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# Implementing Acute Stroke Services in sub–Saharan Africa: Steps, Progress and Perspectives from the Tanzania Stroke Project

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Title: Implementing Acute Stroke Services in sub–Saharan Africa: Steps, Progress and Perspectives from the Tanzania Stroke Project

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Short Title: The Tanzania Stroke Project

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**Abstract**

**Introduction:** Stroke is a leading cause of morbidity and mortality globally, with Africa bearing a disproportionately high burden of poor outcomes. In sub-Saharan Africa, acute stroke care remains inconsistent, with organized stroke units being either absent or rarely available, contributing to the high stroke mortality rates in the region. To address this issue, the Tanzania Stroke Project (TSP) was launched**,** aimed at establishing acute stroke services at two of the largest tertiary care centers in collaboration with the Tanzanian Ministry of Health, the World Stroke Organization and Hospital Directorates.

**Methods:** TSP utilized a three-tier implementation approach to establish a more organized stroke care system in two large academic hospitals. Here, we detail the process of this initiative, which took place between August 2023 and August 2024. The three-tier approach included: 1) The establishment of stroke registries; 2) The training of healthcare workers (HCWs); and 3) The development of acute stroke protocols and establishment of stroke units at Muhimbili National Hospital-Mloganzila and Bugando Medical Centre in Tanzania.

**Results:** Tier one (Stroke registry): Two comprehensive stroke registries were established, including 460 adults (mean age 60±15years). Hemorrhagic stroke was the most common subtype, accounting for 59% of cases (n=269). Premorbid hypertension was the most prevalent risk factor, affecting 81% (n=373) of the patients. More than half of patients (58%, n=171) arrived at the hospital after 24 hours from stroke symptoms. Only 11%

(n=50/452) had documented swallowing screenings, and among patients with intracerebral hemorrhage, 11% (n=28/251) achieved the target for blood pressure control, while 47% (n=99/213) met blood glucose control targets. The in-hospital mortality rate was 27% (n=93/340). Tier two (Training of HCWs): Extensive evidence-based mentorship training was provided with higher participation rates among HCWs at Bugando Medical Centre compared to Muhimbili National Hospital-Mloganzila (57% (29/51) vs. 23% (7/31), p=0.002). Tier three (Stroke unit protocols): Stroke protocols were developed based on the training and current evidence; leading to the establishment of dedicated stroke units at each facility, with a minimum of 8 beds per unit. The full impact of these implementations has yet to be fully assessed.

**Conclusion:** This was the first initiative to implement stroke services at two large tertiary healthcare centers in Tanzania. Our findings highlight the importance of multi-level stakeholder engagement through a 3-tier approach in countries starting to establish stroke services and the need for ongoing quality-of-care monitoring and continuous efforts to sensitize both HCWs and the broader community.

## Introduction

Globally, stroke is the third leading cause of death and the fourth leading cause of disability-adjusted life years (DALYs), accounting for 7.3 million deaths and 160.5 million DALYs in 2021 (1). Mortality and DALYs from stroke are projected to increase by 50% and 31% by 2050, with more than 90% of the deaths occurring in low- and middle-income countries (LMICs), particularly in sub-Saharan Africa (SSA) (2).

Tanzania, a country in SSA with a population of 69 million, ranks stroke among its top ten leading causes of death (3). Between 2004 and 2006, the age-adjusted incidence of stroke in urban areas of Tanzania was 315.9 per 100,000 person-years (4), compared to 118.7 per 100.000 in high-income countries (HICs) (5). Stroke in Tanzania primarily affects individuals in their fourth to sixth decades of life and is associated with substantial morbidity and mortality (6).

Despite this high burden, Tanzania faces significant shortages in stroke care infrastructure (7), with only one active stroke registry, lack of dedicated stroke units and most adults treated for stroke do not receive care that meets standard quality recommendations (7,8). To address these unmet needs, we established the Tanzania Stroke Project (TSP) in cooperation with the Tanzanian Ministry of Health, the World Stroke Organization (WSO), WSO Future Stroke Leaders Program (WSO-FSLP) and Hospital Directorates. TSP highlights the baseline results from the stroke registries, details the training of health care workers (HCWs) and describes the establishment of stroke units.

## Methods

### Study setting

The TSP was an implementation study that ran from August 2023 to August 2024 at two of the largest academic referral hospitals in Tanzania: The Muhimbili National Hospital-Mloganzila (MNH-M) in Dar es Salaam and Bugando Medical Centre (BMC) in Mwanza. These study sites were chosen because they received official endorsement from the Tanzanian Ministry of Health, highlighting the urgent need to improve stroke care in the region, and the consent of the Hospital Directorates.

