Investigate the role of Technology in Improving Disaster Preparedness and Response in Healthcare Settings: A Systematic Review of Quantitative Evidence

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Abstract: This research investigates the pivotal role of technology in enhancing disaster preparedness and response within healthcare settings. Employing a systematic review approach, empirical studies focusing on the impact of technology were scrutinized, excluding qualitative research. Databases such as PubMed, Scopus, Web of Science, Medline, and CINAHL were systematically searched using defined keywords related to technology, disaster preparedness, and healthcare response. The systematic review process filtered an initial 3000 studies down to 15 relevant ones meeting the inclusion criteria. These studies encompassed diverse aspects of technological integration, including telemedicine, blockchain, social media, and AI-driven predictive models, revealing their multifaceted contributions to disaster management. The findings underscored the instrumental role of technology in proactive disaster planning, resource allocation, remote patient care, and real-time communication during crises. Additionally, these technologies exhibited the potential for revolutionizing healthcare systems' resilience and adaptability in emergency situations. The discussion highlighted the varied applications of technology in disaster scenarios, emphasizing the need for continual innovation, staff training, and policy implementation for effective integration. Moreover, the conclusions drawn emphasized the critical role of technology in shaping the future landscape of disaster preparedness in healthcare.

Keywords: Technology; Disaster Preparedness; Healthcare; Telemedicine; Blockchain; AI-Driven Predictive Models.

1. INTRODUCTION

1.1. Background

In the face of rising natural and man-made disasters, vital industries like healthcare must adapt quickly. Due to the increasing frequency of these unanticipated events, hospitals, primary care clinics, rehabilitation facilities, and remote telemedicine platforms have recognized the need to be disaster-ready and have effective response mechanisms. Technology has permeated many aspects of human life in the past two decades. Healthcare disaster management has also embraced technology (Fontes & Bello, 2020). Technology shapes how healthcare organizations plan, respond, and recover from disasters. Digital technologies and sophisticated software platforms have transformed healthcare disaster management operations. Previously, data was collected manually; now, it is quickly collected and distributed. This transitional moment is crucial in critical situations where seconds can mean life or death (AlHinai, 2020; Jung, 2022).

When faced with natural disasters like earthquakes, floods, and tropical cyclones, technology protects healthcare facilities. Advanced simulation technologies can predict the effects of such events, helping build more resilient healthcare infrastructures. EHRs can be securely backed up and accessed from multiple locations, ensuring patient data accessibility in the event of a primary care facility breach (Tsai et al., 2020; Ye, 2020).

Technology also affects healthcare training and skill enhancement for disaster preparedness beyond infrastructure and communication. VR and AR are being used to create immersive catastrophe simulation environments, allowing medical

professionals to practice in a controlled environment. Immersion training ensures that healthcare workers have academic knowledge and simulated practical experience, improving their performance in high-stress situations like disasters. These factors demonstrate technology's benefits, but its drawbacks must be acknowledged. The growing use of technology requires strong cybersecurity measures to protect patient data and ensure critical service continuity. To adapt to new technology, healthcare workers need ongoing training (Jung, 2022; Asadzadeh et al., 2021; Lurie & Carr, 2018). People who are confined or separated due to extraordinary circumstances can still get expert advice from far away. Resilient and high-capacity communication networks enable telemedicine, eliminating geographical barriers to medical care. Wearable technology and health monitoring apps enable patient surveillance. These instruments help healthcare professionals prioritize medical attention in emergencies by using current health information. In limited resource situations, this helps distribute resources efficiently. Drones are also being investigated for delivering medical supplies to natural disaster-stricken areas. This novel method ensures that urgent medical patients receive critical pharmaceuticals and equipment on time (Ghazal et al., 2021).

1.2. Problem Statement

In contemporary times, healthcare systems on a worldwide scale are confronted with the escalating uncertainty and frequency of both natural and anthropogenic calamities. These pivotal occurrences require strong readiness and prompt response measures to protect the well-being of the general population. The importance of technology in improving disaster preparedness and response in the healthcare industry has yet to be fully comprehended despite its promise as a transformative force in other industries. While certain studies and anecdotal evidence have hinted at the advantages of technology, there is a noticeable lack of comprehensive quantitative research that thoroughly examines and emphasizes the effectiveness, difficulties, and consequences of technology in this particular field. In the pursuit of enhancing their disaster preparedness and response plans, healthcare institutions must prioritize a comprehensive comprehension of the technology resources available to them, as well as the empirical substantiation endorsing its use. The objective of this systematic review is to fill the existing knowledge gap by compiling and conducting a thorough analysis of quantitative data from various sources. The aim is to establish a comprehensive comprehension of the influence of technology on disaster management within healthcare environments. The primary objective of this undertaking is to provide significant and valuable perspectives, inform the development of policies, and highlight potential avenues for further investigation within the intersection of technology and healthcare disaster management (Ye, 2020; Fontes & Bello, 2020).

1.3. Project Aim

The aim of this research is to identify the role of technology in improving disaster preparedness and response in healthcare settings through a systematic review of quantitative evidence.

1.4. Research Objectives

- To analyze and synthesize quantitative evidence on disaster preparedness and response using technology in healthcare settings.

- Evaluate the impact of technology on healthcare disaster preparedness and response.

- Identify common disaster preparedness and response technology in healthcare settings.

- To examine obstacles to implementing technology in healthcare disaster preparedness and response.

- To identify literature gaps and suggest future research areas.

- To advise policymakers and healthcare providers on disaster preparedness and response technology use.

1.5. Research Questions

- What is the impact of technology on improving disaster preparedness and response in healthcare settings?

