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Development and Applicability Evaluation of a Pre-Hospital Patient/Injured Identification, Missing Search, and Tracking Software System in Disasters

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Abstract:
A disaster-response software system has been developed to minimize the risk of missing patients/injured individuals, infants, and children, and to track them during disasters. This study investigates the software's contributions to field use and healthcare personnel's triage experiences. Software has been developed based on contributions of 10 expert senior managers and assessed via Lawshe's technique; the Content Validity Index (CVI) is 0.988. Subsequently, 25 disaster-experienced healthcare workers from Istanbul's 112 Emergency Health Services station evaluated the system through semi-structured, in-depth interviews. Collected qualitative data were coded and analyzed using content analysis in MAXQDA 24. The research is organized into two themes—disaster software system and triage experiences—with subcodes. Findings show that triage depends not only on clinical knowledge but also on environmental conditions, social response, intra-team communication, and psychological factors. The disaster software supports triage by facilitating identification, patient tracking, acceleration of interventions, and data security. Integrated modules—such as QR codes, fingerprint, photo, and location—reduce healthcare personnel's workload and improve data accuracy. However, challenges include inadequate infrastructure, manual data entry burdens, mobile device incompatibility, and a lack of legal regulation. Suggested improvements by participants include integration with MERNİS (Turkey's central population registry), voice command capability, barcode technology, and DNA-based modules. Overall, digital solutions can critically support triage in disaster settings operating within multidimensional dynamics.

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INTRODUCTION

Disasters are sudden, often unpredictable events that directly endanger lives and cause widespread loss of life and destruction (Teh & Khan, 2021). These catastrophic events not only result in mass fatalities but also involve missing infants and children. Since earthquakes can affect a large number of people, they often result in significant loss of life and property (Yücel, 2023). The impact of a major earthquake would be devastating, with high numbers of injuries and significant tracking challenges. In mass-casualty events—such as earthquakes, floods, or wars—the quality of pre-hospital emergency care becomes a critical determinant of disaster response effectiveness (Lindquist et al., 2025).

Timely on-site treatment and rapid transport to appropriate medical facilities increase survival chances. However, identifying unconscious, separated from family members, or unidentified patients in the field remains a significant challenge (Liu, 2022). Infants, children, the elderly, Alzheimer's patients, and unconscious individuals are especially at risk for going missing during disasters (Alghamdi, 2022).

In large-scale disasters in Turkey, such as the Kahramanmaraş earthquake, it was observed that more than 50,000 lives were lost, family members were separated from each other, and identification processes were primarily carried out through corpses (Sert et al., 2024). However, to reduce losses and ensure the traceability of individuals within the health system, it is vital to establish identification and tracking systems not only after death but also at the scene of the incident for living individuals. However, the lack of an integrated software system that digitally manages this process in current field applications draws attention (Park, 2021).

In the chaotic environment experienced during disasters, the most basic requirement for healthcare personnel working at the scene is access to technological tools that support the ability to make quick decisions and identify individuals (Ajemu et al., 2024). Digital tools—such as fingerprint scans, facial recognition, and QR-based ID solutions—support triage by reducing uncertainty in chaotic environments and enabling comprehensive patient tracking. Literature indicates that digitization enhances service quality and reduces workload in pre-hospital care (Hammami & Jebali, 2021).

Today, most health systems focus on identifying deceased individuals after a disaster; however, they often overlook the importance of identifying and tracking living individuals immediately after the disaster (Stewart & Stewart, 2023). However, tracking of unconscious patients or individuals lost during secondary transports is only possible with software systems (Yilmaz et al., 2024).

In a disaster environment, the ability of different institutions (health, police, AFAD, funeral affairs, etc.) to share data and carry out joint work over the same system is the basic condition for accurate and rapid identification of disaster victims both in live and post-mortem processes (Atalay et al., 2024). However, the fact that healthcare teams working in the field are not supported by hardware such as mobile device applications and QR printers, the limitations of existing software, and the lack of user-friendly interfaces make it difficult to widely use these systems. Therefore, investments in digitalization for disaster management should be directed at the central institutional level and in the pre-hospital area (Rinkinen et al., 2024).

In response, the Pre-Hospital Identification & Missing Person Software (HÖKKB) was developed to digitally record victims on-site, associate data with QR codes, and share them across health, security, and administrative agencies. These systems, similar to those in the literature but lacking in Turkey, enable the identification of individuals and the traceability of every step in the healthcare process, starting from pre-hospitalisation. This innovation ensures traceability from the scene through all subsequent medical and legal stages. It also helps prevent infant-child kidnapping and confusion during transfers (Faizatiwahida & Andani, 2025).

The main problem question of this study focuses on what the solution for the missing and inaccurate identification of individuals such as infants could be, children, sick/injured, unconscious, first conscious and then unconscious individuals or individuals with special needs (Alzheimer's, etc.) due to the lack of software that will ensure the correct identification of individuals affected by mass disasters. In addition, the research also seeks answers to various sub-problem questions while seeking answers to the problem in question: For example, whether the developed Pre-Hospital Identification and Lost and Found (PAHLF) software can prevent mother-infant separations, whether it can follow up secondary transfers, whether it can reduce the risks of child abduction, its capacity to strengthen identity verification processes, and what kind of contributions it can make to the process with biometric applications such as fingerprint and face recognition. Therefore, this study focuses on a problem arising from theoretical deficiency and structural and technological inadequacies in field practices (Konrad et al., 2025).

The primary purpose of this research is to provide accurate and rapid identification of infants, children, patients/injured, unconscious individuals, individuals who are conscious first and then become unconscious or individuals with special needs who are at risk of getting lost in disasters, to prevent them from getting lost and to evaluate the applicability of a software system that will enable the whole process to be digitally tracked by health professionals in the field. The developed software offers a holistic approach based on registering disaster victims from the incident scene. Thanks to this system, individuals reached at the scene are automatically given an 'ID' code, fingerprints (heel prints in newborns), facial photographs, visual records of apparent wounds or surgical scars, and all information that can contribute to identification is integrated into the digital platform. This code can be printed out during the disaster and pasted on the triage wristband of the disaster victim, or the wristbands with code numbers already available in the triage wristbands in the ambulance can be attached to the disaster victim. All this information is matched with the QR code tag and processed into the individual's digital file. This file can be actively used in all stages of the disaster, including transport from the scene to the hospital, treatment, secondary transfer, and, if necessary, judicial processes (Berawi et al., 2021).

