Challenges and Clinical Impact of Medical Search and Rescue Efforts Following the Kahramanmaraş Earthquake

Mustafa Ferudun Celikmen, MD;[1] Ali Cankut Tatliparmak, MD;[2] Verda Tunaligil, MD, MPH, PhD;[3] Sarper Yilmaz, MD[4]

1. Yeditepe University Medical Faculty, Dept. of Emergency Medicine, Istanbul, Turkey
2. Uskudar University Faculty of Medicine, Dept. of Emergency Medicine, Istanbul, Turkey
3. SIMMERK Medical Simulation Center, Presidency of Disaster Health and Emergency Medical Services, TR MoH Health Directorate of Istanbul, Istanbul, Turkey
4. University of Health Sciences, Dept. of Emergency Medicine, Kartal Dr. Lutfi Kirdar City Hospital, Istanbul, Turkey; Chair, Disaster Commission of the Turkish Emergency Medicine Association, Ankara, Turkey

Correspondence:
Sarper Yilmaz, MD
Department of Emergency Medicine
University of Health Sciences
Kartal Dr. Lutfi Kirdar City Hospital
Kartal, Istanbul, Turkey
Disaster Commission of the Turkish Emergency Medicine Association
Ankara, Turkey
E-mail: sarperyilmaz08@gmail.com

Conflicts of interest/disclaimer: The authors declare that there is no conflict of interest regarding the publication of this article. The views expressed in the submitted manuscript are those of the authors and not necessarily those of the institution or funder.

Keywords: Disaster Medicine; earthquakes; Emergency Medical Services; hypothermia; public health emergencies; search and rescue operations

Abbreviations:
AFAD: Afet ve Acil Durum Yönetimi Başkanlığı [Turkey's Disaster and Emergency Management Presidency]
DMAT: Disaster Medical Assistance Team
EMT: Emergency Medical Team
GCS: Glasgow Coma Scale
MCI: mass-casualty incident
MRC: Medıcal Reserve Corps
mSAR: medical search and rescue
NGO: nongovernmental organization
SAR: search and rescue
UMKE: Ulusal Medikal Kurtarma Ekibi [National Medical Rescue Team]
WHO: World Health Organization

Abstract

Background: This study assesses the operational challenges and clinical outcomes encountered by a university-based Emergency Medical Team (EMT) during the medical search and rescue (mSAR) response to the February 2023 earthquakes in Kahramanmaraş, Turkey.

Methods: In this observational study, data were retrospectively collected from 42 individuals who received mSAR services post-earthquake. The challenges were categorized as environmental, logistical, or medical, with detailed documentation of rescue times, patient demographics, injury types, and medical interventions.

Results: In this mSAR study, 42 patients from 30 operations were analyzed and divided into environmental (26.2%), logistical (52.4%), and medical (21.4%) challenge groups. Median rescue times were 29 (IQR 28–30), 36.5 (IQR 33.75–77.75), and 30.5 (IQR 29.5–35.5) hours for each group, respectively (P = .002). Age distribution did not significantly differ across groups (P = .067). Hypothermia affected 18.2%, 45.5%, and 66.7% in the respective groups. Extremity injuries were most common in the medical group (88.9%). Intravenous access was highest in the medical group (88.9%), while splinting was more frequent in the medical (55.6%) and logistical (18.2%) groups. Hypothermia was most prevalent in the medical group (66.7%), followed by the logistical group (45.5%). Ambulance transport post-rescue was utilized for a minority in all groups.

Conclusion: The study concludes that logistical challenges, more than environmental or medical challenges, significantly prolong the duration of mSAR operations and exacerbate clinical outcomes like hypothermia, informing future enhancements in disaster response planning and execution.

Celikmen MF, Tatliparmak AC, Tunaligil V, Yilmaz S. Challenges and clinical impact of medical search and rescue efforts following the Kahramanmaraş earthquake. ***Prehosp Disaster Med.*** **2024;00(00):1–6.**

Introduction

Over the past two decades, a general overview of disasters reveals that earthquakes, constituting eight percent of all global calamities, rank third after floods (3,254 incidents, accounting for 44% of the total) and storms (2,043 incidents, 28% of the total) with 552 occurrences.[1] Notably, two of these earthquakes struck on February 6, 2023, nine hours apart, with epicenters in the Pazarcık and Elbistan districts of Kahramanmaraş, Turkey, measuring magnitudes of 7.7Mw and 7.6Mw, respectively.[2] These seismic events severely