2. LITERATURE REVIEW

2.1. Historical Context of Disaster Preparedness and Response in Healthcare

Within the realm of healthcare, the domain of disaster planning and response has experienced a significant and profound metamorphosis. Prior to the integration of technology, healthcare systems had challenges in effectively managing large-scale disasters due to their reliance on manual data recording, oral communication, and traditional methods. As per the World Health Organization (WHO) noted by Canton (2019), the initial phase of the 20th century was characterized by basic and inadequate response mechanisms, often leading to significant morbidity and mortality in the context of disasters. The

Spanish Flu pandemic of 1918 provides a solemn lesson from a historical perspective. According to Guimbeau et al. (2022), the lack of instantaneous communication systems resulted in the dissemination of inaccurate information and the incitement of fear. The period spanning from the mid to late 20th century witnessed the emergence of novel technological developments, albeit in their early stages of development. The implementation of these technologies, while with certain constraints, demonstrated a pivotal moment (Sezgin et al., 2020). According to the postulation of Budd et al. (2020), healthcare facilities frequently encounter obstacles in the proficient utilization of these instruments because of inadequate training, restricted infrastructure, and reluctance to embrace novel methodologies.

During the late 1990s and early 2000s, there was a significant increase in the usage and availability of the Internet and mobile communication technologies. The era marked a pivotal stage in the advancement of healthcare catastrophe preparedness (Munasinghe & Matsui, 2019). The advent of modern technology has facilitated the ability to transmit real-time updates, access centralized databases containing patient information, and deliver telehealth services in times of emergencies or disasters. Torous & Wykes (2020) argue that the expeditious distribution of information via the Internet has had a substantial impact on enhancing the coordination between healthcare providers at both local and worldwide levels. This, in turn, has led to the optimization of medical response and the quality of patient treatment (Munasinghe & Matsui, 2019).

The process of evolution continues to persist. With the occurrence of each global tragedy, valuable insights were gained, and technological advancements were made to effectively address the arising challenges. For example, the earthquake that occurred in Haiti in 2010 brought to light the need for improved mobile communication systems, resulting in the eventual use of mobile health (mHealth) instruments during future disasters (Raila & Anderson, 2017; Nohrstedt & Baekkeskov, 2017).

2.2. Modern Technological Tools in Healthcare Disaster Preparedness

Mobile applications and digital platforms have now become crucial components. Within this domain, there exist health-focused applications such as the emergency apps developed by the Red Cross. Pourhosseini et al. (2015) assert that these platforms played a pivotal role in times of calamity by providing individuals with crucial, up-to-date information, such as evacuation strategies and surrounding healthcare facilities. However, the effectiveness of these instruments is closely linked to the progress made in communication technologies. The study conducted by Gope & Hwang (2016) investigates the impact of IoT and 5G and edge computing on enhancing the functionality of these technologies. The integration of 5G and edge computing enables accelerated data transfer, reduced latency, and improved analytics, hence supporting more efficient disaster preparedness and response efforts (Gope & Hwang, 2016; Kruse et al., 2018). The broad implementation of EHRs is considered a fundamental aspect of contemporary healthcare response. According to Rasmi et al. (2018), EHRs serve the dual purpose of consolidating patient history and facilitating real-time data interchange across healthcare institutions. The seamless sharing of data played a vital role during the COVID-19 pandemic by enabling informed decision-making through the utilization of real-time patient data (Fagherazzi et al., 2020). Wang et al. (2020) and Tsai et al. (2020) focuses on EHRs and highlights their capacity to optimize the efficiency and security of patient data in emergency situations. The domain of real-time epidemic monitoring is of equal significance. The study conducted by Choi et al. (2016) provided a complete analysis of the significance of digital disease surveillance platforms in the prediction of outbreaks. This line of inquiry underscores the revolutionary capacity of real-time data in the management of health crises (Sinha et al., 2017; Choi et al., 2016).

Lukas et al. (2020) provide a comprehensive analysis of the ways in which telemedicine facilitates medical consultations in the absence of direct physical contact, hence reducing the potential for transmission of infectious diseases. Ohannessian et al. (2020) illustrates the transformative development of telemedicine as an essential instrument during the COVID-19 crisis, highlighting its crucial function in situations where face-to-face medical consultations have become difficult (Lurie & Carr, 2018; Ortega et al., 2020). The use of telehealth supports long-distance medical care and increases the remote monitoring of patients using mobile medical healthcare applications during disaster situations (Ortega et al., 2020; Shen et al., 2021). Fontes & Bello (2020) explored the initial implementations of VR technology in the context of medical training. The significance of wearable technology in health monitoring is a relatively recent area of research that is experiencing significant growth (Gunasekeran et al., 2020; Asadzadeh et al., 2021). Piwek et al. (2016) provided valuable insights into the increasing prevalence of wearable devices and their prospective use in the collecting of health-related data. Gao et al. (2020) align with those previously mentioned, as they conducted a study on the utilization of wearables in the context of triaging in catastrophe situations (Cheng & Mitomo, 2017).

Jung (2022) offered valuable insights into the potential of AI to enhance decision-making processes in emergency situations. The researchers demonstrated how AI may be utilized to effectively anticipate patient requirements and allocate resources

in a prioritized manner within the healthcare sector (Sun et al., 2020). Sakurai & Murayama (2019) examined the use of predictive analytics in healthcare disaster management. They emphasized the potential of machine learning models in forecasting patient influxes, identifying resource shortages, and optimizing care delivery during crises (Wani et al., 2022; Raza et al., 2020). Chamola et al. (2020), which demonstrated the efficacy of AI in accurately forecasting the dissemination patterns of the Zika virus. Islam et al. (2015) play a vital role in both preparedness for and reaction to disasters by providing up-to-date health measurements and environmental data, which facilitate prompt interventions (Avazov et al., 2021; Wani et al., 2022).

AlHinai (2020) examined the potential of social media platforms to improve disaster response by facilitating immediate and ongoing communication between the general population and healthcare professionals. Merchant & Lurie (2020) elaborated on the discoveries, demonstrating the significant contributions of platforms such as Twitter in the context of natural disasters such as hurricanes. These platforms have proven to be crucial in promoting community resilience and facilitating the efficient allocation of resources (Li et al., 2020; Merchant & Lurie, 2020).

