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CARDIOVASCULAR DISEASE AND STROKE (SHYAM PRABHAKARAN, SECTION EDITOR)

Implementing Evidence-Based Practices for Acute Stroke Care in Low- and Middle-Income Countries

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Abstract

Purpose of Review Most strokes occur in low- and middle-income countries where resources to manage patients are limited. We explore the resources required to providing optimal acute stroke care and review barriers to implementing evidence-based stroke care in settings with limited resources using the World Stroke Organization's Global Stroke Services Action Plan framework.

Recent Findings Major advances have been made during the past few decades in stroke prevention, treatment, and rehabilitation. These advances have been translated into practice in many high-income countries, but their uptake remains suboptimal in low- and middle-income countries.

Summary The review highlights the resources required to providing optimal acute stroke care in settings with limited resources. These resource levels were divided into minimal, essential, and advanced resources depending on the availability of stroke expertise, diagnostics, and facilities. Resources were described for the three stages of acute care: early diagnosis and management, acute management and prevention of complications, and early discharge and rehabilitation. Barriers to providing acute care at each of these stages in low- and middle-income countries are reviewed, explaining that some barriers persist in essential or advanced settings where some aspects of organized stroke units are available.

Keywords Acute stroke management · Low- and middle-income countries · Barriers · Evidence-based practice

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Introduction

An estimated 17.9 million people died from cardiovascular diseases (CVDs) in 2015; of these deaths, an estimated 6.3 million were due to stroke [1]. Age-standardized rates of stroke mortality have decreased worldwide by 30% in the past two decades [2••]. However, the absolute numbers of people who have an incident or recurrent stroke every year or live with the consequences of stroke are increasing, not only largely because of population growth and aging but also because of reductions in stroke case fatality rates [3].

Major advances have been made during the past few decades in stroke prevention, treatment, and rehabilitation [4]. As a result, recommendations in clinical practice guidelines have shifted from passively monitoring acute stroke patients to earlier interventions that increase functional survival. These interventions include thrombolysis therapy [5], early neurosurgery [6], admission to stroke units with an interdisciplinary team of healthcare providers [7], planned discharge [8], and early rehabilitation [9].

Research on the prevention and treatment of stroke has focused primarily on the needs of high-income countries (HICs), with implementation strategies applicable to those

settings, rather than low- and middle-income countries (LMICs), which are defined by the World Bank as those countries with an annual per capita gross national income of US$3955 or less (worldbank.org). This discrepancy in acute stroke care is demonstrated in higher case fatality rates seen for acute stroke among LMIC in the Prospective Urban Rural Epidemiology Study, which included 156,424 participants from 17 countries [10]. This discrepancy is further reflected in trends in age-adjusted stroke mortality and disability-adjusted life year (DALY) rates. Figure 1 presents estimates from the 2015 Global Burden of Disease study comparing HIC to LMIC. In 2013, age-standardized mortality rates and DALYs were twofold higher in LMIC compared to HIC. Further, stroke mortality rates have almost halved since 1990 in HIC. On the other hand, LMIC have experienced only a 15% decrease in stroke mortality rates. Similar trends were observed in DALYs [3].

In this paper, we review the stages of stroke care as described the by the Global Stroke Services Action Plan, developed by the World Stroke Organization [11••]. For each stage of care, we explore the resources required to providing optimal acute stroke care and describe barriers to implementing evidence-based practices in LMIC.

The Global Stroke Action Plan defines the dimensions of stroke management, including (1) recognition and early diagnosis, (2) acute care and prevention of complications, (3) rehabilitation, (4) prevention of recurrent stroke, (5) community reintegration, and (6) long-term recovery. Here, we condense these into three broad stages of acute stroke management: (1) recognition and early diagnosis, (2) acute management and prevention of complications, and (3) early discharge planning, which covers rehabilitation, prevention of recurrent strokes, community reintegration, and recovery.

What Is the Evidence and What Resources Are Required for Stroke Care?

Important evidence-based improvements have been made in the delivery of acute stroke services. For example, stroke units

and their components are key to effective in-hospital stroke management and optimal outcomes. Stroke units include diagnostic and treatment facilities that have the ability to provide acute management, monitoring of physiological abnormalities, prevention and treatment of complications, and early discharge planning [12]. Stroke units are typically geographically defined locations within the hospital and have a multidisciplinary team that provides stroke care to patients admitted to the unit [13].

