THE ROLE OF DIGITAL TECHNOLOGY IN SUPPORTING DISASTER EMERGENCY RESPONSE: LITERATURE REVIEW

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Abstract

Background: The increasing frequency and complexity of global disasters require health care systems to respond quickly, appropriately, and in a coordinated manner. Digital technology is a strategic solution to strengthen emergency response capacity, especially in the triage process, communication, and training of health workers. **Objective**: This study aims to review the literature on the use of digital technology in the context of disaster emergency response, with a focus on nursing and pre-hospital services. **Method**: A literature review method was used with reference to the PRISMA guidelines. Searches were conducted on the PubMed, Scopus, and ScienceDirect databases using a combination of keywords related to disasters, digital technology, and health workers. A total of 707 articles were obtained, filtered based on inclusion and exclusion criteria, leaving 12 articles for narrative analysis. **Results**: Four main themes were found: (1) mobile applications and digital triage systems, (2) utilization of telemedicine and telenursing, (3) integration of artificial intelligence and digital sensors, and (4) innovation in nursing training and documentation. This technology has been shown to improve the speed of patient classification, access to remote medical services, and health worker preparedness. However, limited infrastructure, digital literacy, and ethical aspects are significant challenges. **Conclusion**: Digital technology has great potential to improve the quality and efficiency of disaster response. Policies that support inclusive technology integration, as well as ongoing training for health workers are needed to ensure successful implementation across disaster contexts.

Keywords: digital technology, disaster triage, emergency response system.

1. INTRODUCTION

The increasing frequency and complexity of disasters around the world, both natural disasters such as earthquakes, floods, and forest fires, as well as man-made disasters, such as social conflicts and pandemics, are putting significant pressure on health care systems. This puts tremendous pressure on health care systems, especially in the emergency response phase. Without the support of digital technology, disaster responses are often slow, uncoordinated, and inaccurate. This can lead to delays in the triage process, errors in medical decision-making, overloading of health facilities, and increased mortality and preventable deaths [1]. According to WHO (2020), more than 60% of post-disaster deaths occur in the first two hours due to delays in medical treatment. In many developing countries such as Indonesia, the Philippines, and Bangladesh, triage processes and field communications are still largely done manually without the support of real-time technology. As a result, the process of identifying critical victims is slow, coordination between agencies is hampered, and hospital capacity is quickly filled without efficient prioritization [2]

In contrast, developed countries such as Japan, South Korea, and the United States have successfully integrated digital systems into disaster management, ranging from mobile-based triage applications, real-time communication platforms between emergency units, to AI-based and geospatial victim mapping systems [3]. In Japan, the Disaster Medical Assistance Team (DMAT) system is supported by mobile technology that allows direct reporting of victim conditions to the command center in less than 5 minutes [4]. In South Korea, the use of smart drones to monitor victims and deliver medical logistics has become standard in emergency response since 2019 [5].

Digital transformation has changed the way healthcare workers, including nurses, respond to crisis situations. Triage-based mobile applications enable rapid classification of victims in the field and real-time data transmission to control centers. A study by Tahernejad et al. (2024) found that the use of triage applications in mass incidents can increase the speed of initial assessment and reduce the risk of misclassification of victims [6]. Furthermore, the integration of artificial intelligence (AI) in triage systems is starting to show positive results, such as the ability to predict the severity of injuries or the need for evacuation through machine learning algorithms [7].

In addition to triage applications, telemedicine and telenursing have become important pillars in providing remote health services in emergency situations. Telemedicine has proven to be useful in disasters where physical access to health facilities is limited or interrupted. A study by Litvak et al. (2022) showed that telenursing can be used not only for triage, but also for medical consultation, patient monitoring, and psychosocial support for disaster victims [8]. This is reinforced by the results of a review by Nejadshafiee et al. (2020) which stated that teletriage was able to reduce visits to the emergency room by more than 20%, as well as increase service efficiency and patient satisfaction [9].

Digital technology also plays a role in supporting the capacity building of health workers through application-based training or distance learning. Applications such as the Clinical Triage Education App (CTEA) have been used in nurse training and have proven effective in improving triage competency and reducing under-triage rates in disaster simulations [10]. With digital training, healthcare institutions can build staff readiness sustainably and flexibly, even outside disaster zones. However, the use of digital technology in disaster response still faces various challenges. In developing countries, the main obstacles include limited electricity and network infrastructure, low digital literacy of health workers, and issues of security and privacy of victim data [11]. Without systemic support from the government, health institutions, and adequate training, the great potential of digital technology will be difficult to realize optimally.