MNH-M is a branch of the main national hospital serving the entire population, while BMC is a large tertiary hospital that serves approximately 15 million people. MNH-M has a bed capacity of 608, while BMC has 1080. Both hospitals are equipped with 24-hour emergency medicine departments, intensive care units, laboratories, computed tomography scans (CT-scan), magnetic resonance imaging and rehabilitation departments. They serve as the main referral hospitals for stroke patients. Staffing in the neurology unit at MNH-M includes 7 neurologists, 5 neurology residents, 2 internal medicine physicians and 2 general medical doctors. BMC on the other hand, is staffed by 1 internal medicine physician and 1 general medical doctor. Both hospitals lacked dedicated stroke units, trained multidisciplinary stroke teams, and access to acute stroke therapies (thrombolysis and mechanical thrombectomy), limiting stroke treatment to secondary prevention.

### Study population

We prospectively collected de-identified data from consecutively admitted adults (≥18 years) to the medical wards presenting with the World Health Organization (WHO) clinical definition of stroke (9) at MNH-M and BMC between October 2023 and August 2024.

HCWs were selected to participate in the training by the department heads, through the Directors of Medical Services, and included: neurologists, neurosurgeons, neuroradiologists, radiologists, physicians, cardiologists, general medical doctors, emergency medicine physicians, ICU intensivists, nurses, physiotherapists, speech therapists, occupational therapists, psychologists, psychiatrists, and nutritionists. The training was also made available to HCWs from other departments.

**Description of intervention**

The intervention followed a 3-tier approach: 1) Establishment of a stroke registry; 2) Training of HCWs; 3) The development of stroke protocols and establishment of stroke units.

**Establishment of a stroke registry**

Stroke experts from the WSO, in collaboration with neurologists from Tanzania, standardized the variables for the stroke registry. The registry design followed recommendations from the global register of stroke care quality (RES-Q) https://eso-stroke.org/projects/eso-east/registry-of-stroke-care-quality-res-q/, the Swedish Stroke Register and the WHO stepwise stroke surveillance in LMICs (10,11), (Supplementary File 1).

Quality performance indicators were assessed through chart review and elements included: time from symptom onset to admission and imaging, medical complications, assessment of swallowing function, availability of physiotherapy, and administration of deep venous thrombosis prophylaxis. Compliance with recent ICH bundled care was reviewed, this included blood pressure <140/90mmHg, temperature <37.5°C, blood glucose levels of 6.1-7.8mmol/L for non-diabetics, and 7.8-10mmol/L for diabetics on arrival (12), and secondary prevention medication.

The registries were hosted on the web-based software (REDCap, Vanderbilt University, Nashville, TN), and designated general medical doctors in the neurology unit were responsible for daily patient registration under the supervision of a senior consultant.

**Training Modules**

Collaborators from WSO developed training modules based on the ESO Stroke Guidelines: https://eso-stroke.org/guidelines/eso-guideline-directory/ , AHA/ASA (13,14) and the Angel's initiative: https://www.angels-initiative.com/). The modules covered 31 topics on core competencies in stroke, focusing on hyper-acute, acute, and post-acute care, as well as specialized nursing tasks and rehabilitation (Supplementary File 2). Training was delivered in English language and conducted virtually. At MNH-M, sessions were held twice a week for 1 hour from January to March 2024, while at BMC, daily 1-hour sessions were held from Monday to Friday over a 3-week period in June 2024. This was followed by an extensive one-day onsite mentorship training in August 2024, reviewing key aspects of stroke unit care and incorporating case-based simulations.

**Module Assessment**

Three questionnaires were developed for pre- and post-training assessments: 1) hyper-acute, acute, and post-acute care module (20 multiple-choice questions, total score: 20 points), 2) nursing module, (10 multiple-choice questions, total score: 10 points), 3) rehabilitation module (10 questions with single and multiple-choice answers, total score: 20 points) (Supplementary File 3). Participants were required to complete both the pre- and post-assessments and attend at least 70% of the module topics to successfully complete the training.

**Stroke Units and Protocols**

Stroke unit protocols were developed by WSO collaborators and site neurologists, using the WSO Roadmap for essential stroke services and other international guidelines (13,14), adapted to the local context based on experiences from stroke unit initiatives in Nepal, Zambia, and Ethiopia (15–17), (Supplementary File 4). Stroke units were established by designating 8-beds within the general medical ward for each facility. The units were equipped with cardiac monitors, digital blood pressure machines, glucometers, and thermometers. The stroke units started their services after completing the training in August 2024.