A 2013 Cochrane review of 21 trials, involving 3994 participants, compared stroke unit care with care provided in general wards. Stroke unit care showed a lower odds of 1-year mortality (18% in stroke units versus 23% in general wards; odds ratio (OR) 0.81, 95% confidence Interval (CI) 0.69 to 0.94) at a median of 1 year of follow-up. Reductions in the odds of death or institutionalized care (35% in stroke units versus 40% in general wards; OR 0.78, 95% CI 0.68 to 0.89) and death or dependency (56% in stroke units versus 62% in general wards; OR 0.79, 95% CI 0.68 to 0.90) were also observed. These improvements were not accompanied by longer hospital stay [7]. Translation of these trials into clinical practice shows that implementation of stroke units is feasible with sustained benefits [14] and with evidence of cost effectiveness [15, 16].

However, organized stroke units require resources for implementation and maintenance. Therefore, implementation of these evidence-based practices and the resulting improvements in patient survival and independence have been largely restricted to HIC with limited data assessing effectiveness and describing implementation strategies in LMIC. More recently, investigators have explored the effectiveness of organized stroke units in LMIC. A 2012 systematic review identified eight studies that compared case-fatality rates of patients with stroke admitted to a stroke unit with rates in general wards in LMIC. These results indicate that even outside of HIC settings, stroke units can improve survival after stroke [12]. For example, in South Africa (one facility; $n = 195$ participants), inpatient mortality rates were reduced from 33 to 16% after implementing a stroke unit (OR = 0.35 (95% CI 0.18–0.69) [17].
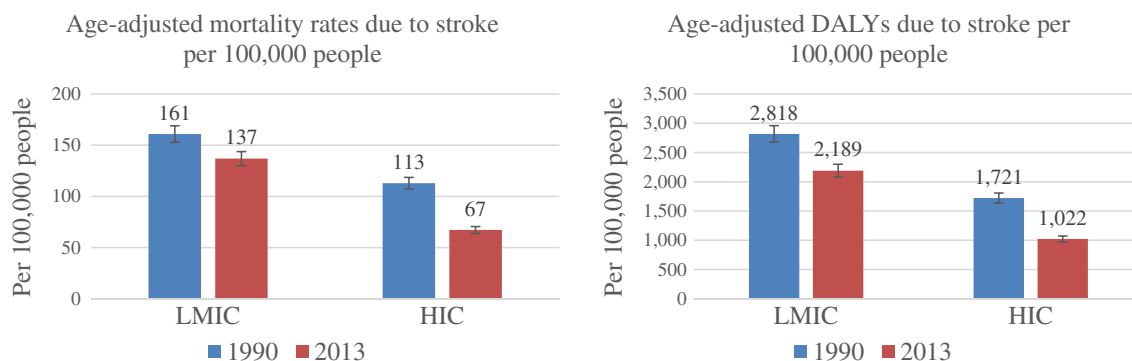

Fig. 1 Age-adjusted DALYs and mortality rates due to stroke per 100,000 people [3]

Global Stroke Services Action Plan

The World Stroke Organization produced the Global Stroke Services Action Plan to create and promote a strategy for global uptake of evidence-based stroke care [18]. The action plan provides a roadmap to guide local, regional, and national healthcare officials in establishing stroke systems of care and in implementing evidence-based guidelines that are applied across the continuum of stroke care. The action plan recognizes that there are large resource variations across LMIC, including human resources, healthcare facilities, diagnostic and laboratory services, medications, and access to transportation. The limited availability of these resources influences the extent to which evidence-based stroke care can be provided.

The action plan includes a list of services and resources that are required for optimal stroke care for each of the stages of care. These services and resources are divided into three levels depending on resource availability [18]. At the *minimal* level of resource availability, stroke care delivery is based at a local clinic staffed predominantly by non-physicians. Care in these settings is focused on bedside clinical skills and prevention of complications with limited access to laboratory tests and diagnostic studies. At the *essential* level of resource availability, care is provided by physicians, although stroke expertise may be difficult to access. Access to a computed tomography imaging and the potential for acute thrombolytic therapy exist in these settings. At the *advanced* level, multidisciplinary stroke expertise, multimodal imaging, and comprehensive therapies are available.

Stages of Stroke Care, Resource Requirements, and Barriers to Implementation

Stroke care is complex and requires the availability of resources including diagnostic services and trained healthcare providers with stroke expertise. Understanding barriers and enablers to the implementation of these services is an important step to implementing evidence-based practices [19]. A 2017 systematic review examined provider-reported barriers and enablers to adopting evidence-based practice guidelines for acute stroke care. Three qualitative and seven quantitative studies were included, none of which was conducted in LMIC. Table 1 presents the domains of barriers and enablers that were identified as well as the frequency of each. The table also provides examples and explanations of each domain as discussed by the authors of the review [20•].

