

Impact of Technology on Disaster Medicine in Low-Resource Settings

Wayan Dhea Agastya¹

¹Faculty of Medicine Universitas Pembangunan Nasional Veteran Jawa Timur

Corresponding Author

Wayan Dhea Agastya

Faculty of Medicine Universitas Pembangunan Nasional Veteran Jawa Timur

Rungkut Madya Street Number 191, Rungkut Kidul, Rungkut District, Surabaya, Jawa Timur
60293

Tel/Fax: +628113111846

E-mail: wayan.dhea.agastya.fk@upnjatim.ac.id

Abstract

Background. Technology has become a key to face challenges in improving disaster medicine services in low resources settings. By using technology, some obstacles can be solved and increase the quality of the services.

Methods. Literature searching was conducted using databases such as PubMed, Google Scholar, and Web of Science using Search terms included "disaster medicine," "low-resource settings," "emergency response," and "innovations in disaster care.". Systematic reviews of peer-reviewed articles, reports, and case studies were chosen.

Discussion. Some key innovations which can be used include mobile health (mHealth) solutions, telemedicine, portable medical devices, drones, geographic information systems (GIS), and wearable health monitors. These tools have significantly improved disaster response by enhancing communication, enabling remote diagnostics, optimizing resource allocation, and ensuring continuous care. Telemedicine platforms have proven invaluable during crises like the COVID-19 pandemic, while portable devices and renewable energy solutions maintain medical operations amid power disruptions. Drones and GIS support timely delivery of medical supplies and effective disaster planning.

Conclusion. Future strategies advocate for integrating artificial intelligence, robust governance, community engagement, and innovative research to enhance disaster resilience. This review underscores the critical need for sustainable, technology-driven approaches in disaster medicine to mitigate health disparities and improve outcomes in vulnerable populations.

Keywords. disaster medicine, low resources, healthcare, technology

Introduction

Disaster medicine plays a pivotal role in mitigating the health impacts of emergencies, particularly in low-resource settings where healthcare systems are often underprepared and lack resilience.¹ Technological advancements have emerged as critical solutions to these challenges, enabling improved communication, resource allocation, and access to care during disasters.² Innovations such as mobile health (mHealth) solutions and telemedicine have proven instrumental in expanding the capacity of disaster response teams and delivering specialized care in remote areas.^{3,4}

Portable medical devices designed for low-resource environments, such as solar-powered oxygen concentrators and battery-operated ventilators, have significantly enhanced the ability to provide care in infrastructure-deficient areas.⁵ Additionally, tools like Geographic Information Systems (GIS) and drones have streamlined the distribution of medical supplies and planning of evacuation routes, thereby optimizing disaster response efforts.^{6,7}

This literature review explores the role of these technological innovations in disaster medicine. By highlighting their applications and potential, the review aims to emphasize the need for integrating advanced, sustainable technologies into disaster preparedness strategies to enhance healthcare delivery and resilience in underserved populations.⁸

Methods

A systematic review of peer-reviewed articles, reports, and case studies from 2013 to 2024 was conducted using databases such as PubMed, Google Scholar, and Web of Science. Search terms included "disaster medicine," "low-resource settings," "emergency response," "innovations in disaster care" and "health technology"

Discussion

There are several health technology which might be used to support disaster medicine services.

Mobile Health (mHealth) Solutions

mHealth solutions have expanded the capacity of disaster response teams, particularly in

resource-constrained areas. These technologies facilitate telemedicine, real-time data capture, and provision of health information. For instance, mobile applications designed for disasters can offer health workers protocols with guidelines, enhancing uniformity and quality of care delivered in any field environment.⁹ A study by Chen et al.³ revealed that mHealth tools provided superior and more efficient communication between healthcare providers and patients, hence making triaging and treatment processes quite easy.

Telemedicine

Telemedicine has become one of the most crucial tools in delivering medical expertise into disaster areas affected where specialized care might not be readily available. In the wake of the COVID-19 pandemic, telemedicine platforms played a very key role in the delivery of healthcare services in remote and resource-poor areas of the world. This limits physical presence and averts the risk of disease transmission.⁴ Telemedicine in disaster settings allows specialists to advise local healthcare providers on how to perform a complicated medical procedure to save a victim's life, thereby improving the quality of care.¹⁰

Portable Medical Devices

Development and fielding of portable medical devices customized for low-resource environments have much enhanced disaster response medical capabilities. Portable ultrasound machines, solar-powered oxygen concentrators, among other life support ventilators that are operated by batteries ensure that the much-needed medical interventions can be performed even in the absence of stable electricity and sophisticated medical infrastructure. A study by Ochieng, et al.⁵ indicated that it is possible to have solar-powered medical equipment that can sustain continuous care in the event of disaster situations characterized by long periods of power failure.

