



Original research



## Retrospective comparative analysis of two medical evacuation systems for Ukrainian patients affected by war

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### ABSTRACT

**Introduction:** Coordinated medical evacuations represent an important strategy for emergency response when healthcare systems are impaired by armed conflict, particularly for patients diagnosed with life-threatening conditions such as cancer. In this study, we compare the experiences of two parallel medical evacuation systems developed to meet the medical needs of Ukrainians affected by war.

**Methods:** This retrospective study compared outcomes of two medical evacuation systems, developed by the European Union Emergency Response Coordination Centre (ERCC) and Supporting Action for Emergency Response in Ukraine (SAFER Ukraine) collaborative, in the first 10 months after the war's intensification in Ukraine (February 24 to December 21, 2022). Each groups' respective registries served as data sources. Patient demographics and allocation data were summarized descriptively. Median time for patient referral were analyzed statistically.

**Results:** The ERCC pathway evacuated 1385 patients (median age: 36 [0 – 85] years) to 16 European countries; 78.7 % (n = 1091) suffered from trauma-related injuries and 13.4 % (n = 185) from cancer. SAFER Ukraine evacuated 550 patients (median age: 9 [0 – 22] years) to 14 European and North American countries; 97.1 % (n = 534) were children diagnosed with cancer or blood disorders. The median evacuation time for the SAFER Ukraine cohort was shorter than the ERCC cohort (p < 0.001), though comparable (six versus seven days).

**Conclusion:** The ERCC and SAFER Ukraine collaborative successfully developed medical evacuation pathways to meet the needs of Ukrainian patients impacted by war. System comparison provides opportunity to identify strategies for parallel system harmonization and a pragmatic example of how to anticipate support of these patients in future armed conflicts.

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## 1. Introduction

On February 24, 2022, Russian military forces intensified the invasion of Ukraine causing widespread damage to urban centers and critical civilian infrastructure, including electricity, water and gas systems, transportation hubs, and schools. It is estimated that more than 11,000 Ukrainian civilians have been killed and an additional 32,989 injured. [1] Official casualty figures for Ukrainian military personnel have not been disclosed but estimates suggest that 70,000 have been killed and more than 100,000 injured. [2] The World Health Organization (WHO) has recorded more than 1300 attacks on healthcare facilities in Ukraine during this time. [3] As of October 2023, more than 3.7 million people are internally displaced and almost 6 million have sought refuge outside the country. [4,5].

This magnitude of damage to healthcare and civilian infrastructure led to development of multiple rapid-response systems, including coordinated medical evacuation pathways. Medical evacuation may be indicated when there is an ongoing and severe threat to patients' physical safety or when local healthcare systems can no longer render life-saving care. [6] Evacuation pathways serve the affected population by addressing direct effects of war, such as injuries from exposure to bombs and bullets, as well as indirect effects including destruction of essentials of life, such as food supplies, shelter, and health services. [7].

For common types of cancer, a significant delay in diagnosis and therapy is associated with poorer overall survival. [8,9] Disruption of treatment due to armed conflict can result in catastrophic outcomes, including foreshortening of life. The success of cancer treatment is highly dependent of precise timing and often requires a multidisciplinary approach and access to requisite supportive care. As a result, cancer patients are highly vulnerable during humanitarian crises and medical evacuations are an important strategy to support these patients.

This study compares the experiences of two medical evacuation systems developed in parallel to provide essential care to Ukrainians affected by war. The Emergency Response Coordination Centre (ERCC) of the European Commission implemented a system to transfer Ukrainians with direct, traumatic injuries and other life-threatening conditions, including cancer, to medical facilities across the European Union (EU) (Appendix Fig. 1). [10] The Supporting Action for Emergency Response in Ukraine (SAFER Ukraine) collaborative addressed the indirect effects of war experienced by Ukrainian children diagnosed with cancer and other serious blood disorders (Appendix Fig. 2). [11].

## 2. Methods

### 2.1. Human subjects

For the statistical analysis only, anonymized data was used from both evacuation registries. Analysis of the SAFER Ukraine registry for this study was reviewed by the Institutional Review Board at St. Jude Children's Research Hospital (SJCRH) and deemed exempt. Analysis of ERCC de-identified registry data rendered data anonymous in such a way that the data subject was no longer identifiable hence did not require the data subject's consent. [12].