**Data analysis**

Continuous variables were summarized and presented as means and standard deviations (SDs) for normally distributed data and medians with interquartile ranges (IQRs) for non-parametric data with comparisons made using the Wilcoxon Rank sum test by stroke subtype. Clinical characteristics and outcomes were summarized as proportions, and differences by stroke subtype were assessed using Chi-square tests or Fisher's exact tests, with significance level set as p-value <0.05.

**Results**

**Performance of the stroke registry**

There were 526 patients registered between October 2023 and August 2024, with 290 patients from MNH-M and 236 from BMC. Sixty-six patients were excluded due to missing brain imaging findings, leaving 460 patients in the final analysis, of whom 66% (303/460) had complete patient information.

**Characteristics of stroke patients**

Among all patients, 58% (269/460) had hemorrhagic stroke and of these, 94% (253/269) had intracerebral hemorrhage (ICH), 4% (12/269) subarachnoid hemorrhage (SAH), and 2% (4/269) isolated intraventricular hemorrhage. The mean NIHSS at presentation was 18±8**.** Compared to ischemic stroke patients (n=191), patients with hemorrhagic stroke were younger (57±14 years vs. 65±15 years, p<0.001), more likely to have been referred from another healthcare facility (86% (229/269) vs. 63% (120/191), p<0.001), and had higher prevalence of premorbid hypertension (86% (231/269) vs. 74% (142/191), p=0.002) compared to those with ischemic stroke, Table 1. Overall, in-hospital mortality was 27% (93/340) and was significantly higher in adults with hemorrhagic stroke compared to ischemic stroke (33% vs 21%).

**Key performance indicators**

The median door to imaging time was 0 days IQR (0,1). Swallow screening was documented in only 11% (n=50/452) of patients. The most common medical complication was aspiration pneumonia 20% (90/460). Few patients achieved ICH bundle of care targets for blood pressure and glycemic control 11% (28/253) and 47% (99/213) respectively, Table 2.

**Training of the HCWs**

**Participation and completion rates**

For the main training module, 82 HCWs registered and 43.9% (36/82) completed the modules for both study sites. The nursing module was attended by 27 HCWs with a completion rate of 59.3% (16/27) and the rehabilitation module was attended by 58 HCWs with a completion rate of 44.8% (26/58). The number of participants was higher in BMC in the majority of the modules compared to MNH-M (main module: 51 vs 31; nursing: 13 vs 14; rehabilitation 27 vs 31 respectively), Table 3.

Notably, the completion rate was significantly higher in BMC compared to MNH-M: (main module: 57% (29/51) at BMC vs 23% (7/31) at MNH-M; nursing: 85% (11/13) at BMC vs 36% (5/14) at MNH-M; rehabilitation module: 71% (22/31) at BMC vs 15% (4/27) at MNH-M.

**Pre-and Post-assessment**

HCWs at BMC showed significant improvement in their post-assessment quiz over all modules, with no improvement at MNH-M.

In the main module, HCWs at BMC demonstrated improved performance in the post-assessment, with mean scores of 18±3 compared to 12±4 in the pre-assessment (p<0.0001), with no improvement at MNH-M (post-assessment, mean score 15±4 vs. 12±4 pre-assessment mean score, p=0.1842).

In the nursing module, HCWs at BMC demonstrated improved performance in the post-assessment, with mean scores of 9±1 compared to 6±2 in the pre-assessment (p<0.0001), with no improvement at MNH-M (post-assessment mean score 8±1 vs. 7±6 pre-assessment mean score, p=0.7227).

The same was observed for the rehabilitation module, where BMC HCWs showed improved post-assessment, mean scores of 18±4 vs. 8±6 mean pre-assessment score, p=0.0001), with no improvement at MNH-M (post-assessment mean score 13±4 vs. 10±5 pre-assessment mean score, p=0.7227).

**Discussion**

The TSP was the first initiative to improve acute stroke services in a resource-limited healthcare setting in Tanzania. Within one year, two large academic referral hospitals successfully established their first stroke units using a three-tier implementation approach. The successful establishment of a stroke registry and the effective training of HCWs in our study provides a scalable framework that can be adapted to similar resource-limited healthcare settings. These experiences highlight the potential for replicable strategies to improve stroke care delivery and foster the development of standardized protocols and capacity building in underserved regions.

**Setting up the stroke registries**

We successfully established comprehensive stroke registries at the two sites, which were crucial for creating baseline measurements for the acute stroke units. Challenges included missing data with only two-thirds of registered patients having complete information. These challenges are consistent with those reported in the Nepal Stroke Project (16). Our data collection sheet comprised of 100 items and acknowledging that not all fields may be equally relevant for outcome improvement and system development. In response, the project team is refining the registry variables to prioritize the most critical fields, thereby reducing the rate of missing data. Additionally, systems are being developed to identify missing fields early, generate weekly quality assurance reports, and engage hospital directors to allocate dedicated time for registry management. Importantly, this registry has laid the groundwork for the development of a National Stroke Registry in Tanzania.

