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Barriers delaying treatment in cases at risk of crush syndrome in major disasters: Kahramanmaraş earthquake experience

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Abstract

Background **Crush syndrome is a life-threatening condition in disasters, particularly earthquakes. Early fluid therapy is critical to reduce morbidity and mortality, yet disaster settings often hinder timely intervention.**

Methods **This qualitative phenomenological study explored the experiences of 20 emergency medical service personnel involved during the acute phase of the February 6, 2023 Kahramanmaraş earthquakes. Data were collected through in-depth interviews, transcribed verbatim, and analyzed using MAXQDA 2020.**

Results **Three primary treatment initiation points were identified: during extrication, after rescue at the scene, and inside the ambulance. Five key barriers to timely crush syndrome intervention emerged: (1) crowd density, (2) media interference, (3) inadequate search and rescue training, (4) lack of scene safety, and (5) resource shortages. These factors significantly delayed early fluid therapy for high-risk patients.**

Conclusions **Although emergency medical service personnel recognize the urgency of early crush syndrome treatment, operational barriers impede timely care. Integrating health-care professionals into search and rescue teams, improving inter-agency coordination, and ensuring scene safety are essential strategies for enabling earlier intervention. These findings highlight the need for targeted disaster preparedness policies addressing crush syndrome-specific response requirements.**

Keywords emergency medical care, crush syndrome, early fluid therapy, EMS

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Graphical abstract

Barriers Delaying Treatment in Cases at Risk of Crush Syndrome in Major Disasters: Kahramanmaraş Earthquake Experience

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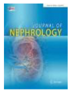
Background
Crush syndrome (CS) is a life-threatening complication after earthquakes.
Early fluid therapy is critical to prevent acute kidney injury and mortality.
Disaster conditions may delay timely initiation of treatment.

Methods
Qualitative phenomenological study.
Semi-structured interviews with 20 EMS personnel involved in the Kahramanmaraş earthquakes.
Thematic analysis using MAXQDA.

Results
Five main barriers delaying treatment were identified:
- Crowded disaster scenes,
- Media interference,
- Inadequate rescue training,
- Lack of scene safety,
- Resource shortages.

Treatment was initiated:
- under debris,
- at the scene,
- in the ambulance.

Conclusions
Operational and environmental barriers delay early fluid therapy in patients at risk of crush syndrome.
Improved coordination and integration of healthcare staff into rescue teams may enable earlier treatment.



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Introduction

Millions of people worldwide face disaster risks each year. Major disasters, particularly earthquakes, often result in severe trauma and crush injuries, significantly increasing the risk of crush syndrome.[1] Crush syndrome is defined as a systemic condition caused by crush injuries that can lead to organ dysfunction or death. In large-scale earthquakes, crush syndrome represents the second leading cause of death following direct trauma. It develops when prolonged compression of muscle tissue leads to ischemia and necrosis, releasing toxic metabolites such as potassium, phosphate, and myoglobin once the pressure is relieved. These metabolic disturbances may cause hyperkalemia, metabolic acidosis, hypocalcemia, and acute kidney injury (AKI), which, if not treated promptly, can result in multiple organ failure and death.[2,3] Therefore, early diagnosis and timely treatment are essential for achieving a favorable prognosis.[4,5]

The most effective way to reduce mortality related to crush syndrome in disasters is the rapid initiation of treatment. In addition to addressing life-threatening injuries, key treatment steps include extricating the victim, performing triage, initiating fluid resuscitation, and ensuring appropriate hospital transfer. Fluid resuscitation is particularly critical for maintaining survival and preventing kidney injury.[6,7] The strategy is based on early and aggressive fluid resuscitation, which helps to preserve renal perfusion, reduce myoglobin precipitation in renal tubules, and prevent the development of AKI.[8,9] Delayed or insufficient fluid replacement can lead to hypovolemia, life-threatening electrolyte imbalances, and progressive kidney failure.[10] Moreover, reperfusion of severely traumatized extremities during rescue operations can trigger the systemic release of toxic muscle breakdown products, resulting in fatal cardiac arrhythmias and what is known as "rescue death."[1]

Scientific studies related to crush syndrome cases associated with earthquakes have received considerable attention in the literature. However, several issues remain unresolved. During the 2023 Kahramanmaraş earthquakes in Türkiye, which caused more than 50 000 deaths and injured many thousands, numerous crush syndrome cases were observed.[11] Approximately 10% of victims trapped under debris experience crush injuries, and 40%–70% of these patients develop crush syndrome.[1] Although early initiation of treatment is a widely accepted principle, disaster-specific conditions such as resource scarcity often hinder timely intervention. Consequently, essential treatments such as fluid replacement, and hemodialysis may not be initiated promptly.[12]

Numerous factors can delay the timely initiation of treatment in large-scale disasters. These include resource scarcity, infrastructure collapse, difficulties in accessing trapped victims, and coordination gaps among health-care teams. Such conditions highlight the need for rapid decision-making among health-care professionals working in disaster environments.[7] Under these circumstances, where resources are severely limited, health-care providers are frequently required to adapt and modify standard protocols to meet situational demands.

