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Evaluation of Earthquake Victims Following the 2023 Kahramanmaraş-Türkiye Earthquake: A Multicenter Trial with 8025 Cases

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Abstract

Aim: Our multicenter study includes the largest number of earthquake victims reported in the literature, aiming to evaluate demographic data and outcomes of patients who presented to emergency departments following 2023 Kahramanmaraş, Türkiye earthquake.

Materials and Methods: Patients admitted to hospital emergency departments after the February 6, 2023 Kahramanmaraş earthquakes were retrospectively evaluated over a 22-day period. Data analyzed included age, gender, triage scales, overall health status, vital signs, laboratory and imaging results, definitive diagnoses, outcomes of patients, and emergency interventions.

Results: Of the 8025 patients reported in 18 centers, 51.2% (n=4112) were female, and the average age of the patients was 40.91±20.12. A total of 3578 people (57.6%) had a green triage tag, indicating good overall health with relatively minor injuries. Lower extremity fractures were the most prevalent finding in radiographs, accounting for 33.7% (n=663), of the cases, while cerebral hemorrhage, rib fractures, and lumbar fractures were the most common results in tomography scans. The three most common diagnoses were soft tissue trauma (n=1270; 21.1%), crush syndrome (n=932; 15.5%), and lower extremity fractures (n=851; 14.2%). Cast-splint application (n=813; 22.18%), central venous catheterization (n=393; 10.72%), and fasciotomy (n=322; 8.78%) were the primary procedures performed in the emergency departments. Out of the 1886 hospitalized patients, the orthopedics clinic received the highest number of admissions (n=600). A total of 3461 patients were discharged, and 495 died.

Conclusion: Findings of our study revealed higher rates of morbidity and mortality than in previous earthquakes, with orthopedic injuries being the most common outcome of earthquake-related trauma. We believe that establishing tent hospitals in earthquake-prone regions and surrounding provinces, constructing long-term healthcare facilities and trauma centers with emergency services, testing facilities, imaging areas, operating rooms, hemodialysis and intensive care units, employing horizontal architecture designs, and improving referral networks can help to reduce these rates.

Keywords: Earthquake, trauma, morbidity, mortality, precautions

Introduction

Throughout history, natural disasters resulting in significant loss of life and property damage have occurred in many of our country's earthquake-prone areas. Notable catastrophic events include the earthquakes in 1939 Erzincan, 1949 Karlıova, 1998 Adana Ceyhan, 1999 Gölcük, 2003 Bingöl, 2011 Van, 2020 Elazığ, and, most recently, the Kahramanmaraş earthquake on February 6, 2023, which also devastated the surrounding provinces.

In the immediate aftermath of an earthquake, disruptions frequently occur during the initial response, subsequent follow-up, and patient treatment. These challenges arise from unavailable hospital transportation routes, insufficient healthcare personnel, and limited healthcare facilities (1,2). Such difficulties became particularly evident following the large-magnitude Kahramanmaraş earthquake. The extent of injury caused by earthquakes directly influences the incidence of fatalities and life-threatening conditions such as crush syndrome, myocardial infarction, hemopneumothorax, vascular injuries, intra-abdominal injuries, pelvic injuries, and renal failure (3). Over the past century, earthquakes have accounted for 100,000 fatalities in Türkiye (4). According to official data from April 2023, the Kahramanmaraş earthquake alone resulted in over 50,000 deaths and more than 120,000 injuries. Our study aims to contribute to the existing literature by analyzing information obtained from multiple hospitals that managed victims of the 2023 Kahramanmaraş earthquake. (Photograph 1a-e).

Materials and Methods

Ethical approval for this study was obtained from the University of Health Sciences Türkiye, Adana City Training and Research Hospital Clinical Research Ethics Committee (decision number: 2569, date: 11.05.2023). Following this approval and authorization from hospital administrations, hospital records of earthquake victims brought to emergency services after the two Kahramanmaraş earthquakes, first, with magnitude 7.7 (duration 65 seconds, depth 9.1 kilometers) at 04.17 local time, and second, with magnitude 7.6 (duration 45 seconds, depth 16.4 kilometers) at 13.24 on February 6, 2023, were reviewed. Age, gender, mode of arrival, triage rankings, general health status, vital signs, physical examination findings, laboratory and imaging results,

Photograph 1a. A patient suffering from crush trauma and subsequent compartment syndrome

Photograph 1b. Patient evacuation via aircraft

definitive diagnoses, emergency interventions, hospitalized clinics, patient transport methods, consultations, and outcomes were evaluated by combining the data with records from both assigned and volunteered earthquake response teams.