**Patient characteristics and KPI**

We observed a high proportion of hemorrhagic strokes (58% of all included stroke patients), particularly ICH (94%), occurring in younger age groups (mean age 57±14 years) and high prevalence of pre-existing and under-treated hypertension (86% and 90% respectively), similar to other studies conducted in SSA (18,19). In contrast, stroke in HICs has been reported to occur predominantly in people over 70 years of age, with only 10-15% of patients suffering hemorrhagic stroke (20). Hypertension remains a leading global risk factor for stroke and is a key driver for stroke in SSA (21). More than 45% of adults in Africa over the age of 25 years are estimated to have hypertension, with less than half of those with hypertension aware of their BP status and at least half of those diagnosed do not receiving treatment (22). This highlights the urgent need to promote primary preventive strategies for early detection, treatment and control of hypertension. Additionally, further investigations are warranted to better understand the etiologies of hypertension in this younger adult population. Other risk factors for stroke identified in our cohort included a history of previous stroke (13%) and diabetes mellitus (10%). A small proportion of patients (less than 5%) had HIV infection, cardiac diseases (atrial fibrillation and heart failure) and history of smoking and alcohol consumption.

It is notable that only a small proportion of patients with ICH achieved targets for blood pressure and glycemic control as recently recommended by the INTERACT-3, ICH bundle of care (12). This likely contributed to the high in-hospital mortality rate observed (27%), which was significantly higher in adults with hemorrhagic stroke compared to ischemic stroke (33% vs 21% respectively), emphasizing the need for immediate intervention. Our study population was characterized by severe clinical presentations, with a median NIHSS score of 18. We hypothesize that the high incidence of ICH and stroke severity observed may be attributed to the fact that only the most critical cases are referred to the specialized hospitals.

Over two-thirds (75%) of adults in this cohort were referred from lower-level healthcare facilities, with over 50% of adults arriving after 24 hours after the onset of stroke-symptom. This delay underscores the importance of community and HCW awareness and the need to strengthen pre-hospital referral systems to ensure rapid transfer of stroke cases to stroke-ready centers in Tanzania. Based on these data, a stroke awareness campaign using '*UPESI',* the Swahili translation of the FAST acronym for community sensitization (23) is being implemented. This initiative aims to improve early recognition of stroke symptoms and promote timely medical intervention, ultimately reducing delays in seeking and receiving appropriate care.

Beyond delayed presentation, the high in-hospital mortality rate also reflects gaps in the quality of stroke care. Limited adherence to essential care practices, such as swallowing screening, was evident, with more than two-thirds of patients (86%) lacking a documented swallow screen assessment. This likely contributed to the high incidence of aspiration pneumonia (20%). Similarly, over one-third of patients did not receive speech and language therapy due to the unavailability of a speech therapist, while the majority received physiotherapy only after 48 hours of arrival. These delays in post-stroke rehabilitation can lead to prolonged functional recovery and negatively impact long-term patient outcomes. Given that strokes primarily affect young adults in this setting, the long-term socioeconomic consequences have implications beyond individual patients, potentially influencing both the family and nation's economy.

**Results of the training modules**

Robust training modules were provided by WSO collaborators to our local teams focusing on core stroke management skills. While the training aimed to provide comprehensive stroke knowledge, several limitations were noted: there were notable differences in training completion rates between the two hospitals. Similarly, HCWs at the BMC had better scores on the post-assessment quizzes compared to MNH-M. This is likely because MNH-M was the first study site to initiate the trainings, which were open to all HCWs without the identification of focal persons to form the multi-disciplinary teams. Similarly, the trainings in MNH-M lasted longer (about 3 months), which increased the likelihood of dropout rates and non-adherence. Conversely, BMC, identified focal HCWs to attend the training that were shorter in duration (3 weeks), which likely increased attendance rates and therefore knowledge acquisition, which was reflected in the post-evaluation quizzes. Another plausible explanation for the higher benefit of the latter BMC cohort is that the WSO–FSLP trainers adapted their lecture content to align more closely with the specific needs of Tanzanian healthcare workers following the initial training session at MNH-M. Consequently, the subsequent training sessions conducted at BMC were more effectively tailored to address the participants' requirements, enhancing their relevance and impact. Our findings support the need for continued training of HCWs at least twice a year, with shorter intense duration. However, it has to be assessed if the shorter training duration will still lead to long-lasting gain in knowledge.

