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Comparative analysis of clinical phenotypes in pediatric and adult stroke survivors admitted to intensive care units in low income countries

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Keypoints

Pediatric and adult stroke survivors in low-income ICU settings exhibit distinct clinical phenotypes. Pediatric strokes are primarily hematologic or arteriopathic, with sickle cell disease as a major contributor, while adult strokes are mostly vascular, driven by hypertension and atherosclerosis.

Abstract

Stroke in low-income countries poses special problems, particularly in intensive care units (ICUs), where both pediatric and adult survivors exhibit distinct clinical phenotypes. Pediatric stroke is often associated with sickle cell disease, congenital heart defects, and infections, while adults predominantly present with hypertension-driven ischemic and hemorrhagic strokes. Resource constraints—including limited access to neuroimaging, thrombolysis, and specialized stroke units—exacerbate delays in diagnosis and management, contributing to higher morbidity and mortality. Emerging preventive strategies, such as transcranial Doppler screening and hydroxyurea therapy in children with sickle cell disease, demonstrate significant potential in reducing stroke incidence and improving neurocognitive outcomes. A comparative analysis of pediatric and adult stroke phenotypes highlights the necessity for age-specific ICU protocols, contextually tailored management, and capacity-building initiatives in resource-limited environmentsThis mini-review highlights critical differences in etiology, presentation, and prognosis and provides perspectives for future research and intervention strategies aimed at improving stroke care across age groups in resource-limited environments.

Keywords

Adult stroke; ICU; Low-income countries; Neurocognitive outcomes; Pediatric stroke; Stroke survivors

Introduction

Stroke remains a leading cause of morbidity and mortality worldwide, and its burden is rising rapidly in low-income countries, particularly in sub-Saharan Africa. Rapid demographic transitions, urbanization, and increasing prevalence of non-communicable diseases such as hypertension and diabetes contribute to this trend [1]. Unlike high-income settings, where stroke

predominantly affects older adults, African countries experience a shift toward younger ages at onset, including pediatric populations, resulting in a unique spectrum of ICU admissions [2, 3]. In adults, hypertension remains the most significant modifiable risk factor, often leading to both ischemic and hemorrhagic strokes [4]. Hospital-based studies from rural Kenya and other sub-Saharan regions indicate that adult stroke patients frequently present with severe neurological deficits, delayed referral, and complications requiring intensive care [5]. Environmental and toxic exposures, including xenobiotics, may also contribute to stroke pathophysiology and acute severity [6].

Pediatric stroke, although less common, carries substantial long-term morbidity and poses diagnostic and management challenges in resource-limited settings [2,3]. In African children, the causes are varied, with sickle cell disease (SCD), congenital heart defects, and infections being the most common [7, 8]. Scarce access to neuroimaging and trained personnel limits early recognition, thereby delaying critical interventions [9]. Transcranial Doppler (TCD) screening and hydroxyurea therapy have emerged as effective strategies to reduce stroke incidence and improve neurocognitive outcomes in children with SCD [10–14]. Previous reviews have largely focused on adult populations or high-income country settings, leaving a critical knowledge gap regarding age-specific ICU stroke phenotypes in low-income countries [1,2]. Understanding the comparative clinical features of pediatric versus adult stroke survivors in ICUs is essential for developing context-adapted management protocols, guiding preventive interventions, and informing resource allocation.

This mini-review aims to synthesize current evidence on the clinical phenotypes, survival outcomes, and management strategies of pediatric and adult stroke survivors admitted to ICUs in low-income countries, with a particular focus on sub-Saharan Africa. By highlighting differences in etiology, presentation, and prognosis across age groups, the review reveals context-specific approaches to stroke care and identifies research and implementation priorities for improving outcomes in resource-limited ICU settings.

Epidemiology of Stroke in Low-Income Countries

Low-income countries, particularly in sub-Saharan Africa, bear a disproportionately high burden of stroke due to limited infrastructure and personnel in their healthcare systems [1, 2]. Recent continental analyses indicate that Africa is witnessing one of the most rapid increases in stroke incidence and mortality globally, with affected individuals frequently younger than those in high-income regions [1, 3]. Contributing factors include uncontrolled hypertension, diabetes, urbanization, persistent infectious diseases, and limited public health awareness [1,5]. Hospital-based studies illustrate regional variations in stroke presentation and severity. In rural Kenya, Ominde et al. reported that adult stroke patients often arrive late with significant neurological deficits, indicative of both geographic obstacles and delayed referral [5]. Hypertension-related ischemic stroke primarily affects adults, and intracerebral hemorrhage continues to be common and associated with higher mortality [5]. Environmental exposures, including xenobiotics, may interact with vascular and genetic risk factors to influence the severity of stroke in adults [4, 6].