Given the vast geographic scope of the disaster and the large number of victims who suffered crush injuries under the debris simultaneously, varying experiences were expected regarding resource management and the initiation of early fluid therapy. In this context, the Kahramanmaraş earthquakes represent a unique example in the field of disaster medicine for understanding

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resource allocation and intervention priorities. This study aims to explore the barriers that delayed treatment in cases at risk of crush syndrome during the February 6, 2023, Kahramanmaraş earthquakes—an event that holds a significant place in global disaster history—through the experiences of pre-hospital emergency medical services (EMS) personnel.

In the literature, both quantitative[13,14] and qualitative[15–17] studies focusing on crush syndrome during earthquakes are available. These studies investigate the impact of early fluid therapy on AKI and mortality, as well as the logistical and operational challenges encountered during disaster response. However, there is limited research directly examining the factors that lead to delays in initiating early fluid resuscitation in crush syndrome cases.

Considering the increasing frequency and severity of natural disasters, the present study is expected to contribute to shaping future large-scale disaster response organizations. A qualitative research design was used to explore the perceptions and experiences of emergency medical service personnel regarding early fluid resuscitation and treatment initiation under resource-limited conditions during the 2023 Kahramanmaraş earthquake.

Methods

Research design

This study employed a qualitative methodology with a phenomenological design to explore the lived experiences of emergency medical service personnel involved in disaster response.[18] Data were collected through semi-structured interviews, an effective method for capturing participants' emotions, thoughts, and experiences.[19] In phenomenological research, it is essential that participants have directly experienced the phenomenon under investigation.[18] Semi-structured interviews provide flexibility within a guided framework, allowing the interviewer to adapt questions based on participant responses.[20] All interviews were conducted via Microsoft Teams and lasted approximately 30–45 minutes. Verbal informed consent was obtained prior to each session. The interview form consisted of demographic questions followed by open-ended items aligned with the study objectives. Clarification probes such as "Did you mean to say this?" were used when necessary to ensure accurate interpretation.

The interviews were conducted after obtaining approval from the institutional ethics committee, and the data collection process lasted approximately 1 month. To prevent researcher fatigue and ensure the preservation of data quality, interviews were limited to 2 participants per day.

Participants

Inclusion and exclusion criteria

The inclusion criteria comprised emergency medical services personnel who actively served during the first 3 days of the Kahramanmaraş earthquakes, intervened in cases with a high risk of crush syndrome, and voluntarily agreed to participate in the study. The exclusion criteria were individuals who did not serve during the acute phase, did not intervene in treating patients at risk of crush syndrome, declined participation, failed to respond to the email invitation, or were unable to complete the interview.

Population and sample

The study population consisted of 497 emergency medical service personnel who were members of the Emergency Medicine Technicians and Paramedics Association and who served during the acute phase of the Kahramanmaraş earthquakes. The participants came from different provinces across Türkiye to the 11 affected disaster regions. A total of 497 invitation emails containing information about the study and the inclusion criteria were distributed, and 36 individuals responded and agreed to participate. During preliminary screening, 4 respondents were found not to have served during the first 3 days of the earthquakes and were excluded from the study. Interviews were subsequently scheduled with the remaining eligible participants . Data saturation was reached after 20 interviews, at which point no new information, codes, or themes emerged from participants' responses, and interviews were therefore discontinued.[21] The 12 eligible respondents who were not interviewed were re-contacted via email and informed that the data collection process was concluded and no additional participation was required. Furthermore, a follow-up email was sent to the 461 individuals who did not respond to the initial invitation, notifying them that the study had been completed.