Statistical Analysis

A chi-square test was used to examine the associations between two categorical variables. Descriptive statistics for categorical variables are provided as numbers and percentages. Hypotheses were evaluated bidirectionally, with p-values less than 0.05 signifying statistical significance. SPSS Windows version 24.0 (Statistical Package for the Social Sciences) by IBM Corporation in Chicago, United States, was utilized.

Results

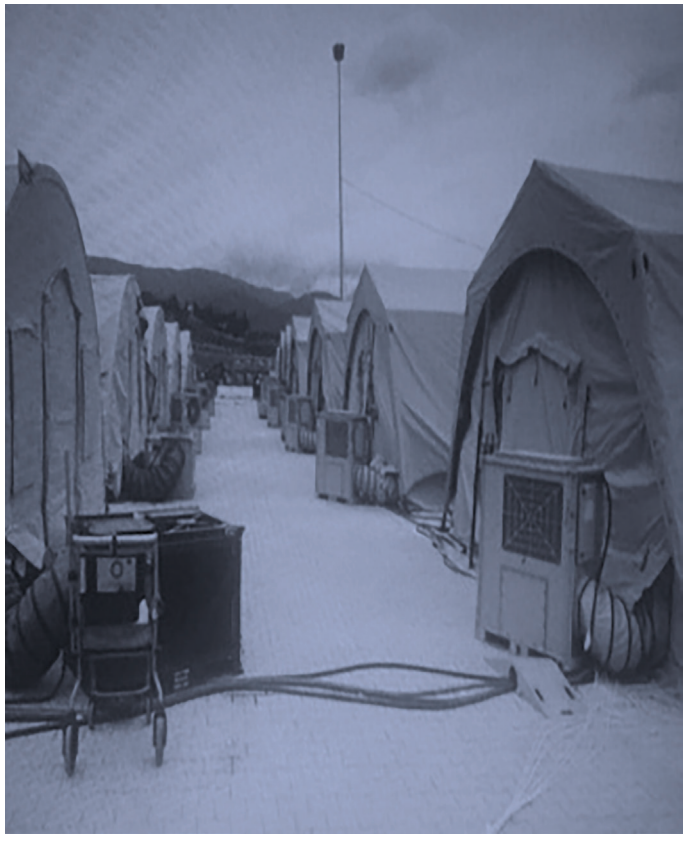
A total of 8025 patient records were obtained from 18 different healthcare centers. Of all patients, 51.2% (n=4112) were female, and average age of patients was 40.91±20.12. More than half (59.6%, n=4446) of the patients presented to the hospital by their own means, and of these, 3578 (57.6%) patients were categorized with a green triage tag, indicating good overall health and relatively minor injuries. University of Health Sciences Türkiye, Adana City Training and Research Hospital, received the highest number of patients, accounting for 11.8% (n=944) of the study population (Table 1).

Table 2 displays the summary of the patients' laboratory parameters and vital signs.

