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Factors affecting the mortality of February earthquakes victims in Türkiye

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ABSTRACT

Objective: >50,000 people died in the February 2023 earthquakes in Türkiye. The aim of this study was to identify the factors affecting mortality rates of the trauma patients who were presented to the emergency department (ED) after the earthquake and provide suggestions for better preparedness strategies for future natural disasters.
Methods: This retrospective, cross-sectional study encompassed data from 955 trauma patients out of 3072 patients aged 18 years and above who sought assistance in the ED. Patients were divided into two groups: the survivor group and the exitus group. Age, gender, the city where patients came from, type of presentation, injured organ systems and mechanisms of injury, laboratory findings, the diagnoses in the ED, time spent in the ED, surgical intervention, and hemodialysis sessions were analyzed. The characteristics of those who could not be identified at the presentation to the ED were subjected to additional analysis.
Results: Out of 955 patients, 75.9% had extremity injuries, with crushing injuries (23.6%) being predominant. There were no significant differences in age or gender between the survivor and exitus groups ($p = 0.776$, $p = 0.522$), nor in the province of admission ($p = 0.249$). Clinical factors indicated that the exitus group were more likely to lack identification documents (29.6%), have spent longer trapped under debris, and have a higher frequency of ambulance transportation. Injuries such as chest and abdominal trauma, specific injury types, and amputation or open wounds were notably more frequent in the exitus group. Diagnoses revealed that metabolic causes were more common in exitus group ($p < 0.001$). While no significant difference existed in the need for emergency surgical intervention ($p = 0.939$), a higher frequency of emergency hemodialysis was observed among exitus group ($p = 0.001$). Laboratory findings indicated higher levels of various markers and lower calcium, base excess, and pH levels among those in the exitus group.
Conclusion: In the aftermath of a devastating earthquake, this study underscores the formidable challenges faced by healthcare systems during natural disasters. To prepare for future disasters, healthcare systems must enhance resilience, develop rapid identification techniques, and adopt a holistic patient care approach.

1. Introduction

On February 6, 2023, a series of earthquakes struck 11 provinces in southeastern Türkiye and northern Syria, leaving a trail of substantial devastation. With magnitudes of Mw 7.6 (Pazarcık/Kahramanmaraş) and Mw 7.5 (Elbistan/Kahramanmaraş) on the Richter scale, these seismic events etched themselves into Turkish history as some of the most impactful natural disasters witnessed in the past century, rivaled only by the 1939 Erzincan and 1999 Gölcük/Kocaeli earthquakes. According to data provided by the Disaster and Emergency Management Presidency (AFAD) of Türkiye, a staggering total of 50,783 lives were lost, and an additional 115,353 individuals were injured [1]. In the aftermath of these earthquakes, hundreds of people tragically perished beneath the debris, while numerous others died of trauma and its related complications [2].

Undoubtedly, preparedness and preventive strategies stand as paramount approaches to reducing the mortality precipitated by such natural disasters. Yet, an equally essential dimension involves the meticulous examination of variables shaping the survival prospects of individuals extricated from disaster sites—an occurrence often evocatively regarded as a 'miracle' in society. Therefore, it is crucial to understand the factors that affect the survival of rescued patients after an event when they are quickly saved from areas affected by debris and destruction.

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The main goal of this study was to identify the factors that affect the mortality rates of the trauma patients who were presented to the Adult Emergency Department (ED) of Balcali Hospital after the February 2023 earthquakes referenced above. Additionally, by using the information gathered from these factors, the study aimed to provide suggestions for better preparedness strategies for potential future disasters.

2. Materials and methods

Balcali Hospital has played an important role as a regional health institution in Adana province for the last 50 years. After the earthquakes, its significance grew even further, and as a trauma center, it not only helped patients from nearby areas but also those from nearby provinces. Our center had 1000 hospital beds, 100 of which were intensive care beds, 40 operating rooms, 25 dialysis devices only in the hemodialysis unit in total and 10 hemodiafiltration devices in wards and intensive care units for adults. The post-earthquake disaster plan was put into practice in our center, elective surgeries were postponed, maximum beds that could be opened in inpatient wards were opened, and patients whose treatment plan did not require urgency were discharged. The city of Adana was also in the earthquake zone and some patients under treatment at the hospital were voluntarily discharged to move away from this area. Shared crush wards and intensive care units were created to serve the admitted patients.