Sampling method

Criterion sampling, a subtype of purposive sampling, was employed to identify participants with direct experience relevant to the study's objectives. This approach enables an in-depth exploration of specific phenomena based on predetermined eligibility criteria. Although purposive sampling does not allow for statistical generalization, it ensures the richness and contextual relevance of qualitative data.[22] Emergency medical service personnel who intervened in crush syndrome cases during the disaster and consented to participate were included. Data saturation was reached with 20 participants, whose demographic and professional characteristics are summarized in Table 1.

Data analysis

All findings were presented without interpretation, and audio recordings were obtained during the interviews to prevent data loss and enhance internal reliability. The recordings were transcribed verbatim and analyzed using MAXQDA 2020 (Verbi Software, Berlin, Germany) software. Transcription facilitated a more structured and systematic analysis of qualitative data.[23] The coding process aimed to distill the raw data into its essential meanings, identify the underlying phenomena, and establish a coherent chain of evidence.[24,25] Four researchers with expertise in emergency medical service and disaster response independently coded the data. Themes were developed through collaborative discussions to ensure consensus and strengthen the study's reliability and validity.

Trustworthiness

In qualitative research, ensuring the credibility, transferability, dependability, and confirmability of findings is essential.[22] To enhance credibility, consensus was reached among researchers during the development of interview questions, which were also reviewed by 2 independent experts for clarity and readability. Open-ended questions in the semi-structured interviews allowed

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participants to express their views freely, minimizing researcher influence and strengthening the authenticity of responses.[26] Participant statements were restated during interviews to confirm understanding and clarify potential ambiguities. Before each interview, participants received a detailed explanation of the study's purpose and process, fostering a natural and open dialogue. A limitation of this study was the absence of data triangulation, as interviews were the sole data source.[27] Transferability was supported by clearly outlining the research design, participant selection, and data collection and analysis procedures, ensuring coherence with the study's objectives.

Results

This study gathers in-depth interviews with 20 emergency medical service personnel who served during the February 6 Kahramanmaraş earthquakes to explore barriers delaying treatment initiation for patients at risk of crush syndrome. Two main themes emerged: (1) location of treatment initiation, and (2) factors affecting treatment delay, with 5 sub-themes under the second theme: (i) presence of crowd, (ii) media influence, (iii) lack of knowledge and equipment among rescue personnel, (iv) inadequate scene safety, and (v) resource shortages.

Location of treatment initiation:

Participants agreed on the importance of early intervention but identified three potential stages for initiating treatment: during extrication, immediately after rescue, or inside the ambulance (Figure 1). Ideally, fluid therapy should begin during the rescue operation.[6] However, practical challenges often caused delays. Some participants reported administering fluids while the patient was still trapped, whereas others had to wait until safe extrication or transfer to the ambulance. Safety concerns frequently determined the timing of interventions, emphasizing the need for flexible and context-sensitive disaster response protocols.

"*When sufficient safety precautions were taken, we initiated fluids under the debris. If we could safely access the patient, we applied treatment immediately*" (P17).

"*Once search and rescue teams handed over the patients, we initiated treatment inside the ambulance and continued intervention during transfer*" (P12).

"*Fluid therapy was initiated after the patients were removed from the debris and then transferred to the ambulance*" (P11).

"*In one case, we intervened during the rescue operation; in another, due to scene chaos, we had to wait and initiate intravenous access in the ambulance after extrication*" (P1).

"*Because of safety concerns and the fact that patients were brought to us by other teams, we could only start treatment in the ambulance en route to the field hospital*" (P9).

Factors affecting the time to initiate treatment:

Participants identified several factors that affect the time to initiate treatment, including crowds of people in the vicinity, media

Table 1 Descriptive characteristics of the participants.