2.3. Enhanced Decision-making through Technological Innovations

The healthcare industry, which plays a vital role, especially in times of calamities, has experienced significant changes in its decision-making processes because of these developments (Wani et al., 2022). GIS platforms have the capacity to promptly ascertain impacted regions, pinpoint medical establishments, and offer the best pathways for the transfer of resources (Tomaszewski et al., 2015; Thomas, 2017). Jefferson & Johannes (2016) assert that GIS has played a crucial role in the cartographic representation and surveillance of disaster effects. By utilizing real-time data input, healthcare organizations can prioritize different areas based on their severity and level of need. Asfaw et al. (2022) utilized GIS techniques to delineate areas with high infection rates and to develop effective resource distribution strategies, including the allocation of testing sites and quarantine facilities. Furthermore, GIS facilitates the visual representation of patterns that may be less discernible through conventional data analysis methods (Thomas, 2017). The authors discuss how GIS technology was utilized to accurately map the dissemination of cholera, hence facilitating the efficient allocation of interventions and resources. Simulations played a crucial role in the preparation of urban areas for future epidemics of the Ebola virus. They were essential in assessing patient mobility, devising effective quarantine techniques, and optimizing resource distribution (Torres, 2018; Fischer et al., 2015). Abid et al. (2021) assert that the utilization of AI-powered predictive modelling holds the potential to facilitate the anticipation of patient intake, hence enabling hospitals to make proactive preparations. In addition, AI has the capability to enhance the optimization of resource management, hence facilitating the optimal allocation of limited resources such as ventilators or intensive care units (ICUs) in times of crisis (Siddique & Chow, 2021; Abid et al., 2021; Raza et al., 2020).

Qadir et al. (2016) indicated that the utilization of AI in the examination of radiographs, prognostication of disease outbreaks through extensive datasets, and surveillance of patient health indicators has demonstrated encouraging outcomes. As an illustration, in the context of disease outbreaks, algorithms have the capacity to undergo training to analyze extensive quantities of social media and news data with the objective of identifying preliminary indications of an epidemic (Alimadadi et al., 2020; Goel et al., 2022; Raza et al., 2020). Data plays a crucial role in facilitating informed and successful decision-making processes (Shin & Kang, 2020). The utilization of blockchain technology, characterized by its decentralized and transparent attributes, holds the potential to offer a viable solution. Poonia et al. (2021), it is posited that blockchain technology has the potential to foster trust among stakeholders who may be geographically or organizationally separated (Sharma et al., 2020; Azaria et al., 2016; Sharma et al., 2020).

2.4. Challenges and Opportunities with Technological Integration in Disaster Preparedness

Effective implementation of modern technology solutions necessitates the presence of a resilient infrastructure. These encompass high-speed internet connections, cloud storage options, sophisticated technology, and uninterrupted electrical supplies (Costin et al., 2018; Alcaraz & Zeadally, 2015; Wang et al., 2020). Ransomware attacks targeting healthcare facilities, such as hospitals, have the potential to restrict access to vital patient data during crucial periods. The existence of breaches not only presents risks to individuals but also undermines confidence in the technology platforms designed to facilitate disaster response (Kruse et al., 2018; Maddikunta et al., 2021). Training programs are of utmost importance; nonetheless, they present difficulties in terms of resource allocation, particularly in environments with restricted financial resources or workforce capacity (Rezaeianjouybari & Shang, 2020; Jabbar et al., 2020; Hussien et al., 2021). The growing reliance on technology in healthcare settings for disaster preparedness and response poses a potential risk of excessive dependence (Wu et al., 2021; Mahomed, 2018).

Aruru et al. (2020), have engaged in discourse regarding the possible operational disruptions that may arise because of technological failures, particularly in instances where healthcare systems exhibit excessive reliance on said technology. Ye

(2020) brought attention to the apprehensions surrounding the cybersecurity vulnerabilities that arise from a significant dependence on technology (Choi et al., 2018). Abid et al. (2021) highlighted that by incorporating technology such as the IoT, AI, and sophisticated analytics, healthcare systems have the capability to consistently monitor, evaluate, and address various scenarios. Artificial intelligence systems have the capability to efficiently analyze extensive datasets, enabling them to make predictions regarding outbreak trends and identify potential resource deficiencies (Mahomed, 2018; Goel et al., 2022; Mahomed, 2018).

The convergence of contemporary communication tools, alongside the integration of cloud computing and 5G technology, offers an exceptional prospect for the efficient facilitation of cooperation in times of calamities (Javaid & Haleem, 2019; Zulman et al., 2015). Cheng & Mitomo (2017) highlighted that Telemedicine platforms provide remote delivery of consultations, diagnostics, and specific therapies. Patients have the opportunity to access high-quality healthcare services without the need to face potential risks associated with exposure or travel (Lukas et al., 2020; Ohannessian et al., 2020). Digital platforms have the potential to accommodate growing user populations with minimal supplementary resources (Torous et al., 2016). Given the widespread availability of cell phones and access to the internet, there exists a valuable opportunity to actively involve the public in the realms of disaster preparedness and response (Mat Dawi et al., 2021). Mobile applications have the capability to deliver alerts in real-time, offer recommendations for administering first-aid, identify evacuation routes, and serve as platforms for gathering crucial information through community participation. (Liao et al., 2020; aud et al., 2020; Mat Dawi et al., 2021).