A color-coded triage system outlined by the Ministry of Health of the Republic of Türkiye categorizes all patients (including trauma and non-trauma) presented to the ED into different groups. Patients designated with a green code indicate individuals at minimal risk, necessitating non-urgent interventions and treatment, such as managing conditions like sore throats or minor traumatic injuries. The yellow code designates patients whose issues warrant attention and treatment within the ED; however, their evaluation and therapeutic measures might span several hours. This category encompasses cases such as acute cholecystitis or uncomplicated extremity fractures. Patients classified under the red code are those confronting life-threatening medical conditions, including critical scenarios such as myocardial infarction or severe trauma, where prompt and aggressive interventions are imperative due to their acute nature and inability to endure delays [3]. This retrospective, cross-sectional study encompassed data from 955 trauma patients out of 3072 patients aged 18 years and above who sought assistance at the ED from February 6, 2023, at 04:17, continuing until February 21, 2023, at 16:00. The study period was defined in consideration of the seismic event that led to the hospital's evacuation on February 20, 2023, due to structural damage.

Patients were divided into two groups: the survivors group and the non-survivors group. Demographic data such as age, gender, the city where patients came from, type of presentation to the ED, laboratory findings such as hemogram, lactate, creatine kinase levels, and neutrophile lymphocyte ratio, the diagnoses in the ED, time spent in the ED, surgical intervention, and hemodialysis sessions were obtained from the hospital automation system and ED record forms and analyzed comparatively. The characteristics of those who could not be identified at the presentation to the ED were subjected to additional analysis.

Patients included in our study were specifically identified as trauma patients based on the established medical criteria (body integrity impaired by external factors such as traumatic injury involving three body cavities, open or closed bone fracture in the extremities, burns in body parts), our focus was on individuals with physical injuries resulting from the earthquakes, patients with psychological trauma excluded. Patients who did not have any identification document on them at the time of presentation to the emergency department, who were not in a position to declare their identity information or who did not have any relative to declare their identity information were recorded as ID unknown. Other patients were recorded as ID known. The identification of crush syndrome was determined through the application of established clinical criteria, with a focus on parameters encompassing prolonged compression, muscle injury, and the potential manifestation of subsequent renal complications. Moreover, diagnostic indicators inclusive of elevated serum levels of creatine kinase, alongside electrolyte imbalances and the potential risk of acute kidney injury, were incorporated into the classification process [4].

The study received ethical approval from the Cukurova University Non-Interventional Research Ethics Committee on July 14, 2023 (decision no:135).

2.1. Statistical analysis

The IBM SPSS Statistics 29.0.1.0 package was used to analyze the study data. Continuous variables were evaluated using the Shapiro-Wilks test, histogram, and q-q plots to determine whether they conformed to normal distribution. Continuous variables conforming to normal distribution were reported as mean and standard deviation; those not conforming to normal distribution were reported as median and interquartile range. Categorical variables were defined by number and frequency. The Pearson's chi-square test and Fisher's exact test were used to compare categorical variables. The Student's *t*-test was used for variables with a parametric distribution and the Mann Whitney *U* test was used for variables without a parametric distribution. Multivariate logistic regression test was used to analyze the factors affecting mortality. Due to the chaotic environment created by the earthquakes, there were many factors that made data collection difficult and missing data were available. In order to perform multiple regression analysis, variables with missing data were not included in the analysis. Therefore, laboratory data could not be included in this analysis. Since hypernatremia was recorded as both numerical and categorical data, the presence of hypernatremia could be used in the regression analysis. In all conducted tests, the predetermined level of statistical significance was established as $p < 0.05$.

3. Results

Data from 3072 patients underwent examination, with a focus on 955 (31.1%) trauma patients subjected to detailed analysis. When the February 6th accepted as day 0, the daily number of patients brought to the emergency department is shown in Fig. 1.

