

## Neuro-oncology access in Sub-Saharan Africa: A literature review of challenges and opportunities

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### Abstract

**Background.** Ensuring equitable access to treatments and therapies in the constantly evolving field of neuro-oncology is an imperative global health issue. With its unique demographic, cultural, socioeconomic, and infrastructure characteristics, Sub-Saharan Africa faces distinct challenges. This literature review highlights specific barriers to neuro-oncology care in the region and explores potential opportunities for enhancing access.

**Methods.** Predetermined keyword searches were employed to screen titles and abstracts using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework. Inclusion criteria were studies published between January 1, 2003, and June 20, 2023, specifically addressing the capacity and challenges of neuro-oncology in the Sub-Saharan African region. The data sources queried were PubMed and Google Scholar. Systematic reviews and meta-analyses were deliberately excluded. All authors conducted independent screening and structured data extraction meticulously.

**Results.** Our paper identified multiple challenges that impede access to quality treatment for brain tumors. These include constrained resources, insufficient training of healthcare professionals, certain cultural beliefs, and a general lack of awareness about brain tumors, all contributing to delayed diagnosis and treatment. Furthermore, the lack of detailed data on the incidence and prevalence of primary central nervous system tumors impairs the accurate assessment of disease burden and precise identification of areas requiring improvement. However, we discovered that ongoing research, advocacy, enhanced training, mentorship, and collaborative efforts present valuable opportunities for substantial progress in neuro-oncology access.

**Conclusions.** While we provide a glimpse of the current state, we hope these results will help stimulate dialogue and catalyze initiatives to surmount highlighted obstacles and improve neuro-oncology outcomes across Sub-Saharan Africa.

### Key Points

- Sub-Saharan Africa faces challenges in neuro-oncology access such as resource constraints, training deficits, and delayed diagnosis.
- Collaborative efforts in research, training, and advocacy present opportunities to enhance access and outcomes.

In Africa, brain and spinal cord tumor incidence between 1960 and 2017 was estimated at 226.98 per 100 000 population.<sup>1</sup> Historically, brain tumors were considered relatively uncommon in Sub-Saharan Africa, attributed to environmental and genetic factors. However, their prevalence has increased significantly, making them a leading cause of mortality and morbidity in the region. This trend reflects the growing incidence of noncommunicable diseases in the area.<sup>2</sup>

Neuro-oncologic care requires a comprehensive, multidisciplinary team, including neurosurgeons, neuro-oncologists, radiation oncologists, neurologists, pathologists, oncology nurses, and physical and occupational therapists. In cases where curative treatment options are limited, the significance of palliative care becomes paramount, as it plays a crucial role in optimizing the quality of life for patients. Timely access to palliative care positively impacts health-related quality of life, mood, and end-of-life

## Importance of the Study

This study addresses the challenge of ensuring equitable access to neuro-oncology treatments in Sub-Saharan Africa, a region with unique challenges due to its demographic, cultural, socioeconomic, and infrastructural landscape. Prior literature has often overlooked these specific regional barriers. The study highlights these barriers and identifies opportunities for improvement, such as increased research, advocacy,

and collaborative efforts, thereby contributing to academic discourse and providing practical significance. In addition, the study lays a foundation for future initiatives aimed at overcoming these barriers, thereby potentially enhancing healthcare outcomes in neuro-oncology within this region and setting a precedent for other similar contexts globally.

care.<sup>3</sup> However, many Sub-Saharan African countries lack the essential medical equipment, technologies, and expertise for accurate diagnosis and effective treatment. For example, in Ghana and Nigeria, there is only one neurosurgeon for every 2.4 million citizens,<sup>1,2</sup> and one for every 3.3 million citizens on the continent as a whole.<sup>2</sup> As a result, patients experience significant delays in diagnosis, limited treatment options, and suboptimal outcomes, leading to increased morbidity and mortality rates.

Ensuring equitable access to neurosurgical care is crucial for promoting the health and well-being of individuals and remains a pivotal goal worldwide. Nevertheless, this goal is far from being realized. Many people worldwide continue to face numerous challenges in accessing care, despite recognized efforts to promote the equitable distribution of healthcare.<sup>4,5</sup>

Due to factors such as aging, population growth, and changing risk factor prevalence, the number of new cancer cases is projected to increase by 70% by 2030, primarily due to demographic changes alone.<sup>3</sup> Within this context, the burden of neuro-oncology extends beyond individual patients, affecting families and society as a whole. Low- and middle-income countries (LMICs) bear a significant share of this burden with considerable gaps in access to neurosurgical and neuro-oncologic care.