3. METHODOLOGY

This research work is concerned with finding the role of technology in improving disaster preparedness and response in healthcare settings with the help of conducting the systematic review approach. Only the empirical references were included in the systematic review, which means that according to the inclusion criteria of the study, the research studies based on the qualitative research approach have not been included in this work. The quality of the selected studies has been assessed by using the two major assessment techniques, which include the Joanna Briggs Institute (JBI) assessment and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) analysis (Ally et al., 2022; Aldera et al., 2020). The present systematic review employs a methodical strategy to find, assess, and include quantitative evidence pertaining to the impact of technology on disaster planning and response in healthcare settings. To obtain definitive findings from the available literature, the study approach will place emphasis on primary quantitative research, encompassing experimental, quasi-experimental, and observational investigation (Castillo et al., 2020; Karim et al., 2020).

Thorough searches have been conducted across various electronic databases, such as PubMed, Scopus, Web of Science, Medline, and CINAHL. A comprehensive set of keywords and Medical Subject Headings (MeSH) terms pertaining to the domains of technology, healthcare, disaster preparedness, and response will be utilized. Furthermore, the reference lists of the incorporated papers and pertinent reviews have been manually examined to detect any overlooked studies. Initial inquiries have been undertaken to enhance the approach and guarantee the most effective retrieval of pertinent scholarly publications. The step-by-step search strategies have been applied in this research work to extract the results (Krnic Martinic et al., 2019; Mengist et al., 2019). The search strategy involved utilizing a combination of terms related to "technology," "disaster preparedness," "healthcare," and "response." Synonyms and variations of these terms were incorporated to enhance inclusivity. Additionally, specific technological interventions, such as "telemedicine," "informatics," and "health information technology," were included to capture studies focusing on distinct technological applications.

The inclusion criteria of this study are as follows:

❖ Primary quantitative research studies, including experimental, quasi-experimental, and observational studies, have investigated the role of technology in disaster preparedness and response in healthcare settings.

❖ Studies that have introduced, assessed, or compared technological tools, platforms, or systems aimed at improving disaster preparedness and response.

❖ Quantifiable outcomes related to the efficacy, speed, reliability, or challenges of technology in enhancing disaster preparedness and response, including but not limited to patient care quality, data accessibility, communication efficiency, and resource allocation.

❖ Studies published in the last ten years to ensure the relevance and contemporaneity of the technological tools and systems evaluated.

❖ Articles published in English.

The exclusion criteria of this study are as follows:

❖ Qualitative studies, editorials, opinion pieces, reviews, case reports, and studies without primary quantitative data.

❖ Studies not set in a healthcare environment or unrelated to disaster preparedness and response.

❖ Studies focus exclusively on populations that are not directly involved in healthcare disaster preparedness and response (e.g., the public without a specific healthcare context).

❖ Studies assessing interventions that do not have a primary technological component or are unrelated to disaster preparedness and response.

❖ Studies published more than 10 years ago might not accurately represent current technological tools and systems.

❖ Articles not published in English or without an official English translation.

The quality of the studies has been assessed with the help of the JBI assessment and the PRISMA analysis. The 27-item checklist of the PRISMA and JBI assessment of experimental, quasi-experimental, and observational studies has been used for the assessment of the studies. In the first stage, the PRISMA is applied to the data to evaluate the studies based on the inclusion and exclusion criteria (Morgado et al., 2022). The JBI assessment has been applied to the studies to assess their methodology that qualified for the systematic review in the PRISMA analysis. The studies fulfil the inclusion and exclusion criteria used for the systematic review after the assessment of the qualities through the JBI assessment and the PRISMA analysis (Peters et al., 2021; Peters et al., 2021; Yasin et al., 2019). The inclusion criteria are used to assess the full-text publications. The process of data extraction is involved in capturing information such as the design of the study, the size of the sample, the technology utilized, the outcomes that were measured, and the significant discoveries that were obtained (Raharjana et al., 2021; Yasin et al., 2019).
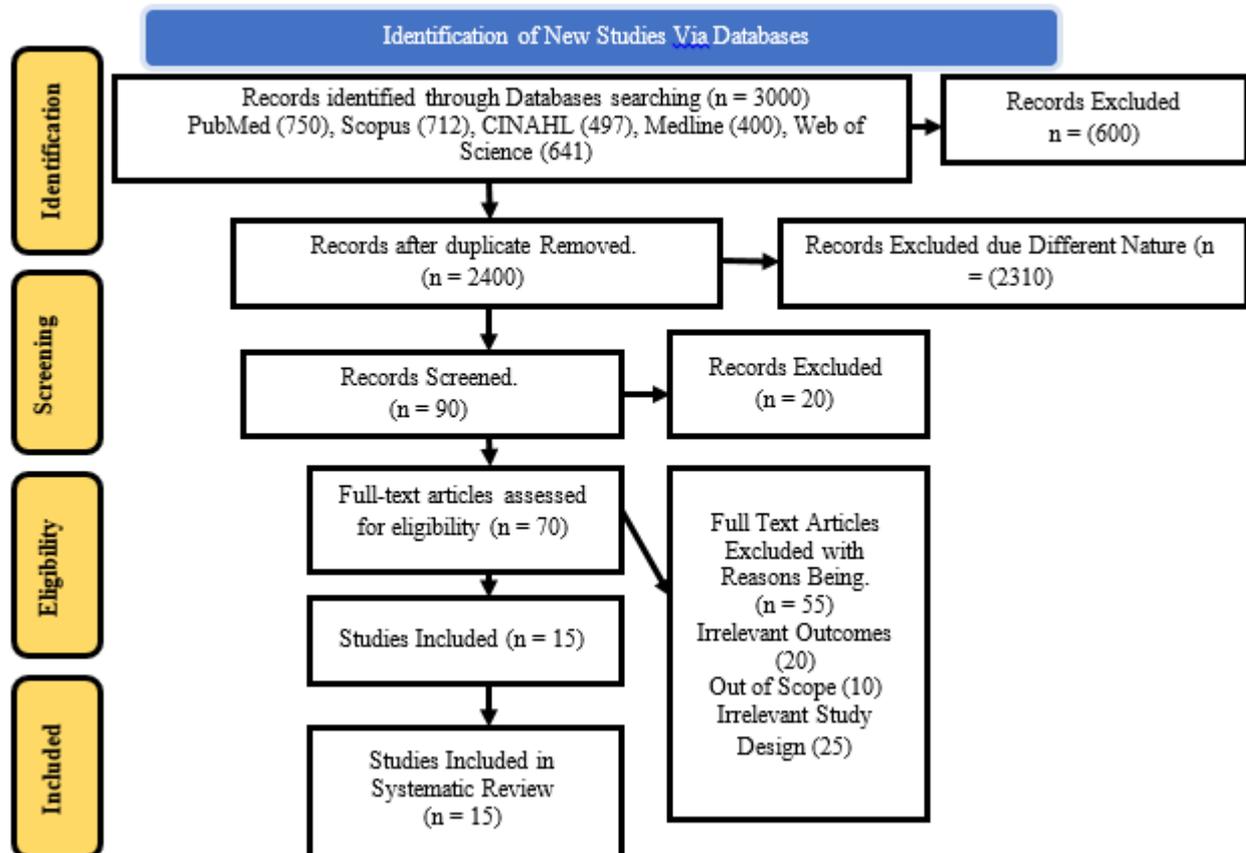