In the next section, we start by reviewing the resource requirements for each of the three stages of acute stroke care modified from the action plan [18]. The resources are discussed for settings with minimal healthcare service availability, essential, and advanced services. We then follow with

a review of barriers to implementing these services in LMIC. The barriers reported herein are largely based on observational studies that report on practices of acute stroke care in LMIC and one qualitative study from Ghana [21•] based on our review of the literature (Fig. 2). Studies that focus on barriers often refer to enablers as the opposite of barriers, and we have adopted a similar framework in this review [20•].

Global Stroke Services Action Plan's Stages of Stroke Care

Early Diagnosis and Management

Resource Requirements Early stroke diagnosis and management occur within the first hours following a stroke with the goal of diagnosing the type of stroke (ischemic or hemorrhagic) and initiating time-sensitive treatments to minimize the impact of stroke and prevent further tissue injury.

In settings with minimal healthcare services, early diagnosis and management could take place in a community clinic. These clinics have limited access to physicians, and non-physician healthcare workers provide the most care. These providers are usually able to conduct standard clinical history and examination. Diagnostic imaging services are not available; however, providers are also able to conduct basic neurological assessments, if trained. Providers at these settings could also be trained for basic screening of swallow function to evaluate for dysphagia prior to offering any oral medications, food, or drink, thereby reducing the risk of aspiration pneumonia.

Essential stroke services are able to provide early diagnosis and management at a hospital setting, equipped with at least some emergency medical services, including a trained ambulance crew to identify stroke and transport patients to a hospital setting. Electrocardiography (ECG), computed tomography (CT) scanning, carotid Doppler ultrasound, and echocardiography are available in hospitals with essential stroke services. Intracerebral hemorrhage can be promptly recognized and treated by providers with experience in stoke management. Acute thrombolysis with intravenous tissue plasminogen activator (tPA) should also be available for ischemic stroke patients in these settings. At a minimum, antiplatelet therapy should be available and provided immediately after imaging has excluded intracerebral hemorrhage. Physicians and nurses with some stroke expertise are available in these settings, although trained stroke specialists may not be available.

Advanced stroke services are equipped with advanced diagnostic services, including magnetic resonance imaging (MRI), capability to do magnetic resonance angiography (MRA), CT perfusion imaging, and prolonged ECG monitoring devices, in addition to those listed under essential stroke services. An interdisciplinary team of physicians, nurses, and

Table 1 Provider-reported barriers and enablers from a review of 10 studies conducted in high-income countries

Domain of barriers and enablers	Frequency, n (%)	Examples
Capacity for organizational change	57 (37%)	Inadequate funding opportunities for staff professional development
Individual health professionals	39 (25%)	Lack of skills, self-efficacy, and motivation to implement evidence-based therapies
Incentives and resources	17 (11%)	Limited physical space to establish stroke units, CT scan financial resources, and limited time and stroke beds
Guideline factors	16 (10%)	One third (33%) of neurologists disapproved of thrombolytic therapy use.
Patient factors	15 (10%)	Nearly all (91%) indicated patients' late arrival for acute care led to worse outcomes.
Professional interactions	10 (6%)	One out every seven (14%) respondents cited poor communication between emergency department staff and the neurology team, which affected the use of thrombolytic therapy.

Source: [20•]

rehabilitation specialists with stroke expertise is also available. Early interventions, in addition to acute thrombolysis with intravenous tPA, include endovascular thrombectomy, cerebral aneurysm treatment, hemicraniectomy, and products to reverse coagulopathy in the setting of hemorrhagic stroke.

