Article published online: 2024-03-21

Developing Systems of Care for Stroke in Resource-limited Settings

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Semin Neurol 2024;44:119–129.

Abstract

Although stroke prevention and treatment strategies have significantly advanced in recent years, implementation of these care elements in resource-limited settings can be challenging, since the burden of stroke is higher and access to stroke care is lower. Barriers to stroke care in resource-limited settings include insufficient prevention, reduced awareness of stroke symptoms, limited prehospital care and lack of triage systems, limited access to comprehensive stroke centers, inadequate personnel education, lack of staff and resources, as well as limited access to neuroimaging, thrombolytics, mechanical thrombectomy, neurosurgical care, and rehabilitation. Here, we suggest strategies to improve stroke care in these settings, including public health campaigns, protocols for prehospital notification, organized flow to specialized stroke centers, development of dedicated stroke units, and utilization of telemedicine and telerehabilitation. We also highlight the role of international organizations and governments in reducing the global burden of stroke.

Keywords
- stroke
- systems of care
- resource limited settings
- low- and middle-income countries

Stroke is a significant contributor to mortality and morbidity worldwide.[1] Significant disparities in stroke care and stroke-related outcomes between low- and middle-income countries (LMICs) and high-income countries (HICs) exist due to a confluence of intertwined factors, including gaps in universal health coverage and constrained health care resources. Availability and affordability of acute stroke therapies with proven outcome benefits are often limited, if not absent. The first steps in addressing the burden of stroke in resource-limited settings include prioritizing preventive measures to diminish stroke incidence and establishing comprehensive triage and care systems. To effectively allocate resources, it is critical to gain accurate insights into local stroke incidence, prevalence, and risk factors in LMICs, along with comprehensive data about in-hospital and long-term factors influencing mortality and disability in these settings.[2] In this article, we review challenges of stroke care and highlight prospects around establishing systems of stroke care in settings constrained by limited resources.

Epidemiology of Stroke in Low- and Middle-Income Countries

Between 1990 and 2019, there has been a decline in stroke incidence and mortality in HICs; however, these same metrics have worsened in LMICs during this time frame. LMICs account for a significant majority of stroke-related disease burden, exceeding 75% of global deaths and contributing to over 80% of disability-adjusted life-years attributed to stroke.[1]

One-third of stroke-related mortality worldwide is attributed solely to China.[3] In Latin America, stroke ranks as the second most prevalent cause of mortality, constituting 6.7% of all deaths, with an annual rate of 47.3 deaths per 100,000 residents.[4] Africa is estimated to have one of the highest stroke incidence rates worldwide, reaching up to 316 per 100,000 residents annually.[5] The INTERSTROKE study showed that individuals in LMICs present with more severe strokes and a greater proportion of intracerebral hemorrhage.[2,6] Of note, the Global Burden of Disease study and

article published online March 21, 2024

Issue Theme Neurology in Underserved and Marginalized Populations; Guest Editors: Sarah Wahlster, MD, FNCS, and Aaron L. Berkowitz, MD, PhD, FAAN

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DOI https://doi.org/10.1055/s-0044-1782617.
ISSN 0271-8235.

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Table 1 Data from the INTERSTROKE study on stroke care according to country income level[7]

	High-income country	Upper middle-income country	Lower middle-income or low-income country
CT scan on day 1	96%	95%	89%
MRI scan	20%	10%	1%
Holter monitoring	24%	2%	1%
Carotid Doppler	64%	20%	2%
Antiplatelets for ischemic stroke[a]	91%	87%	85%
Lipid lowering for ischemic stroke	72%	72%	80%
Intravenous thrombolysis for ischemic stroke	20%	4%	3%
Stroke unit available	92%	23%	61%
Postdischarge rehabilitation	92%	37%	31%

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging.

other estimates often rely on extrapolation techniques in nations where data are scarce, and may therefore underestimate the full extent of stroke burden in LIMC.[1]

Challenges in access to health care services and utilization of diagnostic procedures and therapeutic interventions based on country income level are summarized in ►**Table 1**.[7]

Challenges of Stroke Care in Resource-limited Settings

Health Care Systems

Many LMICs operate with a dual-tier health care system, with a government-funded universal health care tier accessible to all at little-to-no cost, and a separate, privately funded tier available to those with greater financial means. In several LMICs, privately funded health care options offer advanced, expeditious treatments and quality of care similar to that in HICs, albeit at a significant personal expense to the patient and their family. This cost difference has led to a marked divergence in access to health care and quality of care between the two tiers. Governments face the challenge of narrowing this disparity and ensuring universal provision of high-quality health care.[8]