**Strengths and limitations**

Our study represents a significant milestone in advancing the understanding of stroke care system development within a resource-constrained healthcare setting. It has made a substantial contribution to enhancing quality monitoring, expanding knowledge, and promoting the standardization of stroke care in Tanzania. The involvement of international stroke experts from diverse healthcare environments ensured the development of high-quality training modules and protocols. Nonetheless, our study is not without its limitations**:** A limitation of the TSP was that it involved only two sites. Similarly, the high rates of high hemorrhagic strokes observed is contrary to the previous population level data (24) and likely influenced by selective admission, where patients with more severe disease are likely to be referred and seek hospital care, hence limiting generalizability of the results.

Furthermore, the stroke unit protocols and algorithms were primarily derived from HIC recommendations and may not always be practical in a resource-limited setting. Missing data and the relatively short study duration also pose challenges in drawing definitive conclusions regarding the impact of KPI's on patient outcomes.

Future implementation strategies will focus on tailoring standard operating procedures to better align with the local healthcare context to enhance feasibility and effectiveness in Tanzania. Additionally, efforts will include comparing patient outcomes pre- and post-training, assessing HCWs acceptance and satisfaction with the model.

**Conclusions**

This was the first initiative to implement acute stroke services in two large academic centers in Tanzania. Few patients received and achieved standard of care treatment targets as recommended by the WSO roadmap. Our findings support the need to strengthen Tanzania's healthcare systems to improve screening, treatment, and control of hypertension to prevent complications such as stroke. Additionally, the TSP highlights the need for multilevel stakeholder involvement using a three-tier approach in countries beginning to establish stroke services. Continuous monitoring of care quality, HCWs training, and community sensitization are essential for sustained improvements in stroke care delivery.

## Statements

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**Statement of Ethics:** This study was performed in accordance with the Declaration of Helsinki. This human study was approved by National Institute of Medical Research- approval: NIMR/HQ/R.8a/Vol.IX/4555. Written informed consent to take part in the study was obtained from patients and from patient's next of kin, where they were unable to provide written informed consent.

**Conflict of interest statement:** Ms. Menglu Ouyang, Dr. Emily Ramage and Professor Craig Anderson were members of the journal's Editorial Board at the time of submission. The remaining authors have no conflicts of interest to declare.

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**Author's contributions:** Sarah Shali Matuja: Conceptualization, healthcare worker training, stroke registry and protocol development, data collection, analysis, interpretation, writing the initial manuscript. Christine Tunkl, Tamer Roushdy, Linxin Li, Menglu Ouyang and Faddi G. Saleh Velez: Training module development, healthcare worker training, stroke registry and stroke unit protocol development and writing the initial manuscript. Meron Gebrewold, Jatinder S Minhas, Zhe Kang Law, Aristeidis H. Katsanos, Teresa Ullberg, Maria Giulia Mosconi, Maria Khan, Matias Alet, Radhika Lotlikar, Alicia Richardson, Bogdan Ciopleias, Mirjam R Heldner, Susanna Maria Zuurbier, Emily Ramage, Selam K Kifelew, Vasileios Lioutas, Marika Demers, Marina Charalambous, Dorcas BC Gandhi, Urvashy Gopaul, Leonardo Carbonera and Ralph Akyea: Training module development, healthcare worker training, stroke registry and stroke unit protocol development, critically reviewing and revising the manuscript. Ladius Rudovick: Conceptualization, data collection, critically reviewing and revising the manuscript. Bahati Wajanga, Semvua Kilonzo and Robert Peck: Conceptualization, critically reviewing and revising the manuscript. Mohamed Mnacho and Faraja S Chiwanga: Conceptualization, training, stroke registry and protocol development. Brighton Mushengezi, Kigocha Okeng'o, Henrika Kimambo and Mohamed Manji: Training, stroke registry variables and protocol development and data collection. Akili Mawazo: Data analysis and interpretation. Paschal Ruggajo, Tumaini Nagu and William Matuja: Conceptualization, critically reviewing and revising the manuscript. Louise Johnson, Octávio Pontes-Neto, Craig Anderson and Sheila Ouriques Martins: Conceptualization, developing the training modules and stroke unit protocols, training healthcare workers, critically reviewing and revising the manuscript. All authors read and approved the final manuscript.

**Data availability statement**: The data that support the findings of this study are not publicly available to maintain patient confidentiality but are available from the corresponding author upon reasonable request.

## References

1 Feigin VL, Abate MD, Abate YH, ElHafeez SA, Abd-Allah F, Abdelalim A, et al. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet Neurol [Internet]. 2024 Oct 1 [cited 2024 Oct 7];23(10):973–1003.

