AI-Enhanced Healthcare Resilience Transforming Disaster Management

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Abstract

Increasing global challenges posed by natural disasters and public health emergencies, the healthcare sector is under growing pressure to enhance its disaster management strategies. By harnessing the power of AI technologies such as predictive analyses - early warning systems, digital mapping, data-driven decision-making, and real-time monitoring, healthcare systems can significantly improve disaster preparedness, response, and recovery plans and programs. In this review article study, its being highlight the tangible benefits AI brings to healthcare resource allocation, patient triage, risk assessment, and communication. This paper underscores the potential of AI to revolutionize disaster management within the healthcare domain and examines the need for collaborative efforts among stakeholders like AI experts, healthcare professionals, and policymakers to develop robust frameworks that ensure the responsible and effective use of AI technologies for healthcare in disaster scenarios.

Categories: Emergency Medicine, Public Health, Occupational Health

Keywords: emergency response, ai protocols for healthcare, early warning system, triage, ai and robotics in healthcare, disaster management

Introduction And Background

Nature is testing human capacity in civilization and innovation time by time. Human capacity and capacities are getting stronger and stronger by research and development in science and technology day by day. Smart cities are emerging needs based on the latest R&D due to immense pressure on world economy in developing and developed states, climate changes globally and increasing the intensity of natural disaster gradually.

Artificial intelligence - AI is an innovative tool, it’s a tailor made science and technology helping hand which added in human capabilities to make the societies more efficient and objective oriented.

In an increasingly unpredictable world marked by natural disasters, pandemics, and other emergencies, the role of artificial intelligence (AI) in healthcare has taken on new significance. AI’s capacity to rapidly analyze vast amounts of data, predict trends, and facilitate decision-making has positioned it as a valuable tool in disaster response and management. This article delves into the ways AI can play a crucial role in healthcare during times of crisis, helping to save lives, allocate resources efficiently, and enhance overall disaster preparedness.

The criticality and complexity of disaster operations requires robust and validated ML and DL solutions. Disaster operations affect human life; therefore, the developed models should also be explained to be understood by domain experts and decision makers. Moreover, research should focus on improving the quality of the data and developing novel data capture techniques as well as using crowdsourcing to improve the performance of ML/DL-based methods for disaster management operations.[1]

Review

Discussion

Early Detection and Prediction

AI plays a pivotal role in early detection and prediction of disasters, allowing healthcare professionals and authorities to proactively prepare and allocate resources. Machine learning algorithms can analyze historical data and environmental factors to forecast disease outbreaks, identify potential epidemics, and predict the impact of natural disasters on public health. For example, AI-driven models can track the spread of infectious diseases, such as the flu or COVID-19, Flooding, Tornado etc.... by analyzing social media posts, hospital admissions, and other relevant data sources.

WHO’s Early Warning, Alert and Response System (EWARS) is designed to improve disease outbreak detection in emergency settings, such as in countries in conflict or following a natural disaster.[1]
Resource Allocation and Management

During a disaster, efficient resource allocation is paramount to ensure that medical facilities have adequate supplies and manpower. AI-driven analytics can help optimize the allocation of medical equipment, personnel, and medication to areas most in need. By analyzing real-time data on patient inflow, bed availability, and supply levels, AI can recommend strategies for resource distribution, preventing bottlenecks and shortages.

Remote Patient Monitoring and Telemedicine

Disasters often disrupt healthcare access and infrastructure, making it challenging for patients to receive timely medical attention. AI-powered remote patient monitoring and telemedicine solutions bridge this gap by enabling healthcare providers to remotely assess and treat patients. Wearable devices equipped with AI algorithms can monitor vital signs, detect abnormalities, and alert healthcare professionals to intervene when necessary. Telemedicine platforms allow doctors to provide virtual consultations, prescribe medications, and offer medical advice, ensuring continuity of care even during chaos.

Diagnostics and Triage

AI-enhanced diagnostic tools can aid healthcare providers in making rapid and accurate assessments, particularly when faced with a high volume of patients during a disaster. AI algorithms can analyze medical images, such as X-rays and CT scans, to detect anomalies and assist radiologists in prioritizing cases. This technology expedites the diagnostic process, enabling timely treatment for patients in critical condition.

Triage—a French word meaning “sorting”—is the phase of personal interviews with a health professional at the ED to categorize patients by emergency level so that those in most need of treatment will be assisted first.[2]

Contributing factors and their effect on decision-making is a challenging issue in disaster triage. [3]

Emergency Departments’ (ED) modern triage systems implemented worldwide are solely based upon medical knowledge and experience. This is a limitation of these systems, since there might be hidden patterns that can be explored in big volumes of clinical historical data. Intelligent techniques can be applied to these data to develop clinical decision support systems (CDSS) thereby providing the health professionals with objective criteria. Therefore, it is of foremost importance to identify what has been hampering the application of such systems for ED triage.[4]

There is some overlap in the basic principles of the roughly dozen or so mass casualty and disaster triage systems currently in use around the world, but data regarding their true efficacies is limited in the literature. Since it is inherently difficult to investigate and compare disaster protocols by using an evidence-based approach, there is no definitive data on which disaster triage technique would save the largest number of victims. Currently, two of the most commonly accepted triage protocols are START (Simple Triage and Rapid Treatment) and SALT (Sort-AssessLifesaving Interventions-Treatment/Transport).[5]

The utilization of AI-based triage decision support may potentially improve patient outcomes and reduce healthcare costs, and these are claims that still need to be evaluated with future research.[6]

Drug Discovery and Treatment

AI-driven drug discovery accelerates the search for potential treatments during a crisis. By analyzing vast databases of molecular and clinical data, AI algorithms can identify existing drugs that might be repurposed for new treatments. This expedites the development of therapies for emerging diseases, potentially saving lives during a disaster. In the face of emerging infectious diseases, AI accelerates drug discovery and vaccine development. Machine learning models can sift through vast molecular data to identify potential drug...
candidates and predict their efficacy. AI algorithms also assist in simulating the behavior of viruses and predicting their mutations, aiding in the design of targeted treatments and vaccines.