Pediatric stroke, although less frequent, contributes substantially to long-term disability. Population-based data indicate that children and adolescents represent a meaningful proportion of stroke-related disability-adjusted life years, with relative increases greatest in low- and middle-income countries [3]. In African settings, hospital-based studies indicate that sickle cell disease (SCD), infections, and congenital heart defects are the leading pediatric stroke etiologies [7, 8]. Limited access to neuroimaging and trained personnel contributes to delayed recognition and suboptimal management [9]. Preventive strategies such as transcranial Doppler (TCD) screening and hydroxyurea therapy have demonstrated effectiveness in reducing stroke risk and improving neurocognitive outcomes among children with SCD in resource-limited

environments [10–14]. ICU admissions reflect the convergence of severe adult and pediatric strokes. Children often present with SCD-related ischemic stroke or infection-associated cerebrovascular events, whereas adults typically exhibit hypertensive or atherosclerotic strokes with systemic complications [7,8,5]. Young adults may show overlapping phenotypes combining vascular and hematologic risk factors [6].

Overall, the epidemiology of stroke in low-income countries is characterized by early age at onset, high case fatality, and systemic healthcare limitations that exacerbate delays in diagnosis and treatment [2,1]. These contextual factors define the spectrum of clinical phenotypes seen in ICUs and demonstrate the value of age-specific prevention strategies, timely diagnosis, and context-adapted critical care approaches.

Clinical Phenotypes: Pediatric vs Adult Stroke

Stroke phenotypes differ markedly between pediatric and adult populations admitted to intensive care units (ICUs) in low-income countries. Understanding these distinctions is critical for age-specific management, prognosis, and preventive strategies [1,2].

Pediatric Stroke

In African children, sickle cell disease (SCD) is the leading cause of ICU-admitted stroke, often manifesting as ischemic events [7,8]. Other etiologies include congenital heart defects, severe infections, and rare arteriopathies [7,8]. Children often have hemiparesis, seizures, and neurocognitive problems that can last for a long time if they don't get help right away [3, 9]. Early identification via transcranial Doppler (TCD) screening is increasingly implemented to detect children at high risk for stroke [10,11]. Hydroxyurea therapy has been shown to significantly reduce stroke incidence and improve neurocognitive outcomes in SCD patients, even in low-resource settings [12–14]. Neuroimaging advances, including MRI and CT, facilitate etiological classification and management decisions, but access remains limited in many low-income ICUs [9]. Malnutrition, underweight status, and concurrent infections further complicate pediatric presentations and affect survival [15,16].

Recent studies demonstrate that structured interventions combining TCD screening, hydroxyurea therapy, and nutritional support yield measurable improvements in cognitive and motor outcomes over 12–18 months [12–14,17].

Adult Stroke

In contrast, adult ICU admissions are dominated by hypertensive and atherosclerotic strokes, frequently with comorbid diabetes or renal disease [1,5].

Adults exhibit significant neurological deficits, including hemiplegia, aphasia, and altered consciousness, frequently exacerbated by systemic complications such as sepsis or multiorgan dysfunction [5,6].

Environmental exposures, such as xenobiotics, have also been implicated in adult stroke severity in these settings [4,6,18]. Young adults represent a mixed phenotype, combining vascular risk factors with hematologic or inflammatory predispositions [6].

Comparative Insights

Comparative analysis highlights the following distinctions:

- Pediatric stroke is predominantly hematologic or arteriopathic, whereas adult stroke is largely vascular.
- Children benefit from preventive interventions (TCD screening, hydroxyurea), whereas adults face delayed presentation and limited acute therapies.
- ICU mortality is generally higher among adults due to comorbidities and delayed intervention, while pediatric mortality is influenced by SCD severity and nutritional status [3,5,7,15].