Participant	Job	Years of professional experience	Education level	Time to reach the scene	Field of duty	Number of patients treated	Interview duration with participant (min.)
P1	Paramedic	2 years	Associate's degree	Day 3	Ambulance	2	35
P2	Paramedic	1 year	Associate's degree	Day 1	Ambulance	1	30
P3	Paramedic	4 years	Bachelor degree	Day 2	Rubble area	2	34
P4	Paramedic	2 years	Associate's degree	Day 2	Ambulance	1	41
P5	Paramedic	4 years	Associate's degree	Day 3	Rubble area	+3	36
P6	Paramedic	2 years	Associate's degree	Day 2	Rubble area	2	45
P7	Paramedic	4 years	Bachelor degree	Day 3	Ambulance	1	42
P8	Paramedic	4 years	Bachelor degree	Day 2	Rubble area	2	31
P9	EMT	12 years	Bachelor degree	Day 2	Ambulance	+3	44
P10	Paramedic	2 years	Associate's degree	Day 2	Ambulance	1	35
P11	Paramedic	5 years	Bachelor degree	Day 2	Rubble area	2	37
P12	Paramedic	5 years	Associate's degree	Day 3	Ambulance	+3	43
P13	Paramedic	5 years	Bachelor degree	Day 2	Ambulance	+3	33
P14	Paramedic	3 years	Associate's degree	Day 3	Ambulance	1	39
P15	Paramedic	2 years	Associate's degree	Day 2	Ambulance	2	45
P16	EMT	13 years	Bachelor degree	Day 1	Rubble area/Ambulance	+3	37
P17	Paramedic	5 years	Associate's degree	Day 1	Rubble area/Ambulance	+3	41
P18	EMT	10 years	Bachelor degree	Day 1	Rubble area	+3	34
P19	Paramedic	2 years	Associate's degree	Day 1	Ambulance	2	38
P20	Paramedic	3 years	Associate's degree	Day 1	Ambulance	+3	43

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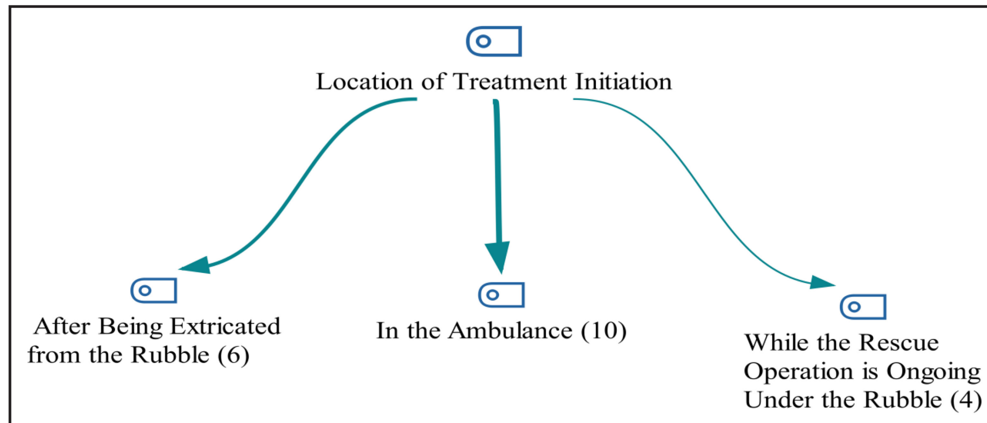

Figure 1 Hierarchical sub-code and main code themes related to the theme of location of treatment initiation.

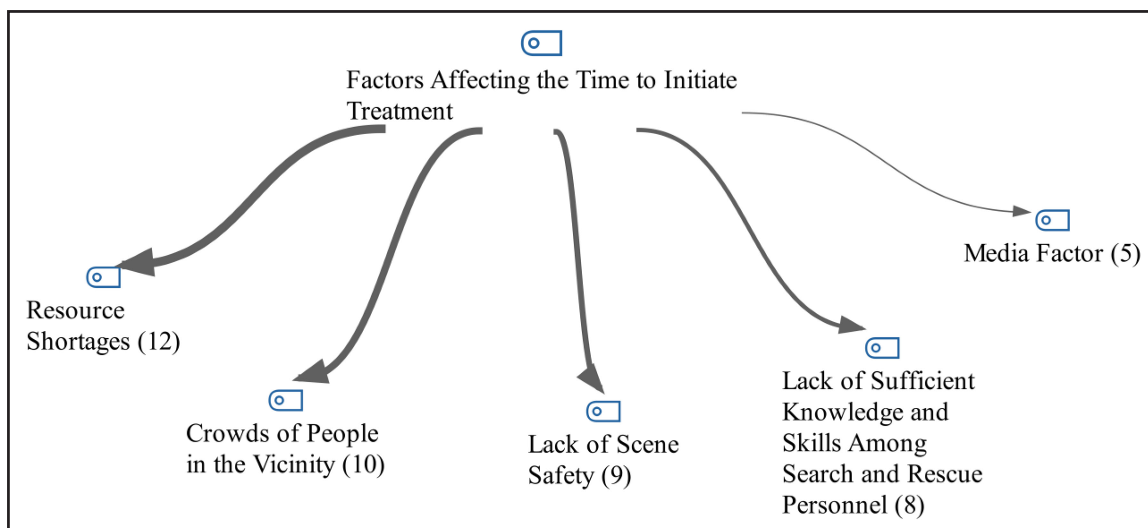

Figure 2 Hierarchical sub-code and main code themes related to the theme of factors affecting the time to initiate treatment.

factors, insufficient knowledge and equipment among search and rescue personnel, and the lack of scene safety (Figure 2).