A study in Brazil compared stroke care and outcomes of patients undergoing treatment at an established public health care institution and patients receiving care at a private hospital. While most treatments, including intravenous thrombolysis, were available in both settings, mechanical thrombectomy was not available and there was no stroke rehabilitation program at the public health care institution; higher prevalence of severe strokes, higher modified Rankin Scale scores, and worse patient-reported outcome measures were observed in this setting.[9,10]

Notable disparities also exist in health care between rural and urban areas in LMICs, with specialized staff, clinical expertise and experience, resources and technology often concentrated in urban settings, and larger medical centers. Rural regions experience a higher incidence of major cardiovascular events and mortality.[11] Patients with stroke in rural communities have limited access to specialized stroke units and intravenous thrombolysis or mechanical thrombectomy, resulting in elevated in-hospital mortality rates compared with their urban counterparts.[12,13]

Stroke Prevention

Hypertension, diabetes mellitus, smoking, obesity, and physical inactivity are the predominant risk factors for ischemic and hemorrhagic stroke worldwide.[6] Limited access to care and lack of resources to diagnose these modifiable risk factors likely contribute to the higher rates of stroke in LMICs. Additional stroke-risk factors beyond the classic cardiovascular risk factors are more prevalent in LMICs, including household air pollution, unhealthy diet (defined by the Alternative Healthy Eating Index),[14] and low education level.[11] Awareness and prevention of risk factors such as hypertension vary by country income level and are higher in urban communities compared with rural areas in LMICs. Degree of education also impacts risk factor awareness, control, and treatment in low-income countries (LICs).[15]

Stroke Awareness

Awareness of stroke symptoms among the general public remains limited within LMICs.[16] A cross-sectional survey of a randomly selected adult population in Uganda showed that only 18% could identify paralysis as a potential stroke warning sign, with significant differences between urban and rural populations (34 and 15%, respectively).[17] In a 2009 study from Brazil, 22% of participants did not recognize any stroke warning signs, only 35% could accurately identify Brazil's nationwide emergency telephone number, and 28 distinct Portuguese terms to describe "stroke" were used.[18]

Barriers to adequate stroke awareness include low level of health education among the general population, lack of public education and campaigns regarding stroke prevention and treatment options, as well as varying concepts of stroke symptoms.

Prehospital Evaluation

Challenges related to hospital access and timely, effective triage to stroke centers pose a major barrier to acute stroke care in LMICs. Ambulance services do not exist in many of these regions, or may be insufficiently equipped and staffed,

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and the personnel may not be adequately trained.[19] Additionally, ambulance response times can be significantly delayed in large urban settings with high vehicle density and inefficient traffic infrastructure.

Also, in LMICs, only a small fraction of patients with stroke reach health care facilities via ambulances. The preference for using personal vehicles to seek medical assistance is widespread, and can contribute to delays in arriving at a comprehensive stroke center. For instance, 85% of patients with stroke in Lebanon, and 82% of patients with stroke in Brazil have been described to arrive at hospitals through private transport.[20]

To date, 80% of reported mobile stroke units are present in HICs and in most LMICs, this option is not available.[21]

Access to Neuroimaging

Neuroimaging is an integral part of stroke care, enabling the distinction between ischemic and hemorrhagic stroke, guiding thrombolysis and thrombectomy decisions, detecting large vessel occlusions, dissections, vascular malformations, and vasospasm, and establishing the need for urgent neurosurgical interventions such as decompressive craniectomy or external ventricular drainage. However, LMICs face major shortages of imaging equipment, with less than one computed tomography (CT) scanner per 1 million inhabitants in LMICs compared with approximately 40 scanners per 1 million inhabitants in HICs.[22] These disparities are likely even bigger for magnetic resonance imaging (MRI).

In addition to limited availability of CT and MRI machines, access to imaging is often limited by operational aspects and excessive out-of-pocket costs to patients and their families. An evaluation of stroke services across Africa showed that even in regions equipped with operational CT or MRI machines, only 13 to 36% of patients presenting with acute stroke symptoms received any neuroimaging. In Ghana, two-thirds of hospitals have a functional CT scanner accessible only during weekday working hours.[23] Only 9% of patients with stroke in Nigeria and 38% in Ethiopia had the financial means to undergo CT scans.[24,25]

Lack of trained staff and infrastructure to operate and maintain scanners, and experts to provide prompt and accurate interpretation of imaging pose additional barriers in access to and utilization of neuroimaging. For example, there are 1.9 radiologists per 1 million inhabitants in LICs, compared with 97.9 per 1 million in HICs.[22] Due to absent or delayed neuroimaging acquisition and interpretation, patients with stroke are underdiagnosed and/or cannot receive time-sensitive critical treatments.

