

Practicing Stroke Medicine in War Zones

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Conflicts and wars are on the rise globally. According to the Uppsala Conflict Data Program at Uppsala University in Sweden, a leading authority on global armed conflict data since 1946, the year 2023 witnessed a record number of 59 armed conflicts involving states. This is the highest number recorded since the program's data collection began, marking a significant escalation compared with previous years.¹

The Armed Conflict Location and Event Data Project reported a 12% increase in global conflicts from 2022 to 2023, with >147 000 conflict events recorded in 2023 alone. This increase is particularly notable, building on a cumulative rise of over 40% from 2020 to 2023. Such widespread conflicts mean that 1 in 6 people live in active conflict areas.²

Moreover, the International Crisis Group highlights that wars have risen since around 2012, after a relative decline in the 1990s and early 2000s. This article aims to document and analyze the impact of armed conflicts on the delivery of stroke care, with a focus on identifying the challenges faced by healthcare providers and stroke patients in war zones.

By understanding these challenges, we seek to improve the resilience and effectiveness of healthcare systems in conflict-affected regions. Specifically, we focus on 3 war scenarios: Ukraine, Yemen, and Sudan. We relied on a combination of official reports from organizations like the World Health Organization (WHO) and national health ministries, as well as peer-reviewed scientific publications from authors working in the affected regions.³⁻¹⁰

UKRAINE

Ukraine has one of the highest stroke incidence and mortality rates globally. Before the war, up to 130 000

people had strokes annually, with high mortality rates.³ The conflict has exacerbated these statistics, delaying access to hospitals and treatments due to bombings and limited transportation. Kharkiv, a heavily impacted city, highlights these challenges. Despite difficulties, emergency departments have remained open, providing 24/7 care for acute stroke patients. However, limited access to safe transportation and specialist staff has hindered timely and effective stroke treatment, with mechanical thrombectomy not performed in 2022 to 2023 due to staff shortages.³

The WHO's Surveillance System for Attacks on Health Care has recorded over 1824 attacks on healthcare infrastructure, resulting in 143 deaths and 344 injuries.⁵ Security concerns, restricted mobility, broken supply chains, and shortages of medical supplies have severely affected access to medical services, with over 1% of medical personnel leaving the country. Moreover, there has been a significant stroke incidence in servicemen of young age. Although some of the strokes were caused by poorly controlled hypertension or excessive smoking, others were related to head and neck injuries on or near the battlefield. During the evacuation and in military hospitals, servicemen with stroke had to compete with other groups of patients with injuries, and few of them received timely and high-quality care in the early phase.³

International Support and Initiatives

The European Stroke Organisation formed a Task Force for Ukraine to support Ukrainian stroke victims and healthcare workers. The Task Force for Ukraine promoted several initiatives, including waiving annual membership fees for European Stroke Organisation,

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supporting Ukrainian stroke physicians' relocation to other European institutions, offering grants for Ukrainian neurologists to visit stroke units in other European countries, and building educational forums supported by the Angels Initiative. Weekly Zoom calls for stroke physicians were organized, and participation grew from 30 to over 100 with expert presentations. Simulation and online training for ambulance teams resumed.⁴

Collaborations with WHO and other European institutions helped address gaps in stroke care by mapping services and providing equipment.

Healthcare System Resilience and Improvements

Despite the challenges, there have been signs of stroke care improvement in Ukraine during the war. Professional stroke societies, the Ministry of Health, the National Health Service, and the WHO country office in Ukraine have become key stakeholders in building a stroke agenda for the country. National stroke conferences, local workshops, and on-site events continued to be held. Four sets of national medical standards were developed and published, focusing on Intracerebral hemorrhage management, secondary stroke prevention, cognitive and psychological consequences of stroke, and ischemic stroke management. The rates of intravenous thrombolysis and mechanical thrombectomy in ischemic stroke have risen, exceeding 10% and 2% in 2024, respectively. Since 2020, the National Health Service of Ukraine has prioritized this critical area by introducing higher tariffs for the acute stroke treatment package. This strategic move underscored the growing recognition of the importance of specialized stroke care. Furthermore, with significant support from the World Bank, Ukraine secured a substantial loan to invest in state-of-the-art medical equipment, including ≈200 computed tomography scanners, numerous magnetic resonance imaging machines, and angiographic suites. These proactive measures laid a robust foundation for stroke treatment, ensuring that essential infrastructure and pathways were in place even before the onset of war. Despite the challenges that followed, these initiatives continued to evolve, driving meaningful improvements in stroke care delivery across the country.³