Understanding these age-specific phenotypes is essential for tailoring ICU protocols, resource allocation, and preventive strategies in low-income countries. Integration of early pediatric screening and age-adapted adult care can help reduce disparities in stroke outcomes and optimize resource use in constrained healthcare settings. (Table 1)

Feature	Pediatric Stroke	Adult Stroke
Predominant Etiologies	Sickle cell disease, congenital heart defects, infections, rare arteriopathies	Hypertension, atherosclerosis, diabetes, environmental exposures
Typical Clinical Presentation	Hemiparesis, seizures, neurocognitive impairment	Hemiplegia, aphasia, altered consciousness, systemic complications
ICU Interventions	Transcranial Doppler screening, hydroxyurea therapy, nutritional support	Blood pressure control, acute management of vascular events, supportive ICU care
Prognostic Determinants	Disease-modifying therapy adherence, nutritional status, comorbid infections	Timely ICU admission, control of comorbidities, systemic complications
Mortality Risk	Influenced by SCD severity and nutritional status	Higher in older adults, exacerbated by delayed treatment and comorbidities

Table 1. Comparative Clinical Phenotypes of Pediatric vs Adult Stroke in ICUs

Survival and Prognostic Determinants

Survival outcomes for stroke patients admitted to intensive care units (ICUs) in low-income countries are influenced by age, etiology, comorbidities, and the timing of interventions [1,2].

Mortality is disproportionately high in both pediatric and adult populations due to delayed presentation, limited acute care infrastructure, and scarcity of specialized personnel [5,6].

Pediatric Determinants

In children, sickle cell disease (SCD) remains the principal risk factor influencing ICU survival [7,8]. Early identification of high-risk patients through transcranial Doppler (TCD) screening enables timely interventions, such as initiation of hydroxyurea therapy, which reduces stroke incidence and improves neurocognitive outcomes [10–14,17]. Nutritional status is also critical; underweight children with SCD have an increased risk of early mortality, particularly in resource-limited settings [15,16]. Comorbid infections, delayed access to neuroimaging, and lack of trained ICU staff further exacerbate mortality risk [9].

Adult Determinants

In adults, hypertensive and atherosclerotic strokes predominate, and survival is closely linked to rapid blood pressure control, early neuroimaging, and management of systemic complications [1,5]. Delayed referral, restricted access to thrombolysis or thrombectomy, and the presence of comorbidities such as diabetes or renal impairment adversely affect outcomes [5, 18]. Environmental and xenobiotic exposures may further complicate prognosis by affecting vascular integrity and recovery potential [4,6,18]. Young adults present a mixed phenotype, where hematologic or inflammatory predispositions intersect with vascular risk factors, adding complexity to prognostic predictions [6].

Comparative Insights

Comparing pediatric and adult populations reveals key prognostic distinctions:

- Disease-modifying interventions (hydroxyurea, TCD screening) and nutritional support strongly influence pediatric survival [10–14, 15].
- How well adults survive mainly depends on managing blood vessel risks, getting to the ICU on time, and reducing overall health problems.
- Delays in diagnosis and treatment exacerbate mortality in both age groups, which points to the importance of context-adapted ICU protocols [2, 6, 9].

Overall, survival in low-income ICU settings is a multifactorial outcome dependent on age, etiology, access to preventive and acute interventions, and health system capacity. Targeted strategies addressing these determinants can significantly improve outcomes in both pediatric and adult stroke populations.

Health System Challenges

The management of stroke in intensive care units (ICUs) of low-income countries faces multiple systemic challenges that significantly affect patient outcomes [1,2]. Limited healthcare infrastructure, scarcity of trained per

sonnel, and restricted access to neuroimaging and laboratory diagnostics delay diagnosis and intervention, both in adults and children [3,5,9]. These limitations are especially significant in pediatric patients with sickle cell disease (SCD), as prompt transcranial Doppler (TCD) screening and hydroxyurea therapy can avert stroke but necessitate trained personnel and continuous oversight [10–14].

Adult ICU stroke care is similarly hampered by insufficient acute intervention options. Thrombolysis and thrombectomy, standard in high-income settings, are largely unavailable, leading to prolonged time-to-treatment and increased mortality [5,18].

Young adults often present a mixed phenotype, where comorbidities and environmental exposures complicate both diagnosis and prognosis [6,4].

Rehabilitation and post-ICU care are other major bottlenecks. Inadequate physiotherapy services, absence of structured follow-up, and lack of community-based stroke support programs exacerbate long-term disability [2,20].

Additionally, malnutrition, prevalent in pediatric populations, and underweight status among older children with SCD further compromise recovery [15,16].

Innovative models of care and capacity-building initiatives have demonstrated potential in mitigating these limitations.