Barriers to Implementation Early access to the appropriate healthcare facility is crucial to receiving optimal early stroke diagnosis and management. However, delays in arrival represent a common barrier in LMIC. Among other reasons, delays

in arrival occur due to lack of awareness of symptoms by patients, family members, and bystanders. For example, in Pakistan, only 29% of patients arrived to a hospital facility within 3 hours of symptom onset, and 18% arrived after 24 h. Due to lack of understanding of stroke management, 63% of patients chose to first contact a general practitioner rather than immediately attending a hospital [22]. In Turkey, 32% of stroke patients who presented late to the hospital did not realize the urgency of seeking early medical care [23]. Delays in presentation also occur due to the lack of availability

Level	1. Early diagnosis and monitoring	2. Acute management	3. Discharge planning
Minimal	• Standard clinical history and examination	• Basic risk factor assessment and management (e.g. pulse for atrial fibrillation) • Ongoing neurological assessments • Swallow screening and management of dysphagia	• Early assessment of discharge needs • Early rehabilitation planning • Secondary prevention
Essential	• Neurological assessments • Electrocardiography, computed tomography scanning, carotid Doppler ultrasound, echocardiography • Acute thrombolysis	• Admission to an organized stroke unit • Depression assessment and management	• Referral to rehabilitation and lifestyle medication specialists
Advanced	• Magnetic resonance imaging, computed tomography perfusion scans, prolonged electrocardiographic monitoring devices • Endovascular thrombectomy, neurosurgery, hemicraniectomy, products to reverse coagulopathy	• Multidisciplinary team of stroke experts • Coordinated stroke care provided across geographically discrete regions	• Referral to rehabilitation and lifestyle medication specialists
Barriers	• Delays in patient arrival • Lack or malfunction of diagnostics • Unavailability of standardized stroke protocols • Cost, especially for advanced care	• Staff shortages and lack of stroke experts • Lack of medications • Shortages in bed capacity • Cost, especially for advanced care	• Lack of research on effectiveness and applicability • Insufficient training in rehabilitation and primary care for secondary prevention • Cost, especially for advanced care

Fig. 2 Services required for optimal acute stroke care at each stage of care and different levels of resource availability [18]

or affordability of ambulatory services in remote areas [21•].

Lack of availability of essential diagnostic equipment can also delay or prevent interventions at the early stages of stroke. For example, healthcare providers in Ghana reported the lack of availability of blood pressure-monitoring devices, telemetry monitors, suction devices (e.g., Yankauer), and adjustable hospital beds [21•]. However, hospitals that have these types of equipment may also report delays in receiving services due to bottlenecks in care. In Burkina Faso, for example, patients wait an average of 21 h (ranging from 30 min to 9 days) to receive a CT scan despite availability at the hospital [24]. Healthcare providers in Ghana report that diagnostic services, including CT scanners, are not always functional when needed. When a CT scanner is available and functional, some patients experience difficulty paying for acquisition and interpretation costs, as well as costs of other more basic diagnostic tests, such as laboratory tests that are not covered by insurance, which is uncommon for many [21•].

Lack of standardized protocols to manage acute stroke was commonly reported by nurses as a barrier that delayed emergency care in Ghana. This was especially problematic when an acute stroke patient arrives to the hospitals in the absence of a specialist [21•].

Acute thrombolysis with intravenous tPA is rarely performed in many LMIC due to infrastructure-, socio-cultural-, and economic-related barriers [25]. Administration of acute thrombolysis requires a well-organized stroke system that can promptly diagnose stroke and closely monitor patients for complications and neurological complications. Very few countries are able to provide these services, especially at public hospitals. For example, in Brazil, only 1% of patients admitted with an ischemic stroke received thrombolysis [26]. This is compared to 3–5% who received thrombolytic therapy in the USA in 2009 [27]. Data on barriers to receiving intravenous tPA in LMIC are limited. In an analysis of 100 consecutive acute ischemic stroke patients in India, only four (4%) received intravenous tPA. Reasons for not receiving treatment primarily included delays in hospital arrival (73%) and lack of affordability of the treatment (56%). Very few patients (2%) were aware of thrombolysis treatment, which may have been another reason for not delayed arrival [28].

Acute Management and Prevention of Complications

Resource Requirements Acute management and monitoring usually take place after an acute stroke is diagnosed and once the patient is admitted into the hospital. Care goals shift to monitoring for neurologic deterioration, management of physiological abnormalities and risk factors, and prevention and treatment of complications.

In settings with minimal healthcare services that do not have access to hospitals or physicians with stroke expertise, acute management is provided by non-specialized physicians and non-physician healthcare workers. Diagnostic services are minimally available in these settings; however, providers could be trained to assess and diagnose basic stroke risk factors and complications. For example, swallow function should be routinely assessed to prevent aspiration pneumonia. Pulse assessment could identify atrial fibrillation. Blood pressure and blood glucose can be measured and managed. Fever, infections, and pressure ulcers could also be monitored and managed with limited diagnostic services and without stroke expertise. Providers should also continue to perform neurological assessments to identify changes indicative of deterioration.

