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Potential Use of Artificial Intelligence (AI) in Disaster Risk and Emergency Health Management: A Critical Appraisal on Environmental Health

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ABSTRACT: The risk evaluation of natural disasters is an obstacle to ensuring healthcare services during catastrophic events worldwide. Therefore, timely and appropriate environmental health risk evaluation is essential. In this study, we incorporated the information from databases such as PubMed, Google Scholar, and Scopus. We performed this study to explore the feasibility of using artificial intelligence (AI) in disaster risk and emergency health management. Natural disasters have some phenomenon that is bound to happen. So, we can use AI to inform healthcare authorities about environmental health risks and emergency medical management. The recent innovations in technology have created novel opportunities for improving healthcare services across the world. AI technology would be the backbone of the fourth industrial revolution because we are entering an AI-based world this decade. Therefore, we suggest the authorities consider this positive aspect of AI technology to minimize the disastrous outcomes of any catastrophic events.

KEYWORDS: Environmental health, artificial intelligence, natural disasters, risk assessment, emergency medical services

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Background

Environmental health risk management (EHRM) is a specialized field that deals with disaster preparation, planning, response, and recovery providing medical care during and after disaster, and emergencies to the survivors.¹ Saving lives, alleviating suffering, and ensuring the best medical care to those affected people by natural disasters (hurricanes, earthquakes, floods), man-made disasters (terrorist attacks, industrial accidents), and public health emergencies (eg, pandemics) are the main areas where EHRM contributes. Due to rapid worldwide disasters, EHRM has recently gained prominence as a critical issue.² Nowadays, EHRM education has advanced to new concepts and technologies enhanced by artificial intelligence (AI).³ AI can enhance and predict accurate prediction of floods when it is used alongside global luminescence.⁴ Researchers have been able to predict tsunami amplitudes by combining data from the Global Navigation Satellite System with artificial intelligence. Early warnings of earthquakes may also be possible through using AI technology.⁵ AI and machine learning can be used for hurricane forecasting as well.⁶ Terrorism has caused a severe humanitarian and economic crisis. Numerous research projects based on artificial intelligence (AI) have been presented and improved in literature to anticipate and combat terrorist actions. AI with Machine learning may help us to predict and combat upcoming terrorist attacks.⁷ AI can be a big asset in public health emergencies. It may dictate proper

resource allocation and timely decision-making. We have already seen the use of AI in the COVID-19 pandemic to disseminate resources properly, early diagnosis, contact tracing, and development of vaccines.⁸ While detecting the global threat of climate change, there has been a surge of interest in the potential of AI. It can be used as an indicator for future disasters and it may also be used for mitigation of any disaster situation as well.⁹ AI can be used in disaster situations in 4 ways such as disaster mitigation, preparedness, response, and recovery. AI may be implemented to predict any disaster to mitigate it. It may also help to prepare for it by proper allocation of resources. During disaster situations, AI can help the concerned authority to evaluate the situation and respond accordingly. Lastly, AI can pave the way toward recovery through optimized planning. For example, machine learning assisted by AI may be used to predict earthquakes. Further, it may also be implemented to find out the most affected area and distribute the food and other necessities accordingly. Finally, it may also assist in recovering from the disaster.¹⁰ We reviewed articles after searching from databases: PubMed, Google Scholar, and Scopus. We used these 3 databases for information sources as they cover most articles in the field of medicine and life sciences. The choice of database was done as per the literature published in the similar field. We tried to review the articles from peer reviewed journals. Some authentic websites were also used to obtain information. We searched the articles



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using keywords: environmental health, disaster medicine, artificial intelligence, natural disasters. These keywords were selected after reviewing some related articles in the similar fields. These keywords were also found in the MeSH database as well. We searched the articles from 1995 to 2023 as there are some instances of major disasters in earlier decades. But we tried to incorporate the latest studies in the manuscript. Most of the citations are from 2017 to 2023. In our article, we would like to emphasize the use of AI technologies in disaster situations so that the harmful impact of any sort of disaster can be curbed as much as possible.

Prevalence of Catastrophic Events Across the World

AI is a field of computer science that have been designed to acquire the simulation of human intelligence in machines that are programmed to think and learn and the machine is capable of performing the tasks typically as human intelligence.¹¹ AI plays a vital role in reduction and management of health risk. Over the past 20 years, the rate of negative impact and severity on public health as well as economic loss from natural disasters like floods, drought, earthquakes, heavy rainfall, heat waves, and tsunamis have significantly increased. According to the Center for Research on the Epidemiology of Disasters (CRED), the recent annual occurrence of natural disaster has exceeded the previous record (2001-2020). Natural hazards like floods, storms, and earthquakes dominated the major events of 2021. A total of 432 catastrophic events were recorded in 2021 which is significantly higher than the average of 357 annual catastrophic events in previous years. Floods as well as earthquakes have been a regular incident in various parts of the world in the last few years. Specially, South Asian countries are vulnerable to natural disasters due to their geographical locations. They regularly face tropical cyclones, floods, heatwaves, other weather-related catastrophes, and earthquakes that affect a large number of people annually.¹² In the past 200 years, Bangladesh has experienced mild to devastating earthquakes ranging from more than 3 to 8.9 magnitude. The 1897 Great Indian Earthquake was one of the most powerful earthquakes in world history with a magnitude of 8.7, where 1542 people lost their lives.¹³