Access to Acute Stroke Treatments

Despite the widely established outcome benefits of thrombolysis and mechanical thrombectomy, access to these treatments remains largely limited in LMICs.[21] Main barriers include limited access to CT and delays in neuroimaging, limited availability and prohibitive costs of thrombolytic therapy, lack of trained staff and equipment for interventional procedures, limited availability of devices for mechanical thrombectomy, and inadequate infrastructure to ensure prompt treatment within critical time windows.

The cost of alteplase is around $1,400 per person in resource-limited settings.[24]

A global survey showed that acute stroke treatments such as thrombolysis, thrombectomy, or neurosurgical interventions (decompressive craniectomy, aneurysm repair) were available in 60% of HICs compared with 26% of LICs.[26] A systematic review evaluating the use of thrombolytic therapy for acute ischemic stroke within 214 countries found that it was only reported in 30% (3% in LICs and 19% in LMICs, compared with 50% in HICs), and appeared unavailable in regions with the highest stroke burden.[27]

In a multicenter prospective study conducted in the northeast of Brazil between 2009 and 2010, only 1.1% of patients with acute ischemic stroke received thrombolysis; in contrast, at private hospitals in wealthier regions of the country, 13% of all acute ischemic strokes arriving within 2 hours and 69.5% of eligible patients received thrombolysis.[9,28]

There are also substantial delays between authorization and availability of alteplase in LMICs. For instance, the Brazilian regulatory agency approved thrombolytics 5 years after food and drug administration (FDA) approval, and its use was initially limited to private hospitals, excluding >80% of citizens who depended on the public health care system. More than 15 years after the benefit of intravenous thrombolysis was established, the Brazilian Ministry of Health approved a national policy that made intravenous alteplase available in public hospitals.[27,29]

Access to thrombectomy is even more limited, and has been reported in only 33 countries (68% of which are HICs).[21] A survey of 75 countries revealed that only 2.8% of patients with large vessel occlusion received mechanical thrombectomy, with significant differences based on country income level (0.48% in LICs vs. 21.6% in HICs). Access to thrombectomy was associated with the country's per-capita gross national income, presence of prehospital large vessel occlusion triage policies, and the availability of mechanical thrombectomy operators and centers.[30]

Access to prompt reversal of anticoagulation or thrombolytics is another major challenge in LMICs. Inconsistent surveillance and protocols, logistical barriers, and high cost can impede timely reversal of anticoagulation for patients with acute intracranial hemorrhage. Fresh frozen plasma (FFP) is more widely available and its costs are lower compared with prothrombin complex concentrate (PCC); however, FFP requires donated blood type-specific matching, thawing of product, and delivery from the blood bank, which all delay administration. Furthermore, it can take 7 to 32 hours to effectively reverse anticoagulation and, at times, large amounts of product are required. While PCC is considered more effective and efficient, its availability is more limited in both HICs and LMICs.[31] Novel and costly medications such as idarucizumab and andexanet α are not available in most resource-limited settings. A Colombian study showed that only 11 private institutions had access to idarucizumab, only 23.6% of the 337 interviewed physicians reported access to the medication at their institution, and 34.9% were unaware of the use of this medication for stroke.[32]

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Stroke Units and Infrastructure

While the importance of specialized stroke units and their impact on outcomes is widely recognized,[33–35] they are available in merely 18% of LICs, compared with 91% of HICs.[26] The main barriers to establishing stroke units in LMICs include inadequate infrastructure, lack of adequately trained personnel, limited space and insufficient allocation of hospital beds for stroke, lack of neuroimaging, absent or limited neurosurgical capacity, lack of context-specific protocols, and financial constraints.[13,36]

Lacking awareness among policymakers about the importance of organized stroke care and its cost-effectiveness results in reduced funding and allocation of resources toward stroke services. Also, health care professionals in resource-limited settings often receive little stroke-specific training, which further precludes delivery of specialized care.

Rehabilitation Services

Although the degree of moderate-to-severe disability after stroke reaches 77% in LMICs compared with 38% in HICs, access to stroke rehabilitation is limited in LMICs due to both structural and individual-level factors. Structural barriers include insufficient prioritization of rehabilitation services, lack of national protocols, and inadequate numbers of skilled rehabilitation specialists and programs. Individual-level factors include limited health literacy, financial constraints, and limitations in transportation.[37] The proportion of patients receiving rehabilitation after stroke and type of rehabilitation support varies widely. For instance, in Rwanda, access to rehabilitation has been reported for 40% of patients with stroke, compared with 98% in South Africa. The number of reported in-hospital sessions ranged from two sessions per 16-day length of stay in Nigeria to two sessions per 7-day length of stay in South Africa.[38] Physiotherapy is generally more established than speech/language and occupational therapy, which is rarely performed. A global survey assessing stroke care in 84 countries showed that only 34% of countries reported established protocols for swallow assessments.[26] An African survey described full reimbursement of rehabilitation programs for only 23% of stroke cases.[23]