Figure 1: PRISMA Flow Diagram

The results of the PRISMA analysis indicate that in the first stage, 3000 studies were searched for conducting the systematic review, which contains PubMed (750), Scopus (712), CINAHL (497), Medline (400), and Web of Science (641). After the removal of the duplication, the 2400 studies qualified for the next stage, and 2310 studies were excluded at this stage due to unsuitable outcomes. The 90 studies have been qualified for the screening process, and at this stage, 20 more studies have been excluded. Seventy studies were eligible for the full-text assessment of the articles, and 55 studies were excluded at this stage. Fifteen studies have been qualified for the final analysis that was used for the extraction of the results on the basis of their findings. 20 Studies were excluded because of the irrelevant outcomes, 10 studies were out of scope, and 25 studies were excluded because of the irrelevant study design.

Table 1: Results of JBI Assessment

Included Studies	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total Yes
(Anthony Jnr., 2020)	Y	Y	Y	Y	Y	N	Y	Y	7
(Bhagavathula et al., 2020)	Y	Y	Y	Y	N	Y	N	Y	6
(Dubey et al., 2020)	Y	Y	Y	Y	Y	Y	N	Y	7
(Gautam et al., 2023)	Y	Y	Y	Y	Y	Y	Y	Y	8
(Govindan et al., 2020)	Y	U	Y	Y	Y	Y	Y	Y	7
(Houston et al., 2014)	Y	Y	N	Y	Y	Y	Y	Y	7
(Johnston et al., 2015)	Y	Y	NA	Y	Y	Y	Y	Y	7
(Kamal et al., 2020)	Y	Y	Y	Y	Y	Y	Y	Y	8
(Koonin, 2020)	Y	Y	Y	Y	Y	N	Y	Y	7
(Leahy et al., 2017)	Y	Y	Y	Y	Y	N	Y	Y	7
(Muhammad et al., 2018)	Y	Y	Y	Y	N	Y	Y	Y	8
(Naser & Saleem, 2018)	Y	Y	Y	Y	Y	Y	N	Y	7
(Pacific, 2020)	Y	U	Y	Y	Y	Y	Y	Y	7
(Smith, 2019)	Y	Y	N	Y	Y	Y	Y	Y	7
(Spector et al., 2015)	Y	Y	NA	Y	Y	Y	Y	Y	7

Y* (Yes); N* (No); NA* (Not Applicable); U* (Unclear)

Q1. Were the criteria for inclusion in the sample clearly defined?

Q2. Were the study subjects and the setting described in detail?

Q3. Was the exposure measured in a valid and reliable way?

Q4. Were objective, standard criteria used for measurement of the condition?

Q5. Were confounding factors identified?

Q6. Were strategies to deal with confounding factors stated?

Q7. Were the outcomes measured in a valid and reliable way?

Q8. Was appropriate statistical analysis used?

The table presents a comprehensive assessment of various studies' methodology quality and reliability using the JBI (Joanna Briggs Institute) criteria. Each row represents a study, while columns Q1 to Q8 denote specific criteria evaluated. 'Y' indicates 'Yes' or compliance with the criterion, 'N' signifies 'No' or non-compliance, and 'U' represents 'Unclear' or insufficient information to make a definitive judgment. The total 'Yes' count for each study reveals the number of criteria met out of eight. Overall, the assessments indicate consistent methodology across most studies, with a predominant trend of meeting six to eight criteria, showcasing robustness, reliability, and adherence to quality standards in their methodologies. Notably, studies like Kamal et al. (2020), Muhammad et al. (2018), and Woo et al. (2017) scored the highest with eight 'Yes' counts, suggesting more comprehensive methodological adherence within their research frameworks.