This study aims to assess the current capacity, identify the challenges, and shed light on the prospects of neuro-oncologic care across Sub-Saharan Africa. By examining the current landscape, this paper aims to provide a comprehensive understanding of the strengths, limitations, and potential advancements in the field of neuro-oncologic care in Sub-Saharan Africa.

## Materials and Methods

### Search Strategy

A literature search was conducted using methodology according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1). On June 20th, 2023, an extensive search was conducted on the online database PubMed and Google Scholar. The search strategy employed the following key terms: "Neuro-oncology AND Africa," "Neuro-oncology AND Sub-Saharan Africa," "Brain tumor AND Africa," "Brain tumor access AND Africa," and "Neuro-oncology challenges AND Africa." The

search was limited to articles published after January 1st, 2003. Both English and non-English articles were included in order to expand the available number of articles. Google Translate was used with such articles to obtain English translations. Exclusion criteria were systematic reviews and meta-analyses. This study aimed to examine and analyze original articles that focused on the neuro-oncology landscape in Sub-Saharan Africa. In addition, secondary objectives included evaluating the accessibility of neuro-oncology care, exploring the challenges associated with access, and examining patient outcomes and perspectives.

### Data Extraction

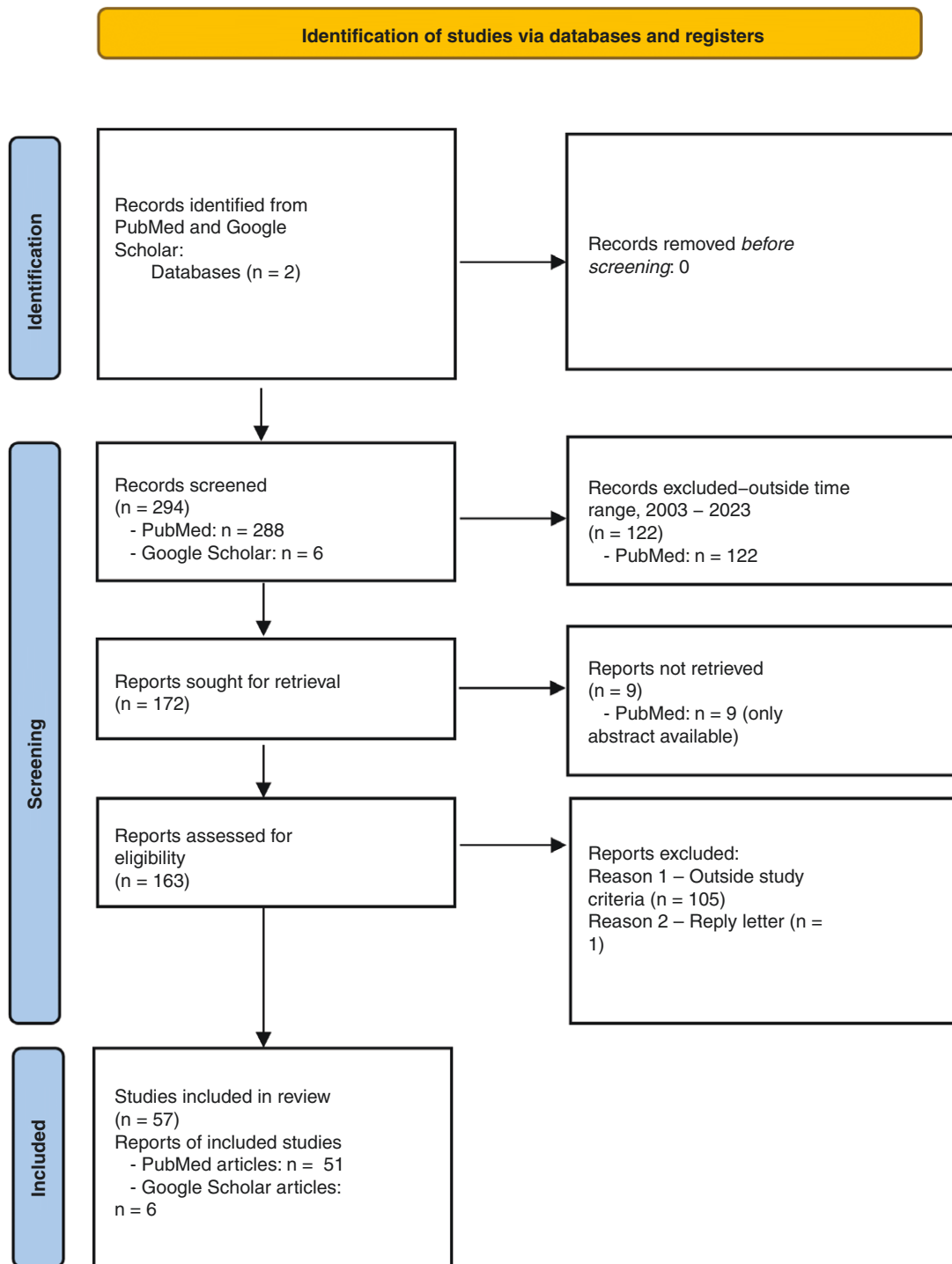
The data extraction process was independently conducted by 3 authors (W.E.Y., K.D., V.B.), following the previously mentioned search strategy. When discrepancies arose concerning inclusion criteria or collected data, the authors assessed and deliberated on them to achieve a consensus. Initially, identified articles were screened based on their titles, followed by a thorough evaluation of abstracts and full texts to determine their inclusion. An extensive analysis of the full texts of all articles was carried out to extract relevant data. The bibliography of the included articles was scrutinized to identify any additional articles that might meet our predetermined inclusion criteria.