SUDAN

A civil war began on April 15, 2023, concentrating around Khartoum and Darfur. By July 2024, the conflict had killed 13 000 to 15 000 people. Since the outbreak of hostilities, an alarming 11 million people have been internally displaced, making Sudan home to the largest population of internally displaced individuals worldwide. Nearly 25 million people, almost half the nation's population, need immediate humanitarian aid and protection.⁶

Healthcare Predicament

With its 47 million inhabitants and median age of 19, Sudan is in the throes of a critical healthcare predicament. Despite its young demographic, Sudan bears a significant burden of stroke, with 48 595 new stroke cases reported in 2019 and a mortality rate of 48.09 deaths per 100 000 people.⁶

Stroke has become the third leading cause of death in Sudan. Although data have documented the incidence of stroke and its associated risk factors, such as hypertension and diabetes, the country's healthcare infrastructure has consistently struggled to provide comprehensive care. Limited access to advanced treatments, stroke units, and rehabilitation services has hindered efforts to manage and treat stroke effectively.⁶ These challenges were present even before the onset of political conflicts, which have further destabilized the healthcare system. The conflict-ravaged landscape has wrought havoc on healthcare infrastructure, causing shortages of vital resources and severely restricting access to specialized care, particularly for stroke management. Stroke care is often overlooked, deepening existing disparities in treatment and resulting in catastrophic outcomes for patients, including increased preventable deaths and disability.

Healthcare Infrastructure Challenges

The scarcity of hospitals, primarily concentrated in the capital city of Khartoum, severely limits healthcare accessibility in rural regions where the majority of the population resides. Inadequate healthcare facilities, a lack of dedicated stroke centers, and a shortage of healthcare professionals, especially neurologists, contribute to poor stroke outcomes. Before the war, intravenous thrombolysis was available in only 2 hospitals in the capital, but without a structured treatment pathway. Meanwhile, mechanical thrombectomy was—and remains—entirely unavailable in Sudan.

The ongoing conflict has forced the closure of hospitals, further exacerbating the significant challenges already facing the healthcare system, with nearly 70% of hospitals in conflict-affected regions lying in disrepair. The WHO has documented at least 77 attacks on healthcare facilities, resulting in the loss of 38 healthcare workers. These events have led to restricted, and at times nonexistent, access to healthcare for millions nationwide.⁶

Funding and Response Efforts

Funding for humanitarian response efforts has fallen significantly short of requirements, with only 26% of the revised humanitarian response plan for 2024 secured as of June 27.⁶

YEMEN

The current population of Yemen is 35 million, based on Worldometer elaboration of the latest United Nations data. Updated on July 16, 2023, with the latest July 2023 to July 2024 estimates from the United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2022 Revision (medium-fertility variant).⁷

Yemen is a resource-limited country, and its healthcare system has been devastated by political crises and military conflicts since 2011. Many health facilities lack essential services like magnetic resonance imaging/computed tomography imaging, and patients often rely on private healthcare providers due to the lack of public healthcare services. Stroke care in Yemen is further restricted by financial barriers, making thrombolysis treatment inaccessible for many patients.⁸ Until March 2023, there was no data on any stroke unit or use of reperfusion therapy in Yemen.⁹ The first stroke thrombectomy center, Borg Al-Atiba Stroke Center, was established in March 2023 and registered in the Registry of Stroke Care Quality, receiving the first World Stroke Organization Angel Award, the diamond status in Q3 2023.

The Borg Al-Atiba Stroke Center is in Aden city and serves almost 6 million people in Aden, Lahj, Al-Dhalea, Abyan, and parts of Ibb and Taiz governorates. In Aden city, there are only 5 neurologists, and most stroke cases are managed under the supervision of general internists, cardiologists, or neurosurgeons, even in teaching hospitals with no neurology departments or stroke units.

Current Barriers to Acute Stroke Treatment in Yemen

The barriers to acute stroke treatment in Yemen are multifactorial, including limited access to neuroimaging, medications, and funding for acute stroke care. Alteplase is now sourced from neighboring countries and is difficult to transport, as there is no local supplier. Stockouts have occurred, preventing timely treatment. Bringing tools for mechanical thrombectomy is challenging, akin to smuggling. Stroke treatment is not free as patients and families must pay for thrombolysis and thrombectomy upfront, a challenge given the war economy.

Moreover, there is a lack of neurologists, vascular and interventional neurologists, physiotherapists, speech therapists, and occupational therapists. No computed tomography perfusion and limited access to computed tomography angiography hinder timely stroke management. The adapted pathway includes direct transfer to the Angio-suite for expected large vessel occlusion, as computed tomography angiography is unavailable 24/7. Military checkpoints and security concerns delay rapid transport. There is also a lack of a prehospital hotline/helpline. Finally, Yemen is on the not to go list for the

United States and Europe, with no embassies to facilitate travel for training or conferences. Banking restrictions hinder membership renewals in international organizations.