Developing Comprehensive Systems of Stroke Care

Primary Prevention Strategies and Raising Awareness

Given the substantial impact of addressing modifiable risk factors such as hypertension, diabetes, obesity, and smoking, tailored approaches to mitigate these risk factors and diminish stroke incidence in LMICs are necessary.[4] Such strategies encompass a broad spectrum of interventions, ranging from public health campaigns aimed at raising awareness and promoting healthy lifestyles to enhancing health care infrastructure for screening, timely diagnosis, and effective management of risk factors. Collaborative efforts between governments, health care organizations, and communities are integral to addressing the unique challenges of socioeconomic disparities, insufficient public health education, limited resources, and cultural factors that impact stroke risk and prevention efforts in LMICs. Collaborating with community leaders, traditional healers, and religious organizations can enhance awareness and acceptance by communities. By embracing comprehensive and culturally sensitive primary prevention strategies, LMICs can substantially curtail the burden of stroke on the individual and the health care system and contribute to improved public health outcomes.

Enhancing Prehospital Evaluation

Implementing effective prehospital systems for stroke in LMICs requires a multifaceted approach. One crucial aspect involves understanding and sensitively addressing cultural factors that might hinder a patient from swiftly seeking treatment. Since cultural norms and religious beliefs can influence health care-seeking behaviors, targeted educational campaigns addressing concerns and misconceptions surrounding stroke symptoms and treatments may encourage more patients to seek prompt medical attention. Partnering with local healers, religious organizations, and community leaders can be useful strategies to reach a wider audience in these efforts.

The development of organized national triage networks with an easily accessible phone number that connects patients and families to ambulance services and facilitates triage can augment effective health care delivery. In areas where operational ambulance services are available, their utilization should be encouraged and streamlined to ensure targeted triage to specialized stroke centers. Partnering of ambulance systems with hospitals can further enhance the triage system, for example, implementation of protocols to prenotify the destination hospital can optimize efficient stroke care[39] by streamlining resource allocation, ensuring smoother transitions, preparedness, and earlier interventions upon arrival at the medical facility. Training emergency medical technicians and other ambulance staff on conducting acute stroke evaluations and screening for pertinent history can further enhance and expedite transitions of care.

Furthermore, harnessing the readily accessible resource of personal vehicles with available guidance from a triage system can also expedite transport to specialized stroke centers. By synergistically integrating these approaches, LMICs can significantly enhance their prehospital stroke care capabilities.

Streamlining Acute Care

Facilitating emergency care for stroke in LMICs necessitates the implementation of targeted strategies and systems to ensure swift and effective diagnostic assessments and guide time-sensitive treatment decisions. A fundamental step involves comprehensive training for doctors, nurses, and other multidisciplinary health care professionals to adeptly conduct rapid evaluations and recognize which patients may be candidates for acute interventions. Introducing stroke code activation systems and emergency department protocols can minimize delays in the evaluation of eligible patients for thrombolysis, mechanical thrombectomy, or urgent neurosurgical interventions.[40] Involving health care professionals from multiple specialties, including radiology and

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pharmacy in these stroke code activation systems can improve time to neuroimaging and treatments such as thrombolytics and reversal of anticoagulation, optimizing care within critical time windows.[41] In regions with limited expertise, telestroke has become a valuable tool to guide these time-sensitive decisions.

Improving Access to Thrombolysis

Thrombolysis has demonstrated comparable safety and outcomes in LMICs compared with HICs in small case series.[42,43] Various strategies can be employed to enhance access to thrombolysis, including targeted training of health care professionals and the wide implementation of telemedicine to identify more eligible patients and facilitate their subsequent referral to stroke centers. This could especially improve treatment options for patients from remote and rural areas.[44] Recent trials have showcased the efficacy of tenecteplase for acute ischemic stroke.[45,46] Utilizing this medication can enhance access to thrombolytic treatment in resource-constrained settings due to its cost-effectiveness, single bolus administration, and the absence of a need for a second intravenous catheter or infusion pump.[47]

Implementing Mechanical Thrombectomy

Mechanical thrombectomy has emerged as a transformative intervention in stroke care.[48–50] The recent Randomization of Endovascular Treatment with Stent-retriever and/or Thromboaspiration versus Best Medical Therapy in Acute Ischemic Stroke due to Large Vessel Occlusion Trial (RESILIENT) trial conducted in Brazil demonstrated the feasibility of mechanical thrombectomy in a resource-limited setting.[29] This study was performed in the public health care sector with various limitations common to resource-limited settings. Of the 12 participating centers, only 1 had prior experience with endovascular stroke treatment, although all of them had fellowship-trained neurointerventionalists.[51] Although patients had higher overall mortality and a lower likelihood of good outcomes compared with previous trials in HICs, the trial was stopped early due to efficacy and showed that endovascular treatment within 8 hours after the onset of stroke symptoms resulted in better functional outcomes than standard care alone.