The risk of bias for each study was assessed using the Risk Of Bias In Non-randomized Studies—of Interventions (ROBINS-I) tool. Subsequently, the identified articles were integrated into our review and evaluated using our established data extraction methodology. The relevant data encompassed the research aim, the Sub-Saharan countries under study, the diagnostic tools, the available treatment and palliative care services, the barriers to access, and the patients' perspectives.

## Results

### Search Yield

We conducted a search of PubMed and Google Scholar databases following PRISMA guidelines yielding a total of 294 sources. Of these, 122 sources were excluded as they fell out of the designated time frame, 172 were sought for retrieval and 163 were assessed. A total of 106 references that



**Figure 1.** PRISMA flow diagram.

fell outside the study criteria were then excluded. A final list of 57 articles was included in this literature review (**Table 1**).

### Study Characteristics

The studies included in this review were conducted in various countries across Sub-Saharan Africa (**Figure 2**). These

studies employed different methodologies, including scoping reviews, cross-sectional studies, retrospective reviews, and case series. Including this range of study methodologies aligns with our objective to encompass various perspectives while remaining attentive to potential bias. Each study included in this review explored at least one theme related to neuro-oncology care, which could

**Table 1.** All Articles Included in the Review of Neuro-Oncological Care in Sub-Saharan Africa

#	First author	Country	Study design	Aim
1	Kedia, Shweta 2023	54 countries and 4 territories in Africa; 48 countries and 3 territories in Asia	Cross-sectional analytical study	Assess the current status, challenges, and future perspectives of brain tumor programs in Asia and Africa.
2	Awuah, Wireko Andrew 2023	N/A	Letter	Highlight the challenges of evaluating brain tumor surgical management capacity in Sub-Saharan Africa (SSA).
3	Balogun, James A. 2023	Nigeria	Retrospective case series	Report the initial experience with the utility of the endoscopic endonasal approach (EEA) in the surgical management of pituitary neuroendocrine tumors (PitNETs), particularly in large and giant tumors, despite limited resources.
4	Aderinto, Nicholas 2023	Nigeria, Egypt, Uganda, Morocco, Kenya, Ghana, Sudan, Ivory Coast, Namibia, South Africa, Malawi	Review	Discuss the challenges and opportunities related to neuro-oncology in Africa.
5	Gerstl, Jakob V. E. 2022	173 countries total from Africa, Asia, Europe, North America, South America, and Oceania	Analysis	Investigate the macroeconomic losses related to central nervous system (CNS) cancer in 173 countries and identify pertinent epidemiological trends.
6	Botwe, Benard 2022	Ghana	Cross-sectional study	Investigate the variability of basic imaging protocols used for CT imaging of common indications in Ghana.
7	Balogun, James A. 2022	Nigeria	Retrospective review	Describe the epidemiology of brain tumors among adolescents and young adults (AYA) in Nigeria
8	Kanmounye, Ulrick Sidney 2022	The review encompassed 119 articles, with contributions from 24 Sub-Saharan African (SSA) countries. While not all contributing countries were specified, the most significant contributions came from Nigeria, South Africa, Senegal, Sudan, Ethiopia, Ghana, and Zimbabwe.	Scoping review	Identify regional differences in the landscape of adult brain tumors in Sub-Saharan Africa (SSA) and highlight disparities in research output, disease epidemiology, service delivery, and patient outcome.
9	Balogun, James A. 2022	N/A	N/A (perspective paper)	Contribute to the understanding and improvement of surgical neuro-oncology practices in Sub-Saharan Africa.
10	Tadipatri, Ramya 2021	Nigeria, Cameroon	Survey report	Gather data on the current state of palliative care in the region, identify common challenges faced by physicians, and explore potential differences between the Nigeria and Cameroon populations.
11	Uche, Enoch Ogbonnaya 2021	Nigeria	Retrospective cohort survey	Evaluate the school performance among survivors of pediatric brain tumors (PBT) in a specific region.
12	Henderson, Fraser 2021	Kenya	Case report	Discuss the potential benefits and feasibility of online tumor boards in the field of neurosurgical oncology, particularly in low- and middle-income countries (LMICs) in Africa.
13	Haizel-Cobbina, Joseline 2021	Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Réunion, Rwanda, Seychelles, Somali, Somaliland, South Sudan, Sudan, Tanzania, Uganda	Review	Shed light on the distribution of primary central nervous system tumors, neuro-oncologic care, and the contributions of scientists and institutions in East Africa over the past 5 decades. Also highlights the gaps in knowledge and resources in the field of neuro-oncology in East Africa.
14	Balogun, James A. 2020	Algeria, Ghana, Namibia, Nigeria	Editorial	Discuss the efforts of the Society for Neuro-Oncology (SNO) in establishing a global organization to unite regional and national neuro-oncology societies.
15	Elhassan, M. Mohammed Ali 2019	Sudan	Retrospective survey	Evaluate baseline information about the epidemiology, treatment types, and outcomes of childhood CNS tumors at the National Cancer Institute, University of Gezira (NCI-UG) in Wad Madani, Sudan
16	Tagoe, N.N. 2019	Ghana	Retrospective cohort	Investigate the visual outcome of patients with pituitary adenomas following surgery and identify the factors that contribute to their recovery.