This study aims to literature review the literature related to the use of digital technology in disaster emergency response, especially in the context of nursing and emergency health services. The main focus includes the types of technology used, their impact on service effectiveness, and challenges in implementation and integration in the field. Thus, the results of this review are expected to be the basis for the formulation of policies, training, and development of digital-based emergency response systems that are more resilient and adaptive to current and future disasters.

2. METHODOLOGY

This study used a literature review design, which is a method of literature and transparent literature search and evaluation to answer predetermined research questions. This approach follows the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), which provides a framework to ensure the completeness and transparency of review reporting. We used the PCC framework to develop eligibility criteria. P represents a population that includes health workers or nurses. C represents the concept of Digital technology. C indicates the context of disaster emergency response. The inclusion criteria used in the selection of articles are as follows: a) Articles published in English; b) Studies in the form of empirical research (quantitative/qualitative); c) Focus on the use of digital technology in disaster emergency response; d) Articles published between 2020–2025.; e) Studies involving health workers or nurses in the context of disaster management. The exclusion criteria include: a) Studies on animals or non-human populations.; b) Review articles, opinions, editorials, or letters to the editor; c) Articles that are not available in full-text. d) Studies that are not relevant to the focus of digital technology in the context of disaster emergencies. Literature searches were conducted through three major electronic databases, namely PubMed, Scopus, and ScienceDirect. See table 1 for databases and table 2 for keywords.

Table 1 Database link

Pubmed	https://pubmed.ncbi.nlm.nih.gov/
Scopus	https://www.scopus.com
ScienceDirect	https://www.sciencedirect.com

Searching Strategy
Literature reviews use Boolean operators to extract relevant findings.

Table 2 Keyword and Boolean

Pubmed	(("Disasters" OR "Emergency Medical Services"OR "Triage") AND ("Technology" OR "Telemedicine"OR "Mobile Applications" OR "Artificial Intelligence" OR "Remote Consultation") AND ("Nurses" OR "Health Personnel" OR "Emergency Medical Technicians"))
Scopus	(("Disasters" OR "Emergency Medical Services" OR "Triage") AND ("Technology" OR "Telemedicine" OR "Mobile Applications" OR "Artificial Intelligence" OR "Remote Consultation") AND ("Nurses" OR "Health Personnel" OR "Emergency Medical Technicians"))
ScienceDirect	(("Disasters" OR "Triage") AND ("Technology" OR "Telemedicine"OR "Mobile Applications" OR "Artificial Intelligence") AND ("Nurses" OR "Health Personnel"))

The researcher's search process is described as follows: (1) The first step is to enter a combination of keywords into the selected databases. (2) The second step produces a total of 707 articles from three databases over the past 5 years (2020-2025): PubMed with 290 articles, Scopus with 33 articles, and sciencediret 384 articles. (3) Next, duplicate articles were identified and removed using Mendeley, resulting in the removal of 38 articles. (4) After removing duplicates, the remaining 669 articles were screened for title and abstract, (584 articles were removed) resulting in 85 articles. (5) A full-text review was then conducted and assessed based on eligibility criteria. Finally, 73 articles were excluded because: a) full text was not available for 15 articles; b) 7 articles were not available in English; c) 17 articles used a non-quantitative/qualitative research design; d) 19 articles did not discuss the use of digital technology in disaster emergency response; e) 15 articles did not involve health workers or nurses. A total of 12 articles will be reviewed.