Crowds of people in the vicinity:

In disaster settings, large crowds often obstruct health-care access and delay interventions. Participants highlighted that crowds and uncoordinated teams created major barriers:

> "*Among the factors delaying treatment, the primary issue was the excessive crowd of people in the area. Our workspace needed to be more manageable so that we could perform our duties effectively. However, due to the overwhelming crowd, there were delays in treatment in some cases*" (P17).

> "*There were many intervention teams at the scene, especially those formed by NGOs. We often had conflicts with these teams whose competencies we were not fully aware of. Despite our aim to provide swift intervention to patients, the chaos at the scene sometimes prolonged the intervention time*" (P18).

Media factor:

Media platforms play a crucial role in facilitating coordination, disseminating information, and enhancing communication among stakeholders during disaster response operations. However, some participants in this study reported that certain rescue organizations prioritized media visibility over patient care, leading to delays in emergency medical interventions.

> "*When a patient was extricated from the rubble, some rescue teams wanted to carry the patient to the ambulance themselves due to concerns about being visible in the media. They sometimes withheld the patient, delaying our ability to start treatment by two or three minutes*" (P16).

> "*During the rescue and intervention, despite our objections, some rescue teams insisted on taking photos or recording videos. There were even arguments about posing while carrying the patient. We tried to manage the situation just to get the patient to the ambulance as quickly as possible*" (P18).

Lack of sufficient knowledge and skills among search and rescue personnel:

The lack of sufficient knowledge, skills, and equipment among some search and rescue teams significantly impacted the disaster response process. Participants indicated that the inability of

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certain teams to recognize the urgency of initiating fluid therapy for patients at risk of crush syndrome caused delays.

> "*The professionally trained teams operated with excellent organization and coordination. However, some groups could not understand our urgency to initiate treatment due to the CS risk. We had to convince some of them*" (P20).

> "*During prolonged rescue operations, we struggled to collaborate effectively with some teams, which delayed reaching patients and starting CS treatment*" (P17).

Lack of scene safety:

Ensuring scene safety is critical during disasters and emergencies. Without proper precautions, effective intervention becomes impossible, and risks to both health-care workers and patients increase significantly. Some participants reported serious safety deficiencies at the rubble sites, which delayed treatment initiation.

> "*Due to the crowd in the hot zone and the lack of safety measures, we faced a significant risk of collapse, forcing us to delay treatment*" (P17).

> "*We stayed away from unstable structures. When the injured were ready, we prepared the necessary equipment and crossed the rubble to intervene. However, the lack of safety made our work very difficult*" (P19).

> "*Scene safety was poor, as the earthquake's scale overwhelmed security forces and rescue personnel. Safe zones could not be established in time*" (P16).

Resource shortages:

In disasters, ensuring an adequate number of well-trained personnel and timely deployment of support teams is critical. Some participants reported that a shortage of emergency medical service personnel and delayed reinforcement negatively impacted treatment initiation.

> "*There weren't enough EMS personnel in the first 24 hours. Weather conditions caused further delays. Supplies ran out, and we couldn't start fluid therapy for some patients*" (P17).

> "*The number of patients was overwhelming compared to the supplies available. Despite our efforts to ration resources, fluid shortages occurred, worsened by severe weather conditions*" (P19).

Discussion

The Kahramanmaraş earthquake experience revealed that extricating patients at risk of crush syndrome often required prolonged periods, with entrapment durations ranging from 4 to 42 hours.[10] Extended entrapment has been shown to worsen clinical outcomes, particularly by increasing both the likelihood and severity of crush syndrome.[28] The literature strongly supports initiating fluid therapy as early as possible—even during rescue operations—to prevent crush syndrome progression.[29,30] Consistent with these findings, emergency medical service personnel in this study emphasized the importance of starting treatment while patients were still trapped under the rubble. However, real-time challenges such as unsafe environments and inter-agency coordination problems frequently hindered early intervention. These results underscore the need for disaster preparedness frameworks to explicitly integrate early-stage crush syndrome management protocols.