As a result of the examinations and treatments, 502 (52.6%) patients were discharged from the ED, 344 (36%) patients were hospitalized in the Crush wards, 80 (8.4%) patients were hospitalized in intensive care units, and two (0.2%) patients were hospitalized in the burn unit. A total of 25 (2.6%) patients died, 10 (37%) of whom died in the ED. Although 2 victims survived the earthquake, they experienced cardiopulmonary arrest during their transfer to our hospital, were brought to the emergency ED but could not be saved and were declared dead in the ED.

There was no statistically significant difference between the median ages, gender of the survivors and non-survivors groups ($p = 0{,}776$ and $p = 0{,}522$). Patients most frequently hailed from Hatay province; however, there was no statistically significant difference between the two groups according to the province of admission ($p = 0.249$).

In the non-survivors group, no identification (ID) information was achieved for 8 (29.6%) patients when presented to the ED, compared to 89 (9.6%) in the survivors group. The non-survivors group had 17 (63%) patients with Glasgow Coma Scale scores of 3, 6 (22.2%) with 15, 1 (3.7%) with 14, 1 (3.7%) with 13, 1 (3.7%) with 12, and 1 (3.7%) with 8. Mortality was more common in those who were under debris and had more days to be rescued from debris ($p \leq 0.001$ and $p = 0.001$). See Table 1.

The rate of extended focused assessment with sonography for trauma (*E*-FAST) performed in the non-survivors group ($n = 15$, 55.6%) was significantly higher than the rate performed in the survivors group ($n = 159$, 17.1%), and the difference between the 2 groups was statistically significant ($p < 0.001$). When traumatic diagnoses were analyzed, there was no difference between the groups (p value >0.05 in

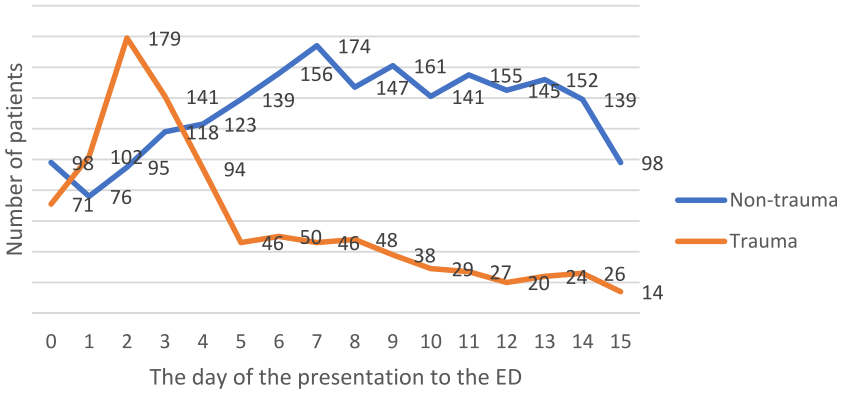

Fig. 1. Number of patients admitted to the emergency department per day (ED: emergency department).

all), but metabolic causes (crush syndrome, acute kidney injury, hypernatremia) were more common in the non-survivors group ($p \leq 0.001$, p ≤0.001 and $p = 0.002$, respectively). Furthermore, there was no significant difference between the two groups in terms of the frequency of patients requiring emergency surgical intervention ($p = 0.939$). However, as seen in Table 2, a significantly higher frequency of patients requiring emergency hemodialysis was observed in the non-survivors group and this difference was statistically significant ($p = 0.001$).

Table 1
Characteristic features of patients by groups.