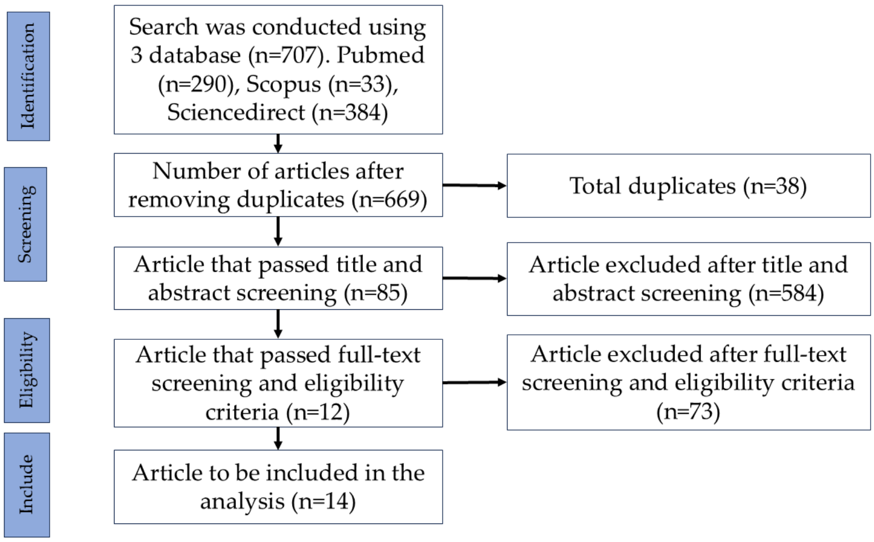

Figure 1 PRISMA Flow Diagram

3. RESULTS

The 12 extracted articles were analyzed and summarized based on author, year of publication, type of technology, population, and main findings. The authors identified 12 articles and presented them as narrative tables for inclusion in Table 4.

Table 3 Author (Year) Type of Technology Population Key Findings

No	Author (Year)	Type of Technology	Population	Key Findings
1	Keesara et al. (2020)	Telemedicine, a digital health application	The health care system in the US	The COVID-19 pandemic has accelerated the adoption of digital technology to replace conventional health service systems that still rely on face-to-face meetings.
2	Schmollinger et al. (2024)	Mobile triage application (mSTART)	38 medical students in MCI simulation	The mobile-based triage application demonstrated reliability in triage decision making and was well received by users in a mass casualty event simulation.
3	Moon & Cho (2022)	CTEA based triage mobile application	Data from Thailand's emergency system	The application helps to classify patients quickly and accurately based on protocols, increasing efficiency in emergency management.
4	Urbanelli et al (2024)	Telegram Chatbot (ERMES)	Emergency practitioner	ERMES chatbot improves two-way communication in disaster management, with user-based design and validation through real field testing.
5	Sykora et al. (2020)	Audiovisual consult (AVC)	791 low-urgency events were randomized; per-protocol analysis was performed on 643 cases.	Audiovisual consultation (AVC) was no more effective than telephone consultation in increasing the number of patients treated on site and not admitted to hospital. AVC increased physicians' sense of security, but did not

				improve paramedic or patient satisfaction. AVC use tended to increase return visits within 48 hours of patients being left on site
6	Zhang et al. (2024)	Smart glasses application for EMS telemedicine	43 EMS providers (urban and rural) for 2 years	Smart glasses improve pre-hospital communication, with positive feedback from paramedics regarding efficiency and ease of use, although there are concerns about integration into workflow.
7	Schröder et al. (2021)	Telemedicine EMS (tele-EMS)	10,362 tele-EMS consultations; 4,293 life-threatening conditions	ele-EMS effectively improves vital signs of patients in life-threatening conditions, without the need for a doctor to be present on site in person.
8	Pizzolato et al. (2021)	Mobile application "Nursing APHMóvel"	Not explicitly stated, focus on application development	The application enables documentation of nursing processes by SAMU nurses offline and supports systematic processes in the pre-hospital setting.
9	Tian et al. (2014)	Mobile-based triage decision support system	Not explicitly stated, based on system development	Mobile-based systems can assist triage decision making using the Cox Proportional Hazard model, providing dynamic survival predictions for MCI patients.
10	Anschau et al. (2021)	Smart Check (automated clinical evaluation tool)	11,466 patients, including 220 patients for COVID-19 symptom analysis	Smart Check speeds up triage time by up to 33 seconds and helps identify early symptoms of COVID-19 effectively.
11	Park (2021)	IoT-based e-triage tag system	System testing by a group of experts (number not mentioned)	The developed e-triage system can monitor vital signs in real-time, increasing triage efficiency and the chance of survival in mass casualty events.
12	Lu et al. (2023)	UAV (drone) + AI (OpenPose, YOLO) + 5G	8 volunteers in a mass-casualty incident (MCI) simulation	The intelligent triage system based on UAV, AI, and 5G is proven to be feasible for MCI triage simulation and can be an innovative approach in emergency rescue.