Delays in treatment initiation were primarily attributed to crowd congestion, media interference, insufficient training among rescue personnel, and unsafe working conditions. Crowds at disaster sites not only impaired emergency medical service mobility but also disrupted communication and logistical coordination, as reported in other recent earthquake responses.[31,32] Similar to prior disasters, uncoordinated volunteers and overlapping non-governmental organizations further complicated the timely delivery of medical care.[33] Scene safety also emerged as a major constraint. Although emergency medical service workers are typically expected to operate in cold zones, the scale and urgency of the disaster often forced them into unstable, high-risk environments. These findings highlight the need to re-evaluate the operational roles of emergency medical service personnel in large-scale disasters and to strengthen safety protocols and personal protective training.[34]

A major barrier to crush syndrome-specific intervention was the insufficient disaster-related knowledge among search and rescue teams. Previous studies have recommended integrating health-care professionals into rescue units to facilitate the early recognition and management of crush syndrome.[35] The inclusion of medical personnel, as exemplified by Türkiye's National Medical Rescue Team model, has been shown to enhance operational capacity and improve outcomes in complex disaster environments.[36]

Although media coverage plays a critical role in promoting disaster awareness, participants reported that some individuals' attempts to gain media exposure interfered with medical procedures. Specifically, certain rescue personnel delayed transferring patients to ambulances to appear on camera, which directly postponed the initiation of early medical interventions by several minutes. Previous research has similarly emphasized that media-driven volunteerism and opportunistic behavior can hinder emergency operations and compromise the dignity of victims.[37,38]

Finally, shortages of personnel, medical supplies, and logistical support significantly delayed the initiation of early treatment efforts. This problem was most pronounced during the first 24–48 hours, when access to essential equipment and support teams was severely limited.[37] These findings highlight the need to integrate scalable and context-sensitive resource mobilization strategies into future disaster preparedness plans, particularly in scenarios involving crush syndrome.

This study offers important insights into the barriers to early treatment for crush syndrome risk based on the experiences of emergency medical service personnel during the Kahramanmaraş earthquakes. By focusing on firsthand experiences of frontline emergency medical service professionals, it provides a qualitative perspective on how disaster conditions, resource scarcity, and media involvement interact to delay interventions. Although the use of in-depth interviews strengthens the study, the limited sample size and purposive sampling method restrict the generalizability of the findings. The inclusion of emergency medical service

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personnel deployed from different provinces across Türkiye to the 11 affected regions allows the results to reflect a broad range of practices related to clinical interventions in large-scale disasters.

Conclusion

Although emergency medical service personnel recognize the importance of early intervention for patients at risk of crush syndrome during disasters, factors such as the lack of scene safety, the inability to manage crowds at the disaster site, and resource scarcity may delay treatment. Patients often had to remain under rubble for extended periods, largely due to the scale of the destruction: to enable treatment, especially for high-risk patients, and to begin it as early as possible—ideally while rescue operations are still ongoing and the patient is under the rubble—it is crucial to enhance the knowledge and skills of search and rescue personnel.

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Author contributions

Kadir Okan Bağiş and Ali Ekşi (Methodology). Kadir Okan Bağiş (Ethics committee approval). Kadir Okan Bağiş , Melih Gümüş, Hande Kekreli Göylüsün, Teslime Çakaloğlu, and Ertuğrul Erik (Data collection). Kadir Okan Bağiş, Sezgin Durmuş, Hande Kekreli Göylüsün, and Teslime Çakaloğlu (Data analysis). Kadir Okan Bağiş, Ali Ekşi, Süreyya Gümüşsoy, Hande Kekreli Göylüsün, Teslime Çakaloğlu, and Sezgin Durmuş (Data curation). Ali Ekşi and Kadir Okan Bağiş (Writing—review & editing). Kadir Okan Bağiş (Writing—original draft). All authors approved the final version to be published.

Conflicts of interest

None declared.

Funding

None declared.

Data availability

Due to ethical considerations and participant confidentiality, the data generated and analyzed during this study are not publicly available. However, de-identified data may be shared upon reasonable request to the corresponding author, provided that such requests comply with institutional ethical guidelines and relevant data protection regulations.

Ethical disclosure

This study was conducted in accordance with the Declaration of Helsinki. Prior to the study, written approval was obtained from the university's scientific research ethics committee (Ege University Medical Research Ethics Committee—28.01.2024/59). All participants were informed about the purpose of the study, assured of confidentiality, and notified that their participation was entirely voluntary. Informed verbal consent was obtained prior to data collection. Participant identities were anonymized using codes such as P1, P2, and P3 to ensure confidentiality.

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