### 2.2. Study population

Patients who were evacuated from Ukraine to a European or North American country by ERCC or SAFER Ukraine between February 24, 2022 and December 21, 2022 were included in this study.

### 2.3. Evacuation strategies

#### 2.3.1. Emergency response coordination centre (ERCC)

The ERCC is the operational arm of the EU Civil Protection Mechanism and coordinates delivery of assistance to countries affected by natural and man-made disasters by supporting civilian and military

patients of all ages with any acute (e.g. trauma or conflict-related injury) or chronic illness (e.g. cancer). [10] The ERCC facilitates evacuations through the Early Warning and Response System (EWRS) and Common Emergency Communication and Information System (CECIS) (Appendix Table 2) and is funded by the EU and participating governments. Evacuation requests are submitted to the ERCC by the Ukrainian Ministry of Health (MoH). The ERCC organizes international patient referral directly to one of the Union Civil Protection Mechanism Member and Participating States (Appendix Table 3) or via the EU evacuation hub, located in Poland, staffed by the Polish Center for International Aid (PCPM), a non-governmental organization (NGO) specializing in humanitarian assistance designated by the Polish MoH. [13] Health care and social benefits such as housing costs are covered by the EU under the temporary protection mechanism. [14].

#### 2.3.2. Supporting action for emergency response in Ukraine (SAFER Ukraine)

The SAFER Ukraine collaborative supports Ukrainian children diagnosed with cancer or blood disorders and their families and provides multifaceted assistance including direct patient evacuation and referral abroad as well as support for the Ukrainian healthcare system to maintain and build workforce and research capacity [11,15] Patient evacuations leverage an international referral network led by pediatric hematology-oncology (PHO) experts and over 100 collaborating hospital, foundation, and government partners from 18 countries. [11,15] The collaborative is funded by St. Jude Children's Research Hospital (American Lebanese Syrian Associated Charities, ALSAC), local NGOs (e.g. in providing housing support), and governmental institutions (e.g. MoH). Healthcare services at the receiving institutions are financed either by the EU under the temporary protection mechanism or respective MoH or accepting hospitals. [14,16].

To meet the evacuation needs of this vulnerable patient cohort, a two-step triage approach was designed to ensure safe transfer, with initial medical assessment in Ukraine at the Western Ukraine Specialized Children's Medical Center (WUSCMC) and second assessment at an evacuation hub in Poland staffed by six clinic and foundation partners, including WUSCMC, Tabletochki foundation, the Polish Society for Oncology and Hematology, Herosi Foundation, and SJCRH, with support from the Ukrainian and Polish MoH. [15] Children in need of evacuation are identified by the local medical teams and evacuations were requested through the WUSCMC and Tabletochki (Appendix Table 4). [15] Children who received direct evacuation support are included in this analysis, those who received other forms of support (e.g. medical record translation) were excluded. Detailed evacuation pathways descriptions can be found in Appendix Figures 1 and 2.

### 2.4. Data sources and collection

The ERCC evacuation database and the SAFER Ukraine patient registry served as data sources for this study. Patient data were anonymized for data extraction. Patient evacuation times, demographics, and allocation data were extracted. Patients included in the analysis were those 1) whose evacuation requests were submitted to the ERCC by the Ukrainian MoH or 2) who requested evacuation support from SAFER Ukraine.

### 2.5. Statistical analysis

Statistical analysis was performed using STATISTICA version 13 (TIBCO). Evacuation times were compared using either the Mann-Whitney U test or Kruskal-Wallis test with post-hoc Dunn test;  $p < 0.05$  was considered significant and all tests were two-sided. Plots were created using Python matplotlib package (version 3.7.1). [17].

The median evacuation time was defined as the time between receiving the evacuation request and patient arrival at the final referral center. To indicate the statistical dispersion of the median evacuation

time in days, the interquartile range (IQR) was calculated between the 25th and 75th percentile (25%–75%). Medical evacuation times could not be reported for 49 patients from the SAFER Ukraine cohort due to missing information related to the exact final arrival date, including 14 non-PHO patients and 2 patients who died during evacuation.