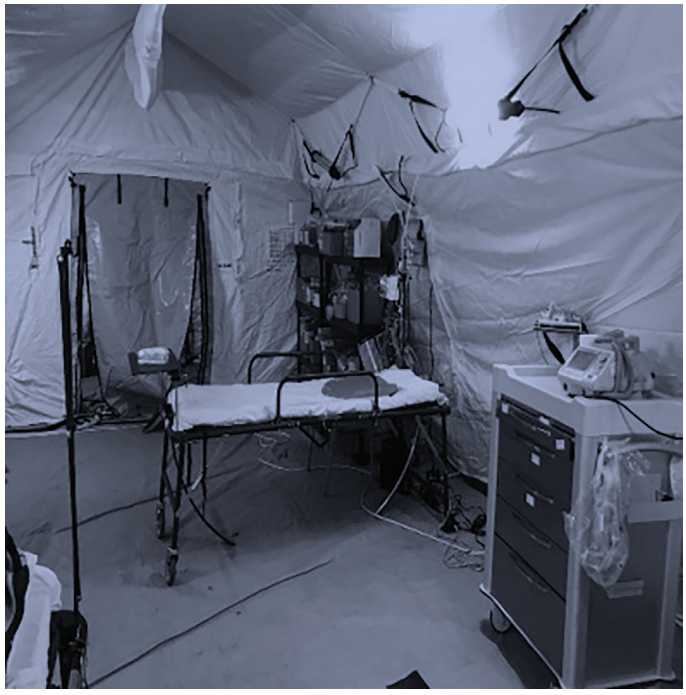
Among patients whose electrocardiographys could be obtained, 909 exhibited sinus rhythm, 197 had sinus tachycardia, and 34 presented with atrial fibrillation. Direct radiography results revealed that lower extremity fractures were the most common injuries sustained by patients, accounting for 33.7% (n=663) of findings. Pelvic fractures, rib fractures, lumbar fractures, free fluid in the abdomen, and cerebral hemorrhage were the most common injuries observed in the computed tomography results. (Table 3).

Soft tissue trauma (n=1270, 21.1%), crush injuries (n= unspecified, 15.5%), and lower extremity fractures (n=851, 14.2%) were the three most frequent diagnoses (Table 4).

The most frequent procedures performed on patients were casting-splinting (22.18%, n=813), central venous catheterization



Photograph 1c. Exterior view of a mobile field hospital



Photograph 1d. Interior view of a mobile field hospital

Photograph 1e. Photo of a severely damaged building following the earthquake

(Images taken from the archive of Ali Karakuş)

(10.72%, n=393), and fasciotomy (8.78%, n=322). Table 5 outlines all interventions performed.

Orthopedics (n=2225, 35.57%), internal medicine (n=1312, 20.98%), and neurosurgery (n=672, 10.74%) were the most frequently consulted departments by emergency department physicians. Consistent with this, these three clinics also received the highest number of admissions (Figure 1).

Transportation between healthcare facilities occurred primarily by patients' own means (38%), followed by ambulance (35%), sea vehicles (20%), and aircraft (7%). Outcomes included 495 deaths, 1,886 hospitalizations, and 3,461 discharges (Figure 2).

Discussion

The February 2023 earthquake in Kahramanmaraş, Türkiye, impacted more than 13 million individuals across a vast geographical area. Government statistics released following the event reported over 50,000 deaths and 107,000 injuries (5). In the aftermath of such catastrophic disasters, technological shortcomings and unexpected adverse outcomes can render registration systems inadequate, leading to patient information being missing or unrecorded in healthcare facilities. The ability to accurately record and maintain patient registration information, as well as medical status details, is crucial in both routine and extraordinary situations. During such disasters, healthcare centers often face impaired registration due to factors such as crowding in emergency departments, disruptions in the information recording and automation systems, and insufficient personnel. Similar issues have been oberved in previous disasters, yet adequate measures were not consistently taken to establish the necessary precautions despite acknowledging the challenges of maintaining records and their critical role (6-10). Our study