This software system is designed to be open to integrating healthcare professionals and other relevant public institutions, such as police, gendarmerie, AFAD, municipal officials, and funeral units. Thus, a multi-actor and interdisciplinary usage area will be created. In order for the software system to function successfully, it is envisaged that inter-institutional data sharing will be ensured, appropriate digital devices (e.g. mini printers or wristbands with QR codes printed on them) will be provided to the 112 emergency health teams that first reach the field, a mobile version of the application will be developed and training materials will be prepared for the users (Sarı, 2021). The research aims to holistically address the integration of technological hardware and the software system developed in field conditions. This study aims not only to produce a software solution but also to evaluate the applicability, sustainability, and impact of this solution within the health system.

METHOD

A qualitative research model was adopted in the study, which provides the researcher with the opportunity to obtain in-depth and meaningful data to understand the complex nature of social phenomena. The qualitative approach is a powerful research model, especially when examining the experiences, perceptions, and meanings that participants attribute to events. The multi-layered nature of the research questions, the human-oriented approach, and the need to evaluate practices in the field from different perspectives demonstrate that the qualitative method is suitable for this study.

A case study was used as the research design. A case study comprehensively analyzes a specific event, individual, group, institution, or process. The case addressed in this research is the identification difficulties experienced during mass disasters and the effects of a digital application developed to facilitate this process. The primary focus of the research is to evaluate the functional capacity of the developed software and its applicability in the field in light of the experiences of health managers and employees. A multidisciplinary approach was adopted in the software development process, and the application's functionality was ensured through technical support from IT expert Vedat Calis, particularly during the software programming phase.

The application has been designed to enable healthcare workers in disaster areas to quickly and securely register individuals, digitize identity information, record their location, and follow

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hospital processes. A user-friendly structure was adopted in the interface design, with the home page, information entry fields, button structures, and security protocols organized effectively. The main functional modules in the system are listed as lost search, patient personal information (identification), health information record, triage information, transport information, and QR code integration. The developed program can run on mobile devices and allows instant data generation in the field with portable QR printers.

To ensure the system's security, a special user login has been defined for each healthcare worker, and a system for verifying Turkish ID numbers and passwords has been developed during login. In this way, the authorization and responsibility of the person who made the registration have also become digitally traceable. The application enables the automatic collection of location information of individuals at the first contact at the incident scene. It enables the recording of biometric data, such as fingerprints, facial photographs, and surgical scars. In addition, the system is intended to work in synchronization with official databases through advanced identity verification supports, such as the Central Population Administration System (MERNIS) integration.

All records are associated with a unique 'ID' number assigned by the system, and all patient transactions can be tracked through this ID number. Health information, medications administered, and triage information can be recorded in detail on separate pages. In the triage information section, information such as the patient's position, the treatment applied, the resuscitation interventions performed, and the name of the health professional who performed the triage can be entered separately. Through the transfer page, the entire process can be digitally monitored in case individuals are sent to another hospital. Finally, the QR code generation page enables the individual's data to be matched with their own by printing it on a wristband or tag. Figure 1 shows a screenshot of this interface.

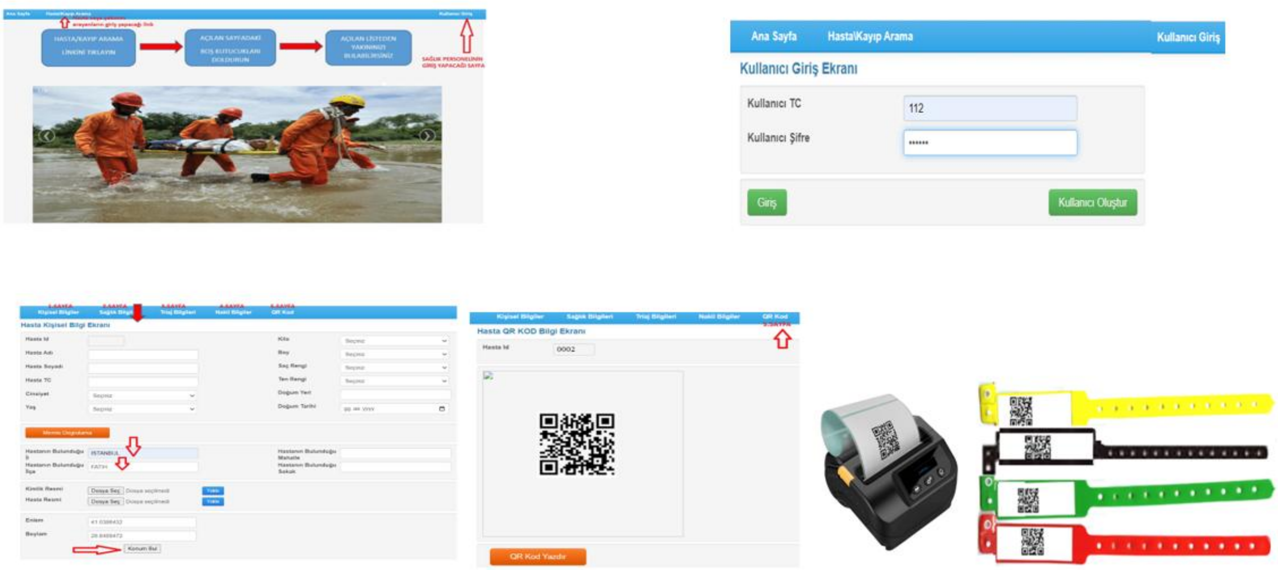

Figure 1. QR code generation page. (Note: Created by the author).

This system makes it possible to integrate the identification and monitoring process initiated at the scene of the incident into health institutions without interruption. Thus, information such as to which health institution the sick or injured individual was transferred from the disaster area, which treatment procedures he/she was subjected to, and which health workers were involved in this process can be tracked through a holistic digital record with a single QR code. This structure aims to prevent post-disaster crisis areas, such as the separation of mothers and children, confusion of unconscious patients, or loss of information that may occur in secondary transfers.

The system is structured per KVKK (Personal Data Protection Law) No. 6698 regarding data security. Login operations are carried out after user authentication is authorized with the Turkish ID number, and the data stored in the system can only be viewed; no deletion or modification can be made to this data. This design is compatible with the need for rapid intervention inherent in pre-hospital emergency health services and is important in patient safety and ethical data management.

The CGI (Content Validity Index) of the software, which was prepared by taking expert opinions from 10 senior health managers, was 0.988, which was evaluated by the Lawshe technique. The Lawshe technique is widely used to assess items' content validity by utilizing expert opinions. The Lawshe technique allows experts to evaluate each item and determine how much it represents a particular construct (Baghestani et al., 2017). Ethics committee and institutional permissions were obtained to evaluate the interaction of health sector professionals with the software during the implementation process. Afterwards, 25 healthcare professionals working in 112 Emergency Health Services Stations in Istanbul, who had at least one disaster experience before, were asked to evaluate the software with a semi-structured in-depth interview form. The feedback obtained enabled the software to be reorganized according to the user experience and simplification of the missing or complex areas in the system. The software has a modular and developable structure and is designed to be expandable to allow data sharing with the police, forensic medicine, funeral services, and local administrations when needed.