Health and Economic Impacts of Catastrophic Events

Natural calamities like floods, drought, heavy rainfall, earthquakes, and tsunamis are inevitable aspects of nature that cannot be dodged. This natural phenomenon may be regarded as a disaster for humans when they cause significant loss of health and economy. These sorts of disasters may completely breakdown the economy of a country. Apart from that, it may cause widespread fatalities and injury to a large number of people. Mostly poor people are affected by the devastating outcomes of disasters as they tend to live in the remote areas or areas close to the coastal lines. Compared to the 2 previous decades, the

number of disastrous events in 2021 increased significantly causing substantial economic loss of 252.1 billion USD. Also, these tragic events resulted in 10 492 fatalities, and 101.8 million people were affected.¹⁴ Nearly half of all fatalities and 66% of all injuries have been reported particularly in China and India, which shows the severe impacts of catastrophic events in these 2 countries of Asia. In October 2021, heavy rainfall resulted in floods and destroyed crops, washed away bridges, and lots of casualties across India and Nepal. Even in Uttarakhand,¹⁵ people lost their lives and hundreds more were stranded in hillside resorts with flooded lakes and roads. This incident shows the devastation caused by a changing climate.¹⁶ In 2021, the USA had a significant negative impact on economic loss of up to 112.5 billion USD.¹⁷ On 12th September 2023, the U.S. experienced several weather-related catastrophes which are denoted as "Hurricane Idalia" and Idiala became the 23rd "billion dollar" weather disaster.¹⁸ Additionally, Europe had experienced unanticipated cold and heat waves in 2021. France, Algeria, Bulgaria, Cyprus, Greece, Italy, Macedonia, Tunisia, and Turkey faced summertime wildfires that resulted in substantial agricultural damage and disastrous outturn on the global economy and public health. On 6th February 2023, the 2 most powerful earthquakes took place in northern and western Syria as well as southern and central Turkey at a magnitude of 7.8 and after 9 hours at a magnitude of 7.5. These earthquakes have been recorded as the "fourth costliest earthquake" where damages in Turkey and Syria are estimated to be US\$104 billion and US\$14.8 billion respectively.¹⁹ The intensity of this deadly earthquake was felt across a wide geographical area including Turkey and Syria as well as Lebanon, Cyprus, Iraq, Israel, Jordan, Iran, and Egypt.²⁰ Roughly 14 million people, or 16% of Turkey's population, were affected by these 2 influential earthquakes, which damaged an area of about 350 000 km².²¹ Over 50 000 people lost their lives due to these earthquakes which took place on the Eastern Anatolian Fault Line in 11 provinces. It had a devastating effect on the mental health of other people in the region.²² These catastrophic events not only resulted in physiological injuries but also elevated severe emotional distress and various traumas like acute stress disorder (ASD), posttraumatic stress disorder (PTSD), and other psychiatric disorders.²³ According to researchers, PTSD rates may reach up to 74% and the percentage of people with psychiatric disorders may be as high as 60% following such events.²⁴ The recent COVID-19 outbreak has been a global public health emergency since the year 2020. It has caused significant economic and social damage.²⁵⁻³¹

Discussion on Potential Use of AI in Disaster Risk and Emergency Health Management

The disastrous outcome of natural disasters is inevitable if the precautionary measures are not taken. AI is a new talking point for researchers as well as the government. The recent launching of software like ChatGPT has created a buzz

among researchers as well as the general population. These AI-based software modules can be used by individual mobile phones simply. These AI-based software may be used for the prediction of disasters. It may also be used for the distribution of proper aid before any disaster, during any disaster, or after any disaster. AI and machine learning- (ML) are a generic term that compiles a wide array of hardware and software programs that enable computers to determine the relationship between data and apply this relationship to predict something. Generally, machine learning refers to a process by which the input and output of a system are provided. It enables a computerized system to establish a relationship between 2 datasets. Machine learning helps to predict any possible outcomes through the analysis of the data fed earlier.³² Satellite images have been used in disaster management for a long period. Recently, satellite images have been linked with AI technologies for the proper management of disasters. Satellite night-time lights known as global luminescence is being used for the analysis of flood worldwide.⁴ Unmanned aerial vehicles (UAVs) or drones are small aircraft that can operate without humans through the use of AI or remote-control technology. A drone is an effective tool for mapping, search, and rescue operations during any sort of disaster situation. Besides, drones can be used against militants so terrorist attacks can be monitored.³³ Geographic Information System is referred to as GIS. It is a system made to gather, organize, handle, examine, and present geographic or spatial data. It can help to estimate the extent and intensity of disaster. It may also help to design the recovery process and raise awareness among citizens. Even, mobile GIS can be used to effectively manage disaster situations.³⁴ The process of gathering data about a phenomenon or object without physically touching it, is known as remote sensing. NASA uses remote sensors on satellites and aircraft to observe Earth and other planetary bodies by detecting and recording energy that is reflected or emitted. Through remote sensing, a large amount of data can be obtained. Later, it may be used for machine learning methods. Thus, remote sensing along with GIS can be an extremely useful tool for mapping and managing disasters.³⁵ Artificial neural network (ANN) refers to a machine-learning approach that uses the processing of the human brain as a base to create algorithms that can be used to simulate intricate correlations between spatial phenomena and determine the spatial susceptibility of floods.³⁶ Therefore, AI implementation is necessary for monitoring and forecasting floods by analyzing weather conditions, river levels, soil moisture, and other relevant information to predict the prognosis of a flood event and provide emergency responses early to authorities and residents. So, AI technology is vital for mitigating the devastating impacts of floods on economic damage as well as public health.⁹ Already, ANN has been used successfully for the assessment of flood-prone zones in Ethiopia. Researchers successfully assessed and identified the flood-prone area of the Dire Dawa watershed and Awash