2 Feigin VL, Owolabi MO. The Lancet Neurology Commissions Pragmatic solutions to reduce the global burden of stroke: a World Stroke Organization-Lancet Neurology Commission. The Lancet. 2023;22(12):1160-1206.

3 World Health Organization 2024 data.who.int, United Republic of Tanzania [Country overview]. [Internet]. [cited 2024 Nov 19]. Available from: https://data.who.int/countries/834

4 Walker R, Gray WK, Whiting D, Unwin N, Alberti G, Walker R, et al. Stroke incidence in rural and urban Tanzania: a prospective, community-based study. Lancet Neurol. 2010;9:786–92.

5 Prendes CF, Rantner B, Hamwi T, Stana J, Feigin VL, Stavroulakis K, et al. Burden of Stroke in Europe: An Analysis of the Global Burden of Disease Study Findings from 2010 to 2019. Stroke. 2024;55(2):432–42.

6 Matuja S, Munseri P, Khanbhai K. The burden and outcomes of stroke in young adults at a tertiary hospital in Tanzania: a comparison with older adults. BMC Neurol. 2020;20(1):206.

7 Roushdy T, Aref H, Kesraoui S, Temgoua M, Nono KP, Gebrewold MA, et al. Stroke services in Africa: What is there and what is needed. Int J Stroke. 2022;17(9):972–82.

8 Matuja SS, Ngimbwa J, Andrew L, Shindika J, Nchasi G, Kasala A, et al. Stroke Characteristics and Outcomes in Urban Tanzania: Data from the Prospective Lake Zone Stroke Registry. Int J Stroke. 2023;19(5):536–46.

9 WHO Noncommunicable Diseases and Mental Health. The WHO STEPwise approach to stroke surveillance report [Internet]. 2005 [cited 2022 Sep 5]. Available from: https://apps.who.int/iris/handle/10665/43420

10 Asplund K, Hulter Åsberg K, Norrving B, Stegmayr B, Terént A, Wester PO. Riks-Stroke – A Swedish National Quality Register for Stroke Care. Cerebrovascular Diseases. 2003;15(Suppl. 1):5–7.

11 Standard method for developing stroke registers in low-income and middle-income countries: experiences from a feasibility study of a stepwise approach to stroke surveillance (STEPS Stroke). 2007;6(2):134-9.

12 Ma L, Hu X, Song L, Chen X, Ouyang M, Billot L, et al. The third Intensive Care Bundle with Blood Pressure Reduction in Acute Cerebral Haemorrhage Trial (INTERACT3): an international, stepped wedge cluster randomised controlled trial. Lancet. 2023;402(10395):27–40.

13 Greenberg SM, Ziai WC, Cordonnier C, Dowlatshahi D, Francis B, Goldstein JN, et al. 2022 Guideline for the Management of Patients With Spontaneous Intracerebral Hemorrhage: A Guideline From the American Heart Association/American Stroke Association. Stroke. 2022;53(7):E282–361.

14 Powers W, Rabinstein A, Ackerson T, Adeoye O, Bambakidis N, Becker K, et al. Guidelines for the Early Management of Patients With Acute Ischemic Stroke: 2019 Update to the 2018 Guidelines for the Early Management of Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke. Stroke. 2019;50(12):E344–418.

15 Lindsay P, Furie KL, Davis SM, Donnan GA, Norrving B. World stroke organization global stroke services guidelines and action plan. International Journal of Stroke. 2014;9(A100).

16 Tunkl C, Paudel R, Bajaj S, Thapa L, Tunkl P, Chandra A, et al. Implementing stroke care in a lower-middle-income country: results and recommendations based on an implementation study within the Nepal Stroke Project. Front Neurol. 2023;14;1272076.

17 Saylor D, Braun S, Sneh G, Kinkata M, Nanduri S, Chen P, et al. An Evidence-based Approach to Stroke Unit Development in Zambia (P3-5.013). Neurology. 2024; 9;102(17_supplement_1).

18 Akinyemi RO, Ovbiagele B, Adeniji OA, Sarfo FS, Abd-Allah F, Adoukonou T, et al. Stroke in Africa: profile, progress, prospects and priorities. Nature Reviews Neurology 2021 17:10. 2021;17(10):634–56.

19 Okekunle AP, Jones S, Adeniji O, Watkins C, Hackett M, Di Tanna GL, et al. Stroke in Africa: A systematic review and meta-analysis of the incidence and case-fatality rates. 2023;18(6):634–44.