Feature/Variable	Survivors group ($n = 928$)	Non-survivors group ($n = 27$)	p
Gender, n (%)			
Male	492 (53)	16 (59.3)	0.522
Female	436 (47)	11 (40.7)	
Age (years)			
Median (IQR) [min-max]	43 (31–57) [18–93]	43 (23–63) [20–90]	0.776
ID information on presentation to the ED, n (%)			
Unknown	89 (9.6)	8 (29.6)	**0.004**
Known	839 (90.4)	19 (70.4)	
City of Origin, n (%)			
Adana	253 (27.3)	1 (3.7)	0.249
Osmaniye	10 (1.1)	0 (0)	
Hatay	599 (64.5)	24 (88.9)	
Kahramanmaraş	14 (1.5)	0 (0)	
Gaziantep	11 (1.2)	0 (0)	
Malatya	2 (0.2)	0 (0)	
Diyarbakır	1 (0.1)	0 (0)	
Adıyaman	9 (1)	0 (0)	
Şanlıurfa	4 (0.4)	0 (0)	
Unknown	25 (2.7)	2 (7.4)	
Trapped under debris, n (%)			
No	482 (51.9)	2 (7.4)	**<0.001**
Yes	446 (48.1)	25 (92.6)	
The day rescued from the debris (if known)			
1st day	156 (35)	0 (0)	**0.001**
2nd day	74 (16.6)	7 (28)	
3rd day and later	216 (48.4)	18 (82)	
Type of presentation to the ED, n (%)			
By own means	430 (46.3)	0 (0)	**<0.001**
By Ambulance	494 (53.2)	26 (96.3)	
Unknown	4 (0.4)	1 (3.7)	
Triage code, n (%)			
Green	382 (41.2)	0 (0)	**<0.001**
Yellow	420 (45.3)	1 (3.7)	
Red	126 (13.6)	26 (96.3)	

Abbreviations: ID: identification, ED: emergency department.

Table 2 also illustrates that the median length of stay alive in the ED was notably prolonged within the non-survivors group, with a statistically significant difference between the two groups ($p < 0.001$). Notably, among patients in the non-survivors group, the individual with the longest stay alive in the ED exceeded 12 h.

Patient's laboratory results shown in Table 3.

The parameters found to be significant in univariate analyses were added to the model in Table 4 and the factors affecting mortality were analyzed by multivariate logistic regression analysis and it was found that acute renal failure had a 4.35-fold (OR: 4.347; CI: 1.362–13.877) effect on the mortality of the patients ($p = 0.013$).

The rate of being trapped under debris, and the need for emergency dialysis and emergency surgical intervention were higher in patients without ID information, and this difference between the two groups was statistically significant ($p < 0.001$, $p = 0.022$, and $p = 0.024$, respectively).

The majority of patients with missing identification information were from Hatay ($n = 78$, 80.4%), followed by 2 (2.1%) from Adana, 1 (1%) from Osmaniye, and 16 (16.5%) from an unknown province. Patients without identification were more likely to be from Hatay and were also more common among victims with an unknown origin. This difference was statistically significant (p < 0.001). The additional analysis of patients with lacking ID information shown in the Table 5.

Table 2
Diagnosis and interventions of patients by groups.

Feature/Variable	Survivors group (n = 928)	Non-survivors group (n = 27)	p
Diagnosis, n (%)			
Crush Syndrome	213 (23)	23 (85.2)	**<0.001**
Head injury	28 (3)	3 (11.1)	0.053
Thorax injury	122 (13.1)	5 (18.5)	0.390
Abdominal injury	38 (4.1)	3 (11.1)	0.105
Spinal injury	95 (10.2)	1 (3.7)	0.510
Bone fractures in the extremities	235 (25.3)	4 (14.8)	0.214
Maxillofacial injury	66 (7.1)	0 (0)	0.250
Vascular injury	15 (1.6)	1 (3.7)	0.370
Acute kidney injury	102 (11)	19 (70.4)	**<0.001**
Hypernatremia	29 (3.1)	5 (18.5)	**0.002**
Length of stay in the ED alive (mins)			
Median (IQR) [min-max]	150 (46.5–360) [10–2880]	445 (230–600) [30—1320]	**<0.001**
Emergency hemodialysis, n (%)			
No	854 (92)	14 (51.9)	**0.001**
Yes	74 (8)	13 (48.1)	
Emergency surgical intervention, n (%)			
No	716 (77.2)	21 (77.8)	0.939
Yes	212 (22.8)	6 (22.2)	

Abbreviations: ED: emergency department.

Table 3
Laboratory results of patients.