Data Analysis for Decision-Making

The rapid influx of data during a disaster can be overwhelming for healthcare professionals. AI-powered analytics tools can process and analyze data in real-time, extracting insights that aid decision-making. Whether it’s identifying infection hotspots, predicting patient surges, or evaluating the effectiveness of interventions, AI equips responders with actionable information.

Geospatial data is especially important for decision-makers in the various stages of emergency management operations. The perception and investigation gaps in emergency simulations can be filled by GIS technology, which can display a variety of events and their temporal characteristics.[7]

During a disaster, healthcare professionals often face complex decisions that require rapid analysis of available information. AI-powered decision support systems can assist doctors and administrators by providing evidence-based recommendations and treatment protocols. These systems consider a patient’s medical history, current condition, and available resources to guide medical interventions, thereby improving patient outcomes.

Psychological Support

Disasters take a toll not only on physical health but also on mental well-being. AI-powered chatbots and virtual assistants can offer psychological support by providing coping strategies, resources, and a listening ear. These tools contribute to the overall mental health resilience of affected individuals and healthcare providers.

Conclusions

The integration of AI into healthcare during disasters represents a transformative shift in disaster response strategies. By harnessing AI’s capabilities in early detection, resource allocation, remote monitoring, diagnostics, drug discovery, and decision support, healthcare systems can effectively mitigate the impact of disasters on public health. As AI technologies continue to advance, they hold the potential to revolutionize disaster response and save countless lives in times of crisis. However, it is crucial to ensure the ethical and responsible use of AI to maximize its benefits and minimize potential risks.

In an era marked by increasing environmental volatility and health crises, AI’s role in healthcare during disasters is transformative. By leveraging AI’s capabilities in data analysis, prediction, diagnostics, and more, healthcare systems can enhance their disaster preparedness and response strategies. As the field of AI continues to advance, the potential for its integration with healthcare becomes even more promising, offering new avenues for saving lives, reducing suffering, and mitigating the impact of disasters on communities worldwide.

Appendices
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<th>Disaster phases</th>
<th>Healthcare management</th>
<th>Proposed AI features to adopt</th>
<th>AI domains</th>
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<td>Mitigation - Preparedness – Response Recovery</td>
<td>Legislation, regulatory guidelines, SOPs, local, national, and regional legal and ethical reforms, farmworks for best practice.</td>
<td>Necessary approvals for institutions and individuals to use the AI and robotics for practice of healthcare sector.</td>
<td>Limited or unlimited, access in healthcare management, with specific or all types of AI and Robotics. Multiple Medical algorithms can be developed for existing needs and future requirements to communicate one module of algorithm with other algorithms with different protocols.</td>
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<td></td>
<td>Healthcare master plan for each vulnerable area, covering the stock for medical supplies and logistics routes.</td>
<td>Applications like GIS and Remote sensing can be useful for digital mapping and highlighting the medical / healthcare emergency point.</td>
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<td>Alternatives of healthcare infrastructure as backup including volunteer human resources available in the area.</td>
<td>AI and Robotics based smart applications Activate backup plan automatically for medical staff – rescue teams, public by sending SMS, emails in the communities.</td>
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<td>Rapid detection and verification of health emergencies is essential for healthcare teams to save lives in disaster situations. Local, national, regional, and global surveillance system for public health threats can be captured.</td>
<td>Smart, tested, drilled and effective Early Warning system can be installed. Once an event is verified, level of risk and sounds the alarm to help protect populations from the consequences of disasters, conflict, and other emergencies.</td>
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<td>Motivation to use the AI for the medical staff and volunteers to promote the AI culture in healthcare.</td>
<td>Special packages and incentives can be start for AI research, awareness and trainings, and its benefits to successful learners in societies and healthcare communities at all levels.</td>
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<td>Pre arrival info for paramedic’s healthcare rescue teams for live root traffic conditions, best way to enter the premises / incident location for safe evacuation with less damages to human beings and environment.</td>
<td>Ariel surveillance – Drones support from AI and robotics domain can be controlled from rescue operations rooms before or parallel of paramedics and ambulances mobilization towards disaster locations.</td>
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<td>Triage for the victims with or without paramedic supervision at disaster areas for low, medium, and large-scale level with headcount for efficient value adding to emergency healthcare management</td>
<td>In hospital emergency department AI is being used, but it is not verified from literature review that triage by robotics, AI or other innovation and technology is successfully completed victim primary triage on site.</td>
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<td>Damaged assessment of healthcare infrastructure.</td>
<td>AI and robotics can support for the collection of data and estimating current damages in healthcare sectors and future needs for the vulnerable areas.</td>
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**TABLE 1: AI and robotics in Healthcare for DM**

**Additional Information**

**Disclosures**

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