In an essential stroke service setting, basic diagnostic services are available, and therefore, providers can continue to use these tools to further confirm diagnoses (e.g., repeat CT scan). Healthcare providers are more likely to be specialized and have some experience in delivering stroke-related care. Protocols to guide acute stroke care that are based on clinical practice guidelines can be implemented in these settings. In some settings, a stroke unit may be available, and an interdisciplinary team may attend to stroke patients admitted into these units. This team includes physicians and nurses specialized in neurology (though not sub-specialized in stroke neurology), cardiology, internal medicine, geriatrics, emergency medicine, intensive care, and general rehabilitation providers. These providers can access diagnostic services to assess complications such as acute myocardial infarction, aspiration pneumonia, or deep-vein thrombosis and to manage patients accordingly. Stroke treatment-related experience may be more widely and consistently available, and members of an interdisciplinary team can better manage these complications. For example, patients with reported swallowing deficits can be referred to a rehabilitation provider or to dieticians for more detailed assessments and management. Depression is also assessed using validated tools and can be managed by healthcare providers with necessary training and experience to help these patients.

Advanced stroke services are able to provide more expert diagnostic and tailored treatment services. The combination of these resources and access to a multidisciplinary team of stroke experts allow for more advanced interventions such as revascularization and neurosurgery. Acute management takes place in an organized stroke unit within a geographically defined location. Care is coordinated and includes different stroke pathways that define movement of stroke patients to higher and lower levels of services as required in the hospital. The multidisciplinary team comprising advanced neurological (including stroke neurologists), medical, nursing, physiotherapy, occupational therapy, speech therapy, and social work staff is an essential feature of stroke unit care. They coordinate their work through regular, pre-planned meetings. These meetings introduce the patients to the team and provide a forum for multidisciplinary assessment, identification of

problems, and setting of short-term and long-term recovery goals. Advanced stroke services usually follow standardized protocols to care for stroke patients, as well as to assess, prevent, and treat complications.

Barriers to Implementation An adequate number of providers with staff expertise are important for the acute management of stroke patients and for the prevention of in-hospital complications. In Ghana, shortages in nurses made it difficult to perform basic care including regular checking of blood pressure levels, blood glucose levels, regular turning of patients to prevent pressure sores, and management of urinary incontinence to minimize risk of urinary tract infections [21•].

Prevention and management of comorbidities and complications require basic medications such as blood pressure-lowering, lipid-lowering, and diabetes medications. These medications are included in the essential medicine list developed by the World Health Organization and should be available in LMIC. However, they are not optimally used. For example, in a study of 12 hospitals that admitted 1754 stroke patients in Brazil, in-hospital blood pressure-lowering medications were administered to 82% of patients and statins to 47% of patients, suggesting that the use of these medications is not optimal [26].

In-hospital complications after stroke remain a problem in LMIC and are a major cause of death following a stroke [29]. Few studies have reported rates of in-hospital stroke complications in LMIC, although available estimates seem to be high. In Brazil, for example, aspiration pneumonia was reported in 18% of admitted stroke patients, and in Nigeria, 54% of patients developed aspiration pneumonia [30]. These data contrast with the markedly lower 7% rate of stroke-related pneumonia in Canada among a cohort of 8251 patients [31].

Reasons for the higher rates of these complications in LMIC have not been investigated. Studies comparing stroke unit to general ward admissions show fewer complications in the former group. In Oman, aspiration pneumonia was reported among 10% of patients admitted to the general ward compared to 6% of patients admitted to the stroke unit (*p* value = 0.02), although pulmonary embolism events were similar in the two groups (0.6% in the general ward and 0.4% in the stroke unit, p-value = 0.67). The study authors suggest that clinical pathways and protocols and the availability of neurologists and nurses with training in stroke management are possible reasons for the difference in observed outcomes [32]. However, even when a stroke unit is available, providers report shortages in bed capacity and as a result, many patients are admitted to general wards. For example, the only hospital in Ghana that has a stroke unit reported having only six beds, limiting admissions of patients to receive optimal care [21•].

Discharge Planning and Rehabilitation

Resource Requirements Discharge planning is the development of an individualized discharge plan for patients prior to leaving the hospital to their post-discharge setting, including home, rehabilitation, or other non-hospital facilities [8]. Discharge planning improves outcomes by bridging the gap between the hospital and the home and involves providing patients with information about their condition and how to care for themselves post-discharge. It also provides post-discharge support and health care when needed. Early discharge planning for stroke patients includes early assessment of discharge needs, identification of recovery goals, and rehabilitation planning. Discharge planning usually involves the patient and their family or caregivers in the rehabilitation process [12].