Received: February 20, 2024
Accepted: April 14, 2024

doi:10.1017/S1049023X24000463

impacted Turkey (affecting 11 cities) and Syria. According to the Presidential report, the February 6 earthquakes resulted in the demolition or significant damage of approximately 518,000 residences across 11 provinces. Additionally, 128,778 homes sustained moderate damage.[3] Fatalities occurred in 1,559 of these buildings due to collapses triggered by the quakes. Although official figures have not been explicitly disclosed, it is estimated that at least 53,537 individuals lost their lives in Turkey, over 107,000 were injured, and more than 1.5 million people were left homeless.[4] Following the earthquakes, search and rescue (SAR) operations were conducted in 26,000 damaged buildings by national and international teams.[5] Per the United Nations Office for the Coordination of Humanitarian Affairs (OCHA; Geneva, Switzerland - New York USA), upon request from Turkey's Disaster and Emergency Management Presidency (Afet ve Acil Durum Yönetimi Başkanlığı; AFAD), approximately 5,377 personnel and 117 search dogs from 130 international urban SAR teams, alongside national teams, undertook SAR missions.[6] The magnitude of these earthquakes occurring within nine hours of each other and their strong aftershocks caused most buildings to collapse in what is typically referred to as "pancake collapses," characterized by floors compressing without significant gaps, thus necessitating challenging SAR operations as reported by international aid teams.[7] In many cases, survivors were either self-rescued from the rubble or saved by the local community well before the arrival of international teams.[8]

According to the Federal Emergency Management Agency (FEMA; Washington, DC USA), SAR in disaster contexts involves identifying injured persons within damaged areas, extracting those trapped in collapsed structures, and facilitating their transfer to safe environments and medical assistance.[9] Rescue operations from collapsed buildings represent one of the most perilous tasks SAR teams encounter following all mass-casualty incidents (MCIs), including earthquakes. In these scenarios, well-devised and trained rescue techniques and procedures are critical for the survival of the injured.[10] Rescue procedures in collapsed structures are founded on three primary stages: search, extraction, and transportation of casualties. Each stage possesses its unique techniques, procedures, and challenges.

Globally, states exhibit similar management algorithms in disaster response. Many countries have Emergency Medical Teams (EMTs) classified by the World Health Organization (WHO; Geneva, Switzerland) and supported by government or nongovernmental organizations (NGOs).[11] These EMTs, akin to the United States' and Japan's Disaster Medical Assistance Teams (DMATs), are government-backed and conduct national and international SAR operations. There are also teams similar to the United States Medical Reserve Corps (MRC) that perform more regional rescues. In Turkey, the equivalent of DMATs is Ulusal Medikal Kurtarma Ekibi (UMKE; National Medical Rescue Team), typically responsible for national and international SAR missions and classified as Type 2 EMT according to WHO standards. Additionally, municipalities, universities, and various health institutions have established EMT teams, generally tasked with more local SAR operations. However, the February 6 earthquake caused such extensive destruction that many EMT teams, similar to MRCs in Turkey, rushed to the disaster zone to participate in SAR operations. Teams comprised of medical personnel, conducting both SAR and post-rescue medical treatment, can be referred to as medical-SAR (mSAR) teams.

The literature on challenges faced during mSAR operations following major earthquakes is limited. The scarcity of scientific data may be attributed to incomplete records due to chaotic conditions immediately after earthquakes or other MCIs, heavy workloads during those times, and panic. Various other factors (scientific, bureaucratic, political, social, and/or psychological) are also considered to play a role.[12] Thus, despite the availability of data on numerous SAR operations, it has been thought that literature on both the February 6 Kahramanmaraş earthquakes and MCIs world-wide would be uniquely valuable for on-site patient access and management.

This study aims to reveal the challenges faced by an EMT established by a university with a structure similar to the MRC, consisting of health care workers and students, during mSAR operations in the disaster area until the completion of those operations, and the impact of these challenges on the injured.

Methods

Study Design and Setting

This observational study was conducted in the aftermath of the February 6, 2023 Kahramanmaraş earthquakes in Turkey, with a focus on mSAR operations undertaken by a university-established EMT. The team, structured similarly to the MRC and consisting of health care workers and students, responded to the disaster across the affected regions. The challenges encountered during these operations and their impact on the injured were analyzed retrospectively. The study protocol was reviewed and approved by the Yeditepe University (Istanbul, Turkey) Non-Interventional Clinical Research Ethics Committee, approval number E.83321821-805.02.03-337, dated January 12, 2024. Data confidentiality was maintained, ensuring the anonymity of individuals involved in the mSAR operations.