For example, the V-RAMP program in Nigeria has strengthened research administration and management capacity, while capacity-building efforts for primary stroke prevention teams have improved pediatric care outcomes [21,22]. Integrating telemedicine, community health worker programs, and context-adapted ICU protocols can enhance early detection, timely intervention, and follow-up in resource-limited settings [19-21].

Addressing these systemic challenges is essential to reduce disparities between pediatric and adult stroke outcomes. Comprehensive strategies that combine preventive interventions, ICU resource optimization, and health system strengthening are critical for improving survival and quality of care in low-income countries.

Domain	Challenges	Proposed/Effective Interventions
Early Detection	Limited neuroimaging, delayed recognition	Implement TCD screening for high-risk children, training for ICU staff
Preventive Care	Lack of preventive programs, undernutrition	Hydroxyurea therapy, nutritional support, infection control
Acute Management	Scarcity of thrombolysis, insufficient ICU resources	Context-adapted ICU protocols, telemedicine support, rapid referral systems
Post-ICU Care	Limited rehabilitation, poor follow-up	Community-based follow-up, physiotherapy programs, integrated care models
Capacity & Training	Shortage of trained professionals, limited research infrastructure	Capacity-building programs, guideline development, multicenter registries

Table 2. Key Challenges and Potential Interventions in Low-Income ICU Settings

Perspectives and Future Directions

Improving stroke care in intensive care units (ICUs) of low-income countries requires a multifaceted approach, integrating prevention, early detection, and context-adapted management strategies [1,2]. Comparative analysis of pediatric and adult stroke phenotypes points out the need for age-specific interventions to optimize outcomes [3,7].

Pediatric Perspectives

- **Expansion of TCD screening and hydroxyurea therapy:** Early identification of children at high risk for stroke, especially those with sickle cell disease (SCD), can substantially reduce incidence and improve neurocognitive outcomes [10–14,17].
- **Nutrition and comorbidity management:** Addressing underweight status, infections, and other comorbidities is critical for improving ICU survival and long-term recovery [15,16].
- **Capacity building:** Training healthcare professionals in pediatric stroke detection and ICU

management strengthens local systems and improves care quality [21,22].

Adult Perspectives

- **Vascular risk factor control:** Hypertension and diabetes remain the primary drivers of adult ICU strokes; preventive strategies and early intervention protocols are essential [1,5].
- **Acute care optimization:** Improving access to neuroimaging, thrombolysis, and supportive care can reduce mortality and long-term disability [5,18].
- **Integration of environmental and lifestyle factors:** Considering xenobiotic exposures and other local determinants can inform public health strategies for prevention [4,6,18].

Research and Policy Directions

- **Multicenter registries:** Systematic data collection on pediatric and adult ICU stroke phenotypes will enable evidence-based interventions and benchmarking [6,7].
- **Context-adapted ICU protocols:** Age-specific clinical guidelines tailored to resource-limited settings can improve triage, management, and rehabilitation [2,3,9].
- **Community-based interventions and telemedicine:** Linking ICU care with community follow-up and remote monitoring can reduce delays, improve adherence to therapy, and enhance post-discharge outcomes [20,21].

Addressing these priorities will require collaboration among healthcare providers, researchers, and policymakers. Tailored interventions, capacity-building programs, and preventive strategies offer the potential to significantly reduce mortality and long-term disability in both pediatric and adult stroke patients admitted to ICUs in low-income countries.

Conclusion

Pediatric and adult stroke survivors in low-income ICU settings exhibit distinct clinical phenotypes. Pediatric strokes are primarily hematologic or arteriopathic, with sickle cell disease as a major contributor, while adult strokes are mostly vascular, driven by hypertension and atherosclerosis. Early interventions in children, including screening and preventive therapies, improve outcomes, whereas adult survival depends on rapid management of vascular risk factors and systemic complications.

Health system limitations—such as scarce neuroimaging, insufficient trained personnel, and delayed ICU access—impact survival across all age groups. Context-adapted strategies, including capacity building, preventive programs, and integrated ICU protocols, are essential to reduce disparities and optimize care in resource-limited settings. Future research should focus on multicenter registries and evidence-based guidelines to guide age-specific interventions and improve overall stroke outcomes.

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Ethical Considerations

As this article is a perspective piece that does not involve human participants, patient data, or primary data collection, formal ethical approval was not required.

Data Availability

This article did not generate or analyze new data. The content is based exclusively on previously published studies and publicly accessible sources.

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