Parameters	Survivors group (n = 928)	Non-survivors group (n = 25)	p
BUN (mg/dL)	**(n = 626)**	**(n = 25)**	**<0.001**
Median (IQR)	17.3 (11.4–33.2)	61.3 (50.4–89.2)	
Creatinine (mg/dL)	**(n = 632)**	**(n = 25)**	**<0.001**
Median (IQR)	0.7 (0.5–1)	3.1 (2.3–4.5)	
CK (U/L)	**(n = 529)**	**(n = 23)**	
Median (IQR)	594 (212–4959)	10,304 (611–54,983)	**<0.001**
Sodium (mEq/L)	**(n = 624)**	**(n = 25)**	0.364
Mean ± SD	139.3 ± 5.4	140.6 ± 7.4	
Potassium (mEq/L)	**(n = 623)**	**(n = 22)**	**<0.001**
Median (IQR)	4.2 (3.9–4.8)	5.5 (4.9–6.2)	
Calcium (mg/dL)	**(n = 602)**	**(n = 23)**	**<0.001**
Median (IQR)	8.8 (8.1–9.4)	7.5 (6.1–8)	
ALT (U/L)	**(n = 631)**	**(n = 25)**	**<0.001**
Median (IQR)	36 (19–95)	279 (53–490)	
AST (U/L)	**(n = 631)**	**(n = 23)**	**<0.001**
Median (IQR)	54 (28–206)	596 (131–2053)	
D-dimer (mg/L)	**(n = 119)**	**(n = 4)**	**0.019**
Median (IQR)	3 (1.6–7.6)	22.5 (8.6–56.7)	
hsTroponin I (ng/L)	**(n = 574)**	**(n = 23)**	
Median (IQR)	11.4 (3.8–71.6)	589.9 (245.6–3212.4)	**<0.001**
Glucose (mg/dL)	**(n = 614)**	**(n = 24)**	**<0.001**
Median (IQR)	111 (94–137)	146.5 (104.5–207)	
WBC (10^3/μL)	**(n = 640)**	**(n = 25)**	**<0.001**
Median (IQR)	11.8 (8.6–16.4)	19.9 (12–29.5)	
Platelet count (10^3/μL)	**(n = 638)**	**(n = 25)**	0.107
Median (IQR)	226 (181–274)	206 (169–236)	
Hemoglobin (g/dL)	**(n = 639)**	**(n = 25)**	**0.042**
Mean ± SD	12.7 ± 2.7	13.9 ± 2.8	
Lactate (mmol/L)	**(n = 392)**	**(n = 19)**	**<0.001**
Median (IQR)	1.66 (1.25–2.36)	4.54 (2.03–7.41)	
pH	**(n = 266)**	**(n = 12)**	**0.022**
Median (IQR)	7.36 (7.32–7.40)	7.23 (7.14–7.42)	
Neutrophil count (10^3/μL)	**(n = 640)**	**(n = 25)**	**<0.001**
Median (IQR)	8.9 (6.13–13.38)	16.8 (9.05–27.70)	
Lymphocyte count (10^3/μL)	**(n = 640)**	**(n = 25)**	0.286
Median (IQR)	1.35 (0.9–2.0)	1.2 (0.7–1.95)	
Base Excess	**(n = 266)**	**(n = 12)**	
Median (IQR)	1.1 [(−1.8)-(4.43)]	−8.4 [(−11.43)-(0.83)]	**0.005**
NLR	**(n = 640)**	**(n = 25)**	**<0.001**
Median (IQR)	6.81 (3.65–12.73)	12.82 (8.5–23.23)	

Abbreviations: BUN: blood urea nitrogen, SD: standard deviation, CK: creatine kinase, WBC: White blood count, hsTroponin I: high sensitive troponin I, AST: aspartate aminotransferase, ALT: alanine aminotransferase, NLR: Neutrophil lymphocyte ratio.

4. Discussion

Between 1998 and 2017, earthquakes caused nearly 750,000 deaths globally, according to the World Health Organization (WHO) [5].

Table 4
Multivariate logistic regression analysis of factors affecting mortality in patients included the study.