Table 1. Hospitals and patient demographics: age, gender, mode of arrival, and overall health condition of patients included in the study	
Healthcare center	**n (%)**
1. University of Health Sciences Türkiye, Adana City Training and Research Hospital	944 (11.8)
2. Mersin University Faculty of Medicine	892 (11.1)
3. Çukurova University Faculty of Medicine	771 (9.6)
4. Osmaniye State Hospital	727 (9.1)
5. Hatay Mustafa Kemal University Faculty of Medicine	714 (8.9)
6. University of Health Sciences Türkiye, Elazığ Fethi Sekin State Hospital	678 (8.4)
7. Gaziantep 25 Aralık State Hospital	548 (6.8)
8. Adıyaman University Faculty of Medicine	476 (5.9)
9. Malatya İnönü University Faculty of Medicine	467 (5.8)
10. University of Health Sciences Türkiye, Diyarbakır Gazi Yaşargil Training and Research Hospital	413 (5.1)
11. Adana Seyhan State Hospital	392 (4.9)
12. Fırat University Faculty of Medicine	283 (3.5)
13. Harran University Faculty of Medicine	217 (2.7)
14. Dicle University Faculty of Medicine	192 (2.4)
15. Gaziantep Nizip State Hospital	132 (1.6)
16. Malatya Turgut Özal University Training and Research Hospital	90 (1.1)
17. Kahramanmaraş Sütçü İmam University Faculty of Medicine	53 (0.7)
18. Çanakkale Mehmet Akif Ersoy State Hospital	36 (0.4)
Age, mean ± SD (min-max)	**40.91±20.12 (0-103)**
Gender	
Female	4112 (5.2)
Male	3913 (48.8)
Method of arrival to hospital	
Deceased prior to arrival	438 (5.9)
By own means	4446 (59.6)
By ambulance	2524 (33.8)
Other	51 (0.7)
Overall health condition/triage tag	
Non-urgent (green)	3578 (57.6)
Less urgent (yellow)	1634 (26.3)
Urgent/life-threatening (red)	1001 (16.1)
SD: Standard deviation	

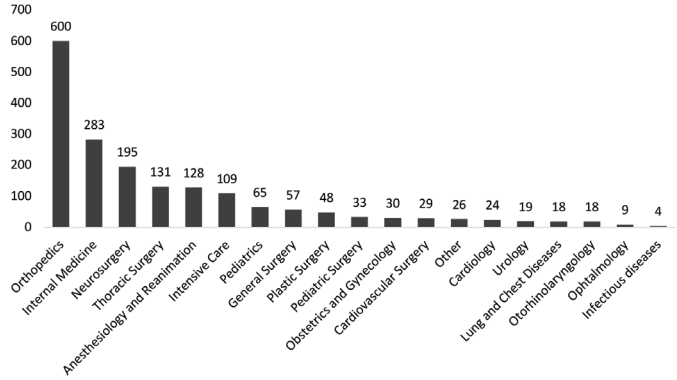


Figure 1. Bar graph showing the distribution of departments where patients were admitted

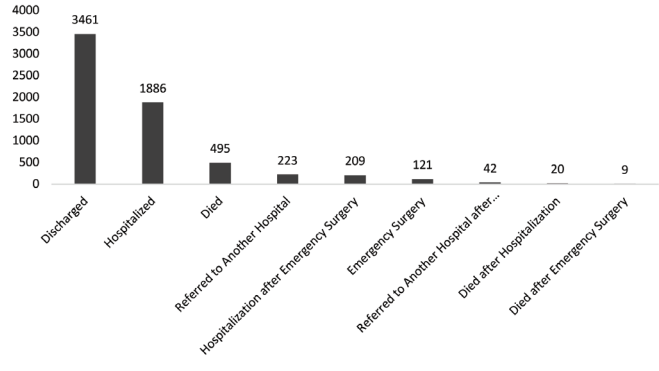


Figure 2. Bar graph showing distribution of patient outcomes

Table 2. Distribution of vital signs and laboratory parameters of the patients		
	Mean ± SD	**Median (min-max)**
Glascow coma score	13.79±3.37	15 (3-15)
Blood pressure (systolic) (mmHg)	124.81±17.55	124 (20-220)
Blood pressure (diastolic) (mmHg)	80.02±13.2	80 (0-158)
Heart rate (bpm)	82.94±16.98	81 (0-154)
Body temperature (°C)	36.45±0.47	36.4 (26.4-39.2)
PO_2 (mmHg)	96.61±4.08	98 (22-100)
White blood cells (x10^9/L)	14.11±7.25	12.43 (0.1-49.98)
Platelet count (x10^9/L)	261949.69±225254.02	237000 (5820-725000)
Blood urea nitrogen (mg/dL)	36.85±33.47	24.8 (1.84-279)
Creatinine (mg/dL)	1.13±1.2	0.78 (0.1-14)
Na+ (mEq/L)	138.41±5.36	138 (110-189)
K+ (mEq/L)	4.46±0.86	4.3 (1-14.92)
CK (U/L)	8870.21±27682.29	790 (2-344650)
CK-Mb (ng/mL)	136.18±149.96	83 (5-635)
Amylase (U/L)	131.59±277.74	58 (10-2947)
AST (U/L)	380.06±625.69	141 (0.3-6363)
ALT (U/L)	189.12±368.74	73.9 (5.5-4055)
Troponin (ng/mL)	727.78±1367.46	193 (0.11-7460)
CRP (mg/L)	103.01±93.78	96 (0-604)
Glucose (mg/dL)	150.26±112.14	112.5 (20-676)
Albumin (g/dL)	17.23±11.11	15 (2.6-36)
Calcium (mg/dL)	7.18±0.9	7.5 (5.1-8.2)
Lactate (mmol/L)	3.43±3.48	2.3 (0-21.5)
pH (blood gas)	7.34±0.12	7.37 (6-7.72)
HCO_3 (blood gas) (mEq/L)	21.4±6.27	22.3 (0-64.2)