Participants

The study population comprised victims of the earthquakes who were subjected to mSAR operations, along with the health care workers and students who were part of the EMT. Inclusion criteria for the study were participation in the SAR operation as a rescuer or being rescued during the mSAR operations. Exclusion criteria included victims and rescuers who were involved in operations beyond the scope of this study's EMT.

Data Collection

Data were retrospectively collected from field operation reports, medical records, and debriefing sessions with mSAR team members. This included information on environmental, logistical, and medical challenges encountered during SAR operations. Demographic information, including age, gender, and nationality, was recorded. Each victim's identification status and whether the rescue was performed during daylight were noted. Rescue details were collected, focusing on the rescue time, the number of patients extracted from the same location, and whether the rescuer was a civilian or part of a professional team. Victims' positions when found were documented, with particular attention to whether they were in the fetal position. The Glasgow Coma Scale (GCS) scores were used to assess the neurological status of the victims at the time of rescue. Types of injuries recorded included head, torso, and extremity injuries. Medical interventions performed during or immediately after the rescue were meticulously recorded. These included establishing intravenous access, splinting, performing needle thoracostomies, intubation, and amputation. Conditions such as hypothermia, hypotension, and agitation were also

https://doi.org/10.1017/S1049023X24000463 Published online by Cambridge University Press

documented, along with whether the patient was transported by ambulance. Additional environmental and health conditions were also part of the data collection process.

Challenge Categorization

Challenges were categorized into environmental, logistical, and medical based on their nature. Environmental mSAR challenges included cold weather and inadequate lighting; logistical challenges included transportation, confined space rescue, management of overweight patients, lack of splinting materials, and the degree of victims buried under rubble; while medical challenges encompassed establishing intravenous access, addressing hearing impairments, and managing spinal trauma.

Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences for Windows (SPSS v.29; IBM Corp.; Armonk, New York USA) software. The normal distribution of the groups was assessed using histograms and the Shapiro-Wilk test. Descriptive statistics were used to summarize the data, presenting categorical variables as counts and percentages, and continuous variables as median (interquartile range [IQR], 25th- 75th percentile). For the comparison of categorical variables between independent groups, the chi-square test was employed. The comparison of continuous variables between independent groups was conducted using the Kruskal-Wallis test for non-normally distributed data. Statistical significance was determined at a P value of <.05 All analyses were performed using a two-tailed approach.

Results

The study included 42 patients from 30 mSAR operations, categorized into three groups based on the challenges faced during the mSAR operations. A total of 26.2% of the patients (n = 11) were in the environmental mSAR challenges group, 52.4% (n = 22) were in the logistical mSAR challenges group, and 21.4% (n = 9) were in the medical mSAR challenges group. The median age was 25 (IQR 9 – 28) years for the environmental mSAR challenges group, 11 (IQR 7 – 30.5) years for the logistical mSAR challenges group, and 32 (IQR 21 – 47) years for the medical mSAR challenges group, with no statistically significant difference in age across groups (P = .067; Table 1). The female gender ratio was 81.8% (n = 9) in the environmental mSAR challenges group, 77.3% (n = 17) in the logistical mSAR challenges group, and 33.3% (n = 3) in the medical mSAR challenges group. The rate of established refugees was 28.6% (n = 4) in the environmental mSAR challenges group, 31.8% (n = 7) in the logistical mSAR challenges group, and 33.3% (n = 3) in the medical mSAR challenges group. Identification was possible for 15.8% (n = 3) of patients in the environmental mSAR challenges group, 57.9% (n = 11) in the logistical mSAR challenges group, and 26.3% (n = 5) in the medical mSAR challenges group. Initial contact with victims (location identification) was made by volunteer rescuers or NGOs for all patients (n = 11) in the environmental mSAR challenges group, 72.7% (n = 16) in the logistical mSAR challenges group, and 88.9% (n = 8) in the medical mSAR challenges group. The median rescue time was 29 (IQR 28 – 30) hours for the environmental mSAR challenges group, 36.5 (IQR 33.75 – 77.75) hours for the logistical mSAR challenges group, and 30.5 (IQR 29.5 – 35.5) hours for the medical mSAR challenges group, with a statistically significant difference observed between groups (P = .002). The median rescue time was significantly lower in the environmental mSAR challenges group and medical mSAR challenges group compared to the logistical mSAR challenges group (respectively; P < .001, P = .036) with no significant difference between the environmental and medical mSAR challenges groups (P = .0378). Rescues occurred during daylight hours for 81.8% (n = 9) of patients in the environmental mSAR challenges group, 86.4% (n = 19) in the logistical mSAR challenges group, and 88.9% (n = 8) in the medical mSAR challenges group. The number of survivors found at the same location was a median of two (IQR 1 – 3) for the environmental mSAR challenges group, two (IQR 1 – 2) for the logistical mSAR challenges group, and one (IQR 1 – 3) for the medical mSAR challenges group, with no statistically significant difference between groups (P = .882). Overall, 72.7% (n = 8) of patients in the environmental mSAR challenges group, 77.3% (n = 17) in the logistical mSAR challenges group, and 22.2% (n = 2) in the medical mSAR challenges group were found in the fetal position.