CONCLUSIONS

Integrating data from conflict-affected areas, such as Ukraine, Yemen, and Sudan, presented several challenges. First, the healthcare capacities of Ukraine, Yemen, and Sudan differ substantially. Ukraine had a relatively more developed healthcare system before the conflict compared with Yemen and Sudan. Another major issue was data fragmentation, as healthcare systems in these regions are frequently disrupted due to ongoing conflicts. This disruption leads to inconsistent and incomplete data collection. These findings align with a recent systematic review on emergency care in postconflict settings, which examined healthcare challenges in Kosovo, Serbia, Afghanistan, Israel, Rwanda, South Sudan, Uganda, and Somaliland, reflecting similar patterns to our findings.¹⁰ These regions, affected by protracted conflicts and civil wars, encounter significant barriers to delivering effective emergency care, particularly for conditions like trauma, stroke, and other acute medical emergencies. Key issues identified include fragmented healthcare systems, insufficient medical supplies, and limited access to essential services such as prehospital emergency care, in-hospital treatments, and postemergency rehabilitation.¹⁰

Wars create numerous challenges for healthcare systems, from infrastructure damage and resource scarcity to the psychological burden on healthcare workers. The impact also depends on the prewar organization of stroke care, not just the intensity of the conflict. Well-organized systems may be more resilient and maintain some service continuity despite the chaos.

The implications of these findings for the broader healthcare community are significant, especially in understanding the unique challenges of delivering healthcare, particularly emergency care, in conflict or postconflict settings. By recording these impacts, we can understand the barriers faced by medical professionals and patients during war. Healthcare providers need to be prepared to respond to various emergencies, including wars, pandemics, natural disasters, and other crises, as emphasized by the WHO.⁶

These events disrupt healthcare systems and place an extraordinary burden on the management of noncommunicable diseases like stroke, which require continuous care and timely interventions. Preparedness entails adopting an all-hazards approach, integrating noncommunicable disease management into emergency response plans, and ensuring the availability of essential resources such as medications, equipment, and trained personnel.⁶ This understanding is essential for multiagency assessments and informing future crisis management plans, ensuring that immediate and long-term health needs are addressed.

Table. Challenges and Mitigation for Stroke Physicians During Wartime

Challenge	Mitigation actions	Involved organizations
Stroke falls off the health priority list	Advocate for stroke inclusion in health priorities.	Governments, UN scientific organizations (such as WSO, ASA, ESO)
	Emphasizing thrombolysis as an essential WHO treatment.	WHO
	Promote the WSO's Global Bill of Rights.	
Limited access to medical supplies	Source medications and equipment from neighboring or international suppliers.	Governments, NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
	Improve logistics and establish local supply chains.	Drug and device companies
Damage to healthcare infrastructure	Collaborate with international organizations for rebuilding efforts and provision of temporary facilities.	Governments, UN
		NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
		Drug and device companies
Shortage of healthcare professionals	Implement training programs for local stroke/emergency physicians.	Governments, NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
	Facilitate the relocation of international medical staff.	Drug and device companies
		Scientific societies
Security concerns and restricted mobility	Ensure legal protections for healthcare workers.	Governments, UN, NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
	Develop secure transportation routes for medical supplies and personnel.	
Psychological impact on healthcare workers	Provide mental health support and resilience training for medical staff (tele-support).	Governments, UN, NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
Disruption in continuity of care	Establish mobile medical units, stockpile essential medications, and implement telemedicine solutions.	Governments, UN, NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
		Drug and device companies
Financial barriers for patients	Secure funding and provide financial assistance programs for patients requiring critical treatments.	Governments, UN, NGOs, such as Médecins Sans Frontières International Committee of the Red Cross, Emergency
		Drug and device companies

ASA indicates American Stroke Association; ESO, European Stroke Organisation; NGOs, nongovernmental organizations; UN, United Nations; and WSO, World Stroke Organization.

Supporting healthcare workers through educational programs and mental health support is vital to help them cope with trauma and maintain their ability to work. The chronic stress and trauma in conflict zones can lead to exhaustion, burnout, and even abandonment of the profession. Educational activities provide up-to-date knowledge for navigating modern medicine complexities in wartime, while mental health support helps manage emotional challenges, empowering them to deliver high-quality care.

Legal protections under the rules of war are crucial to safeguard healthcare workers and maintain functionality of the medical services. Ensuring these protections is critical to preserving the sanctity and effectiveness of medical care in war zones (Table).

Specifically for access to stroke treatment, thrombolysis is part of the Essential Medicines List. This should ensure that thrombolysis is recognized as a crucial treatment, making it more accessible and affordable, even in war-torn regions.

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Disclosures

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