Another important milestone for stroke care in LMICs is the Society of Vascular and Interventional Neurology Mission Thrombectomy.[52] This global effort aims to raise awareness, educate, and advocate for the widespread adoption of mechanical thrombectomy, and to build a more equitable and effective stroke care landscape worldwide. By harnessing the power of collaboration among health care professionals, organizations, and policymakers, Mission Thrombectomy seeks to identify and address barriers to access, disparities in care, and limited awareness about the benefits of mechanical thrombectomy, particularly in LMICs. The initiative's emphasis on sharing best practices, facilitating research, and fostering interdisciplinary engagement has played a crucial role in promoting the implementation of mechanical thrombectomy globally. Since its creation, the program has launched road maps developed by regional committees, initiated research evaluating access to mechanical thrombectomy, organized educational workshops, developed a mobile app centered around the workflow for large vessel occlusion, and launched a teleobservership program. By fostering unity and collaboration in stroke care, Mission Thrombectomy symbolizes a collective commitment to improving outcomes and reducing the global burden of stroke.[30]

Establishing Stroke Units

Specialized stroke units provide a comprehensive, multidisciplinary approach to stroke care, and have shown to improve outcomes in both HICs and LMICs.[53,54] The main components include a physical environment with dedicated beds, diagnostic and monitoring equipment, development and implementation of standard operating procedures, staff with expertise and experience, dedicated rehabilitation, tracking of relevant stroke metrics, a stroke registry, as well as acquisition and maintenance of a formal stroke certification to ensure ongoing quality control.

Protocol-driven stroke care ensures standardized management, aiding in the reduction of variability and treatment delays. It is important to adapt protocols to the reality of resource-limited settings and institutional context. The presence of a multidisciplinary team, consisting of neurologists, neurosurgeons, emergency physicians, palliative care specialists, nurses, physiotherapists, speech and language therapists, nutrition specialists, and occupational therapists, ensures a holistic approach to patient- and family-centered stroke care. Experienced nursing and allied staff are especially important to ensure key elements of stroke care, including postthrombolysis or postthrombectomy monitoring, blood pressure control, management of an external ventricular drain, early identification of neurological deterioration, assessment of dysphagia and provision of safe nutrition to minimize aspiration, treatment of fevers, glucose control, and swift recognition of complications, including aspiration and acute infections. Integration of early mobilization and rehabilitation can facilitate recovery. Actively involving family members in the rehabilitation process can alleviate the staff burden, enhance long-term treatment adherence, and facilitate a smoother transition back home after discharge.

By adeptly combining these strategies, stroke units in LMICs can enhance the quality of care. In Brazil, a randomized trial compared the outcomes of stroke unit care to conventional ward treatment, and demonstrated a notable improvement in mortality and the number needed to treat to save one death within the 30-day poststroke period.[53]

The concept of a minimally equipped stroke unit has shown to be effective in resource-limited settings.[55,56] In a public hospital in Guinea without brain imaging facilities, a stroke unit of three acute beds demonstrated reduced stroke mortality and medical complications. This unit was equipped with heart rate, blood pressure and blood oxygen saturation monitoring, and portable oxygen concentrators; patients were evaluated every 4 hours for clinical parameters, body temperature, and National Institute of Health Stroke Scale by a dedicated stroke team, and protocols for fever, pneumonia, and decubitus ulcer prevention were utilized.[57]

The implementation of advanced stroke centers including stroke specialists, operating theaters, neurosurgical teams,

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and endovascular thrombectomy is recommended with at least one center per 2 million people. Such advanced centers require financial support and substantial investment from policymakers, public health organizations, and insurance carriers, and awareness of the cost-effectiveness of acute stroke treatments is crucial in this context.[38]

Rehabilitation and Long-term Support

Rehabilitation and long-term support are essential to the stroke recovery process. Given the high-disability burden of stroke, LMICs should invest in building comprehensive rehabilitation programs tailored to socioeconomic and health care contexts.[58] These initiatives should encompass a spectrum of interventions, including physical and occupational therapy, speech and language therapy, as well as psychosocial support. Given the resource constraints in LMICs, innovative approaches that utilize community-based rehabilitation and telemedicine can extend the reach of rehabilitation services to a larger patient population. Community-based rehabilitation programs have proven to enhance the performance in activities of daily living and cognition of patients with stroke.[59] A randomized trial in 2019 demonstrated improved upper extremity motor function with telerehabilitation in adult stroke survivors who resided at their homes.[60] Furthermore, videoconference-based and self-managed computerized speech and language therapy for individuals experiencing poststroke aphasia have resulted in significant improvements in language function.[61,62] Beyond improving functional outcomes and the patients' quality of life, telerehabilitation can also reduce depression among their caregivers.[63] However, integrating technology into health care delivery poses inherent challenges in LMICs, such as limited availability and scant technological familiarity and confidence, particularly among the elderly population. Despite these hurdles, adopting alternative methods for delivering health care can facilitate access to care, remote monitoring, and professional support, especially in rural areas with fewer resources.