The median GCS was 15 (IQR 13 – 15) for the environmental mSAR challenges group, 15 (IQR 13 – 15) for the logistical mSAR challenges group, and 15 (IQR 12 – 15) for the medical mSAR challenges group, with no statistically significant difference observed between groups (P = .600; Table 2). Head injuries were observed in 18.2% (n = 2) of patients in the environmental mSAR challenges group and 9.1% (n = 2) in the logistical mSAR challenges group, with no head injuries noted in the medical mSAR challenges group. Torso injuries were not observed in the environmental mSAR challenges group but were seen in 4.5% (n = 1) of the logistical mSAR challenges group and 22.2% (n = 2) of the medical mSAR challenges group. Extremity injuries were observed in 27.3% (n = 3) of the environmental mSAR challenges group, 27.3% (n = 6) of the logistical mSAR challenges group, and 88.9% (n = 8) of the medical mSAR challenges group.

Intravenous access and fluid therapy were administered to 27.3% (n = 3) of patients in the environmental mSAR challenges group, 22.7% (n = 5) in the logistical mSAR challenges group, and 88.9% (n = 8) in the medical mSAR challenges group while trapped under the rubble (Table 3). Splinting was not performed for any patients in the environmental mSAR challenges group, whereas it was performed for 18.2% (n = 4) in the logistical mSAR challenges group and 55.6% (n = 5) in the medical mSAR challenges group under the rubble. Needle thoracostomy and orotracheal intubation were performed on site for two patients and one patient, respectively, in the medical mSAR challenges group, with no such procedures conducted in the other groups. Amputation under the rubble was observed for one patient in the environmental mSAR challenges group, with no amputations in the other groups.

Hypothermia developed in 18.2% (n = 2) of patients in the environmental mSAR challenges group, 45.5% (n = 10) in the logistical mSAR challenges group, and 66.7% (n = 6) in the medical mSAR challenges group (Table 4). No evident agitation was observed in patients of the environmental mSAR challenges group, while it was seen in 9.1% (n = 2) of the logistical mSAR challenges group and 11.1% (n = 1) of the medical mSAR challenges group. Post-mSAR ambulance transport to the hospital was facilitated for 9.1% (n = 1) of patients in the environmental mSAR challenges group, 9.1% (n = 2) in the logistical mSAR challenges group, and 22.2% (n = 2) in the medical mSAR challenges group.

Discussion

In the aftermath of MCIs like major earthquakes, which affect and injure catastrophic numbers of people, SAR teams encounter numerous challenges that can impact the success of their efforts. The difficulties and experiences faced by mSAR teams during

https://doi.org/10.1017/S1049023X24000463 Published online by Cambridge University Press

Characteristic	Environmental mSAR Problems (N = 11)	Logistical mSAR Problems (N = 22)	Medical mSAR Problems (N = 9)	*P* Value
Age of Injured (years)	25 (9 - 28)	11 (7 - 30.5)	32 (21 - 47)	.067
Gender (female)	9 (81.8%)	17 (77.3%)	3 (33.3%)	[a]
Nationality (refugee)	4 (28.6%)	7 (31.8%)	3 (33.3%)	[a]
Identification Present	3 (15.8%)	11 (57.9%)	5 (26.3%)	[a]
Rescuer (civilian)	11 (100.0%)	16 (72.7%)	8 (88.9%)	[a]
Rescue Time (hours)	29 (28 - 30)	36.5 (33.75 - 77.75)	30.5 (29.5 - 35.5)	.002
Daylight Rescue	9 (81.8%)	19 (86.4%)	8 (88.9%)	[a]
Patients Extracted from Same Location	2 (1 - 3)	2 (1 - 2)	1 (1 - 3)	.882

Table 1. Demographics and Rescue Details
Abbreviation: mSAR, medical search and rescue.
[a] Indicates that conditions for the chi-square test were not met, preventing comparison.