**Table 1.** Continued

#	First author	Country	Study design	Aim
17	Laeke, Tsegazeab 2019	Ethiopia	Retrospective review	Evaluate the surgical outcome of intracranial meningiomas in 2 hospitals, namely Black Lion Specialized Hospital and Myung Sung Christian Medical Center, in Ethiopia
18	Ibrahim, H 2019	Nigeria	Retrospective analysis	Investigate the use of palliative external beam radiotherapy for advanced breast cancer patients with brain metastasis. The authors sought to evaluate the effectiveness of radiotherapy in terms of symptom relief and improvement in performance status.
19	Balogun, James A. 2019	Nigeria	Case series	Present the feasibility of outpatient craniotomy for brain tumors in a resource-challenged environment in Sub-Saharan Africa.
20	Rifky Khalek, Elhamy 2019	N/A	Conference report	Provide a conference report on the 13th African Continental Meeting of the International Society of Pediatric Oncology (SIOP), which took place in Cairo, Egypt from March 6–9, 2019. The report highlights the keynote lectures, discussions, and recommendations made during the conference, with a focus on cancer-related issues and solutions in African countries.
21	Kakusa, Bina 2019	Uganda	Prospective study	Investigate the outcomes of surgical treatment and complications of central nervous system (CNS) tumors in Uganda.
22	Njami, V. A. 2018	Cameroon	Retrospective cohort study	Investigate the visual outcomes of patients with pituitary adenomas who underwent surgical management at the Yaoundé Central Hospital in Cameroon. The researchers sought to assess the impact of surgical intervention on the visual function of these patients.
23	Balogun, James A. 2018	Nigeria	Case report	Report and discuss 2 cases of cerebellar vermian epidermoid tumors and highlight the clinical and radiological features of these tumors.
24	Kleib, Ahmed-Salem 2018	Mauritania	Retrospective case series	Identify the epidemiological profile and assess the quality of treatment for intracranial meningiomas (ICM) at the National Hospital Center in Nouakchott, Mauritania.
25	Ndubuisi, ChikaAnele 2018	Nigeria	Retrospective observational study	Analyze the tumor characteristics and management outcomes of pediatric brain tumors (PBTs) in Enugu, Southeast Nigeria.
26	Servadei, Franco 2018	Sierra Leone, Liberia	Editorial	Raise awareness of the challenges and opportunities of implementing neurosurgical care in low- to middle-income countries (LMICs).
27	Piersson, A. D. 2018	Ghana	Descriptive study	To investigate the current practice of brain MRI examinations, referral patterns, and the appropriateness of clinical indications.
28	Ndubuisi, ChikaAnele 2017	Nigeria	Retrospective analysis	Study the histology characteristics of brain gliomas managed at a Neurosurgical center in Nigeria. The researchers seek to analyze the demographic, clinical, and histology characteristics of gliomas in this specific setting.
29	Ekpene, Ubong 2017	Ghana	Retrospective, descriptive study	Investigate the pattern of intracranial tumors in a tertiary hospital in Ghana.
30	Elhassan, M. Mohammed Ali 2017	Sudan	Retrospective study	Provide insights into the clinical characteristics, treatment, and outcomes of posterior cranial fossa tumors in children at the National Cancer Institute in Sudan.
31	Ezeala-Adikaibe, Ab 2017	Nigeria	Retrospective study	Investigate the pattern of significant lesions found in computerized tomography (CT) scans of patients with recurrent seizures at a center in Enugu, Nigeria.