SD: Standard deviation, CK: Creatine kinase, CK-Mb: Creatine kinase-myocardial band, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, CRP: C-reactive protein

across eighteen different centers highlighted these shortcomings, as data was often manually recorded on A4-sized blank papers, procedural notebooks, and patient cards. Many patients could not be properly registered at hospitals due to overcrowding in emergency departments, lack of internet connectivity, and faulty automation systems. Some records were eventually entered into the hospital automation using patient lists compiled by assigned staff members.

Alternative solutions for recording system malfunctions should be developed to avoid such issues in the future, and patient information systems should be organized well in advance of unforeseen disasters. Future improvements may include placing wristbands with identifying information, ensuring patient registration cards are easily accessible and readily available in adequate numbers, providing sufficient communication equipment and base stations, and enhancing hospital recording systems and data networks to manage the increased demand. Part of the healthcare staff should be specifically assigned to handle patient data, especially in the initial hours and days following a disaster. Patient cards or pre-made paper frameworks should contain all relevant data about the patient, including name, identifying information, address, physical findings, diagnosis, treatment, and outcomes.

Beyond immediate property damage and casualties, earthquakes can result in a variety of acute and chronic conditions. Injuries sustained after an earthquake are usually caused by falling objects or being trapped under rubble. The most common traumatic complications in the immediate aftermath of earthquakes include head traumas, lower extremity injuries, and crush syndrome, a complication characterized by development of renal failure after crushing trauma (1,4,8,11). According to the study of Ceylan et al. (6), spinal injuries, crush injuries, open and closed fractures, soft tissue injuries, and compartment syndrome were the most frequent orthopedic injuries following an earthquake.

Table 3. Distribution of radiological imaging results	
	n (%)
Direct radiography	
Fracture on skull radiograph	33 (1.7)
Vertebra fracture	27 (1.4)
Rib fracture	24 (1.2)
Pneumothorax	21 (1.1)
Hemothorax	11 (0.6)
Hemopneumothorax	30 (1.5)
Pelvic fracture	120 (6.1)
Fracture of upper extremity	323 (16.4)
Fracture of lower extremity	**663 (33.7)**
Other imaging findings	717 (36.4)
Head CT	
Cerebral hemorrhage	**79 (25)**
Fracture	43 (13.6)
Cerebral hemorrhage and fracture	16 (5.1)
Other intracranial pathologies	178 (56.3)
Thorax CT	
Rib fracture	**111 (26.8)**
Pneumothorax	56 (13.5)
Hemothorax	31 (7.5)
Hemopneumothorax	43 (10.4)
Pericardial effusion	16 (3.9)
Other thoracic findings	157 (37.9)
Spine CT	
Cervical spine fracture	21 (5.3)
Thoracic spine fracture	56 (14)
Lumbar spine fracture	**169 (42.2)**
Sacral spine fracture	26 (6.5)
Other spinal trauma findings	128 (32)
Abdominal CT	
Spleen laceration	25 (8.9)
Liver laceration	12 (4.3)
Diaphragm injury	40 (14.3)
Free intraperitoneal fluid	**47 (16.8)**
Other intra-abdominal ınjuries	156 (55.7)
Pelvic CT	
Pelvic fracture	**125 (47.9)**
Other pelvic trauma findings	136 (52.1)
CT: Computed tomography	