20 Krishnamurthi R V., Ikeda T, Feigin VL. Global, Regional and Country-Specific Burden of Ischaemic Stroke, Intracerebral Haemorrhage and Subarachnoid Haemorrhage: A Systematic Analysis of the Global Burden of Disease Study 2017. Neuroepidemiology. 2020;54(2):171–9.

21 O'Donnell MJ, Xavier D, Liu L, Zhang H, Chin SL, Rao-Melacini P, et al. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. Lancet. 2010;376(9735):112–23.

22 Geldsetzer P, Manne-Goehler J, Marcus ME, Ebert C, Zhumadilov Z, Wesseh CS, et al. The state of hypertension care in 44 low-income and middle-income countries: a cross-sectional study of nationally representative individual-level data from 1·1 million adults. The Lancet. 2019;394(10199):652–62.

23 Waweru PK, Yulu E, Matuja SS, Gatimu SM. UPESI: Swahili translation of the FAST acronym for stroke awareness campaigns in East Africa. African Journal of Emergency Medicine. 2024;14(3):141–4.

24 Walker RW, Jusabani A, Aris E, Gray WK, Mitra D, Swai M. A prospective study of stroke sub-type from within an incident population in Tanzania. South African Medical Journal. 2011;101(5):338–44.

Table 1: Baseline characteristics of the cohort

| Variable | Total 460(%) | Ischemic stroke 191(%) | Hemorrhagic stroke 269(%) | p-value |
|---|---|---|---|---|
| Mean ± SD age in years | 60±15 | 65±15 | 57±14 | <0.001 |
| Females | 245(53) | 109(57) | 136(51) | 0.168 |
| Education | | | | |
| Not educated | 46(10) | 21(11) | 25(10) | |
| Primary education | 218(48) | 82(43) | 136(52) | 0.052 |
| Secondary education | 114(25) | 45(24) | 69(26) | |
| College and above | 74(16) | 41(22) | 33(13) | |
| Occupation | | | | |
| Employed | 53(12) | 25(13) | 28(11) | |
| Unemployed | 299(66) | 133(71) | 166(62) | 0.018 |
| Self employed | 87(19) | 23(12) | 64(24) | |
| Unable to go to work | 15(3) | 7(4) | 8(3) | |
| Residency | | | | |
| Urban | 236(56) | 87(49) | 149(61) | |
| Semi-urban | 109(26) | 54(31) | 55(22) | 0.059 |
| Rural | 78(18) | 36(20) | 42(17) | |
| Referred from another facility | 349(75) | 120(63) | 229(86) | <0.001 |
| Mode of hospital arrival | | | | |
| Ambulance | 210(48) | 43(24) | 167(66) | |
| Own means | 191(44) | 122(67) | 69(27) | <0.001 |
| Other | 34(8) | 17(9) | 17(7) | |
| Possession of Health insurance | 150(33) | 95(50) | 55(21) | <0.001 |
| Premorbid hypertension | 373(81) | 142(74) | 231(86) | 0.002 |
| On regular anti-hypertensives | 77(21) | 56(39) | 21(10) | <0.001 |
| Premorbid Diabetes mellitus | 45(10) | 27(14) | 18(6.7) | 0.008 |
| On regular anti-diabetics | 20(44) | 18(24) | 2(2) | <0.001 |
| Previous HIV infection | 15(3) | 3(2) | 12(5) | 0.085 |
| On regular ARVs | 12(67) | 3(5) | 8(4) | 0.457 |
| Previous stroke | 61(13) | 38(20) | 23(9) | <0.001 |
| Previous Heart failure | 11(2) | 10(5) | 1(0.4) | 0.001 |
| Atrial Fibrillation | 1(0.2) | 1(1) | 0(0) | 0.235 |
| Current smoker | 12(3) | 4(2) | 8(3) | 0.56 |
| Current alcohol consumers | 19(4) | 6(3) | 13(5) | 0.369 |
| Clinical characteristics | | | | |
| Ward admitted | | | | |
| General medical ward | 344(75) | 144(74) | 203(76) | 0.68 |
| ICU | 8(2) | 3(2) | 5(2) | 0.816 |
| Stroke unit | 35(8) | 10(5) | 25(9) | 0.106 |
| High Dependence Unit | 52(11) | 26(14) | 26(10) | 0.122 |
| Time of symptom onset to arrival | | | | |
| Within 3 hours | 2(0.7) | 1(1) | 1(1) | |
| Within 4.5 hours | 1(0.3) | 1(1) | 0(0) | |
| Within 6 hours | 10(3) | 7(5) | 3(2) | 0.079 |
| Within 24 hours | 95(32) | 53(39) | 42(27) | |