Characteristic	Environmental mSAR Problems (N = 11)	Logistical mSAR Problems (N = 22)	Medical mSAR Problems (N = 9)	*P* Value
Fetal Position	8 (72.7%)	17 (77.3%)	2 (22.2%)	[a]
Glasgow Coma Scale (GCS)	15 (13 - 15)	15 (13 - 15)	15 (12 - 15)	.600
Head Injury	2 (18.2%)	2 (9.1%)	0 (0.0%)	[a]
Torso Injury	0 (0.0%)	1 (4.5%)	2 (22.2%)	[a]
Extremity Injury	3 (27.3%)	6 (27.3%)	8 (88.9%)	[a]

Table 2. Position, GCS, and Injury Type
Abbreviations: mSAR, medical search and rescue; GCS, Glasgow Coma Scale.
[a] Indicates that conditions for the chi-square test were not met, preventing comparison.

Characteristic	Environmental mSAR Problems (N = 11)	Logistical mSAR Problems (N = 22)	Medical mSAR Problems (N = 9)
Intravenous Access	3 (27.3%)	5 (22.7%)	3 (33.3%)
Splinting	0 (0.0%)	4 (18.2%)	5 (55.6%)
Needle Thoracostomy	0 (0.0%)	0 (0.0%)	2 (22.2%)
Intubation	0 (0.0%)	0 (0.0%)	1 (11.1%)
Amputation	1 (9.1%)	0 (0.0%)	0 (0.0%)

Table 3. Medical Interventions and Conditions
Abbreviation: mSAR, medical search and rescue.

Characteristic	Environmental mSAR Problems (N = 11)	Logistical mSAR Problems (N = 22)	Medical mSAR Problems (N = 9)
Hypothermia	2 (18.2%)	10 (45.5%)	6 (66.7%)
Hypotension	1 (9.1%)	5 (22.7%)	3 (33.3%)
Agitation	0 (0.0%)	2 (9.1%)	1 (11.1%)
Transported by Ambulance	1 (9.1%)	2 (9.1%)	2 (22.2%)

Table 4. Environmental and Health Conditions
Abbreviation: mSAR, medical search and rescue.

disaster SAR operations create a unique body of literature with each disaster, due to the specific timing, nature, environmental conditions, logistical constraints, and medical mSAR challenges inherent to each earthquake and MCI. The February 6, 2023 Kahramanmaraş earthquakes highlighted diverse combinations of logistical, environmental, and medical challenges due to the earthquake's extensive destruction and wide geographical impact.[13] Analysis of data from this research shows that when the challenges encountered in mSAR operations for earthquake victims are classified into environmental, logistical, and medical difficulties,

https://doi.org/10.1017/S1049023X24000463 Published online by Cambridge University Press

the most significantly affected aspect is the duration of the mSAR operation.

Time is a critical factor in mSAR operations. The longer a victim trapped under rubble remains undiscovered post-earthquake, the lower their chances of survival.[14] Therefore, the primary goal of mSAR teams is to reach victims trapped under rubble early on. This is not only a medical imperative, but also one of the most critical issues in terms of social and logistical considerations following catastrophic earthquakes.[15] It has been reported that 80% of victims die immediately after the collapse of multi-story buildings due to the direct impact of trauma, whereas those who are trapped but alive can be rescued.[16] Literature reviews over the years have highlighted logistical factors in SAR operations, predominantly focusing on tools used in rescue efforts to shorten rescue times, such as stopping use of shovels, picks, or ladders in favor of less-refined methods like employing tractors, cranes, and bulldozers to clear debris.[17] However, this research adds to the logistical mSAR challenges category issues such as transportation, confined space rescue, overweight patients, lack of splinting materials, and a significant portion of the body being buried under rubble, finding that these factors significantly extend mSAR duration, distinctively more than environmental and medical factors. Logistical challenges emerge as the most significant factor affecting mSAR duration. Lack of lighting also significantly impacts mSAR operations. Therefore, improving logistical and lighting infrastructure is essential for more effective conduct of mSAR operations in disasters.