This methodological structure secures not only therapeutic interventions within the scope of health services, but also identification processes with an approach based on information integrity and human dignity in times of crisis. The digital nature of the developed system ensures speed and integrity in data access and prevents confusion and loss of time in manual systems. In addition, it is also possible to commission the offline modules of the system in temporary health stations or mobile units that can be established in the disaster area. In this way, individuals can be identified and tracked even in areas without internet connection, and the data is synchronized to the central server when the connection is established.

RESULT

The data in the table shows the percentage of each code in total responses. In triage experiences, Triage Areas have the highest share (40%), while 'Reasons for Not Performing Triage in Disaster Environment' has the lowest share (25%). On the digital software axis, 'Contributions of the Software System' emerged as a key factor, accounting for almost half of the total (45%), while suggestions and disadvantages remained at lower rates. Table 1 shows the frequency and percentage distribution of the Theme-Code Expression.

Table 1. Theme-Code Statement Frequency Distribution

Theme	Code	Statement (Sub Code)	Frequency	Percentage
Triage Experiences	Triage Areas	Traffic accidents, Earthquakes, Fire, Terrorist attacks, and Poisoning cases.	40	40%
	Difficulties of Triage	Public's approach, Communication problems between team personnel, Environmental safety, Environmental factors, Limitations of Facilities	35	35%
	Reasons for not being able to perform triage in a Disaster Environment	Chaos, Seasonal conditions, Insufficient personnel, and the qualification of personnel	25	25%
Disaster Software System	Contributions of the Disaster Software System	Digitalization	45	45%
		– Software system		
		– Data protection Registration Accessibility for babies and children security,		
		Accessibility to relatives of patients		
	Advantages and Disadvantages of the Software Application	Advantages;	30	30%
		Facilitating patient tracking, identification, accelerating the registration process, adding photo and fingerprint, accelerating the intervention process, and accelerating the identification process		
		Disadvantages;		
		Manual Processes, infrastructure, Compatibility, Legal barriers		
	Suggestions for Increasing Software Effectiveness	Integrated work with MERSIS integration, working with voice commands, fingerprint scanner, QR code reader, and Legal regulators	25	25%

Theme 1: Triage Experiences

In this study, conducted to understand the reflections of triage practices in the field in disaster and multiple injury situations, the data related to the triage experiences of the participants were categorized under three principal codes by content analysis method: (1) Triage Areas, (2) Difficulties of Performing Triage, and (3) Reasons for Not Performing Triage in Disaster Environment. A clear hierarchical structure was observed among the codes, and these structures were presented systematically through visual models.

Code 1: Triage Areas

Traffic accidents, earthquakes, fires, terrorist incidents, and poisoning cases have been classified as Code 1 incidents, based on the incident type. Figure 2 below summarizes the thematic distribution of the triage areas that the participants intensively experienced.

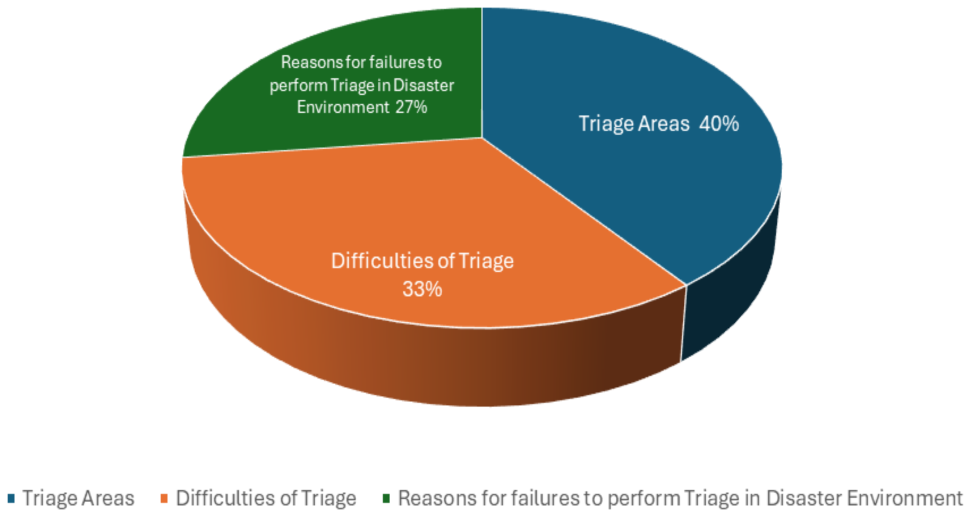

Figure 1. Triage Experiences Code Distribution

The most emphasized incident type was traffic accidents. Participants stated that they experienced triage in various scenarios, ranging from minor accidents with 5-6 people to bus and train accidents with more than 20 injured people. The fact that triage practice can be performed more systematically in traffic accidents is explained by factors such as ensuring crime scene security and the event taking place in an isolated area. However, insufficient lighting, interventions by the public, and the low number of ambulances were identified as the main factors limiting the effectiveness of the practice in accidents occurring at night.

In particular, the example given by participant P1 illustrates how systematic triage works in the field and how the rapid prioritization process is carried out within the framework of colour coding. Participant P1 also emphasized that triage is not only a medical procedure, but also the psychological management of panic-stricken casualties should be integrated into the process. The incidents in which triage practices are carried out vary according to participant experiences. Traffic accidents, earthquakes, fires, terrorist attacks, and poisoning cases stood out as the most frequently encountered areas. Participants stated that systematic triage can be applied especially in traffic accidents since it is more possible to control the scene.

"In an accident where we did triage, we separated the injured on the bus one by one, gave green, yellow, and red codes, prioritized red, and put them in the ambulance" (P1).

P1 directly reflects the structure of this practice in the field. On the other hand, earthquakes witness more complex and large-scale triage scenarios. The participants stated that physical conditions in such events make it challenging to perform systematic triage, with their statements such as:

"In the earthquake, we tried to separate those who could walk by saying “come”, we could not use triage cards (Ministry of Health, 2009) because our cards were wet and there was no light" (P14).

Apart from traffic accidents, earthquake events were identified as the type of event where triage practice became the most critical. Especially the February 6th, 2023, Kahramanmaraş-centred earthquakes took place in the common triage experience of many participants. In this context, Figure 3 presents the hierarchical classification of the sub-codes under the code ‘Triage Areas’.