### 3. Results

#### 3.1. ERCC evacuation results

The ERCC received the first patient evacuation request from the Ukrainian MoH on April 7, 2022, and the first patient evacuation was completed on April 11, 2022 (Fig. 1). The ERCC evacuation hub in Poland opened on September 1, 2022 and the first patients arriving on September 9, 2022 (Fig. 1).

During the study period, the ERCC completed 1385 evacuations of 895 military (64.6%) and 490 civilian patients (35.4%); 135 patients (9.7%) were evacuated via the evacuation hub (Appendix Table 5). The median patient age was 36 (range 0–85) years; with median age of 35 (range 18–67) and 40 (0–85) years in the military and civilian subgroups, respectively (Table 1). Of evacuated patients, 102 (7.1%) were children (age range 0–18 years) (Appendix Table 6).

Most patients evacuated by ERCC were those with direct, traumatic injuries ( $n = 1091$ ; 78.7%) (Table 1). In the military group, almost all patients were evacuated due to trauma ( $n = 832$ ; 92.9%). Half of the civilian patients were evacuated after experiencing traumatic injuries ( $n = 259$  patients; 52.9%) and one-third were those diagnosed with cancer ( $n = 169$ ; 34.5%). In the pediatric subgroup, half ( $n = 52$ ; 51.0%) experienced trauma injury and one-third were diagnosed with chronic illnesses ( $n = 37$ ; 36.3%), including a small group of oncology patients ( $n = 12$ ; 11.7%) (Appendix Table 6).

During this time frame, patients were evacuated to 16 European countries (Fig. 2, Appendix Table 5), with Germany ( $n = 571$ ; 41.2%), Poland ( $n = 166$ ; 12.0%), and Norway ( $n = 107$ ; 7.7%) accepting the highest number of patients (Figure 2, Appendix Table 5). In addition, the ERCC facilitated secondary referral of 234 Ukrainian patients from Poland, Slovakia, and Moldova to 14 EU countries (Appendix Fig. 3).

#### 3.2. SAFER Ukraine evacuation results

The first patient evacuation requests were received by SAFER Ukraine on February 24, 2022, with the first patient evacuation facilitated on March 1, 2022 (Fig. 1). The SAFER Ukraine triage hub in Poland opened on March 4, 2022, with the first group of patients arriving on March 6, 2022 (Figs. 1,3).

During the study period, SAFER Ukraine evacuated 550 patients, and of these, 536 (97.5%) were evacuated through the SAFER Ukraine triage hub (Appendix Table 7). The remaining 14 patients (2.6%) were directly transferred to a medical center in Europe, without stopover at the triage hub, due to urgent medical needs.

The median patient age was 9 (range 0–22 years; Table 2). Patients evacuated were primarily those diagnosed with cancer or blood disorders ( $n = 534$ ; 97.0%). A small number of pediatric patients diagnosed with other chronic diseases were evacuated per the request of the Ukrainian MoH ( $n = 14$ ; 2.6%). Children diagnosed with hematologic malignancies accounted for the largest subgroup ( $n = 260$ ; 47.3%), followed by patients with extracranial solid tumors ( $n = 130$ ; 23.6%) and central nervous system or spinal cord tumors ( $n = 107$ ; 19.5%) (Table 2).

Children supported were evacuated to 14 countries in Europe and North America. To maintain capacity in the Polish healthcare system to accept emergency cases, children were intentionally evacuated to European countries beyond Poland. Countries accepting the highest number of patients included Germany ( $n = 125$ ; 22.7%), Poland ( $n = 81$ ; 14.7%), and Spain ( $n = 65$ ; 11.8%) (Figure 2, Appendix Table 7).

#### 3.3. Comparison of evacuation pathways

The cadence of evacuation requests and transfers varied for each pathway, due to the differences and needs of the supported patient populations. Due to immediate recognition of the risks associated with interruption of cancer treatment, SAFER Ukraine received the highest volume of evacuation requests within the first weeks of the crisis, resulting in high numbers of early evacuations (Fig. 3). Within this cohort, 36% ( $n = 200$ ) were evacuated by the second week of crisis and 73% ( $n = 400$ ) by the sixth week (Fig. 1, Appendix Table 7). Subsequently, the number of evacuation requests decreased and stabilized (Fig. 3).