The February 6 earthquake in Turkey occurred during the winter season. On the day of the earthquake, the weather conditions in the SAR-operated provinces showed snow in Kahramanmaraş, Gaziantep, Malatya, Diyarbakir, Kilis, Sanlıurfa, and Adıyaman, while rain was present in Hatay, Osmaniye, and Adana, with the following days in Kahramanmaraş experiencing temperatures as low as -5° Celsius (23° Fahrenheit).[18] Additionally, the earthquake caused damage to the cities' lighting systems, leaving them particularly dark in the early stages of the aftermath.[19] Darkness and cold were challenging factors for mSAR teams during SAR operations. Although lighting issues were grouped under environmental factors in this research, it was observed that lighting difficulties were particularly prevalent in mSAR operations facing logistical challenges. This suggests that more mSAR operations could be conducted during daylight, indicating that lighting issues also affect mSAR operations. The necessity for strategies to illuminate these environments to ensure uninterrupted mSAR operations is supported by these findings.

Another notable data point from this research is the positions in which SAR teams found survivors. The first of the February 6 Kahramanmaraş earthquakes occurred at 04:17AM, lasting 65 seconds, catching most people asleep or in their bedrooms.[20] Many of the rescued were found in the fetal position. Globally, and by Turkey's leading authority on disaster management, the AFAD, it is recommended to find a safe spot during an earthquake, kneel down, protect your head and neck, and hold onto a stable object.[21] A recent study in Turkey aimed at reducing casualties during earthquakes and reaching a consensus among mSAR professionals on the effectiveness and comparison of the "Drop, Cover, and Hold On" technique versus the fetal position within the Life Triangle, argued that the fetal position offers several advantages: less surface area exposure, fewer crush injuries, better protection for a larger portion of the body against injuries, better protection against hypothermia, and better preservation of basal metabolism.[22] Similarly, this research observed that most of the rescued individuals were in the fetal position.

According to the United Nations High Commissioner for Refugees (UNHCR; Geneva, Switzerland), Turkey hosts one of the largest refugee populations in the world, with 1.7 million refugees living in the areas affected by the earthquake.[23] This study observed that being a refugee did not significantly alter the challenges faced during mSAR operations. Refugees and migrants are considered vulnerable groups during disasters.[24] Although this vulnerability can be attributed to various factors, this research found that, within the analyzed mSAR operations, refugees were similarly affected as non-refugees. The lack of a significant impact of refugee status on the difficulties encountered in mSAR operations suggests that disasters affect all individuals equally.

In mSAR operations, conditions such as the consciousness level (GCS), head injuries, torso injuries, extremity injuries, hypothermia, hypotension, and agitation were assessed; interventions conducted on site included intravenous access, splinting, needle thoracostomy, intubation, and amputation. It is known that as rescue times extend in SAR operations, there could be delays in the emergency treatment of victims with surgical issues like penetrating thoracic and abdominal injuries, open fractures, or bleeding leading to hypovolemic shock, potentially worsening the clinical course and final outcomes of the injured.[15] Hence, a wide range of interventions by medical teams at the scene has been observed. Among the limited number of injured evaluated for these interventions, a significant number were identified with hypothermia, particularly among those facing logistical challenges. In this study, environmental issues related to air temperature did not significantly impact rescue times; however, the condition of hypothermia was more frequently identified among victims experiencing logistical challenges, though the statistical analysis was not feasible due to the small size of this patient group. In the hours following the 7.8 magnitude earthquake on the morning of February 6, temperatures around the epicenter in southern Turkey dropped to approximately 37° Fahrenheit (2.7° Celsius), accompanied by a cold rainstorm.[25] In the following days, temperatures fell below freezing and remained there. These cold weather conditions affected not only the mSAR teams, but also the injured. Injured individuals in groups facing logistical issues experienced longer SAR times, and those assessed with hypothermia were more prevalent in this group. Patients trapped under rubble for extended periods are expected to develop hypothermia due to the seasonal conditions, as most injuries caused by earthquakes are traumatic, and in trauma patients, hypothermia (defined as a core temperature ≤35° Celsius/95° Fahrenheit) is thought to lead to early mortality through impaired clotting factor activity and platelet function, associated with increased blood loss and the need for more blood product transfusions.[26] The more frequent occurrence of hypothermia in victims facing logistical mSAR challenges indicates that cold weather conditions are a significant risk factor during disasters. Therefore, the risk of hypothermia should be considered in disasters occurring in cold weather conditions, and necessary measures should be taken.