Table 1. Continued

#	First author	Country	Study design	Aim
32	Elmezughi, Khaled K. 2017	South Africa	Retrospective	To describe the clinical, biochemical, radiological, and histological features and to determine the outcome of all patients with pituitary tumors treated surgically at Inkosi Albert Luthuli Central Hospital in Durban over a 5-year period.
33	Olasinde, T A 2016	Nigeria	Retrospective review study	Evaluate the role of palliative care in patients who receive Whole-Brain Radiotherapy for Brain Metastases in Ahmadu Bello University Teaching Hospital, Zaria.
34	Olasode, Babatunde J. 2016	Nigeria	Review	Provide an overview of the current state of pediatric neuropathology practice in Africa, with a focus on the local experience in Nigeria and the challenges and prospects for the continent as a whole.
35	Tagoe, N.N. 2015	Ghana	Prospective case series	Investigate the neuro-ophthalmic and clinical characteristics of brain tumors in a tertiary hospital in Ghana.
36	Thiam, Alioune Badara 2015	Senegal	Case series	Present a retrospective study on the management of intracranial meningiomas in Dakar, Senegal.
37	Marston, Joan 2015	South Africa, Kenya, Zimbabwe	Editorial	Discuss the development of an international network to support palliative care for children.
38	Mezue, Wilfred 2015	Nigeria	Retrospective analysis	Investigate the epidemiology, clinical characteristics, and outcomes of seizures associated with primary intracranial tumors.
39	Chan, Michael H. 2015	Niger, Mali, Mauritania, Equatorial Guinea, Guinea Bissau, Lesotho, Swaziland, Rwanda, Madagascar, Comoro Islands, Burundi	Review	Discuss the challenges and opportunities to advance pediatric neuro-oncology care in the developing world.
40	Hatef, Jeffrey 2014	Uganda	Retrospective review	Analyze both pediatric and adult CNS tumors in Uganda and aims to contribute to the limited knowledge of the epidemiology of CNS tumors in Sub-Saharan Africa.
41	Stagno, Vita 2014	Uganda	Retrospective operative series	Review the first operative series of pediatric brain tumors from Uganda, which is the largest series from Sub-Saharan Africa.
42	Ibebuike, K 2013	South Africa	Prospective	Determine the relative frequency of intracranial meningiomas among intracranial neoplasms in the environment of the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) and Chris Hani Baragwanath Academic Hospital (CHBAH), both located in Johannesburg, South Africa.
43	Howe, Kathryn 2013	Ghana, Nigeria	Feasibility study	Assess the feasibility of teaching and sustainably implementing awake craniotomy in resource-poor settings.
44	Uche, Enoch Ogbonnaya 2013	Nigeria	Retrospective descriptive study	Provide a comprehensive understanding of pediatric brain tumors in Nigeria.
45	Mezue, Wilfred 2012	Nigeria	Retrospective analysis	Investigate the management of giant pituitary tumors affecting vision in Nigeria.
46	Ogbole, G.I. 2012	Nigeria	Retrospective study	Evaluate the diagnostic accuracy of low-field MRI in the diagnosis of sellar and parasellar lesions in a developing country hospital. The study also aims to determine the most common types of sellar and parasellar lesions in the study population, as well as the clinical presentations of these lesions.
47	Hadley, Larry G.P. 2012	-West Africa (Côte d'Ivoire), East Africa (Kenya), South Africa	Review	Highlight the challenges faced in pediatric oncology in sub-Saharan Africa
48	Wilson, David 2012	Tanzania	Descriptive study	Report on the early experience of an initiative to teach neurosurgery at Bugando Medical Center in Northwest Tanzania.