4. RESULTS

Table 2: Results of the Systematic Review

#	Title	Author	Date	Study Type	Source	Study Approach	Results
1	Use of Telemedicine and Virtual Care for Remote Treatment in Response to COVID-19 Pandemic	(Anthony Jnr., 2020)	(2020)	Cross-Sectional Study	PubMed	Quantitative	This article offers a hands-on manual on utilizing telemedicine and virtual care amid the COVID-19 crisis. Its findings highlight the opportunities for integrating digital healthcare technologies by leveraging virtual care solutions, potentially shaping the future landscape of healthcare delivery.
2	Knowledge and Perceptions of COVID-19 Among Health Care Workers: Cross-Sectional Study	(Bhagavathula et al., 2020)	(2020)	Cross-Sectional Study	Web of Science	Quantitative	The majority of respondents (276 individuals, making up 61.0% of the total) relied on social media for COVID-19 information. Among healthcare workers (HCWs), a notable portion demonstrated a limited understanding of how the virus spreads (276 individuals, 61.0%) and its symptom onset (288 individuals, 63.6%) while maintaining optimistic views toward COVID-19.
3	Blockchain technology for enhancing swift-trust, collaboration and resilience within a humanitarian supply chain setting	(Dubey et al., 2020)	(2020)	Cross-Sectional Study	PubMed	Quantitative	This research garnered 256 valid responses through a pre-tested survey tool tailored for key informants. Its outcomes conclusively validate the support for all six initial hypotheses. This study makes substantial and credible additions to the existing body of knowledge on ST, CO, SCR, and BT/distributed ledger technology.
4	Transition to professional practice: Perspectives of new nursing graduates of Nepal	(Gautam et al., 2023)	(2023)	Cross-Sectional Study	Medline	Quantitative	The overarching theme of 'eroding confidence' comprised three underlying aspects: 'fearfulness,' 'neglect,' and 'accusation,' depicting the gradual decline in nurses' assurance as they confronted the practical realities of their profession. Within the theme of 'lacking support,' two sub-themes emerged: 'absence of guidance' and 'limited backing from senior staff,' outlining how nurses perceived the support system within their work environment.
5	A decision support system for demand management in healthcare supply chains considering the epidemic outbreaks: A case study of coronavirus disease 2019 (COVID-19)	(Govindan et al., 2020)	(2020)	Cross-Sectional Study	Scopus	Quantitative	Initially, this method categorizes community members into four immune system risk groups: very sensitive, sensitive, slightly sensitive, and normal, based on two factors: age and pre-existing health conditions like diabetes, heart issues, or high blood pressure. Each group is then assigned specific guidelines to follow.
6	Social media and disasters: a functional framework for social media use in disaster planning, response, and research	(Houston et al., 2014)	(2014)	Cross-Sectional Study	Medline	Quantitative	The framework highlights the diverse range of parties involved in generating and utilizing disaster-related content on social media. This implies that the use of social media during disasters can take place across multiple levels, sometimes simultaneously within a single disaster event.
7	Smartphones let surgeons know WhatsApp: an analysis of communication in emergency surgical teams.	(Johnston et al., 2015)	(2015)	Cross-Sectional Study	CHINHAL	Quantitative	The research assessed the adoption of WhatsApp among emergency surgical teams, examining how various team members utilized the messaging service through script analysis of their communications. The findings highlighted a positive reception toward technological advancements within the team, noting that WhatsApp contributed to a more egalitarian dynamic by reducing hierarchical barriers among clinicians.
8	Investigating acceptance of telemedicine services through an extended technology acceptance model (TAM)	(Kamal et al., 2020)	(2020)	Cross-Sectional Study	Scopus	Quantitative	The results indicate that people's willingness to use telemedicine services is influenced by several factors, including how easy they perceive it to use, their concerns about technology, the influence of social factors, the perceived usefulness and ease of the service, trust in it, the supporting conditions available, perceptions of potential risks, and any resistance they might have towards using technology.
9	Trends in the use of telehealth during the emergence of the COVID-19 pandemic — United States, January–March 2020	(Koonin, 2020)	(2020)	Cross-Sectional Study	PubMed	Quantitative	From January to March 2020, the majority of medical visits were by patients addressing health issues unrelated to COVID-19. Yet, there was a notable and significant rise in COVID-19-related appointments, jumping from 5.5% to 16.2%, particularly in the final three weeks of March 2020 (weeks 11-13 of surveillance), marking a statistically significant increase.
10	Improved outcomes and reduced costs associated with a health-system-wide patient blood management program: a retrospective observational study in four major adult tertiary-care hospitals	(Leahy et al., 2017)	(2017)	Cross-Sectional Study	Medline	Quantitative	Adjusted for risk factors, there were notable decreases in-hospital mortality rates (odds ratio [OR] of 0.72 with a 95% confidence interval [CI] between 0.67 and 0.77; p-value below 0.001), lengths of hospital stays (incidence rate ratio of 0.85 with a 95% CI between 0.84 and 0.87; p-value below 0.001), cases of hospital-acquired infections (OR of 0.79 with a 95% CI between 0.73 and 0.86; p-value below 0.001), and occurrences of acute myocardial infarction-stroke (OR of 0.69 with a 95% CI between 0.58 and 0.82; p-value below 0.001). However, there was an observed increase in all-cause emergency readmissions (OR of 1.06 with a 95% CI between 1.02 and 1.10; p-value of 0.001).
11	Early fire detection using convolutional neural networks during surveillance for effective disaster management	(Muhammad et al., 2018)	(2018)	Cross-Sectional Study	Web of Science	Quantitative	The outcomes of our experiments confirm that our fire detection approach surpasses existing methods in accuracy. These results also substantiate the practicality of our framework for efficiently managing fire disasters.
12	Emergency and disaster management training; knowledge and attitude of Yemeni health professionals- a cross-sectional study	(Naser & Saleem, 2018)	(2018)	Cross-Sectional Study	PubMed	Quantitative	Health administrators displayed inadequate qualifications in emergency and disaster planning compared to medical educators. Despite this, the majority of respondents exhibited positive attitudes toward emergency and disaster preparedness. A significant portion, around 41.0%, reported receiving no formal training in disaster preparedness. Those who underwent training often relied on non-governmental organizations (NGOs) and online programs, with percentages of 15.7% and 13.6%, respectively. In contrast, fewer respondents utilized formal resources like the Ministry of Public Health and Population (MoPHP), health facilities, or structured medical education programs (at 10.2%, 9.6%, and 7.3%, respectively). Moreover, a considerable 58.9% of respondents had not engaged in any emergency or disaster preparedness exercises.