Discharge planning and functional assessments should be initiated as soon as possible after the patient is admitted to the hospital to determine rehabilitation needs. This should be feasible at all levels of resource availability. For example, patients could be assessed for communication deficits by trained non-physician healthcare workers or by more specialized providers. In essential and advanced healthcare settings, patients with aphasia are referred to a speech-language pathologist for individualized therapy to improve communication ability, in addition to involving families in the rehabilitation process. In settings with minimal healthcare services, rehabilitation may rely on family-led rehabilitation only, although its effectiveness remains unclear [33•].

Secondary prevention of stroke is also important at the discharge phase. Medications for blood pressure lowering, lipids lowering, antiplatelet treatment, diabetes, and atrial fibrillation (all when indicated) should be prescribed at discharge. Patients should be counseled about the importance of medication adherence and health behaviors such as smoking cessation, dietary modification, reduced sodium intake, increased exercise, reduced stress, and moderation of alcohol intake. Counseling can be performed by trained non-specialized physicians, non-physician healthcare workers, or even peers in settings with minimal healthcare services. In settings with essential and advanced stroke services, this should be performed by more specialized staff. In addition to counseling, patients should be referred to facilities with specialists to assist in the management of health behaviors (e.g., smoking cessation clinic or dietician) when available.

Barriers to Implementation Information on discharge planning from LMIC is lacking. In HIC, discharge planning has been shown to reduce hospital length of stay and readmission rates. A 2016 Cochrane review evaluated the effects of discharge planning to any control group in 30 trials (*n* = 11,964 participants) among patients who were admitted for any medical or surgical reason. The mean

difference in hospital length of stay was − 0.73 days (95% CI − 1.33 to − 0.12, among 1105 patients in the discharge planning group and 1088 patients in the control group), favoring the group allocated to discharge planning. Discharge planning also resulted in reductions in readmission rates (22% in the discharge planning group versus 25% in the control group, relative risk (RR) 0.87, 95% CI 0.79 to 0.97) [34]. The review did not identify any studies conducted in LMIC.

Another review compared outcomes among stroke patients allocated to early discharge and rehabilitation in the home or community to usual care in 17 trials (n = 2422 participants). The mean difference in hospital length of stay was − 5.5 days (95% CI − 3 to − 8 days, among 1148 patients in the intervention group versus 1033 in the control group). At a median length of follow-up of 6 months, the primary outcome of death or dependency was lower in the intervention group (37%) compared to the control group (41%, OR 0.80, 95% CI 0.67 to 0.95) [8].

The effectiveness of early discharge planning will likely depend on the capacity of community-level healthcare at each setting in terms of rehabilitation facilities and primary care clinics. In the absence of these facilities or when they are not affordable or accessible, patients may rely on family-led rehabilitation after discharge. The 2017 Family-led Rehabilitation after Stroke in India (ATTEND) trial investigated whether family-led stroke rehabilitation, initiated at the hospital and continued at home, results in improved outcomes compared to usual care. At 6 months, death or dependency (defined by a score of 3 to 6 on the modified Rankin scale), was similar in the intervention (47%) and control groups (47%; OR = 0.98, 95%CI 0.78 to 1.23) [33•]. These results suggest that in the absence of community rehabilitation facilities, family-led rehabilitation may not be an effective alternative. However, authors report that the neutral results may be because of the limited daily rehabilitation activities, which were reported to be only ~ 30 min per day compared with at least 45 min per day recommended by professional organizations such as the Royal College of Physicians [35]. Task shifting to non-physician healthcare workers, rather than training family members, may be a more effective alternative, although more research is needed to evaluate this hypothesis.

Conclusions

In this review, we present the resource requirements to providing optimal acute stroke care in LMIC. The review used the framework developed by the World Stroke Organization's Global Stroke Services Action Plan [18] to categorize LMIC settings into minimal-, essential-, and advanced-resource levels, depending on the availability of stroke expertise, diagnostics, and facilities. The review shows that some aspect of optimal stroke care can be delivered even in settings with very limited resources. We also highlight barriers to implementing evidence-based stroke care in LMIC across the minimal, essential, and advanced levels of care. The review shows that even in essential or advanced settings where some aspects of an organized stroke unit are available, certain barriers still persist.