In contrast, evacuation requests submitted to the ERCC were not immediate; 14.4% ( $n = 200$ ) of patients were evacuated in the first 13 weeks after intensification of war and 28.9% ( $n = 400$ ) were evacuated within 18 weeks (Fig. 1, Appendix Table 5). Due to ongoing conflict and subsequent traumatic injuries, ERCC evacuation requests have stabilized at a higher volume compared to the SAFER Ukraine cohort (Fig. 3).

The median evacuation time was compared between the two evacuation efforts. The median evacuation time for the SAFER Ukraine cohort was significantly shorter than the ERCC cohort ( $p < 0.001$ ). For the full cohort of ERCC patients (civilian and military), the median evacuation time was 7 days (IQR 25–75%: 5–13 days) whereas for the SAFER Ukraine cohort, the median evacuation time was 6 days (IQR 25–75%: 3–8 days). When comparing the SAFER Ukraine cohort with the ERCC military patient subgroup, the median evacuation time (7 days [IQR 25–75%: 5–13 days]) was significantly shorter for patients evacuated by SAFER Ukraine ( $p < 0.001$ ). There was no significant difference in the median evacuation time of the SAFER Ukraine patient cohort when compared with the ERCC civilian patient subgroup (median evacuation time 6 days [IQR 25–75%: 4–11 days];  $p = 0.018$ ). Overall, evacuation times of both efforts are comparable, and differences can be considered clinically insignificant.

### 4. Discussion

This report describes two medical evacuation systems developed to support patients in Ukraine whose physical safety or life-saving medical care was threatened by armed conflict. While the evacuation pathways share similar goals, these systems support different patient populations and developed processes in response to each group's respective medical and logistical needs. Initially, the ERCC system focused on developing evacuation procedures for all patients suffering from severe and life-threatening conditions. Due to ongoing conflict, adults who sustained traumatic injuries were the largest proportion of patients evacuated by the ERCC. These injuries result from the *direct* effects of war and have been the subject of considerable research and protocol development. [18] In contrast, the SAFER Ukraine evacuation pathway focused on preventing *indirect* effects of war that interrupted the complex therapeutic interventions required by children diagnosed with cancer or blood disorders. While most prolonged conflicts result in greater indirect than direct deaths, strategies to prevent indirect effects, particularly those related to serious chronic conditions, remain relatively unexplored. [19,20].

Although both systems were designed to support Ukrainian patients, the challenges the systems were designed to address differ in important ways. The ERCC evacuation system was to unburden the weakened Ukrainian health system of patients requiring both acute and chronic medical care, including an unpredictable but anticipated rising number of individuals experiencing trauma secondary to conflict. [21–23] In contrast, SAFER Ukraine focused on evacuation of an extant patient population that was deemed highly vulnerable immediately at the start of intensification, a challenge that remains largely unmet in conflict settings. [24–26] The cadence of evacuations support experienced by these systems reflect this difference. SAFER Ukraine evacuated the largest proportion of patients in the first six weeks of crisis, with 400



**Fig. 1. Milestones of evacuation efforts led by the Emergency Response Coordination Centre (ERCC) and Supporting Action for Emergency Response in Ukraine (SAFER Ukraine) teams.** Milestones within the first 10 months after the intensification of war in Ukraine are listed. The following events were defined as milestones in the evacuation efforts: 1) receipt of first evacuation request; 2) first completed medical evacuation; 3) opening of each evacuation/triage hub; 4) first completed evacuation through the respective evacuation/triage hub; 5) each 200th completed evacuation. Evacuation milestones are listed with their date of achievement.

**Table 1**  
**Demographic data of patients evacuated by ERCC within the first 10 months after the intensification of the war in Ukraine.** Demographic data are summarized for the entire ERCC patient cohort and for the civilian and military patient subgroups. Disease category assignment correlated with clinical information obtained evacuation registry. Note, the ‘other’ category summarizes a broad spectrum of disease categories including cardiologic, endocrinologic, gynecologic, hematologic, hepatic, immunologic, neurologic, oncologic, ophthalmologic, otorhinolaryngologic, psychiatric, and pulmonary illnesses.