River (Ethiopia) using AI technology.³⁷ This sort of ANN has also been used for the prediction of draught in India.⁴ Guikema et al have been successful in predicting power cuts during hurricanes in the US coastlines. During any sort of disaster, power cuts, and lack of proper food and sanitation are common scenarios. So, AI can be used to predict these types of situations so that people can prepare for all sorts of situations.³⁸ According to the estimation by WHO, 20% of disaster-affected people suffer from mental health-related disorders.³⁹ AI has been used for the assessment of the mental health of earthquake-affected people in Japan.⁴⁰ So, AI can also be used for assessing the mental health of disaster-affected people. A workshop or webinar on mental health can be arranged for disaster-prone people. With strong mental health, people will be able to withstand the disastrous outcomes more efficiently. A proper supply of food and other necessary aids can be ensured through AI technologies. At first, the disaster can be predicted by AI. Later, proper aid can be sent to those areas before any calamities. Even a proper supply of food and medicine can be ensured by AI during or after the disaster by the assessment of the gravity of the disaster. We have already seen the successful implementation of AI in food supply.⁴¹ Similarly, AI may be used in the supply of aid in disaster management as well. Scientists are still trying to develop an accurate AI-based method to predict earthquakes. Among these circumstances, a disaster of a large scale may put a lot of burden on the health care system.⁴² Therefore, AI should be used in these situations to monitor the disaster and curb the damage as much as possible. Also, AI techniques can improve the diagnosis of diseases. For example, AI techniques aided in the analysis of COVID-19-related medical images which solely contributed to the prevention of life-threatening variants posing substantial hazards to the global healthcare systems.⁴³ Recently, AI has been used extensively in the COVID-19 pandemic. It was used to detect and quantify COVID-19 cases through chest X-ray or CT scan.⁴⁴ AI has a role to play in the outbreak of infectious diseases as well. Robots with artificial intelligence (AI) like Boston Dynamics' Spot, have been deployed for data collection and inspections in disaster-affected areas. It can even go to areas with chemical spills and nuclear wastes.⁴⁵

Limitations

There are some disadvantages of AI technology as well. AI may not always predict disasters accurately. In both cases, computerized systems are used to establish a correlation with datasets. Hence, large data are required to get the accuracy of the result.³² Validation of AI-based data is troublesome.³⁹ Naturally, the general population may not be willing to follow AI-driven recommendations for disaster management. Again, nature does not always abide by the laws. So, AI might fail to give accurate responses every time.⁴⁶ After all, AI is a machine that certainly has a few disadvantages. If these technical flaws can be minimized, AI can be used more efficiently.

Conclusion

Disasters can be either natural or man-made. Public health-related emergencies may also be regarded as disaster situations. The prime objective during any disaster situation is to minimize the damage as much as possible. AI technology would be the backbone of the fourth industrial revolution. It has already proved its worth in different aspects of human life. AI can be efficiently used in the forecasting and management of any disaster situation. AI-driven algorithms can optimize resource allocation, routing for first responders, and evacuation plans to minimize casualties and property loss. In post-disaster situations, AI aids in assessing the damage, identifying potential hazards, and streamlining the recovery process. Machine learning, satellite imaging, GIS, remote sensing along AI technology can pave us advanced ways of disaster management. AI has already shown its effectiveness in the recent COVID-19 pandemic situation as well. Therefore, scientists and the government must consider this aspect of AI so that the deleterious outcomes of any kind of disaster can be prevented as much as possible. Further, researchers should concentrate on establishing accurate AI-driven methods to predict and manage upcoming disaster situations. As we are entering the AI-assisted world, we must embrace it and use it for our benefit.

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Author Contributions

LFB, IA, and AHP conceived and designed this paper. RA and TAZ wrote the manuscript. SS and MRI revised the manuscript. The author(s) read and approved the final manuscript.

Data Availability Statement

The data in this correspondence article is not sensitive in nature and is accessible in the public domain. The data is therefore available and not of a confidential nature.

Transparency Statement

The lead author Lazima Faijah Bari affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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