Based on a review of 12 articles that met the inclusion criteria, it was found that the role of digital technology in supporting emergency response and disaster triage can be grouped into four main themes, namely: (1) mobile applications and digital triage systems; (2) utilization of telemedicine and telenursing; (3) artificial intelligence systems and digital sensors, and (4) innovations in digital training and documentation for health workers.

Mobile Application and Digital Triage System

Four of the 12 studies emphasized the role of mobile applications and digital triage systems in accelerating the victim classification process and decision making. Applications such as mSTART, CTEA, and mobile applications based on triage protocols were used in mass-casualty incident (MCI) simulations and field practice to improve efficiency and accuracy. Schmollinger et al. (2024), demonstrated the mSTART mobile triage application in medical students, demonstrating reliability in classifying MCI victims [12]. Moon & Cho's (2022) research stated that the CTEA application helps rapid classification of patients based on Thailand's national protocol [6]. Anschau et al. (2021) stated that "Smart Check" accelerates triage time and the accuracy of identifying COVID-19 symptoms [13]; and Park's research, (2021), states that the IoT-based e-triage system enables real-time monitoring of vital signs [14].

Utilization of Telemedicine and Telenursing

Four studies have highlighted the use of telemedicine in providing remote consultation and treatment, especially in emergency situations where doctors are not on site. Tele-EMS and audiovisual consult systems were developed to improve access to fast and safe clinical decisions. Research by Keesara et al. (2020) stated that the adoption of telemedicine systems increased significantly during the COVID-19 pandemic in the US [11]; Sykora et al. (2020) showed that audiovisual consult (AVC) by paramedics increased doctors' sense of safety although it was not superior to telephone consultation [15]; Zhang et al. (2024) showed that the use of smart glasses in tele-EMS supports real-time communication between paramedics and doctors [16]; and Schröder et al. (2021) stated that Tele-EMS is effective in improving vital signs of patients in life-threatening conditions [17].

Artificial Intelligence Systems and Digital Sensors

Three articles explore the integration of AI, UAVs, digital sensors, and Telegram chatbox as an innovative way to improve accuracy, response speed, and documentation in disaster victim triage. A study by Lu et al. (2023) stated that AI-based UAV systems (YOLO, OpenPose) and 5G were proven feasible for automated triage in MCI simulation [18]. Tian et al. (2014) showed a mobile-based system with the Cox Proportional Hazard model to dynamically predict patient survival [19]. Urbanelli et al (2024) also stated that the ERMES Chatbot improves two-way communication in disaster management, with user-based design and validation through real field tests [20]

Innovation in Training and Digital Documentation for Health Workers

Two studies have shown the importance of digital systems in supporting nursing documentation and training in the field, especially in pre-hospital settings. Nursing process documentation applications enable accurate data collection and support systematic clinical decision-making. Research by Pizzolato et al. (2021) shows that the "Nursing APHMóvel" application allows nurses to document the nursing process digitally and offline in the field [21]. Anschau et al. (2021) stated that in addition to playing a role in triage, Smart Check functions as an educational tool in recognizing symptoms of infectious diseases [13].

4. DISCUSSION

The development of digital technology in the last decade has brought about a significant transformation in disaster management, especially in the triage process and emergency response in the pre-hospital setting. In mass emergencies such as natural disasters, mass accidents, or infectious disease outbreaks, the ability of the health care system to classify victims quickly and accurately is a crucial element in saving lives. Various technological innovations ranging from mobile applications, telemedicine systems, artificial intelligence (AI), to digital documentation devices are now present as practical and adaptive solutions to these challenges.

One of the most dominant forms of innovation found is the use of mobile applications for digital triage. A study by Schmollinger et al. (2024) showed that the use of the mSTART application in a mass casualty incident (MCI) simulation allowed patient classification to be carried out faster and more accurately than conventional methods. This is in line with the findings of Xia et al. (2019) which stated that an application-based education system can improve the readiness and response of nursing students in dealing with emergency situations [22]. In fact, in Thailand, Moon & Cho (2022) developed an application based on the Thai national protocol which in a field trial was proven to increase the efficiency of patient classification based on clinical conditions. In Japan, Kubo et al. (2021) added that mobile triage tools based on the START or SALT protocol were able to reduce victim misclassification by up to 30%, which had a direct impact on the speed of evacuation and medical decision-making. In contrast, developing countries still face major challenges in implementing this digital application. WHO (2022) emphasized that application design must consider the limitations of digital literacy, especially among volunteers and health workers in the 3T (underdeveloped, frontier, outermost) areas. In Indonesia, for example, several studies have shown that the implementation of application-based triage is still limited to large cities and referral hospitals, while in remote areas health workers still rely on manual forms or one-way radio communication [23].