13	Guidance on COVID-19 for the care of older people and people living in long-term care facilities, other non-acute care facilities and home care	(Pacific, 2020)	(2020)	Cross-Sectional Study	Scopus	Quantitative	Leaders at both regional and national levels ought to intensify their focus on adapting to the "new normal" for older individuals. This can be achieved by advocating self-care practices, embracing technology, bolstering community-centered care, and fostering age-friendly environments. These initiatives lay the groundwork for a transformative "new future" that extends beyond the constraints imposed by the COVID-19 pandemic.
14	Overcoming the 'tyranny of the urgent': integrating gender into disease outbreak preparedness and response.	(Smith, 2019)	(2019)	Cross-Sectional Study	PubMed	Quantitative	The consequences of overlooking gender dynamics and the benefits of using equity-focused strategies in responding to disease outbreaks are highlighted in a case study featuring the Social Enterprise Network for Development (SEND) Sierra Leone. This non-governmental organization (NGO), located in Kailahun, serves as an illustrative example during the Ebola outbreak.
15	Transition to Practice Study in Hospital Settings	(Spector et al., 2015)	(2015)	Cross-Sectional Study	Web of Science	Quantitative	The findings indicated minimal notable variations between the two groups initially. However, upon categorizing hospitals in the control group based on their program status, whether they had established or limited programs, a divergence became evident. Hospitals with well-established programs exhibited higher rates of staff retention. Nurses within these programs reported fewer errors in patient care, utilized fewer negative safety practices, demonstrated higher levels of competence, experienced lower stress levels.

Technology is essential for supporting disaster planning and response plans in healthcare settings. Its effects are felt in many important domains, and new developments are providing creative ways to lessen the effects of disasters (Anthony Jnr., 2020). Advanced technologies-driven early warning systems facilitate proactive steps by forecasting potential hazards, enabling healthcare facilities to prepare and allocate resources effectively (Bhagavathula et al., 2020; Dubey et al., 2020). The smooth accessibility of patient data is guaranteed by integrated health information systems, enabling medical practitioners to act quickly and decisively in difficult situations (Gautam et al., 2023). Healthcare personnel on the ground can receive quick alerts, information, and resources thanks to mobile applications and wearable devices, which also enable real-time communication and data collecting. GIS and GPS are examples of geospatial technology that provide accurate mapping of impacted areas, facilitating resource allocation and focused response activities (Govindan et al., 2020; Houston et al., 2014). Increasing healthcare resilience in the event of disasters will require incorporating these technologies into thorough strategies for disaster preparedness and providing appropriate training for staff members (Johnston et al., 2015; Koonin, 2020). Blockchain and other emerging technologies provide transparent and safe platforms for managing supply chains and medical information, guaranteeing accessibility and integrity even in the face of chaos (Kamal et al., 2020). Moreover, the incorporation of machine learning algorithms augments the predictive powers, assisting in the identification of susceptible groups and proactive resource allocation optimization (Koonin, 2020). The emphasis on innovation, usefulness, and accessibility is maintained as the armoury of technologies grows, guaranteeing that even the most remote or resource-constrained healthcare facilities may take advantage of these developments to save lives in an emergency (Leahy et al., 2017; Muhammad et al., 2018; Anthony Jnr., 2020) delves into telemedicine and virtual care utilization during the COVID-19 pandemic. This study underscores the pivotal role of digital healthcare technologies in navigating healthcare delivery during crises, emphasizing the integration of virtual care solutions. Bhagavathula et al. (2020) scrutinize healthcare workers' knowledge and perceptions regarding COVID-19.

Dubey et al. (2020) explore the potential of blockchain technology in humanitarian supply chain settings. Their study, based on responses from key informants, underscores the validation of hypotheses related to technology, collaboration, and resilience, offering valuable insights into distributed ledger technologies. Gautam et al. (2023) shed light on the transition to professional practice among nursing graduates in Nepal. Govindan et al. (2020) present a decision support system for healthcare supply chains during epidemic outbreaks. Houston et al. (2014) present a functional framework for social media use in disaster planning and response. Johnston et al. (2015) evaluate the integration of WhatsApp in emergency surgical teams, revealing its positive impact on communication dynamics and the reduction of hierarchical barriers among team members. Kamal et al. (2020) investigate the acceptance of telemedicine services, revealing the multifaceted factors influencing individuals' willingness to adopt such services, including ease of use, social influence, trust, and perceived risks. Koonin (2020) explores the evolving use of telehealth during the COVID-19 outbreak in the United States, revealing a significant rise in COVID-19-related medical visits, signifying a shift in healthcare utilization patterns. Leahy et al. (2017) present outcomes of a patient blood management program, unveiling reductions in mortality rates, hospital stays, infections, and acute conditions, yet an increase in emergency readmissions. Muhammad et al. (2018) discuss the efficacy of convolutional neural networks in early fire detection for disaster management, emphasizing the accuracy and practicality of their approach.

Naser & Saleem (2018) scrutinize emergency and disaster management training among Yemeni health professionals, uncovering deficiencies in health administrators' qualifications and highlighting the reliance on non-formal training resources. Pacific (2020) calls for regional and national leaders' emphasis on adapting to a "new normal" for older individuals, advocating for self-care, technology adoption, community-centered care, and age-friendly environments. Smith (2019) focuses on gender dynamics in disease outbreak preparedness, exemplifying Send Sierra Leone's experience during

the Ebola outbreak, emphasizing equity-focused strategies in response. Spector et al. (2015) compare hospitals' programs, showcasing significant variations in staff retention, patient care errors, safety practices, competence levels, stress, and job satisfaction based on program status.