Particularly after the February 6 earthquakes, thousands of health care professionals were dispatched to disaster zones. The need for personnel assistance for SAR operations in disaster areas prevailed over the management of injured in hospitals during the early phase. The concept of health care workers in hospitals and field tents conducting mSAR operations was extensively debated. Consequently, Turkey announced the establishment of the

https://doi.org/10.1017/S1049023X24000463 Published online by Cambridge University Press

UMKE-ATAK structure following the February 6 earthquakes to conduct mSAR operations in future disasters. This research is considered to be a guide for newly established mSAR teams worldwide. This is because, in this literature review, while limited studies on the medical aspects of SAR operations were identified, no research or experience study was found regarding the SAR experiences of teams composed of health care professionals.

Limitations

The interpretation of this study's results must consider certain constraints. The use of retrospective data, while providing valuable insights, may not encompass all variables that could impact the outcomes of mSAR operations. The categorization into environmental, logistical, and medical challenges, although methodical, is based on operational reports and could reflect some degree of subjectivity inherent in post-event documentation. While the sample size was sufficient to highlight significant differences among the challenge categories, it may not fully represent the diversity of circumstances encountered in mSAR operations across different regions and disasters. Additionally, the unique characteristics of the February 6, 2023 Kahramanmaraş earthquakes, including the geographic and infrastructural context, might influence the extent to which these findings can be applied to other disaster scenarios.

Conclusion

The findings of this research highlight the multitude of challenges faced during the mSAR operations in the aftermath of the February 6, 2023 Kahramanmaraş earthquakes. To manage these challenges more effectively within disaster preparedness efforts, several measures are necessary: enhancing logistical and lighting infrastructure, emphasizing the importance of the fetal position for protection during earthquakes in efforts to raise disaster awareness, conducting necessary work to meet the needs of all individuals in disasters, and taking the necessary precautions against the risk of hypothermia in disasters occurring in cold weather conditions. These strategies are crucial for improving the effectiveness of disaster response and ensuring the safety and well-being of affected populations.

Author Contributions

MFC, SY, ACT, and VT conceived the study and designed the trial. MFC and SY supervised the conduct of the trial and data collection. MFC, ACT, and SY undertook recruitment of participating centers and patients and managed the data, including quality control. MFC, VT, ACT, and SY provided statistical advice on study design and analyzed the data. VT and SY chaired the data oversight committee. MFC, VT, SY, and ACT drafted the manuscript, and all authors contributed substantially to its revision. MFC, SY, ACT, and VT takes responsibility for the paper as a whole.