	Civilian Patients (n; %)	Military Patients n; (%)	All Patients (n; %)
<b>Total number of patients</b>	490 (35.4)	895 (64.6)	1385 (100)
<b>Median age in years (range)</b>	40 (0 –85)	35 (18 –67)	36 (0 –85)
<b>Number of patients per patient subgroup and disease category</b>	490 (100)	895 (100)	1385 (100)
Trauma injuries	259 (52.9)	832 (92.9)	1091 (78.7)
Oncologic	169 (34.5)	16 (1.8)	185 (13.4)
Burn injuries	2 (0.4)	5 (0.6)	7 (0.5)
Other*	60 (12.2)	42 (4.7)	102 (7.4)

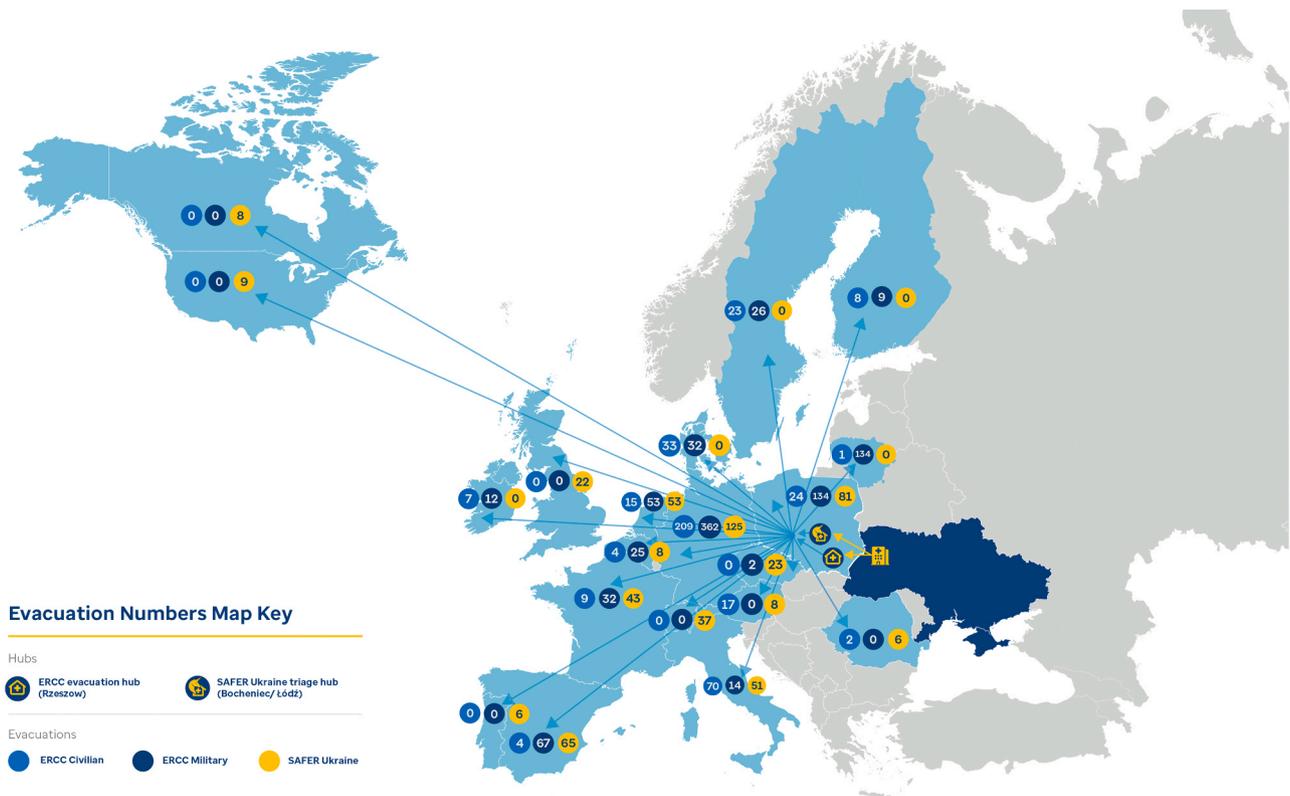
patients referred by April 2022, while the ERCC reached 400 evacuations by June 2022. Despite differences in patient populations and procedures, both systems experienced similar average processing times from initial patient evacuation request to final referral of 6–7 days.