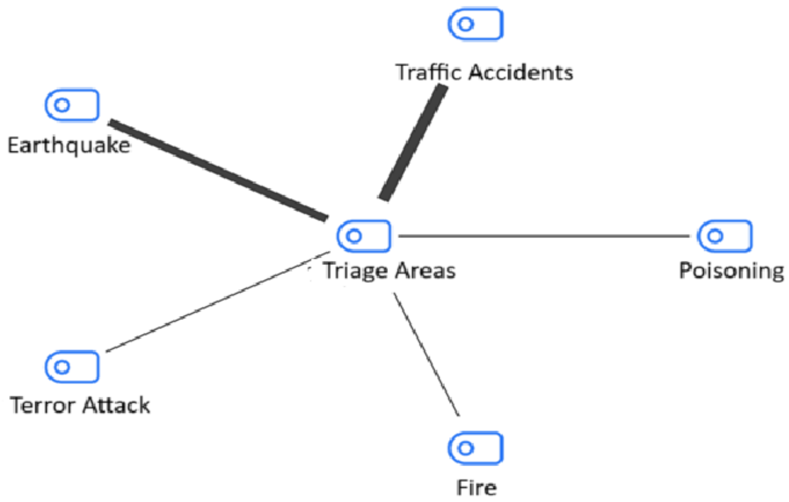

Figure 2. Hierarchical Code-Subcode Model for Triage Areas (Code-1)

Participants stated that the triage process in earthquake zones has become even more complex due to the widespread geographical spread of injured people, infrastructure destruction, power outages, harsh weather conditions, and staff shortages. Participants stated that classical triage protocols often become inapplicable in earthquakes, making it difficult to make quick decisions in a chaotic environment. As reported by P14, pragmatic strategies such as separating the walking wounded by voice command were used.

Participants also had experience with triage in fire, terrorism, and poisoning incidents, but they stated that smaller-scale triage practices could generally be implemented in these types of incidents. They stated that it has been implemented in examples such as the Çorlu train accident (P13) and the Istanbul Atatürk Airport terrorist attack (P3).

Code 2: Difficulties of Triage

The second main code, 'Challenges of Triage', was analyzed through five main sub-factors affecting the sustainability of the practice in the field. These are: (1) Public Approach, (2) Communication Problems between Personnel, (3) Environmental Safety, (4) Environmental Factors, and (5) Limitation of Facilities. This code-subcode structure is presented systematically in Figure 4 below.

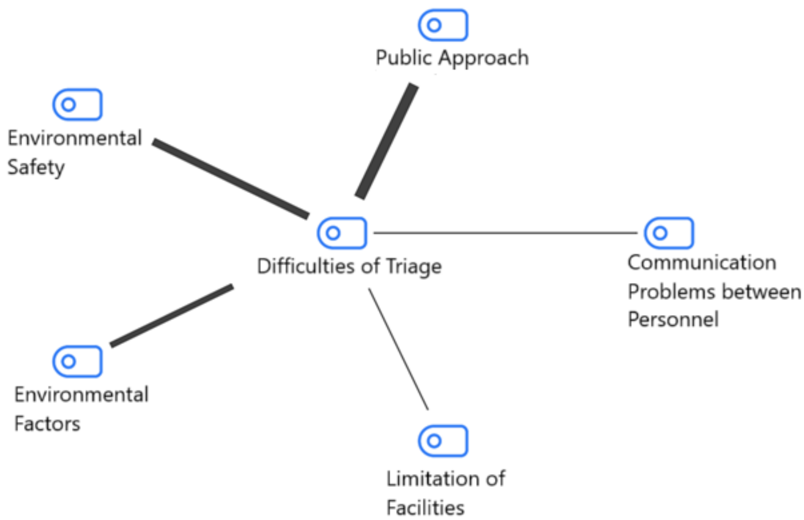

Figure 3. Hierarchical Code-Subcode Model for Difficulties of Triage (Code-2)

The most commonly expressed difficulty was the approach of the public. The main factors that interrupted the process were the lack of acceptance of triage decisions by disaster victims or their relatives and their pressure on health personnel, especially in cases classified with code green or code yellow. Participants stated that the lack of public awareness of disasters and impatience and panic behaviours prevented the methodological implementation of triage (e.g., P12, P16, P25).

> *"The patient's relative asked me, My child is feeling unwell. 'Why did you color it green?" We tried to explain, but he would not listen."* (P12)

Environmental factors, especially harsh weather conditions and nighttime darkness, make it impossible to use physical materials (such as triage cards).

> *"It was raining at night, the card got wet, the writing was erased, and we could barely look at it even with a flashlight."* (P21)

He demonstrated that harsh weather conditions, darkness, and physical materials (such as triage cards) made triage difficult. Environmental factors, especially natural conditions such as rain, snow, cold, and darkness, make it almost impossible to use physical triage cards (P21, P20, P18). In addition, since the priority of teams under threat due to environmental safety, fire, aftershock, and armed conflict is to ensure their own safety, triage can be put on the back burner (P3, P9, P19).

Code 3: Reasons for Failure to Perform Triage in a Disaster Environment

Under this code, situations where triage could not be performed at all or could only be performed symbolically were analyzed. This structure was systematized with four sub-codes: (1) Chaos, (2) Seasonal Conditions, (3) Insufficiency of Personnel, and (4) Qualification of Personnel. The code-sub code relationship is presented in Figure 5.

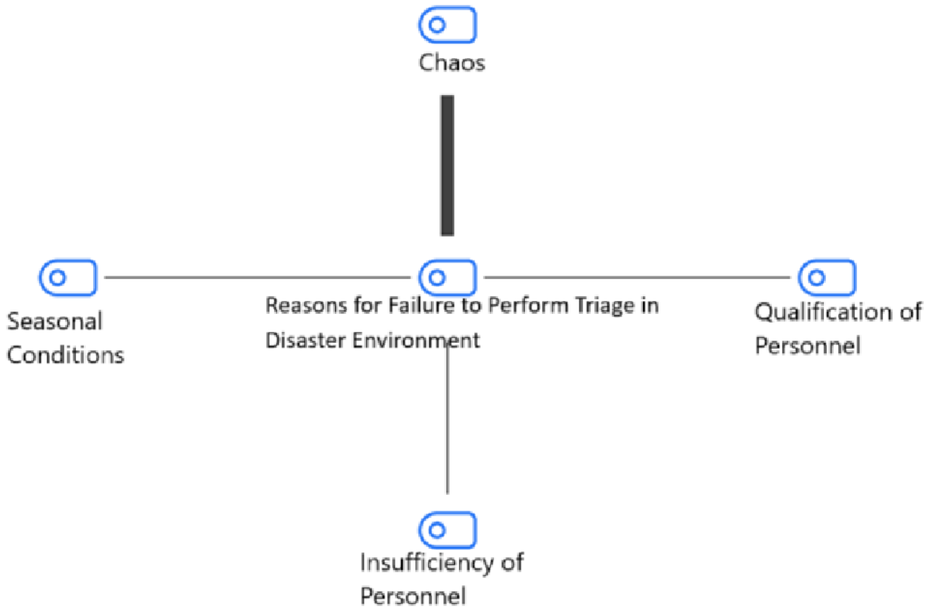

Figure 4. Hierarchical Code-Subcode Model for Reasons for Failure to Triage in Disaster Environment (Code-3)

The most frequently mentioned reason was chaos. The participants stated that panic in the disaster environment, agitated behavior of the relatives of the patients, escape of the wounded, and physical/verbal interventions against the healthcare personnel made triage impossible. Disconnection with command-and-control centers, late arrival of security forces to the scene, and the possibility of a second disaster (explosion, aftershock, etc.) reinforce this situation (P1, P6, P10, P12).