Barriers were mostly identified based on reports from observational studies conducted in LMIC. However, more studies are needed to clearly identify barriers to implementing evidence-based practices for stroke care. Implementation studies and interventions tailored to previously identified barriers have been shown to be more effective than untailored interventions [19]. Barrier assessment research using qualitative techniques that identify barriers from healthcare providers, patients, and family members and covering different regions of the world and settings (e.g., public and private sectors) is needed.

Organized stroke units provide the best outcomes for stroke patients, through rapid and well-coordinated assessment, diagnosis, monitoring, and rehabilitation. Stroke units can reach large proportions of the population and should be a public health priority in LMIC. This has been advocated in the literature [12, 36]; however, little has been yet to be done in terms of implementation into clinical practice. A 2017 systematic review of 31 studies conducted in LMIC addressing studies that highlight evidence-based implementable strategies to improve stroke care found that some strategies are economic, feasible, and reproducible, such as ambulance transportation and training of paramedics, stroke units, thrombolysis therapy offered free of charge, teleconsultation, and simplified but validated neurological assessments (e.g., a modified National Institute of Health Stroke scale). The effectiveness of these strategies remains unclear in LMIC and requires more data on outcomes and sustainability beyond the research setting for global stroke prevention, treatment, and control [37••].

References

Papers of particular interest, published recently, have been highlighted as:

• Of importance

•• Of major importance

1. Roth GA, et al. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. J Am Coll Cardiol. 2017;70(1):1–25.

2.•• GBD 2015 Neurological Disorders Collaborator Group. Global, regional, and national burden of neurological disorders during 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet Neurol. 2015; https://doi.org/10.1016/S1474-4422(17)30299-5. **Global Burden of Disease report of estimates of neurological disorders between 1990 and 2015 that serves as reference point for most low- and middle-income countries.**

3. Feigin VL, et al. Update on the global burden of ischemic and hemorrhagic stroke in 1990-2013: the GBD 2013 study. Neuroepidemiology. 2015;45(3):161–76.

4. Schwamm LH, et al. Recommendations for the establishment of stroke systems of care: recommendations from the American Stroke Association's Task Force on the Development of Stroke Systems. Stroke. 2005;36(3):690–703.

5. Wardlaw JM, et al. Thrombolysis for acute ischaemic stroke. Cochrane Database Syst Rev. 2014;(7):Cd000213. https://doi.org/10.1002/14651858.CD000213.pub3.

6. Badhiwala JH, et al. Endovascular thrombectomy for acute ischemic stroke: a meta-analysis. JAMA. 2015;314(17):1832–43.

7. Organised inpatient (stroke unit) care for stroke. Cochrane Database Syst Rev. 2013;(9):Cd000197. https://doi.org/10.1002/14651858.CD000197.pub3.

8. Langhorne P, Baylan S. Early supported discharge services for people with acute stroke. Cochrane Database Syst Rev. 2017;7:Cd000443.

9. Pollock A, et al. Physical rehabilitation approaches for the recovery of function and mobility following stroke. Cochrane Database Syst Rev. 2014;(4):Cd001920. https://doi.org/10.1002/14651858.CD001920.pub3.

10. Yusuf S, et al. Cardiovascular risk and events in 17 low-, middle-, and high-income countries. N Engl J Med. 2014;371(9):818–27.

11.•• Lindsay MP, NB, Furie KL, Donnan G, Langhorne P, Davis S. Global Stroke Services Guidelines and Action Plan: achieving and monitoring quality stroke care. World Stroke Organization; 2014. http://www.world-stroke.org/images/GSGAAP/Global_Stroke_Guidelines_and_Action_Plan_All_in_one.pdf. Accessed 4 Nov 2017 **World Stroke Organization's Global Stroke Services Guidelines and Action Plan serves as the foundation for this manuscript, including its delineation of available stroke services by resource setting.**

12. Langhorne P, de Villiers L, Pandian JD. Applicability of stroke-unit care to low-income and middle-income countries. Lancet Neurol. 2012;11(4):341–8.

13. Langhorne P, Pollock A. What are the components of effective stroke unit care? Age Ageing. 2002;31(5):365–71.

14. Seenan P, Long M, Langhorne P. Stroke units in their natural habitat: systematic review of observational studies. Stroke. 2007;38(6):1886–92.

15. Zhai S, et al. The cost-effectiveness of a stroke unit in providing enhanced patient outcomes in an Australian teaching hospital. J Stroke Cerebrovasc Dis. 2017;26(10):2362–8.