Table 1. Continued

#	First author	Country	Study design	Aim
49	Adeleye, Amos O. 2012	Nigeria	Prospective, descriptive audit	To audit the surgical results of the first 30 months of practice of a team of neurosurgeons in a developing African country with very severe resource limitations, who have explored and adapted their acquired knowledge of modern-day advanced skull base microsurgery to practice in this particular setting.
50	Ali, Amel 2011	Sudan	Retrospective study	Describe the clinical presentation and outcome of retinoblastoma among children treated at the National Cancer Institute (NCI) in Gezira, Sudan.
51	Awodele, Olufunsho 2011	Nigeria	Retrospective cross-sectional study	Investigate the pattern of cancer distribution in southwestern Nigeria.
52	Idowu, O.E. 2009	Nigeria	Pilot study	Identify the reasons behind the delay in seeking medical treatment and the delay in diagnosing intracranial tumors in this specific patient population.
53	Abdus-salam, Abbass 2007	Nigeria	Retrospective study	To review pediatric malignancy presentation patterns at the UCH Ibadan Hospital.
54	Odeboode, T.O. 2006	Nigeria	Retrospective study	Retrospectively analyze the impact of selected clinicopathological factors on visual and clinical outcomes in patients with histologically verified cranial meningioma. The researchers sought to investigate how various factors, such as tumor characteristics, influence the visual and clinical outcomes of patients with this condition.
55	Olasode, Babatunde J. 2004	General "sub-Saharan Africa"	Non-inferiority study	Compare the accuracy of brain smear to frozen section for rapid intraoperative diagnosis.
56	Wanyoike, P.K. 2004	Kenya	Retrospective study	Review the management of posterior cranial fossa tumors in children at Kenyatta National Hospital in Nairobi, Kenya.
57	Andrews, N.B. 2003	Ghana	Preliminary survey	Investigate the frequency, age distribution, and histological types of central nervous system tumors in Tema, Ghana.

**Abbreviation:** CNS, central nervous system; CT, computed tomography; EEA, endoscopic endonasal approach; LMICs, low- and middle-income countries; MRI, magnetic resonance imaging; NCI-UG, National Cancer Institute University of Gezira; PBT, pediatric brain tumors; PitNETs, pituitary neuroendocrine tumors; SIOP, International Society of Pediatric Oncology; SNO, society for neuro-oncology; SSA, Sub-Saharan Africa; VPS, ventriculoperitoneal shunting; WBRT, whole-brain radiotherapy.

encompass aspects like access, epidemiology, diagnosis, treatment, and outcomes. Some studies addressed multiple themes.

### Risk of Bias

The studies included in this review had varying levels of bias risk. While some studies had a low risk of bias, most were within moderate, moderate to high, and high-risk bias categories (Figure 3). Factors contributing included small sample size, lack of representativeness, and absence of comprehensive data on the incidence and prevalence of primary central nervous system tumors in Sub-Saharan Africa.