Both systems shared important structural components that can inform future evacuation efforts. For complex, high-risk patients, long transport times can pose a significant risk for medical deterioration. Both systems established a hub near the Polish-Ukrainian border, to serve as a secure location for medical assessment, stabilization, and

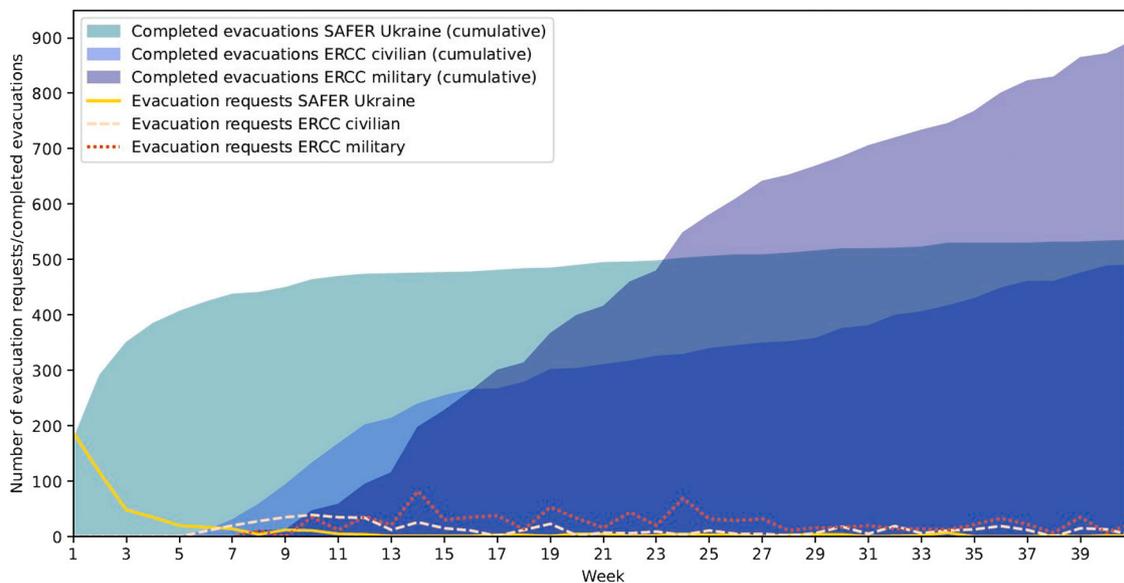
preparation for transport to referral facilities for definitive care. Whereas only 9.7 % of the ERCC patients received care at the ERCC evacuation hub, 97.5 % of the SAFER Ukraine patients were triaged at the SAFER Ukraine evacuation hub. This difference reflects the differing medical needs of these two patient populations. This two-step triage system was crucial for children supported by SAFER Ukraine, particularly those undergoing cancer-directed therapy or with newly diagnosed cancer, due to high risk of clinical deterioration enroute.

Additionally, both evacuation efforts leveraged previously established international collaborations. These collaborations included government agencies, NGOs, and clinical networks, which together provided an essential foundation for responding to the needs of the Ukrainian healthcare system. The financial backbone of both initiatives is the EU’s temporary protection mechanism, which guarantees Ukrainian citizen free access to medical care within the EU Member States. For the ERCC, financing of logistic operations, including patient transportation, was funded by the EU and government funding, inherently more secure and sustainable, compared to financing support for SAFER Ukraine, which is primarily depended on donations from NGOs. Lastly, the ERCC benefited from upfront government support and coordination. In contrast, SAFER Ukraine built government partnerships over time, including co-development of unified evacuation guidelines in August 2022 with the Ukrainian and Polish MoH and three largest PHO departments in Ukraine (WUSCMC, Okhmatdyt Children’s Hospital, and National Cancer Institute) (Appendix Table 4).

Both evacuation systems share the essential challenge of having to respond rapidly to the dynamic nature of war. The burden of direct, military casualties will continue to reflect the crescendos and decrescendos of frontline fighting while civilian injuries will likely result from strikes on residential areas. Attacks on health facilities and personnel and disruptions in medical supply chains will continue to impede the provision of healthcare services. Also of grave concern is the potential that Russia will intensify attacks on Ukraine’s infrastructure, particularly its electric grid, which could result in reduced hospital capacity and



**Fig. 2. Overview of receiving countries and completed evacuations of both medical evacuation pathways within the first 10 months after the intensification of the war in Ukraine.** For the ERCC evacuation effort, the total number of completed evacuations is reported for the civilian and military patient subgroups. For the SAFER Ukraine evacuation effort, the number of completed evacuations corresponds to the entire patient cohort. Within this time period, the ERCC pathway evacuated Ukrainian patients to 16 European countries and SAFER Ukraine evacuated Ukrainian patients to 14 European and North American countries.