Another study conducted on Great Hanshin earthquake survivors identified spinal injuries, extremity fractures, and pneumothorax as common injuries (12). Fractures of the upper and lower extremities were reported to be the most common diagnoses in the study of Keskin et al. (1), which included 532 patients. Many other studies have also highlighted the significance of crush syndrome and acute renal failure associated with it (13-18). Acute compartment syndrome is another significant complication of earthquake-related trauma, with reported incidences varying from 1.36 to 16.6% (19). If left untreated, acute compartment syndrome can result in lifelong problems, including limb loss in severe cases. Consistent with the previous research, lower extremity fractures, crush syndrome, and soft tissue damage were the most common diagnoses in our study. Patients who developed crush syndrome and acute renal failure underwent emergent hemodialysis. Some patients required transfer to nearby institutions in the initial days following the earthquake due to an increase in orthopedic and surgical emergencies and limited operating room availability.

The primary objective of emergency physicians following catastrophic events is to focus on patients with a high likelihood of survival and administer appropriate treatments as soon as possible. Initial management of earthquake survivors includes airway assessment, cardiopulmonary resuscitation, fluid therapy, wound cleansing, tetanus prophylaxis, symptomatic approach, and administration of antibiotics and analgesics. Additional treatments and interventions include emergency fasciotomy, hemodialysis, cast-splint placement, and extremity elevation (15,19). The most frequently administered treatments and performed procedures documented in our study included airway management, cardiopulmonary resuscitation, fluid therapy, tetanus prophylaxis, painkiller administration, plaster splint placement following a symptomatic approach, and emergency fasciotomy.

Among the most significant challenges posed by earthquakes are organizational issues observed both within and between hospitals, as well as issues related to the disaster's epicenter. Following the initial response, a strategic approach with appropriate referral and transportation processes should be implemented without delay (1,2,15). Emergency helicopter transportation has been shown to be particularly successful for patients in this context, given the road network congestion following the earthquake (12). During the aftermath of the 2023 Kahramanmaraş earthquake, patient transfer times were prolonged due to a large number of earthquake victims, limited laboratory capacity, damaged airport roads, traffic jams, and hospital overcrowding in neighboring provinces. Attempts were made to use the İskenderun seaport to transport patients to Mersin and other districts. Many patients

Table 4. Distribution of the most common five diagnoses

	Diagnosis					
	I	II	III	IV	V	Total n (%)
Acute abdominal pain	79	9	0	0	0	88 (1.5)
Crush syndrome	**905**	**27**	**0**	**0**	**0**	**932 (15.5)**
Acute kidney injury	89	140	2	0	0	231 (3.9)
Hemothorax	41	23	7	0	0	71 (1.2)
Hemopneumothorax	208	72	23	0	0	303 (5.1)
Fracture of upper extremity	352	183	41	5	1	582 (9.7)
Fracture of lower extremity	**489**	**217**	**110**	**31**	**4**	**851 (14.2)**
Vascular trauma	38	12	6	2	1	59 (1)
Cerebral hemorrhage	171	23	9	8	1	212 (3.5)
Spinal injury	233	35	33	13	6	320 (5.3)
Pelvic injury	101	40	11	4	1	157 (2.5)
Pneumomediastinum	9	0	3	0	0	12 (0.2)
Amputation	2	0	0	0	0	2 (0.1)
Compartment syndrome	19	0	8	0	0	27 (0.4)
Multitrauma	3	0	0	0	0	3 (0.1)
Soft tissue injury	**1267**	**3**	**0**	**0**	**0**	**1270 (21.1)**
Vertebral fracture	10	0	0	0	0	10 (0.2)
Rib fracture	15	0	0	0	0	15 (0.3)
Other	821	26	5	0	0	852 (14.2)

