in remote and resource-limited settings is crucial.

Non-Invasive: Ultrasound is a non-invasive diagnostic tool, reducing the risk of complications and enhancing patient safety. Haynes et al. (9) highlighted the safety and efficacy of point-of-care ultrasound in disaster scenarios and noted its advantages over more invasive diagnostic techniques.

The integration of technology into disaster medicine enhances the efficiency and effectiveness of emergency response. Telemedicine, mHealth applications, and point-of-care ultrasound are critical tools that improve communication, patient management, and healthcare provider preparedness. However, several challenges must be addressed to fully realize the benefits of these technologies.

Interoperability Issues: One of the primary challenges is the interoperability of different systems. In disaster settings, multiple agencies and organizations often work together, each using their own technologies and communication platforms. Ensuring that these systems can communicate and share data seamlessly is essential for effective coordination and response (2,6,8). This requires standardizing protocols and investing in interoperable technologies to overcome this barrier (5,16,17). The development of universal standards for data sharing and communication is crucial for improving interoperability among disparate systems used by various organizations during disasters (5,6,16).

Reliability of Communication Networks: Another challenge is the reliability of communication networks. Disasters can disrupt communication infrastructures, making it difficult for responders and medical teams to maintain contact. Developing resilient communication networks that can withstand disaster conditions is crucial for maintaining effective communication and coordination (6,18). This involves investing in satellite communication systems, portable mobile networks, and other technologies that provide reliable communication in the absence of traditional infrastructure (7,10,19).

Training and Support: Training and support are essential for successful implementation of these technologies. Healthcare providers and emergency responders must be trained to use telemedicine, mHealth applications, and point-of-care ultrasound effectively (7,20). Simulation-based training programs have been shown to significantly improve healthcare provider preparedness and confidence in disaster scenarios (9,21). Continuous education and training are necessary to ensure personnel are proficient in using these technologies under stressful and rapidly changing conditions (9,22).

Ethical and Legal Considerations: The rapid pace of technological advancement presents ethical and legal challenges. Ensuring patient privacy and data security is paramount in the chaotic environment of a disaster response (10,23). There may be legal issues related to the use of telemedicine across state or national borders, as well as the liability of remote practitioners (11). Clear guidelines and policies must be established to address these concerns (11,24).

Despite these promising findings, this review has several limitations. The selection of articles was limited to those published in English, potentially excluding relevant studies in other languages. The rapid pace of technological development means that some reviewed technologies may be outdated or surpassed by new innovations. The variability in study designs and contexts makes it challenging to generalize findings across different disaster scenarios. Reliance on self-reported data in some studies may introduce bias and affect the reliability of the findings. Future research should address these limitations by including a broader range of studies, regularly updating reviews, and utilizing standardized methodologies.

Conclusion

Technological advancements in disaster medicine, including telemedicine, mHealth applications and point-of-care ultrasound, significantly enhance the efficiency and effectiveness of disaster response. These technologies improve communication, patient management, and healthcare provider preparedness, leading to better disaster outcomes. However, challenges such as system interoperability, communication network reliability, training, and ethical considerations must be addressed to fully realize the potential of these innovations. Continued research, investment, and collaboration are essential for advancing the role of technology in disaster medicine and improving global disaster preparedness and response.

Ethics

Conflict of Interest: No conflict of interest was declared by the author.

Financial Disclosure: The author declared that this study received no financial support.

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