Seasonal conditions posed a significant obstacle, particularly during the winter months, following the Kahramanmaraş and Van earthquakes. The inadequacy of light, wetting of the cards, and decreased physical resistance of the personnel reduced the feasibility of triage (P5, P14, P17). In some cases, it has been observed that triage cannot be performed entirely or can only be performed in a limited way.

> *"It was so crowded that we could not distinguish who was the patient and who was their attendant. A child was running away, someone was screaming, someone was fainting... we could not triage."* (P10)

It clearly demonstrated how the chaotic atmosphere at the scene disrupted decision-making processes. Winter conditions also directly affect triage.

> *"We could not write the cards; there was chaos and confusion, and there was no light anyway"* (P5)

The lack of personnel often causes first responders to carry out only transport, putting triage on the back burner.

> *"We did not have time to do triage; we had to leave directly when the ambulance was full." (P6)*

It is also noted that staff who lack triage training or have limited experience in crisis management have difficulty making quick decisions. It is also noted that staff who lack triage training or have limited experience in crisis management struggle to make quick decisions.

> *"He was a recent graduate, did not know what to do, was on the verge of tears, and wrote on his triage card that he was having difficulty with triage."* (P14)

Theme 2. Disaster Software System

The effectiveness of information management in disaster and multiple injury scenarios is decisive in terms of both coordination of health services and safe monitoring of the injured. In this context, in line with Code 1: Contributions of Disaster Software System Implementation, the participants agreed that digitalization offers significant advantages regarding speed, security, and traceability in field operations. One of the participants expressed this situation as follows:

> *"The card is lost, it may fall... it is difficult to try to fill it with a pen in this environment. Filling triage through the software is beneficial both in terms of not losing records and speed."* (P4)

While this opinion clearly reveals the physical difficulties of traditional triage cards, it also shows how functional software-based systems are regarding record security and processing speed. Similarly, the facilitating effect of the digital system on access to patient relatives was also emphasized:

> *"Since a QR code will be given, identification can be provided very easily."* (P19)

Thus, digital software enables data recording, communication, and organizational coordination.

Code 1: Contributions of Disaster Software System Implementation

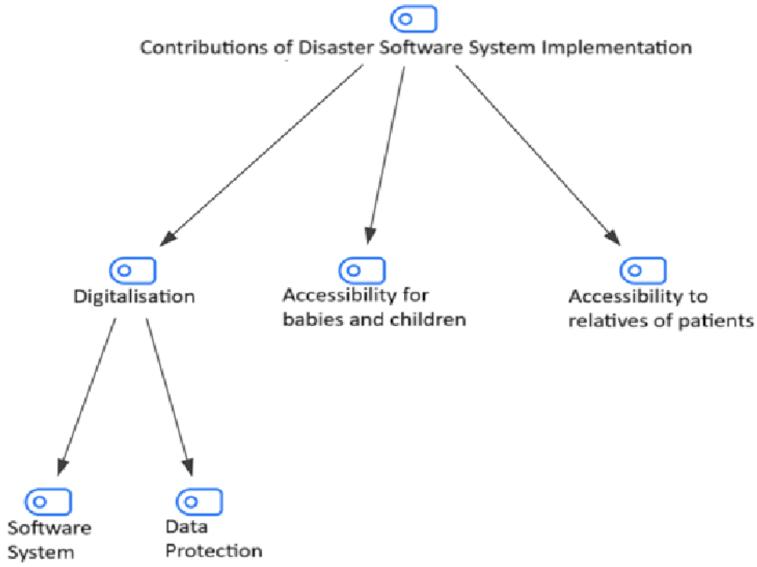

Figure 5. Contributions of the Disaster Software System Application (Code-1) Hierarchical Code-Subcode Model

Code-2: Advantages and Disadvantages of Using Software Applications

Findings Related to Advantages

Most participants stated that the disaster software system offered numerous benefits in terms of time, information security, and patient monitoring during field intervention processes. In particular, emphasis was placed on the importance of functions such as streamlining the intervention process, facilitating registration and identification processes, integrating biometric data (including photographs and fingerprints), ensuring personnel safety, and coordinating work with official institutions. In addition to these advantages, the software system's effect in accelerating response processes is clearly highlighted in Code-2: Advantages and Disadvantages of Using the Software Application.

"Tracking patients using QR codes is very useful. The fact that every hospital the patient visits can scan this code makes it easier to access the interventions performed." (P5)

The statement (P5) emphasizes the need for the software to have a systematic structure in terms of patient monitoring. Digital identification provided by the software is crucial in preventing information loss and reducing the workload of healthcare personnel, particularly for unconscious individuals or infants and pediatric patients.

‘It seems very useful for monitoring infants who cannot express themselves and unconscious patients' (P3).

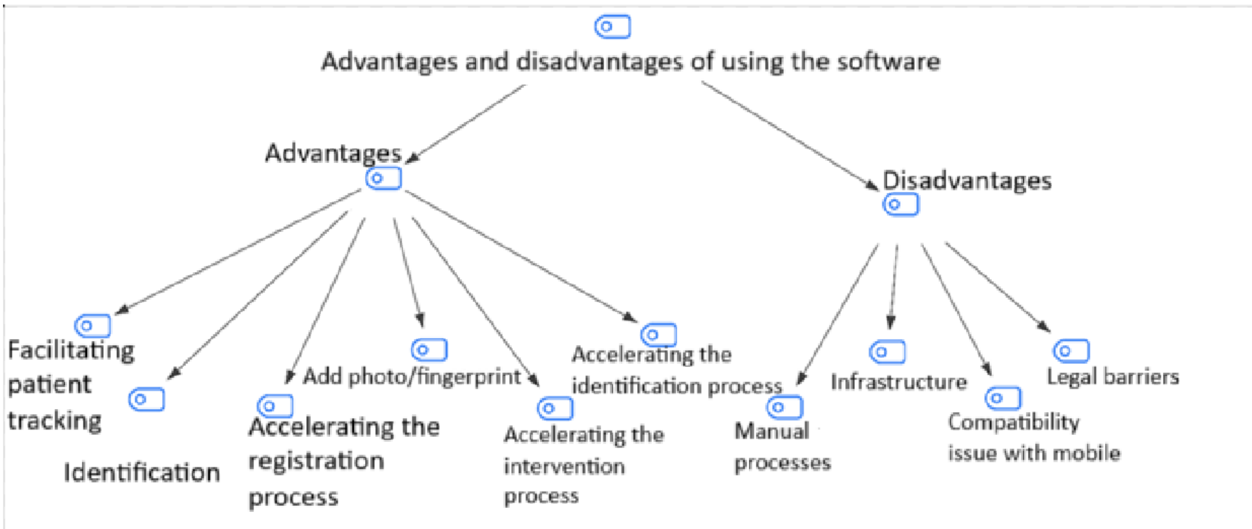

Figure 6. Code-2: Advantages and disadvantages of using disaster software systems