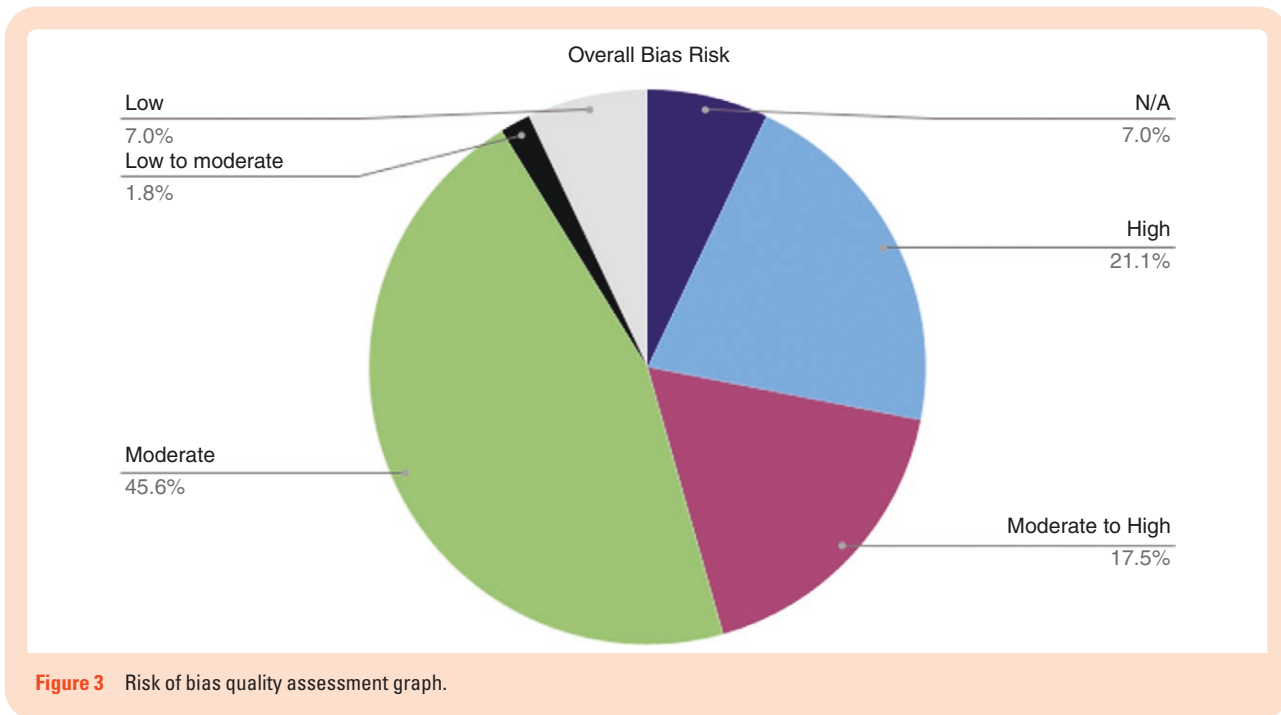
### Challenges and Opportunities

**Availability of diagnostic tools, treatment modalities, and palliative care.**—Forty-one studies<sup>2,6-42</sup> discussed access to diagnostic tools related to neuro-oncology care in

Sub-Saharan Africa (Supplementary Table 1). These studies consistently demonstrated that limited access to diagnostic tools is a significant barrier to neuro-oncology care in Sub-Saharan Africa. The lack of specialized equipment often resulted in delayed diagnosis, misdiagnosis, and suboptimal treatment options.<sup>2,6,7,15,16,20,24,25,27,30,37,38,41,42</sup> For example, Mezue et al.<sup>31</sup> noted that while computed tomography and MRI are available in some healthcare facilities in Sub-Saharan Africa, their accessibility can be restricted in rural areas, leading to delayed diagnosis and treatment of intracranial tumors.

The studies identified several opportunities for improving access to diagnostic tools in neuro-oncology care in Sub-Saharan Africa. These included the development of regional referral networks, the establishment of telemedicine and mobile health technologies, and the improvement of healthcare infrastructure and resources.<sup>14,18,19,27</sup> The studies also highlighted the need for improved quality control measures and imaging equipment maintenance to ensure accurate and reliable results. Furthermore, the studies emphasized the necessity





**Figure 3** Risk of bias quality assessment graph.

to limited access to palliative care services. For example, Tadipatri et al.<sup>3</sup> highlighted the challenges related to the lack of trained palliative care specialists in Sub-Saharan Africa, which contributed to limited access to palliative care services for patients with advanced cancer.

The studies identified several opportunities for improving access to palliative care services in neuro-oncology care in Sub-Saharan Africa such as the importance of addressing sociocultural factors contributing to limited access to palliative care services in Sub-Saharan Africa. Khalek et al.<sup>27</sup> discussed the need to consider cultural beliefs and attitudes toward death and dying, which can impact the utilization of palliative care services. Some studies also highlighted the importance of community engagement and education to increase awareness and understanding of palliative care services.<sup>3,27</sup>

### Financial, Health Infrastructure, Geographical, and Sociocultural Barriers

Twenty-eight articles<sup>2,6,7,10,12,14,16,17,20,23–27,31,35,37,38,41,42,45–47,52–56</sup> discussed financial barriers (Supplementary Table 2). These barriers included the high cost of treatment, lack of insurance coverage, and limited government funding for health-care. For example, Haizel-Cobbina et al.<sup>17</sup> found that the cost of treatment was a major barrier to access for patients in East Africa. Hadley et al.<sup>16</sup> also highlighted the financial barriers to access, including the high cost of laboratory tests, imaging studies, and chemotherapy.

Despite these challenges, the studies also identified opportunities for addressing the financial barriers to access for neuro-oncology in Sub-Saharan Africa. For example, Chan et al.<sup>10</sup> highlighted the need for sustainable funding models to support pediatric neuro-oncology care in LMICs.

They suggested that partnerships between local governments, international organizations, and philanthropic entities can be crucial in securing financial resources for sustainable and accessible care.

Twenty-five articles<sup>2,6,7,10,12,15–20,24,26,27,31,35,38,39,41,42,46,47,53,54,57</sup> discussed infrastructure barriers. These barriers included limited access to imaging and diagnostic services, lack of trained personnel, and inadequate funding. Hatem et al.<sup>18</sup> noted that many LMICs lack the necessary infrastructure to diagnose and treat CNS tumors, including a lack of trained personnel, inadequate imaging equipment, and limited access to pathology services. This can result in delayed diagnosis and treatment, as well as a lack of access to appropriate treatments such as surgery, radiation therapy, and chemotherapy. Balogun et al.<sup>46</sup> also highlighted the limited availability of infrastructure—such as operating rooms, imaging equipment, and support systems—that increased the difficulty of safely performing endoscopic endonasal transsphenoidal resection of pituitary neuroendocrine tumors.