Long-term support mechanisms, including caregiver education and engagement, are important to ensure sustained recovery and quality of life for stroke survivors and their families. Providing educational resources to both stroke survivors and their caregivers, conducting follow-up assessments to ensure their well-being, and remaining attentive to potential hurdles for both are paramount for providing support, especially in settings where financial and transportation-related barriers limit the ability to attend follow-up visits in stroke clinics.[64] By fostering collaboration between health care systems, communities, and families, LMICs can establish a robust framework that provides patients with the tools and support to optimize their chances for recovery and reintegration into society.

Overcoming Challenges with Innovative Solutions and Collaborations

Telemedicine and Technological Innovation

Telemedicine can be a valuable tool to overcome geographical and resource-related barriers in stroke care in LMICs and mitigate the urban–rural divide.[65] Telemedicine can be utilized to guide acute treatment decisions such as thrombolysis, increase access to outpatient stroke care and rehabilitation, and to facilitate networking and education between health care providers.[44]

The JOIN app connects local health care providers with stroke specialists, enabling timely consultations and expert guidance in stroke management. While challenges such as limited technological infrastructure and digital literacy persist, the JOIN telestroke network underscores the transformative possibilities of telemedicine.[66]

As artificial intelligence and machine learning are evolving, these tools may be leveraged to facilitate faster reporting of clinical results, sharing of medical records, imaging analysis, and outcome evaluations also in resource-limited settings. Intelligent Electronic Medical Records may assist in text search and decision support. Reliable speech recognition and context-aware communication/alert systems may enhance efficiency in patient evaluation and treatment. Automated data collection and analysis may aid in quality evaluation and research. Despite ongoing challenges with initial prototypes and data security, these technologies have the potential for enhancing clinician experiences, reducing physician workload and burnout, and reducing disparities by improving access to stroke expertise and care.[67]

Collaborations with Stroke Organizations

The World Stroke Organization (WSO) has played a pivotal role in advancing stroke care in LMICs by providing a comprehensive framework for stroke prevention and management.[68] With its global reach, WSO has led collaborative efforts to catalyze awareness, knowledge, and capacity in stroke care among health care professionals, policymakers, and communities in LMICs. The organization's emphasis on education, advocacy, and research acts as a driving force for promoting evidence-based practices, addressing disparities, and fostering interdisciplinary collaboration in stroke care.[69]

The WSO Stroke Road Map to Delivering Quality Stroke Care, is an initiative that provides a framework for the implementation, monitoring, and evaluation of stroke services globally. Through partnering with local stroke societies, and development of guidelines tailored to LMICs' contexts, the WSO provides essential tools for implementing effective stroke care strategies that are culturally sensitive and resource-appropriate.

A significant milestone in the WSO's commitment to improving stroke care is the introduction of certification for stroke centers. This initiative defined stroke standards globally and has offered a structured pathway for stroke centers worldwide to achieve recognition and validation for their efforts in delivering high-quality care. The certification process enhances the standardization of stroke care, facilitates the adoption of best practices and exchange of knowledge across borders, and fosters continuous quality improvement, with the goal to improve patient outcomes.[70]

Additional initiatives from the WSO include the Future Stroke Leaders Program (FSLP), the Implementation Taskforce, and the World Stroke Academy. The FSLP is a 2-year endeavor that unites trainees and junior investigators around the globe to engage with collaborative stroke

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research, quality improvement tools, and resources designed to support effective delivery of stroke services and advocacy for stroke. The implementation taskforce aims at accelerating the worldwide implementation of evidence-based stroke care, providing specialized support for implementation, service qualification, and quality monitoring. The World Stroke Academy is an educational platform that provides high-quality stroke education to health care professionals through articles, webinars, and podcasts.

The Global Stroke Alliance is another major collaborative platform that transcends geographical boundaries to address the global impact of stroke.[71] A diverse coalition of health care professionals, researchers, advocacy groups, and organizations —this alliance is dedicated to fostering innovative strategies that combat the multifaceted challenges of stroke. By leveraging collective expertise, sharing best practices, and advocating for policy changes, the Global Stroke Alliance is pivotal in raising stroke awareness, promoting stroke prevention, and facilitating treatment and rehabilitation globally. Through its unified efforts, the alliance embodies the spirit of global cooperation, demonstrating how collaborative action can drive meaningful change in stroke care, and ultimately improve the lives of individuals affected by stroke worldwide.