**Fig. 3. Dynamics of evacuation request and completed evacuations of both medical evacuation pathways within the first 10 months after the intensification of the war in Ukraine.** The number of evacuation requests represents the absolute number of new evacuation requests per week (not cumulative). For the ERCC evacuation effort, the total number of evacuation requests and completed evacuations are reported for the civilian and military patient subgroups. For the SAFER Ukraine evacuation effort, the number of completed evacuations corresponds to the entire patient cohort.

require expansion of patient evacuations. [27].

The findings of this report should be interpreted with reservation. The immigration and geopolitical responses to the Russian assault on Ukraine have provided a highly receptive environment for Ukrainians seeking refuge in neighboring countries. [28] Few other armed conflicts

have been characterized by such support for medical evacuation, a context that should be considered when applying these findings to other humanitarian settings. [29] It is also important to recognize that there remain many other seriously ill patients in Ukraine, including children with chronic conditions other than cancer or serious blood disorders,

**Table 2**

Demographic data of patients evacuated by SAFER Ukraine within the first 10 months after the intensification of the war in Ukraine. Disease category assignment correlated with clinical information obtained evacuation registry.

	All Patients (n, %)
Total number of patients	550 (100)
Median age in years (range)	9 (0–22)
Number of patients per disease category	
CNS or spinal cord tumor	107 (19.5)
Extracranial solid tumor	130 (23.6)
Hematologic malignancy	260 (47.3)
Immunodeficiency	10 (1.8)
Non-malignant hematologic disease	27 (4.9)
Other Chronic Illness	14 (2.6)
Unknown	2 (0.4)

who have not been eligible to receive evacuation support. Also, this report describes the two evacuation systems in retrospective and summary form. This may obscure the reality that these systems, like any urgent humanitarian response, are contingent on the daily opportunities and obstacles that emerge in a rapidly evolving conflict environment.

## 5. Conclusion

Both evacuation systems continue to innovate and coordinate their activities in response to evolving patient needs. While SAFER Ukraine continues to patient evacuations, it has also shifted emphasis to strengthen capacity for patient care in Ukraine. [30] In addition, these two systems developed integrated, collaborative procedures allowing selected children with cancer and blood disorders to be evacuated through the ERCC system.

The experience of the ERCC and SAFER Ukraine systems demonstrate how clinicians, governments, and NGOs can partner to successfully evacuate selected patients whose life-sustaining care is threatened by violent conflict. The importance of these cooperations becomes particularly apparent during times of escalation, such as after the attack on the Okhmatdyt Children's Hospital in July 2024. The examination of these two systems provides empirical insight into the potential role of evacuation for both direct, traumatic injury and for the indirect consequences of interrupted treatment of serious chronic conditions such as cancer. Although evacuation remains a humanitarian strategy that is best considered only when no other pragmatic alternatives exist, this report suggests medical evacuation can represent a useful, if incomplete, strategy for providing humanitarian refuge and medical care for those who are suffering from a life-threatening condition.

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## CRedit authorship contribution statement

**Asya Agulnik:** Writing – original draft, Conceptualization. **Roman Kizyma:** Writing – review & editing. **Paul H Wise:** Writing – original draft, Conceptualization. **Anna Vinitzky:** Writing – review & editing. **Maria Zuber:** Writing – review & editing. **Wojciech Mlynarski:** Writing – original draft, Data curation, Conceptualization. **Mikhail Pogorelyy:** Writing – review & editing, Formal analysis, Data curation. **Adam Szyszka:** Writing – review & editing. **Carlos Rodriguez-Galindo:** Writing – review & editing. **Marcin Wlodarski:** Writing – review & editing. **Arman Kacharian:** Writing – review & editing. **Taisiya Yakimkova:** Writing – review & editing, Data curation. **Dmitry Evseev:** Writing – review & editing, Data curation. **Elzbieta Lipska:** Writing – review & editing. **Alexandra Mueller:** Writing – original draft,

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## 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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None.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ejca.2024.114271.

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