| | | | | |
|---|---|---|---|---|
| After 24 hours | 171(58) | 68(50) | 103(66) | |
| Unknown time | 14(5) | 6(4) | 8(5) | |
| Mean ± SD NIHSS on arrival | 18±8 | 18±8 | 18±7 | 0.86 |
| Mean ± SD arrival SBP mmHg | 160±30 | 149±27 | 168±29 | <0.001 |
| Mean ± SD arrival DBP mmHg | 96±19 | 91±19 | 101±18 | <0.001 |
| Mean ± SD arrival glucose mmol/L | 8±3 | 8±4 | 7±2 | 0.063 |
| Median Total cholesterol mmol/L | 5 IQR(4,6) | 5 IQR(4,6) | 5 IQR(4,6) | 0.923 |
| Median LDL cholesterol mmol/L | 3 IQR(2,4) | 3 IQR(2,4) | 4 IQR(3,4) | 0.899 |
| Median mRS | 4 IQR(3,6) | 4 IQR(3,5) | 4 IQR(4,6) | 0.010 |
| Dead, N=340 | 93(27) | 33(21) | 60(33) | 0.001 |
| Median length of hospital stay (days) | 4 IQR(2,7) | 4 IQR(3,7) | 4 IQR(2,6) | 0.897 |

SD- Standard deviation, ICU- Intensive care unit, NIHSS-National Institutes of Health Stroke Scale, GCS-Glasgow coma scale, SBP-Systolic blood pressure, DBP-Diastolic blood pressure, mRS-modified Rankin Scale

Table 2: Key performance indicators

| Key performance indicators | Total 460(%) |
|---|---|
| Swallow screen performed n=452 | |
| Performed and documented | 50(11) |
| Not performed or documented | 388(86) |
| Not examined owing to patients' level of consciousness | 14(3) |
| Assessment of speech function by a speech therapist n=415 | |
| Yes | 5(1) |
| No, no need | 112(27) |
| No; patient has need but no speech therapist available | 192(46) |
| No, but ordered for after discharge | 34(8) |
| No | 46(11) |
| Not known or patient declines evaluation | 26(6) |
| In-patient physiotherapy n=419 | |
| Yes, ≤24hours | 36(9) |
| Yes >24hours but ≤48hours | 128(31) |
| Yes, >48hours | 173(41) |
| No | 72(17) |
| Not known | 10(2) |
| Deep venous thrombosis prophylaxis n=411 | |
| Yes | 120(29) |
| No, did not need it | 123(30) |
| No, not given or no documentation | 91(22) |
| Not known | 77(19) |
| Developed medical complications n=460 | |
| Aspiration pneumonia | 93(20) |
| Deep venous thrombosis | 1(0.2) |
| Urinary Tract Infections | 11(2) |
| Sepsis | 63(14) |
| Bed sores | 5(1) |
| Acute kidney injury | 82(18) |
| Hyponatremia | 27(6) |
| Other complications | 24(5) |
| Targets for bundle of care for Intracerebral hemorrhage within 24hours, n=253 | |
| BP<140/90 mmHg | 28(11) |
| Temperature <37.5 | 229(91) |
| Blood glucose 6.1-7.8 mmol/L for non-diabetics, n=213 | 99(47) |
| Blood glucose 7.8 -10 mmol/L for diabetics, n=15 | 2(13) |
| Drugs for secondary prevention | |
| Adults with ischemic stroke discharged with anti-platelets n=191 | 54(28) |
| Adults with ischemic stroke discharged with statins n=191 | 101(53) |
| Adults with hypertension discharged with anti-hypertensive medications n=373 | 334(90) |
| Adults with diabetes discharged with anti-diabetic medications n=45 | 18(40) |

BP: Blood pressure

Table 3: The total number of healthcare workers who registered and completed the stroke training modules at the study sites

| Module name | Site name | Total number of HCWs who registered | Number of HCWs who completed training (n/% of total) |
|---|---|---|---|
| Main (Hyperacute, acute and post-acute) | | | |
| | MNH-M | 31 | 7 (22.6%) |
| | BMC | 51 | 29 (56.9%) |
| | Total | 82 | 36 (43.9%) |
| Nursing | | | |
| | MNH-M | 14 | 5 (35.7%) |
| | BMC | 13 | 11 (84.6%) |
| | Total | 27 | 16 (59.3%) |
| Rehabilitation | | | |
| | MNH-M | 27 | 4 (14.8%) |
| | BMC | 31 | 22 (71%) |
| | Total | 58 | 26 (44.8%) |

HCWs: Healthcare workers, BMC- Bugando Medical Centre, MNH-M- Muhimbili National Hospital-Mloganzila