Table 5. Distribution of procedures administered to patients

	Applied procedure					
	I	II	III	IV	V	Total n (%)
Central venous catheterization	**391**	**2**	**0**	**0**	**0**	**393 (10.72)**
Amputation	109	49	0	0	0	158 (4.31)
Reduction of dislocated joints	208	40	3	0	0	251 (6.85)
Fixation of fractures	136	98	29	0	0	263 (7.17)
Fasciotomy	**196**	**49**	**56**	**21**	**0**	**322 (8.78)**
Casting-splinting	**611**	**140**	**46**	**14**	**2**	**813 (22.18)**
Suturing	287	21	5	4	2	319 (8.7)
Chest tube placement	177	47	13	3	1	241 (6.57)
Thoracotomy	11	4	3	0	1	19 (0.52)
Craniotomy	14	2	2	5	0	23 (0.63)
Laparatomy	28	16	3	2	0	49 (1.34)
Hemodialysis	89	70	27	5	6	197 (5.37)
Other	420	33	7	4	0	464 (12.66)
Cardiopulmonary resuscitation	102	42	2	0	0	146 (3.98)
Emergent delivery	6	2	0	0	0	8 (0.22)

were able to transport themselves to another hospital during the immediate post-disaster period. Patient transfers were significantly improved after establishing airplane and helicopter ambulance services.

Over the past three decades, earthquakes have caused an estimated 1 million fatalities worldwide. China recorded the largest number of fatalities in 1556, with 830,000 deaths. Türkiye has lost more than 100,000 people to earthquakes during the last century (4). Research suggests that 85-95% of patients can be saved within the first 24-28 hours with the proper interventions. Death rates following earthquakes tend to increase over the following years. The 1995 Hanshin-Awaji earthquake resulted in 6.434 fatalities, predominantly due to thoracic trauma and severe crush injuries. Meanwhile, the 2011 Japan earthquake and tsunami caused an estimated 10,000 to 18,500 deaths (9,12,15,20). While hypovolemia and vital organ damage were the most common causes of mortality in the initial 48 hours following an earthquake, acute renal failure, sepsis, multiorgan failure, and myocardial infarction were identified as the leading causes of death within the first week (1). In the immediate aftermath of the disaster, a lack of available patient records led to some pre-hospital deaths being processed through the emergency room. Most deceased individuals were later moved to the hospital morgue or to established wards within hours. The majority of earthquake-related fatalities resulted from severe vascular injuries, hypovolemia, hypoxia, thoracic or intra-abdominal organ damage, and crush injuries from being buried under the debris. For those admitted to hospital, sepsis and multiorgan failure were the main causes of death. The most valuable lesson learned from earthquakes is that timely preparation is the most effective approach for reducing death and injury. To achieve this goal, seismic studies should be conducted before designing and constructing earthquake-resistant public structures, residential areas, and healthcare facilities.

Study Limitations

While our study represents the largest case series on earthquake-related trauma reported to date, it has several limitations. Data collection was challenging due to infrastructure failure, which may have led to inaccuracies in manually recorded patient information. Heterogeneity across 18 healthcare centers may have introduced variability in practices, and focusing solely on emergency department presentations means the study doesn't capture individuals who died at the scene. Finally, the limited 22-day follow-up, means long-term outcomes were not assessed.

Conclusion

Earthquakes belong to the group of disasters in which preventive measures are essential to avoid catastrophic outcomes. To reduce the number of fatalities and injuries, physicians and healthcare workers should learn from past incidents and proactively implement strong security measures. Our study revealed higher morbidity and fatality rates compared to those reported in previous earthquakes. Rapid deployment of field hospitals is essential at the onset of an earthquake to minimize mortality and morbidity rates and traumatic complications. Construction efforts should include permanent hospitals with horizontal architectural design and equipped with comprehensive departments including emergency services, testing facilities, imaging centers, operating rooms, and intensive care units. The number of trauma hospitals and intensive care units needs to be increased, and referral networks improved, in both earthquake-prone areas and low-risk neighboring provinces. Similar scenarios occurred during previous disasters, but a lack of sufficient precautions meant the outcomes remained largely unchanged. It is crucial to learn from these traumatic experiences to avoid past mistakes.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from the University of Health Sciences Türkiye, Adana City Training and Research Hospital Clinical Research Ethics Committee (decision number: 2569, date: 11.05.2023).

Informed Consent: This is retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: All authors, Concept: A.K., A.A. Ö.Y., Design: A.K., A.A. Ö.Y., Data Collection or Processing: All authors, Analysis or Interpretation: Ö.Y., M.K. B.K., Literature Search: Ö.Y., M.K. Writing: Ö.Y., M.K.

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