5.   DISCUSSION AND CONCLUSION

5.1. Discussion

Through a thorough analysis of several research, a clear picture of the critical role technology plays in transforming healthcare systems during emergencies is revealed. The impact of technological improvements on disaster response paradigms has been demonstrated in several research. From the ability of telemedicine to provide care remotely (Anthony Jr., 2020) to the revolutionary potential of blockchain technology in supply chain management (Dubey et al., 2020), these innovations successfully negotiate the complex networks involved in providing healthcare during emergencies. Bhagavathula et al.'s study (2020), however, sheds light on healthcare personnel' knowledge deficiencies, notably during pandemics like COVID-19, despite technological marvels. The difficulties encountered by recent nursing graduates highlight the complex nature of healthcare practice (Gautam et al., 2023) even more. Themes of diminishing confidence and insufficient assistance highlight the value of strong support networks and mentoring programs in facilitating the transition to professional roles—a crucial aspect that is sometimes disregarded in disaster response plans. Combining GIS, GPS, drones, and robotics improves disaster response systems by providing accurate mapping of impacted areas, effective resource distribution, and even the ability to carry out vital medical operations (Govindan et al., 2020).

Kamal et al. (2020) on telemedicine service acceptance reveals a complicated web of interrelated elements influencing users' preferences. The establishment of trust, perceived utility, and user-friendly interfaces are identified as critical factors that underscore the necessity of open and honest communication in order to guarantee broad adoption. COVID-19 caused a paradigm shift in the way healthcare is delivered (Koonin, 2020), which increased the use of telehealth services and signalled a significant turning point in the history of healthcare. This change highlights the importance of ongoing innovation and technological integration, highlighting the possibility for revolutionary changes in the paradigms of the future of healthcare. Naser & Saleem (2018) highlights gaps in healthcare workers' emergency management training and emphasizes the need for more formal resources and structured training programs. Understanding of technology's involvement in disaster response within healthcare, it becomes clear that extensive, longitudinal research spanning multiple technological worlds and broader settings is necessary (Govindan et al., 2020). Reiterating technology's transformational potential in reducing the impact of disasters and improving patient care highlights the necessity of ongoing innovation, education, and strategic absorption (Johnston et al., 2015).

A revolutionary path in healthcare disaster management may be traced from the transition from manual recording systems to modern instruments like EHRs, GIS, and telemedicine (Johnston et al., 2015). Mid- to late-20th-century technological milestones like radios, telephones, and simple computers made initial progress but faced adoption barriers because of insufficient infrastructure and training (Leahy et al., 2017). Significant advancements were made at the start of the twenty-first century, with the Internet and mobile technologies enabling improved disaster response capacities (Smith, 2019). A wide range of technology instruments are used in modern disaster preparedness, such as EHRs that guarantee data consistency, mobile applications that facilitate disaster planning, and telemedicine that permits remote consultations—a feature that was particularly highlighted during the COVID-19 pandemic (Naser & Saleem, 2018; Woo et al., 2017). Blockchain guarantees data integrity and autonomous contract execution, enabling prompt replies without bureaucratic delays; GIS facilitates logistics and mapping; AI allows predictive modelling and resource optimization. The foundation for developing robust and adaptable systems that can lessen the effects of future disasters is the dynamic interaction between technology improvements and healthcare disaster management (Spector et al., 2015).

5.2. Conclusion

The comprehensive analysis revealed the complex relationship between technology and healthcare crisis planning and response, presenting a paradigm-shifting environment moulded by creative fixes. The integration of telemedicine, blockchain, GIS, and AI-powered models represents a significant change in healthcare paradigms that strengthens response mechanisms during emergencies and promotes resilience. But despite advances in technology, problems still exist. The need for comprehensive measures is highlighted by differences in training, transitional obstacles for recent graduates, and knowledge gaps among healthcare staff. Closing these gaps requires proactive training programs, strong support networks, and specialized education to increase readiness in all healthcare settings. The research that has been evaluated highlight

how technology has revolutionized disaster response and ushered in a time when healthcare systems are more proactive and adaptable than before. However, the lack of generalizability and scope suggests that more thorough, long-term research covering a range of technology domains and wider contexts is necessary. The summary of results provides a road map for future work. Maintaining a focus on innovation, education, and technology integration becomes essential to building robust healthcare ecosystems. This means that in order to fully realize the revolutionary potential of technology, collaborative initiatives, longitudinal studies, and interdisciplinary approaches are required. The summary of findings highlights the critical role that technology plays in altering healthcare's approach to disaster response. Accepting technology as the cornerstone of robust healthcare systems lays out a path for a time when technological innovation, education, and strategic integration come together to strengthen patient care paradigms and lessen the impact of disasters.

5.3. Recommendations and Future Research

5.3.1. Recommendations

Technology Integration: Encourage healthcare facilities to further integrate advanced technologies into disaster preparedness plans. This includes expanding the use of telemedicine, wearable devices, and GIS/GPS technology for swift response and resource allocation during disasters.

Training and Education: Prioritize training programs for healthcare workers in disaster management and technology utilization. Develop comprehensive courses and simulations that incorporate the use of AI, virtual reality, and machine learning for disaster response training.

Policy Implementation: Advocate for policies that support the adoption of innovative technologies in healthcare settings. This might involve incentivizing healthcare facilities to invest in technological infrastructure for disaster preparedness.

Collaboration and Research: Foster collaborations between technological experts, healthcare practitioners, and disaster management authorities. These collaborations could lead to the development of more specialized tools and platforms catering to disaster situations.

5.3.2. Future Research

Long-Term Impact Studies: Investigate the long-term effects of technology integration in disaster preparedness on healthcare systems and communities. Assess the sustainability and adaptability of these technologies over time.

Ethical Implications: Explore the ethical implications surrounding the use of AI, blockchain, and big data in disaster response. Address concerns related to data privacy, equity in access, and potential biases in technology-driven decision-making.

Community Engagement: Conduct studies focusing on community perceptions and acceptance of technological solutions in disaster scenarios. Understand the cultural, social, and economic factors influencing technology adoption during crises.

Comparative Analyses: Compare the effectiveness of different technological interventions in various disaster settings or geographical locations. This could shed light on the best practices for specific contexts.

Resilience and Adaptability: Investigate strategies to enhance healthcare resilience by analyzing adaptive technologies and their role in addressing unexpected challenges during disasters.

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