References

1. Mavrouli M, Mavroulis S, Lekkas E, Tsakris A. The impact of earthquakes on public health: a narrative review of infectious diseases in the post-disaster period aiming to disaster risk reduction. *Microorganisms.* 2023;11(2):419.
2. Şenol Balaban M, Doğulu C, Akdede N, et al. Emergency response, and community impact after February 6, 2023 Kahramanmaraş Pazarcık and Elbistan Earthquakes: reconnaissance findings and observations on affected region in Türkiye. *Bull Earthquake Eng.* 2024.
3. Türkiye S. [Balance sheet of February 6 earthquakes with data]. Sputnik Türkiye. https://sputniknews.com.tr/20240205/6-subat-depreminde-kac-kisi-oldu-neler-yasandi-kac-bina-yikildi-depremin-siddeti-son-depremler-1080416968.html. Accessed February 8, 2024.
4. United Nations in Türkiye. 1.5 million now homeless in Türkiye after quake disaster, warn UN development experts. https://turkiye.un.org/en/220232-15-million-now-homeless-t%C3%BCrkiye-after-quake-disaster-warn-un-development-experts, https://turkiye.un.org/en/220232-15-million-now-homeless-t%C3%BCrkiye-after-quake-disaster-warn-un-development-experts. Accessed February 8, 2024.
5. Türkiye observes 1st anniversary of deadly Kahramanmaraş quakes. Daily Sabah. https://www.dailysabah.com/turkiye/turkiye-observes-1st-anniversary-of-deadly-kahramanmaras-quakes/news. Accessed February 8, 2024.
6. Türkiye Earthquakes Urban Search and Rescue (USAR) Team Snapshot As of 17 February 2023 – Türkiye. ReliefWeb. https://reliefweb.int/report/turkiye/turkiye-earthquakes-urban-search-and-rescue-usar-team-snapshot-17-february-2023. Published February 17, 2023. Accessed February 8, 2024.
7. Pardo Ríos M, Morales Sánchez C, Parra Beneitez Y, et al. Urban search and rescue operations (USAR) in collapsed buildings after the 2023 earthquake in Türkiye. *Emergencias.* 2023;35(4):288–296.
8. Peleg K. Notes from Nepal: is there a better way to provide search and rescue? *Disaster Med Public Health Prep.* 2015;9(6):650–652.
9. Lesson 11: Earthquake Drills, Plans, and Supplies. Learn Science at Scitable. http://www.nature.com/scitable/topicpage/lesson-11-earthquake-drills-plans-and-supplies-8706019. Accessed February 8, 2024.
10. Federal Emergency Management Agency (FEMA). https://www.fema.gov/es/home. Accessed February 8, 2024.
11. World Health Organization (WHO). Emergency medical teams. https://www.who.int/emergencies/partners/emergency-medical-teams. Accessed February 15, 2024.
12. Sever MS, Erek E, Vanholder R, et al. The Marmara earthquake: epidemiological analysis of the victims with nephrological problems. *Kidney Int.* 2001;60(3):1114–1123.
13. Yılmaz S, Karakayali O, Yilmaz S, et al. Emergency Medicine Association of Turkey Disaster Committee summary of field observations of February 6th Kahramanmaras Earthquakes. *Prehosp Disaster Med.* 2023;38(3):415–418.
14. Hakami A, Kumar A, Shim S, Nahleh Y. Application of soft systems methodology in solving disaster emergency logistics problems. *World Academy of Science, Engineering, and Technology International J Industrial Science and Engineering.* 2013;7:786–790.
15. Sever MS, Erek E, Vanholder R, et al. Lessons learned from the Marmara disaster: time period under the rubble. *Crit Care Med.* 2002;30(11):2443–2449.
16. Ron D, Taitelman U, Michaelson M, Bar-Joseph G, Bursztein S, Better OS. Prevention of acute renal failure in traumatic rhabdomyolysis. *Arch Intern Med.* 1984;144(2):277–280.
17. de Bruycker M, Greco D, Annino I, et al. The 1980 earthquake in southern Italy: rescue of trapped victims and mortality. *Bull World Health Organ.* 1983;61(6):1021–1025.
18. [Weather in the earthquake zone: The lowest temperature forecast is -5]. https://bianet.org/haber/deprem-bolgesinde-hava-durumu-en-dusuk-sicaklik-tahmini-5-273792. Accessed February 15, 2024.
19. Üniversitesi TCÜ. [The Scream of a Psychologist from the Earthquake Zone "Acıyaman"]. Üsküdar Üniversitesi. https://uskudar.edu.tr/tr/icerik/41160/deprem-bolgesi-aciyamandan-bir-psikologun-cigligi. Accessed February 15, 2024.
20. AFAD. [The first earthquake lasted 65 seconds, the second lasted 45 seconds]. https://bianet.org/haber/afad-ilk-deprem-65-ikincisi-45-saniye-surdu-274116. Accessed February 15, 2024.
21. AFAD. [Do You Know the Precautions You Can Take Before, During and After an Earthquake?] https://www.afad.gov.tr/deprem-oncesi-ani-ve-sonrasi-alabileceginiz-onlemleri-biliyor-musunuz. Accessed February 15, 2024.
22. Celikmen MF, Yilmaz S, Tatliparmak AC, Colak FU. Drop, cover, and hold on versus fetal position in the triangle of life to survive in an earthquake: a Delphi study. *Prehosp Disaster Med.* 2023;38(3):287–293.
23. [UN High Commissioner for Refugees: Aid after the February 6 earthquakes should continue]. https://www.aa.com.tr/tr/6-subat-depremlerinin-birinci-yili/bm-multeciler-yuksek-komiserligi-6-subat-depremleri-sonrasindaki-yardimlar-devam-etmeli/3129418. Accessed February 15, 2024.
24. Trentin M, Rubini E, Bahattab A, et al. Vulnerability of migrant women during disasters: a scoping review of the literature. *Int Jr Equity Health.* 2023;22(1):135.
25. Westfall S, Granados S. Why freezing temperatures in the quake-struck areas are so dangerous. *Washington Post*. https://www.washingtonpost.com/world/2023/02/08/turkey-syria-cold-dangers-freezing-earthquake-hypothermia/. Published February 12, 2023. Accessed July 16, 2023.
26. Balvers K, Van der Horst M, Graumans M, et al. Hypothermia as a predictor for mortality in trauma patients at admittance to the Intensive Care Unit. *J Emerg Trauma Shock.* 2016;9(3):97–102.