Feature/Variable	B	S.E.	p	Exp (B)	95% CI	
					Lower	Upper
ID information	−0.924	0.476	0.052	0.397	0.156	1.010
Trapped under debris	1.197	1.193	0.316	3.311	0.319	34.333
Crush syndrome	1.472	0.807	0.068	4.357	0.895	21.203
Acute kidney injury	1.470	0.592	**0.013**	4.347	1.362	13.877
Hypernatremia	0.750	0.571	0.189	2.116	0.692	6.475
Emergency hemodialysis	0.267	0.504	0.597	1.306	0.486	3.510
Length of stay in the ED alive	0.000	0.001	0.690	1.000	0.999	1.001
Constant	−3.337	0.632	0.000	0.036		

Abbreviations: ID: Identification, ED: Emergency department.

Table 5
Analysis of patients with unknown ID.

Feature/Variable	ID unknown (n = 97)	ID known (n = 858)	p
Trapped under debris, n (%)			
No	25 (25.8)	459 (53.5)	**<0.001**
Yes	72 (74.2)	399 (46.5)	
Type of presentation to the ED, n (%)			
By own means	19 (19.6)	411 (47.9)	
By Ambulance	77 (79.4)	443 (51.6)	**<0.001**
Unknown	1 (1)	4 (0.5)	
Triage code, n (%)			
Green	30 (30.9)	352 (41)	
Yellow	37 (38.1)	384 (44.8)	**<0.001**
Red	30 (30.9)	122 (14.2)	
Emergency hemodialysis, n (%)			
No	82 (84.5)	786 (91.6)	**0.022**
Yes	15 (15.5)	72 (8.4)	
Emergency surgical intervention, n (%)			
No	66 (68)	671 (78.2)	**0.024**
Yes	31 (32)	187 (21.8)	
Status of survival, n (%)			
Survived	89 (91.8)	839 (97.8)	**0.004**
Deceased	8 (8.2)	19 (2.2)	

Abbreviations: ID: identification, ED: emergency department.

Approximately 60,000 people also lose their lives in natural disasters every year. >50,000 people died in the February 2023 earthquakes in Türkiye [1]. Most earthquake-related deaths occur before victims reach medical facilities due to insufficient earthquake readiness among individuals and societies. While prioritizing disaster preparedness is crucial for reducing mortality, identifying mortality factors of victims rescued from earthquakes or rescued under debris can enhance the ability of healthcare professionals to offer efficient care in the ensuing chaotic circumstances.

Liu et al. [6] analyzed 284 patients from the West China Earthquake Patients Database and found no difference between the gender of the non-survivors and survivors; however, being 65 or older increased the mortality rate. According to research conducted after the 1999 Taiwan earthquake [7], those who died were more likely to be women over the age of 65. In a study of patients hospitalized following the Mw 7.8 Gölcük earthquake in 1999, one of the worst natural catastrophes in the last century, no difference in gender or age was discovered [8] between the non-survivors and survivors. In another study conducted after this earthquake, it was found that mortality in female patients on dialysis was higher. In 2002, in a study examining the mortality markers of patients after the earthquake in Afyon, no difference was found between genders and age in terms of mortality. No statistically significant difference was found between non-survivors and survivors in terms of gender and age in the present study.

Identifying the victims of natural disasters is a difficult process that requires meticulous investigation. Many methods, including genetic analysis, are used to identify the deceased victims [9,10]. Furthermore, it is medically and forensically important to recognize survivors of disasters and to identify patients whose identity information cannot be determined. The identification of 97 trauma patients within the present research could not be completed in the emergency department because they had no identification documents, were unable to provide information on their identity, or had no companion. The post-earthquake dysfunction of hospitals in earthquake zones, as well as the transfer of patients to other facilities outside the province following triage and initial medical care, made it more difficult to identify patients [11].