Drones and Unmanned Aerial Vehicles (UAVs)

In this respect, unmanned aerial vehicles, commonly known as drones, have recently been used on an increasing basis to deliver medical supplies, vaccines, and even blood products in disaster situations where ground transportation is impeded. Many types of debris can be flown over by a drone, and it offers access to isolated communities, thus ensuring timely delivery of critical health commodities. According to Sanz-Martos et al.¹¹ with UAVs, there is a reduced length of time required for the transportation of medical supplies in emergency situations, thus enhancing survival rates and health outcomes; this view is supported by

Thompson et al.⁷

Geographic Information Systems

Geographic Information Systems (GIS) are an integral part of disaster medicine, as they facilitate detailed mapping and analysis of the affected areas. GIS technology will be helpful in identifying vulnerable populations, planning evacuation routes, and optimizing resource use or allocation. For example, immediately after Hurricane Maria in Puerto Rico, GIS served a great deal in the response operations as an effective channel through which medical supplies were distributed into places that were in dire need of them.⁶ Research into GIS in the recent past has made the system more accurate and easier to work on during times of disasters.¹²

Wearable Health Monitors

Wearable health monitors, such as smartwatches and biometric sensors, have established their relevance in disaster medicine through the continuous monitoring of disaster victims and responders. The devices monitor vital signs, detect early symptoms, and raise vital alerts to healthcare providers. According to Wang et al.¹³, wearable technology has been able to track in real-time the health status of populations affected by disasters, thus allowing timely medical interventions and more effective management of chronic conditions during emergencies.

Recommendations

Strengthening Health Infrastructure

In the future, healthcare infrastructures that are disaster-resilient should be built. Disaster-resilient health facilities with provision of essential life-saving health supplies must be incorporated. Novel designs and usage of durable materials can increase, by a great deal, the capacity of the facilities in staying functional during and following disasters.¹⁴

Capacity Building and Training

This makes training programs for health professionals and first responders of importance. Then, there has to be a regular drill and simulation to prepare the staff for any kind of disaster situation. In addition, the theme of disaster medicine could be inculcated into the curriculum of medical and nursing schools so that new professionals have the necessary preparation.¹⁵ Community-based training programs may further enable local volunteers to offer basic medical assistance immediately after a disaster.¹⁶

Leveraging Technology and Telemedicine

Telemedicine can bridge the potential gap that may exist in healthcare delivery to remote and underserved areas during a disaster. Mobile health technologies, together with teleconsultation platforms, may facilitate remote diagnostics and monitoring, easing the burden on local healthcare facilities. Clearly, future research will be focused on the integration of AI into disaster response decision-making in pursuit of timely decision-making and resource allocation.⁴

Supply Chain Management

Effective supply chain management is instrumental in delivering medical supplies on time during disasters. Development of digital tracking systems and creation of regional stockpiles of essential supplies can prevent shortages. Public–private partnerships can generate such resiliencies for a disrupted supply line by leveraging sectoral expertise and resources for both parties.⁷

Improving Community Engagement

Community empowerment in disaster management accrues from public education activities targeted at strategies in preparedness and response. The community will become strengthened if local leaders and local organizations can serve as conduits for disseminating information and coordinating efforts within communities.¹⁷

Policy and Governance

An effective disaster response means the presence of robust policies and governance structures at the national level. Such governance should establish clear protocols and frameworks for disaster management, entailing the coordination between several stakeholders. For example, the incorporation of disaster preparedness into national health policies and plans could provide an opportunity for a better and more coordinated response system that can be more effective.¹⁸ (Ahmed & Rahman, 2020).

Research and Data Collection

As more challenges continue to evolve in regard to disaster medicine, constant research is critical. Institution of comprehensively collected data systems will go a long way to determine the trends, evaluate the effectiveness of interventions, and thus develop strategies for the

future. Such research efforts could be done in collaboration between academic institutions, governments, and international bodies and hence build innovation.¹⁹

International Collaboration

This can also foster international collaboration to increase disaster preparedness and response in low-resource settings. International partnerships can share best practice, resources, and expertise to help build resilient health systems. The frameworks for this sort of collaboration are provided by programs such as the WHO's Emergency Medical Teams initiative.

Conclusions

Future strategies advocate for integrating artificial intelligence, robust governance, community engagement, and innovative research to enhance disaster resilience. This review underscores the critical need for sustainable, technology-driven approaches in disaster medicine to mitigate health disparities and improve outcomes in vulnerable populations.

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