In the context of remote consultation and treatment, telemedicine is a vital element that continues to be developed. In Germany, Schröder et al. (2021) showed that tele-EMS can improve the vital signs of more than 60% of patients with life-threatening conditions, without the physical presence of a doctor. This opens up great opportunities in handling disaster victims in rural or isolated areas. Furthermore, in China, Zhang et al. (2024) reported that the use of smart glasses by paramedics enabled real-time video transmission to doctors in the hospital, allowing immediate assessment of victims and provision of action instructions without delay. A similar study in the United States by Munzer et al. (2018) in the context of wildfires in California also showed that the integration of emergency video calls into EMS officers' helmets increased communication effectiveness and reduced procedural error rates [24]. However, not all forms of teleconsultation showed consistent effectiveness. A study by Sykora et al. (2020) showed that audiovisual consultation (AVC) by paramedics was no more effective than conventional telephone consultations, and even tended to increase return visits within 48 hours. This suggests that the success of a telemedicine system is highly influenced by system design, connection stability, and user convenience, as highlighted by Abbott & Liu (2013) in a systematic review of 35 telehealth studies in conflict zones emphasizing that system success is highly dependent on geographic context, infrastructure, and user training [25].

In developing countries, limited infrastructure is a major challenge. Unstable internet connections, lack of digital devices, and minimal technical training often make the implementation of telemedicine systems less than optimal. In some parts of Africa and Southeast Asia, telehealth services can only be used under certain conditions, while in developed countries this system is already part of the national emergency response protocol [26]. Furthermore, the integration of artificial intelligence and drone technology is also beginning to be utilized in disaster scenarios to support automatic classification of victims. Lu et al. (2023) combined UAVs (drones), AI (YOLO and OpenPose algorithms), and 5G networks to detect victims from the air and perform triage classification in real time. This system allows for victim identification without the need for direct physical approach, which is critical in high-hazard situations such as chemical leaks, tsunamis, or armed conflicts. Zhang et al. (2021) reinforced this by showing that the use of drones for disaster mapping improves logistics efficiency and facilitates coordination of aid distribution. In a predictive context, Tian et al. (2014) demonstrated that a Cox Proportional Hazard-based algorithm integrated into a triage system can estimate the probability of patient survival in real-time, and assist paramedics in setting evacuation priorities. However, ethical and technical challenges related to algorithm accountability, the validity of local training data, and the risk of bias remain important unresolved issues [27].

No less important, the aspect of strengthening the capacity of health human resources through digital media is also a concern in efforts to improve preparedness. The Nursing APHMóvel application developed by Pizzolato et al. (2021) supports offline and systematic nursing documentation in the field, thus ensuring continuity of information between evacuation phases. Anschau et al. (2021) showed that the Smart Check tool can accelerate patient triage while providing clinical training for users. On the other hand, education-based innovations such as virtual simulation (Foronda et al., 2016) and web-based triage games (Astuti et al., 2022) show that digital media can increase learning motivation, triage accuracy, and critical thinking skills of nursing students [28]. The study by Hung et al. (2020) also emphasized that blended learning with the integration of e-learning and live scenarios had a significant impact on participants' psychological and technical readiness in facing disaster simulations [29].

However, the gap in access to training technology remains a real challenge in many developing countries. Not all nursing institutions have adequate infrastructure to conduct digital training on a large scale. Therefore, there needs to be a national and global initiative in the form of capacity building and technology subsidies for institutions in areas with high disaster risk.

5. CONCLUSIONS

Digital technology has opened up great opportunities to improve the effectiveness and efficiency of triage and pre-hospital response in disaster situations. However, the success of its implementation is largely determined by contextual suitability, user acceptance, infrastructure readiness, and humanistic system design. In addition to considering technical and functional aspects, the development of this technology must also involve an ethical, collaborative, and evidence-based approach.

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Finally, the author realizes that this paper still has limitations. Therefore, all forms of input from readers are highly expected for the improvement of this work in the future.

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