It was found that the patients whose identity could not be determined in the ED were mostly from Hatay province, were those rescued from the debris and presented by ambulance, and were critical care patients with red triage code. The emergency department is where quick and crucial decisions are made for patients in this situation, and knowing a patient's background, medications, and allergies is critical for them

to receive proper examination and treatment. The rate of unidentified patients in the non-survivors group was found to be approximately 3 times higher than in the survivors group. Additionally, it is also possible that people searching for relatives in the hospital may unintentionally affect medical care processes, further stress health personnel who are already under stress, and violate patient privacy. Although genetic analysis is undoubtedly the most effective way for identifying unidentified patients, it is not practical, particularly in emergency services, due to its high cost and late results. In 2007, Chung et al. [12] made suggestions for reuniting children lost in disasters with their families. Nowadays, many methods such as biomarkers, facial recognition systems, fingerprints, and retinal scanning are widely used in a variety of setting such as banks and border crossings. Smartwatches and wristbands can also contain medical identity records. The fact that hospital automation systems are not combined with such modern technologies may have made identification difficult.

For the provinces most affected by the devastation caused by the earthquake, the authorities designated rescue provinces. For example, the injured in Kahramanmaraş, the epicenter of the earthquake, were brought to Kayseri for treatment, while the injured in Hatay were brought to Adana because it was closer and less affected by the earthquake. Patients were transferred to other adjacent provinces after first intervention and triage because the medical centers in Hatay, one of the provinces most impacted by the earthquake, were damaged and dysfunctional in the chaotic atmosphere [13]. Adana, which functions as a portal due to its connection to the highways to the east of Türkiye, a port on the Mediterranean coast to the south, and an airport in the city center, was the province to which patients arrived on their own or were referred, particularly from the adjacent province of Hatay. The 200 km highway between Adana and Hatay became an escape route for earthquake victims who could not access the health care they needed or who wanted to leave the earthquake zone. Due to the considerable increase in traffic during the post-earthquake period, traffic accidents and fights were also inevitable. One of the patients who had cardiopulmonary arrest before arrival to the ED and declared deceased in our ED was a 71-year-old man who was rescued from the debris and transported by ambulance who ultimately died after suffering head trauma in a traffic accident due to the increased traffic on the roads. Increased traffic was also a likely cause of death for another patient who was a 68-year-old woman rescued alive from the debris on the first day of the earthquake in Hatay province, with crush injuries to all extremities and head trauma, but who had cardiopulmonary arrest while being transferred by ambulance and declared decased in our ED. Although the majority of both survivors and non-survivors patients came from Hatay, there was no statistically significant difference between the non-survivors and survivors groups in terms of the city they came from.

According to a study of patients presented to Izmir hospitals following the Mw 6.9 Aegean Sea-Izmir earthquake on October 30, 2020 [14], all but one of the deceased patients were rescued from the debris, and the injured person who had been under the debris for the longest time was rescued after 91 h. In a study of patients who arrived in Diyarbakır province following the February 2023 earthquakes in Türkiye, it was found that nearly one-third of those rescued from under the debris were deceased [2]. It is not surprising that the non-survivors group was more likely to be trapped under debris and the duration of time under debris was longer. The victims with black codes (i.e., those with injuries incompatible with life or without spontaneous respiration) who were pulled out from debris were taken directly to morgues without being routed to emergency departments as they should have been, following decisions made by the emergency health coordinators in the region after the earthquakes. Deceased patients pulled out from the debris are the subject of another study, but it is fair to assume that the proportion of patients who died in these earthquakes who became trapped under the debris was significantly larger. Among those presented to the study hospital, the patient who was under the debris for the longest time was rescued after 203 h. Delays in search and rescue operations due to disruption of transportation due to damaged highways, airports and ports, destroyed public buildings, inability of the emergency service system to work effectively increased the length of time the injured were trapped under the debris. Hypothermia, which may have been caused by the colder temperatures of the winter season, may have reduced hypoperfusion injury by slowing down the metabolism of the injured person waiting to be rescued under the debris. However, when the patients were rescued from the debris, eventually the metabolic process continued and the findings of this study support the notion that reasons such as disseminated intravascular coagulation, hyperpotassemia, or metabolic acidosis increased the mortality of these patients.