Findings Related to Disadvantages

Participants stated that the need for manual data entry, the lack of a voice recording system or ready-made button options, uncertainties in legal regulations, and internet outages in disaster environments make it difficult for healthcare personnel to enter data quickly in the field (P9, P14, P25). Participants noted that filling out description fields can be time-consuming in some cases and suggested simplifying text fields or increasing the number of dropdown menus (P4, P6, P7, P10). In addition, the lack of clear procedures regarding the legal collectability of sensitive data such as fingerprints, facial recognition information, or photographs is another important disadvantage that could limit the system's widespread use (P5, P7, P9, P11).

> *“Not having the information appear automatically when we enter the patient's name makes our work difficult.”* (P6)

> *"The lack of a fingerprint recognition system seems to be a disadvantage, but this could be resolved if legal issues related to this can be addressed in the event of a disaster."* (P25)

> *‘If there is a voice recording system, we can record every patient we reach during the initial chaos of a disaster.’’* (P1)

The participants highlight the need to develop voice systems to counteract the time-consuming nature of manual data entry. Despite all these disadvantages, participants indicate that the current shortcomings can be addressed if the software system is developed (P11, P14, P18). In this context, the recommendations outlined in the following subsection under Code-3 provide comprehensive solutions for improving the system.

Code-3: Recommendations for Improving the Effectiveness of Software Applications

The most critical recommendation emphasized by the participants was integrating the software with MERNIS. This would enable the system to automatically retrieve personal and demographic information by entering basic information such as Turkish ID number, name, and surname (P9). This integration would significantly reduce data entry time, increase record security, and minimize manual errors (P9, P11, P18). Additionally, a software system capable of operating in real-time with health information systems and family medicine databases would ensure that critical information, such as chronic conditions or medication allergies, is quickly accessible on-site (P18).

In this regard, participants in the Code-3: Recommendations for Improving the Effectiveness of Software Applications produced a series of solutions recommending the development of the software system at both the technical and organizational levels. One of the most frequently emphasized recommendations was the system's automatic retrieval of identity information through MERNIS integration (P3, P15).

> *"By connecting to MERNIS, it would be very effective for information to be automatically retrieved using the patient's first and last name or Turkish ID number."* (P14)

It is important in reducing manual workload and increasing data security.

> *"If a voice recording system is added, data can be recorded vocally instead of being entered manually."* (P6)

> *“Fingerprint collection would be useful; the patient’s identity could be identified using the fingerprint sent to the file.”* (P14)

There were indications of technological additions that would enable the system to be used more quickly and effectively in the field.

> *"If there is a page containing a sample of deoxyribonucleic acid (DNA), it will be easier to identify individuals whose identities cannot be determined from the debris."* (P22)

It indicates that the software should be used not only for live survivors but also for identifying unidentified missing persons (P22). Of course, the feasibility of these recommendations largely depends on the KVKK and similar legal regulations.

> *"Legal barriers should be redefined in the context of disasters."* (P2)

Another proposal that could speed up the biometric verification process is a fingerprint reading system to identify individuals who are unconscious, unaccompanied, or whose identity cannot be determined (P6, P8, P12, P19). Participants stated that legal barriers like KVKK should be eased in extraordinary disasters (K14, K25).

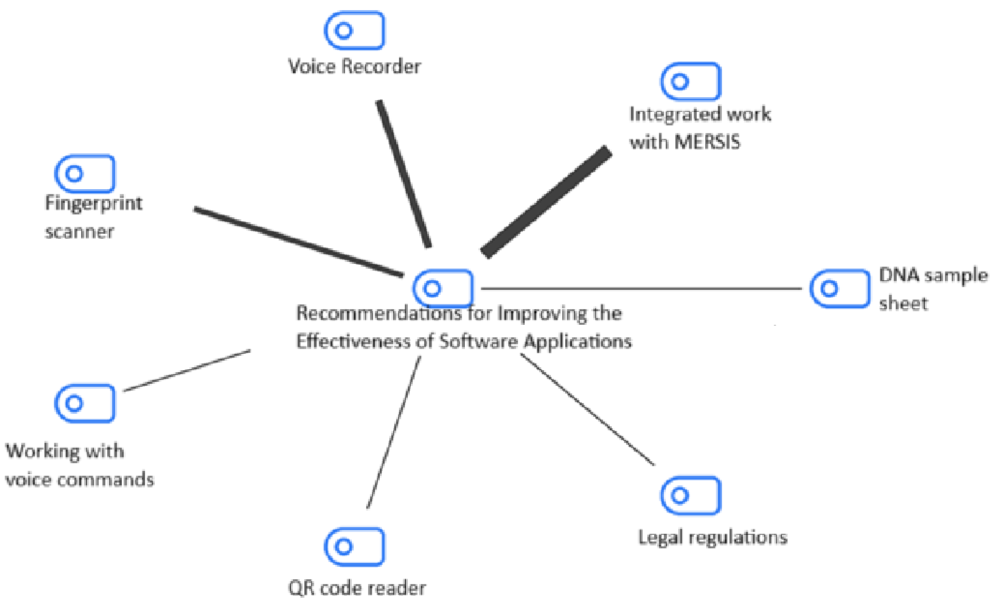

Figure 7. Code-3: Recommendations for Improving the Effectiveness of Software Applications

Additionally, converting this data into text using AI-supported voice recognition systems will simplify file archiving (P13, P27, P24).

Integrating QR code or barcode reader systems to identify injured persons and record medical supplies is another recommendation that enhances record integrity and reduces incorrect interventions (P11, P18, P20). Participants stated that the patient's file could be created chronologically by automatically recording the name, dose, and time of medication administration (K17, K19, K23).

In particular, creating a DNA-based page has been recommended in fatal disaster scenarios where identification is impossible (P16). It has been stated that samples taken from this page could be used in subsequent identification operations.