Additionally, the American Heart Association/American Stroke Association and the European Stroke Organization play major roles in regional and global efforts to enhance stroke care by providing guidelines and recommendations for stroke management, facilitating international collaboration, incentivizing research, and promoting education and awareness.

Case Study: The Brazilian Experience

Brazil is a multiethnic country with an extensive territory and more than 200 million inhabitants. Substantial social inequities result in limited access to stroke care for many. There has been remarkable progress in improving stroke care in Brazil since the approval of the national line of care for stroke in 2012, published by the Brazilian Ministry of Health.[72] This provision regulates reimbursements for thrombolytics, creation of stroke centers, integration of the Brazilian Emergency Medical System, and establishment of budgets for rehabilitation, as well as education and training of health care professionals and the public.[8] This pivotal milestone marked the inception of a comprehensive strategy to enhance stroke care delivery, including prevention, acute management, and rehabilitation. Following this landmark regulation, Brazil witnessed a significant expansion in establishing stroke centers across the country (from 35 in 2008 to 149 in 2017) and reduced mortality from stroke (17.9% in 2010 to 12.8% in 2014).[8] Implementing a national plan to combat stroke is a crucial measure in addressing and reducing the substantial disparities in access to stroke treatment.

The Declaration of Gramado (►**Table 2**), a seminal event in the realm of stroke care in Brazil, marked a significant turning point in shaping the strategies and priorities for stroke management. Convened in 2018, this landmark conference brought together an assembly of international experts, including clinicians, researchers, and policymakers, all united by a common goal: to address the challenges and opportunities in stroke prevention, treatment, and rehabilitation. This declaration underscored the importance of fostering global collaboration, sharing best practices, and advocating for policies to prioritize stroke awareness, prevention, and comprehensive care. It has since served as a framework, inspiring other nations and stakeholders worldwide to enhance their efforts in the fight against stroke, and informing other public health initiatives.

Additionally, Brazil's stroke care system was strengthened by its participation in the RESILIENT trial, which emphasized the commitment among clinicians to improve stroke care in their country, and can serve as a model for implementation and utilization of mechanical thrombectomy in resource-constrained settings.[29] This dedication, combined with a growing body of stroke research, underscores Brazil's contributions to the global effort to enhance stroke care.

While acknowledging these achievements, the path to achieving comprehensive stroke care in this expansive, geographically diverse nation remains challenging, characterized by pronounced disparities between regions. Although the approval of mechanical thrombectomy within the public health system is an important milestone, this treatment still remains unavailable to many. Further collaborations with governmental agencies and community stakeholders are necessary to bridge this gap.

Striving for Better Stroke Care Globally: Ten Practical Tips for Low- and Middle-income Countries

1. Culturally Sensitive Public Education: Identify and address cultural and religious beliefs and concerns that may hinder rapid treatment-seeking. Raise public awareness about modifiable risk factors, stroke warning signs, and the importance of seeking medical help promptly. Engage and partner with communities and religious organizations.
2. Transportation Strategies: Enhance national emergency services to improve targeted and timely triage to comprehensive stroke centers.
3. Rapid Assessment Training: Train health care providers to rapidly assess stroke symptoms and initiate steps toward time-sensitive interventions.
4. Stroke Code Activation: Establish stroke code systems and protocols in emergency departments to streamline the multidisciplinary evaluation and management of patients eligible for acute treatments, reducing times to critical interventions.
5. Access to Neuroimaging: Prioritize immediate transfer of suspected stroke to centers with rapidly available CT for prompt diagnosis and treatment decisions.
6. Access to Thrombolysis and Thrombectomy: Implement telemedicine for patient eligibility and referral, utilize cost-effective thrombolytics, develop lower cost devices, train health care professionals.
7. Infrastructural Reorganization: Develop stroke units within health care facilities to provide specialized care

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Table 2 Declaration of Gramado.[73] Source: Martins et al 2021[73].