Dehydration resulting from remaining under the debris for extended periods of time, hypothermia due to the cold damp weather, trauma caused by the rubble, and muscle damage caused many metabolic problems in earthquake victims examined in this study. When the diagnoses of the patients examined in the study were evaluated, the high rate of crush syndrome, acute renal failure, hypernatremia, and emergency dialysis in the non-survivors group supports this conclusion. However, emergency surgical intervention was similar in both groups. Crush syndrome and related complications are undoubtedly the most important problems in post-earthquake patients. In a study by Bulut et al. [8], 110 of 263 patients with earthquake-related trauma were diagnosed with crush syndrome. The mortality rate in patients diagnosed with crush syndrome was 85% in the same study. Another study investigating patients requiring hemodialysis after the Gölcük earthquake [15] reported that crush syndrome was an important risk factor for mortality.

Many risk factors have been determined for patients dying in earthquakes [4,7,16]. Patients presented after the earthquake should not only receive trauma-oriented care, but their laboratory findings, in addition to examination findings, should be assessed in order to early diagnose and treat problems such as acute renal failure, rhabdomyolysis, sepsis, and thromboembolism. Many laboratory parameters were statistically significantly higher or lower in the non-survivors group.

The higher white blood cell (WBC) count in the non-survivors group could be attributed to the body's increased inflammatory response to trauma and stress. High WBC counts indicate the activation of the body's defensive mechanisms in response to tissue damage, as well as the release of pro-inflammatory cytokines. Elevated lactate levels also indicate metabolic problems at the cellular level as a result of tissue hypoperfusion and increased anaerobic metabolism. Furthermore, in the present study, the neutrophil-to-lymphocyte ratio, a popular marker of pro-inflammatory response in many recent studies [17-19], was found to be significantly higher in the non-survivors group. These hematologic changes can be used to predict patient recovery and survival.

Increased D-dimer levels are indicators of increased coagulation activity due to trauma and related stress response, and immobilization of survivors. A meta-analysis by Sahebi et al. [20] showed an increased rate of deep venous thrombosis in earthquake victims. Thromboembolic processes can be a cause of mortality. Although not assessed in the current study, it is believed that trauma patients do not take anticoagulant therapy in the early stages due to the risk of increased bleeding.

Elevated levels of biochemical indicators such as blood urea nitrogen (BUN), creatinine, and creatine kinase (CK) in earthquake survivors have been related to severe renal and muscle deterioration and are frequently the result of tissue damage and decreased organ perfusion caused by crush injuries. Hyperpotassemia, which must be detected early in emergency departments, is common in individuals with crush syndrome and may require hemodialysis as it cannot be treated with medical interventions [4]. The rate of hemodialysis was found to be higher in the patient group compared to the non-survivors group in the present study. It should be noted that, in non-contraindicated cases, prophylactic treatment of patients in the risk group can save lives.

5. Limitations

The difficulties of keeping records in the chaotic environment made data loss inevitable due to the scale of the disaster and the high number of patients presented to the study center. Although this center serves as a major trauma center in the region, the fact that the number of injured reached thousands made it difficult to generalize the findings because the study was single-centered. We were unable to follow up on patients transferred to other centers after the evacuation because we do not have the authorization to access the national medical database (e-nabız),

6. Conclusion

Following such a devastating earthquake, medical care cannot be expected to be perfect when hospitals and health workers in the region have also suffered. The findings of this study clearly show the challenges that healthcare systems and emergency services face as a result of the difficulties caused by natural disasters. Identification methods that are effective and quick, and which employ new technologies should be used in healthcare, particularly during disasters. In order to be prepared for future disasters, efforts should be directed toward making the structural and service aspects of the health system more resilient to disasters such as earthquakes, developing rapid identification methods, and forecasting metabolic disorders that may not be detected at an early stage. In times of crisis, a method that includes trauma treatment, organ perfusion support, thromboembolism prevention, and infection prevention techniques is required based on the rule of holistic patient evaluation. This can improve the effectiveness of post-disaster health services and save more lives.

CRediT authorship contribution statement

Nezihat Rana Disel: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization. **Omer Taskin:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization. **Gulcin Daglioglu:** Investigation, Formal analysis, Data curation. **Burcu Tor:** Investigation, Formal analysis, Data curation. **Sevcan Secinti:** Investigation, Formal analysis, Data curation. **Gul Filiz Devecioglu:** Investigation, Formal analysis, Data curation. **Adile Asena Emiroglu Taskin:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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