16. Launois R, et al. Estimating the cost-effectiveness of stroke units in France compared with conventional care. Stroke. 2004;35(3):770–5.

17. de Villiers L, Kalula SZ, Burch VC. Does multidisciplinary stroke care improve outcome in a secondary-level hospital in South Africa? Int J Stroke. 2009;4(2):89–93.

18. Lindsay P, et al. World Stroke Organization global stroke services guidelines and action plan. Int J Stroke. 2014;9(Suppl A100):4–13.

19. Baker R, et al. Tailored interventions to address determinants of practice. Cochrane Database Syst Rev. 2015;(4):Cd005470. https://doi.org/10.1002/14651858.CD005470.pub3

20.• Baatiema L, et al. Health professionals' views on the barriers and enablers to evidence-based practice for acute stroke care: a systematic review. Implement Sci. 2017;12(1):74. **These qualitative studies evaluating barriers and enablers to optimal stroke care help readers understand where interventions to improve the quality and safety of stroke care might be feasible in general.**

21.• Baatiema L, et al. Barriers to evidence-based acute stroke care in Ghana: a qualitative study on the perspectives of stroke care professionals. BMJ Open. 2017;7(4):e015385. **These qualitative studies evaluating barriers and enablers to optimal stroke care help readers understand where interventions to improve the quality and safety of stroke care might be feasible in general and in low- or middle-income country.**

22. Siddiqui M, et al. Factors delaying hospital arrival of patients with acute stroke. J Pak Med Assoc. 2008;58(4):178–82.

23. Memis S, et al. Multiple causes for delay in arrival at hospital in acute stroke patients in Aydin, Turkey. BMC Neurol. 2008;8:15.

24. Napon C, et al. Therapeutic route of patients at the acute phase of their stroke in Burkina Faso. J Neurol Sci. 2017;372:75–7.

25. Durai Pandian J, et al. Stroke and thrombolysis in developing countries. Int J Stroke. 2007;2(1):17–26.

26. de Carvalho JJ, et al. Stroke epidemiology, patterns of management, and outcomes in Fortaleza, Brazil: a hospital-based multicenter prospective study. Stroke. 2011;42(12):3341–6.

27. Adeoye O, et al. Recombinant tissue-type plasminogen activator use for ischemic stroke in the United States: a doubling of treatment rates over the course of 5 years. Stroke. 2011;42(7):1952–5.

28. Badachi S, et al. Hurdles in stroke thrombolysis: experience from 100 consecutive ischemic stroke patients. Ann Indian Acad Neurol. 2015;18(4):415–8.

29. Sweileh WM, et al. Predictors of in-hospital mortality after acute stroke: impact of gender. Int J Clin Exp Med. 2009;2(1):41–7.

30. Obiako OR, Oparah SK, Ogunniyi A. Prognosis and outcome of acute stroke in the University College Hospital Ibadan, Nigeria. Niger J Clin Pract. 2011;14(3):359–62.

31. Finlayson O, et al. Risk factors, inpatient care, and outcomes of pneumonia after ischemic stroke. Neurology. 2011;77(14):1338–45.

32. Amal M, Al-Hashmi AA-S, Maheshwari H, Almamai R, Salunga C, Marfil RT, et al. Role of stroke unit in reducing post stroke complications. EC Neurology. 2016;3(4):412–21.

33.• ATTEND Collaborative Group. Family-led rehabilitation after stroke in India (ATTEND): a randomised controlled trial. Lancet. 2017;390(10094):588–99. **Report of a trial demonstrating the neutral effect of a family-based rehabilitation among stroke survivors in India. This intervention has been identified as potentially relevant for low- and middle-income country settings, so the results of this trial are germane to this review.**

34. Goncalves-Bradley DC, et al. Discharge planning from hospital. Cochrane Database Syst Rev. 2016;(1):Cd000313. https://doi.org/10.1002/14651858.CD000313.pub5

35. Intercollegiate Stroke Working Party. National clinical guideline for stroke. 4th ed. London: Royal College of Physicians; 2012.

36. Alim M, et al. Family-led rehabilitation after stroke in India: the ATTEND trial, study protocol for a randomized controlled trial. Trials. 2016;17:13.

37.•• Pandian JD, et al. Strategies to improve stroke care services in low- and middle-income countries: a systematic review. Neuroepidemiology. 2017;49(1–2):45–61. **Systematic review of strategies to improve stroke care in low- and middle-income country settings provides the most up-to-date resource summarizing potential strategies to improve stroke care in resource limited settings.**