DISCUSSION

This research aims to deeply examine the contributions of the developed software in field applications and the triage experiences of healthcare personnel. The disaster software system supports triage in disaster identification, patient tracking, increasing response speed, and ensuring data security. Its integration with modules such as QR codes, fingerprints, photographs, and location information both alleviates the workload of healthcare personnel and increases the accuracy of patient information. The findings of this study show that first responders in disaster and multiple casualty settings are exposed to numerous social, environmental, organizational, and psychological variables while conducting triage, in addition to clinical decision algorithms. Firstly, participants most frequently reported traffic accidents under the 'triage areas' code, reflecting the pre-hospital emergency healthcare services' logistical and time-constrained nature. Our study shows that triage can occur more regularly in small-scale (5-6 injured) accidents, while public pressure and security deficiencies disrupt the process in large-scale incidents. The critical role of crowd management and scene safety after traffic accidents also indirectly confirms that the 'dynamic ambulance relocation' models can improve response times and safety at the scene (Becker et al., 2023).

Our findings indicate that triage becomes more complex in earthquake scenarios. The fact that the affected region in the Kahramanmaraş earthquakes spanned 11 provinces, coupled with the emphasis on the inability to apply standard triage algorithms due to lighting, climate, and transportation barriers, supports the finding by Van et al. (2022) that 'prolonged scene duration increases morbidity' in populations with multiple injuries. In our study, participants brought up pragmatic strategies such as separating those who can walk with verbal commands.

The fact that the most dominant subcode in the 'challenges of triage' theme was the public's approach concretizes how the lack of disaster awareness reduces triage efficiency. Low risk perception and disaster awareness in the community delay intervention. At the same time, the high rate of 'inappropriate visits' to emergency services, even during the pandemic, indicates a lack of public education. Our finding that the public's resistance to triage decisions, especially in the case of green-yellow codes, turns into pressure to 'take us first,' is one of the main triggers of violence against healthcare workers in the field. At this point, it can be argued that the 'social resilience' programs based on disaster education could directly contribute to the triage process (Saja et al., 2020).

Environmental factors (rain, cold, darkness) and physical triage cards becoming wet and unreadable were frequently highlighted as difficulties in our study, pointing to the necessity of using RFID or QR code-based digital cards. An RFID-based triage system reduced form errors by 40% in simulations, and a QR code-based early intervention study significantly increased field speed. Thus, our findings reinforce the call for digitalization in the literature, supported by practical field observations (Bao et al., 2022).

'Inability to triage in disaster settings' is primarily attributed to chaos and personnel shortages. The low number of ambulance crews in low-income countries directly affects mortality rates. In Turkey, the imbalance between the number of crew members and patients is associated with burnout and a decline in the quality of care (Setyawati & Lu, 2025).

The impact of seasonal conditions on triage was highlighted by Carenzo et al. (2024), who emphasized an increase in mortality during winter earthquakes. The findings of the second theme of the study, 'Disaster Software System,' show a high level of consistency with national and international data regarding the support provided by digital solutions for triage.

Participants' observations on the benefits of QR codes, fingerprints, photos, and location integration. Ambulance-emergency service integration reduced errors in patient handover. In particular, our recommendation for QR code-enabled wristbands for infant/child losses focuses on resolving post-disaster child abduction cases with data privacy protection. However, the infrastructure and legal gaps identified in the disadvantages section are fundamental barriers highlighted in the literature (Lovell et al., 2022). RFID use is limited in intermittent GSM networks. At the same time, there is a 'legal tension' between protecting personal data (similar to the KVKK regulations) and rapid information sharing during disasters. Participants' request for MERNIS integration aligns directly with 'big data in healthcare.' At the same time, the proposal for a fingerprint module supports the forensic-medical importance of primary identification methods in mass disasters. The request for a DNA page add-on also stands out as a requirement that localizes the ‘last resort identification’ approach of the INTERPOL DVI Guide.

The need for a voice command and AI-based recording module is parallel, indicating that keyboard use in emergency services causes time loss. The mobile device compatibility issue also proves that different hardware and operating systems cause delays (Bajwa, 2025). Our study predicts that addressing these shortcomings will significantly enhance the software's contribution to response times, as supported by field data showing a 25% reduction in response times for the YOLOv8-based ambulance detection system. In this regard, our research validates the multidimensional fragility of triage applications and the potential balance of benefits and obstacles in digital support solutions, compared with the extensive literature evidence base. The obtained data highlight the need for (i) the rapid implementation of widespread education programs to enhance public disaster literacy, (ii) the implementation of mobile-offline capable digital triage modules that can synchronize in real-time with MERNIS and health databases, (iii) addressing legal gaps between personal data protection and disaster urgency through KVKK-compliant special regulations, (iv) the mandatory strengthening of field personnel through regular simulations focused on digital systems and crisis communication. Unless this comprehensive approach is adopted, the mortality and morbidity risks repeatedly highlighted in the literature may be exacerbated by Turkey’s unique sociocultural challenges, thereby hindering the full realization of the vital role of digitalization and triage in healthcare.

CONCLUSION

The research findings revealed that the disaster software system and triage functioned in a complementary manner in the field; however, numerous obstacles were encountered, including environmental, technical, personnel, and legal challenges. It is also clear that triage practices face many challenges in the field. According to research findings, the most common problems are public intervention and a lack of disaster awareness. It has been observed that relatives of patients, especially those who have not been given a red code, put pressure on healthcare personnel, question triage decisions, and sometimes resort to physical or verbal intervention.

While disaster software systems and triage practices are complementary, implementing them in the field faces significant challenges. Triage is hindered by public interference (especially from relatives of non-priority patients), environmental hazards (such as darkness and inclement weather), and logistical failures (including communication breakdowns and staffing shortages). Conversely, digital disaster software offers transformative potential, significantly improving patient tracking, identification (especially for vulnerable/unconscious individuals via QR codes/biometrics), response times, and data security. Key enhancements—such as integration with national ID/health systems (e.g., MERNIS), voice commands, and supply tracking—could further optimize the system. However, successful adoption requires addressing technical limitations and ensuring legal compliance with data security regulations, while adapting flexibly to disaster realities.