Commitments for facing stroke in Latin American countries
• To provide public education on the stroke signs, treatment urgency, and control of risk factors;
• To promote safe and healthy environments for the practice of physical activity;
• To implement policies to control smoking, to stimulate healthy eating habits and physical activity, to reduce sodium intake and alcohol use, and to control weight, aiming in reducing the incidence of cardiovascular and cerebrovascular diseases;
• To set strategies for the detection of modifiable risk factors, such Ts hypertension, atrial fibrillation, diabetes, and hyperlipidemia;
• To promote health care for the control of modifiable risk factors;
• To organize the prehospital care to prioritize the patient with stroke;
• To prioritize the structuring and implementation of stroke centers by
○ organizing stroke units with a defined physical space and a trained multidisciplinary team
○ providing evidence-based acute treatments
○ providing exams for minimal workup of stroke causes
○ promoting the prescription of secondary prevention therapies in the hospital discharge
○ encouraging the use of telemedicine in hospitals without a specialist 24 hours per day, every day, to advise acute treatment;
• To increase access to inhospital and posthospital rehabilitation;
• To train all the health care professionals engaged in stroke care;
• To monitor national prevalence of the main risk factors and quality indicators of stroke care;
• To set national and regional evidence-based practice guidelines, with frequent updates, to standardize stroke care;
• To prioritize the structuring and implementation of Integrated Networks for Continuous Care of patients with stroke or stroke risk factors, which encompass all levels of health care, creating a line of care;
• To assign human and financial resources for the development of a stroke line of care;
• To implement national stroke care policies;
• To promote exchange of experiences among countries for the improvement of stroke care;
• To implement research in stroke based on the priorities and realities of each country.

and multidisciplinary support. Implement standardized, context-appropriate stroke protocols to ensure consistent, evidence-based treatment practices within and across health care settings. Train nursing and allied health care staff in stroke care, including early rehabilitation and mobilization of patients.

8. Rehabilitation and Long-term Support: Build comprehensive rehabilitation programs tailored to the health care contexts, implement community-based rehabilitation programs, telerehabilitation, and remote monitoring.
9. Engage Caregivers: Involve caregivers early in rehabilitation and provide education and support to enhance patient outcomes and long-term care.
10. Telemedicine Implementation: Leverage telemedicine solutions to bridge geographical gaps and improve access to stroke expertise and acute treatments, as well as remote consultation, follow-up, rehabilitation support, networking, and education.

By focusing on these essential elements of stroke care, LMICs can overcome challenges and make significant strides in stroke care, ultimately improving patient outcomes and reducing the burden of stroke on individuals and communities (►**Fig. 1**).

Conclusion

The burden of stroke remains a major public health challenge in resource-limited settings, necessitating comprehensive strategies that address cultural, infrastructural, and resource-related obstacles. LMICs face unique challenges in stroke prevention, awareness and recognition, acute diagnostics and treatment, specialized care, and rehabilitation, often stemming from limited resources, disparities in access to care, adequate training of health professionals, and diverse cultural beliefs.

Yet, the potential for transformative change is within reach. With the burden of stroke disproportionately affecting LMICs, a collective responsibility arises for global health organizations and governments to take definitive action. Collaborative efforts of international organizations, health care professionals, researchers, policymakers, and local communities are crucial in addressing the gaps in stroke care. The strategies outlined in this manuscript highlight steps that can be taken to build and improve effective stroke care

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Challenges	Solutions
Stroke awareness and prevention	
• Poor control of modifiable risk factors • Low symptom recognition • Cultural barriers	• Public health campaigns raising awareness and promoting healthy lifestyles • Targeted educational campaigns to dispel misconceptions and encourage prompt medical attention
Prehospital evaluation	
• Ambulance and equipment shortages • Inadequately trained personnel • Intense road traffic and delayed hospital arrival	• Protocols for prehospital notification • Organizing flow to specialized stroke centers
Acute care management	
• Insufficient CT and MRI machines • Low rate of thrombolysis • Limited access to thrombectomy • Untrained personnel	• Rapid assessment training of health professionals • Establishment of stroke code protocols • Prioritize immediate transfer to neuroimaging • Stroke units development • Standardized stroke care protocol creation • Telemedicine implementation • Certification of Stroke Centers
Rehabilitation	
• Inadequate access to post-stroke rehabilitation	• Integrating caregivers into the rehabilitation process • Early identification and treatment of dysphagia • Telerehabilitation • Provide education and support for long term care
Governmental Support	
• Lack of public policies addressing stroke prevention, treatment and rehabilitation	• World Stroke Organization support • Global Stroke Alliance participation • Stroke research involving LMIC

Fig. 1 Challenges and suggestions for better stroke care in resource-limited settings. CT, computed tomography; EMS, emergency medical service; LMIC, low- and middle-income country; MRI, magnetic resonance imaging.

systems in resource-limited settings, including awareness campaigns, community engagement, training resources, infrastructural reorganization, telemedicine and telerehabilitation. To assure continued progress in stroke care worldwide, multiple stakeholders must engage in sustained efforts with the ultimate goal of improving patients and family-centered outcomes in LMICs. Investing in culturally sensitive education, telemedicine solutions, rapid assessment training, and establishing stroke units can enhance the quality of stroke care. Global health organizations and governments must commit to prioritizing stroke care in LMICs, recognizing that every patient deserves equitable access to high-quality care from the initial diagnosis throughout their long-term recovery journey.

Conflict of Interest
None declared.

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