REFERENCES

Ajemu, K. F., Hadgu, T., Gebreegziabher, G., Ayele, B., Gebretnsae, H., Desta, A. A., & Kahsay, H. (2024). Conflict and fragmented public health emergency management system in Tigray region of Northern Ethiopia: A double burden to accommodate resilient and advanced public health emergency management. A commentary review for policy-makers and a call to action. *Health Research Policy and Systems*, *22*(1), 121. https://doi.org/10.1186/s12961-024-01176-w

Alghamdi A. A. (2022). The Psychological Challenges of Emergency Medical Service Providers During Disasters: A Mini-Review February 2022. *Frontiers in psychiatry*, *13*, 773100. https://doi.org/10.3389/fpsyt.2022.773100

Atalay, E., Gündüz, F., Aslan, R., & Usta, G. (2024). Informing the Public on Disaster Management: Evaluation of the Disaster and Emergency Management Presidency (AFAD) Press Releases. *Abant Sosyal Bilimler Dergisi*, *24*(2), 747-761. https://doi.org/10.11616/asbi.1454770

Bajwa, A. (2025). AI-based emergency response systems: A systematic literature review on smart infrastructure safety. *Available at SSRN 5171521*. https://dx.doi.org/10.2139/ssrn.5171521

Bao, H., Zeng, C., Peng, Y., & Wu, S. (2022). The use of digital technologies for landslide disaster risk research and disaster risk management: progress and prospects. *Environmental Earth Sciences*, *81*(18), 446. https://doi.org/10.1007/s12665-022-10575-7

Becker, J., Kurland, L., Höglund, E., & Hugelius, K. (2023). Dynamic ambulance relocation: a scoping review. *BMJ open*, *13*(12), e073394. https://doi.org/10.1136/bmjopen-2023-073394

Baghestani, A. R., Ahmadi, F., Tanha, A., & Meshkat, M. (2017). Bayesian critical values for Lawshe's content validity ratio. *Measurement and Evaluation in counseling and development*, *52*(1), 69-73. https://doi.org/10.1080/07481756.2017.1308227

Berawi, M. A., Leviäkangas, P., Siahaan, S. A. O., Hafidza, A., Sari, M., Miraj, P., Harwahyu, R., & Saroji, G. (2021). Increasing disaster victim survival rate: SaveMyLife Mobile Application development. *International Journal of Disaster Risk Reduction*, *60*, 102290. https://doi.org/10.1016/j.ijdrr.2021.102290

Carenzo, L., Gamberini, L., Crimaldi, F., Colombo, D., Ingrassia, P. L., Ragazzoni, L., ... & Caviglia, M. (2024). Factors affecting the accuracy of pre-hospital triage application and pre-hospital scene time in simulated mass casualty incidents. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *32*(1), 97. https://doi.org/10.1186/s13049-024-01257-3

Faizatiwahida, N., & Andani, K. (2025). The Role Of Digital Technology In Supporting Disaster Emergency Response: Literature Review. *Proceedings OPTIMAL*. https://doi.org/10.5281/zenodo.15950552

Hammami, S., & Jebali, A. (2021). Designing modular capacitated emergency medical service using information on ambulance trip. *Operational Research*, 21(3), 1723–1742. https://doi.org/10.1007/s12351-019-00458-4

Konrad, R., Schuster, D., & Heppner, H. (2025). Healthcare assessment tools—A valid source of data for pre-hospital care? Usability for ensuring medical care in the event of a disaster. *Frontiers in Public Health*, *12*, 1409371. https://doi.org/10.3389/fpubh.2024.1409371

Lindquist, A., Al-Azzawi, R., Risør, T., & Raatiniemi, L. (2025). Factors influencing the pre-hospital management of civilian burn mass casualty incidents in the 21st century: a scoping review. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *33*(1), 74. https://doi.org/10.1186/s13049-025-01380-9

Liu, K. (2022). GIS-based MCDM framework combined with coupled multi-hazard assessment for site selection of post-earthquake emergency medical service facilities in Wenchuan, China. *International Journal of Disaster Risk Reduction*, *73*, 102873. https://doi.org/10.1016/j.ijdrr.2022.102873

Lovell, D., Vella, K., Muñoz, D., McKague, M., Brereton, M., & Ellis, P. (2022). Exploring technologies to link better physical evidence and digital information for disaster victim identification. *Forensic Sciences Research*, *7*(3), 467-483. https://doi.org/10.1080/20961790.2021.2023418

Park, J. Y. (2021). Real-Time Monitoring Electronic Triage Tag System for Improving Survival Rate in Disaster-Induced Mass Casualty Incidents. *Healthcare*, *9*(7), 877. https://doi.org/10.3390/healthcare9070877

Rinkinen, T., Kinnula, M., & Nordquist, H. (2024). Technological development roles and needs in pre-hospital emergency care from the advanced level paramedics' perspective. *International Emergency Nursing*, *73*, 101406. https://doi.org/10.1016/j.ienj.2024.101406

Saja, A. A., Teo, M., Goonetilleke, A., & Ziyath, A. M. (2020). Assessing social resilience in disaster management. *International Journal of Disaster Risk Reduction*, *52*, 101957. https://doi.org/10.1016/j.ijdrr.2020.101957

Sarı, B. (2021). Evaluation Of Inter-Institutional Coordination In Disaster Management. *Hastane Öncesi Dergisi*, *6*(3), 393-406. https://doi.org/10.54409/hod.979044

Sert, H., Baris Horzum, M., Gulbahar Eren, M., Pelin, M., & Ucgul, K. (2024). The disaster of the century, Kahramanmaras earthquake: A qualitative study on the experiences of the earthquake victims and search and rescue teams. *International Journal of Disaster Risk Reduction*, *107*, 104462. https://doi.org/10.1016/j.ijdrr.2024.104462

Setyawati, A. D. ., & Lu, Y.-Y. (2025). Triage in disasters: A conceptual analysis . *Jurnal Keperawatan Padjadjaran*, *13*(1), 97–106. https://doi.org/10.24198/jkp.v13i1.2601

Stewart, C., & Stewart, M. K. (2023). Patient Tracking Systems in Disasters. *Ciottone's Disaster Medicine (Third Edition)*, 371-379. https://doi.org/10.1016/B978-0-323-80932-0.00057-4

Teh, D., & Khan, T. (2021). Types, definition and classification of natural disasters and threat level. In *Handbook of disaster risk reduction for resilience: new frameworks for building resilience to disasters* (pp. 27-56). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-61278-8_2

Van, D. B., Song, K. J., & Kim, K. H. (2022). Association between scene time interval and survival in EMS-treated major trauma admitted to the intensive care unit: A multinational, multicenter observational study. *Pre-hospital Emergency Care*, *26*(4), 600–607. https://doi.org/10.1080/10903127.2021.1992053

Yilmaz, S., Tatliparmak, A. C., Karakayali, O., Turk, M., Uras, N., Ipek, M., Polat, D., Yazici, M. M., & Yilmaz, S. (2024). February 6th, Kahramanmaraş earthquakes and the disaster management algorithm of adult emergency medicine in Turkey: An experience review. *Turkish journal of emergency medicine*, *24*(2), 80–89. https://doi.org/10.4103/tjem.tjem_32_24

Yücel, I. (2023). Inevitable disaster for Türkiye: earthquake and nursing. *Health and Technology Journal (HTechJ)*, *1*(5), 474-478. https://doi.org/10.53713/htechj.v1i5.96