Despite these challenges, the studies also identified several opportunities for addressing the infrastructure barriers to access for neuro-oncology in Sub-Saharan Africa. For instance, Servadei et al.<sup>47</sup> noted the potential of telemedicine and mobile health technologies to improve access to care in remote areas. Several studies also discussed the potential of international collaboration and partnerships to improve infrastructure for neuro-oncology in Sub-Saharan Africa. For example, Chan et al.<sup>10</sup> emphasized the importance of developing international networks and partnerships to improve access to pediatric neuro-oncology care and build regional capacity. The review also highlighted the potential of technology transfer and knowledge sharing to improve regional infrastructure.

Fourteen studies<sup>7,10,12,15,16,24,26,27,38,40,47,53,54,57</sup> discussed geography/transportation barriers. These barriers included limited access to healthcare facilities, lack of transportation infrastructure, and long travel distances. Awuah et al.<sup>7</sup> wrote that most neurosurgeons in SSA are concentrated in urban areas, with most rural SSA having almost no available neurosurgical workforce. This means that patients in rural areas may have to travel long distances to access specialized care, which can be a significant barrier to timely diagnosis and treatment. The authors also noted that post-operative care and follow-ups were rarely available in the rural regions of SSA, and those that were available in urban areas were primarily equipped as general intensive care units with no dedicated neurocritical care staff or equipment.<sup>7</sup>

Despite these challenges, the studies also identified several opportunities for addressing the geographical/transportation barriers to access neuro-oncology in Sub-Saharan Africa. Servadei et al.<sup>47</sup> highlighted the potential of telemedicine and mobile health technologies to improve access to care in remote areas. Several studies also discussed the potential of community-based interventions to improve access to care for neuro-oncology in Sub-Saharan Africa. For instance, Servadei et al.<sup>47</sup> mentioned life-saving neurosurgical procedure training for non-neurosurgical specialists working in remote settings.

Sixteen studies<sup>2,3,10,12,16,17,23,27,30–32,38,41,44,47,51</sup> discussed sociocultural barriers. These barriers included stigma, fear, and mistrust of the healthcare system. For example, Khalek et al.<sup>27</sup> found that many patients in Sub-Saharan Africa are reluctant to seek care for neurological conditions due to cancer-associated stigma and misconceptions, instead opting in some cases for traditional or alternative treatments. Servadei et al.<sup>47</sup> also highlighted the challenges related to sociocultural factors, including the lack of awareness and understanding of brain tumors among patients.

Despite these challenges, the studies also identified several opportunities for addressing the sociocultural barriers to access for neuro-oncology in Sub-Saharan Africa. Servadei et al.<sup>47</sup> suggested community-based education and awareness campaigns to improve early detection and treatment of brain tumors. Stagno et al.<sup>38</sup> also highlighted the potential of involving traditional healers and community leaders in these campaigns to improve trust and acceptance of modern healthcare practices. Several studies also discussed the potential of patient-centered care. For example, Marston et al.<sup>51</sup> highlighted the importance of involving patients and their families in treatment decisions and providing culturally sensitive care.

### **Human Resources, Workforce Training and Education, and Policy and Governance**

Twenty-four studies<sup>2,6,7,10,12,15–20,23–27,31,32,35,38,45,47,55,56</sup> discussed human resource barriers (Supplementary Table 3). The studies identified several human resource barriers to access for neuro-oncology in Sub-Saharan Africa, such as a shortage of trained healthcare professionals, uneven distribution of healthcare professionals, and limited access to specialized care. For example, Aderinto et al.<sup>2</sup> found that many countries in Sub-Saharan Africa have a shortage of

neuro-oncologists, which limits access to care for patients with brain tumors. Kanmounye et al.<sup>25</sup> also highlighted the challenges related to human resources, specifically the limited availability of trained healthcare personnel.

Despite these challenges, the studies also identified several opportunities for addressing human resource barriers, such as developing local and sustainable training programs to build capacity and improve access to care.<sup>25</sup> Several studies also discussed the potential of task-shifting to address the shortage of healthcare professionals in Sub-Saharan Africa, such as training rurally located non-neurosurgical specialists in life-saving neurosurgical procedures.<sup>47</sup> Albeit the potential benefits, this is an area of ongoing discussion and warrants further evaluation. Effective short-term strategies include establishing twinning programs between hospitals and faculties in high-income countries. For long-term impact, it is essential to advocate for policy reforms that strengthen human resources capacity over the years. Neuro-oncologists may need to engage with government engagement to successfully advance this cause.

Twenty-five studies<sup>2,3,6,10,14–18,20,24–27,31,34,37,38,41,42,44–47,51</sup> discussed workforce training and education barriers. These barriers included a lack of training opportunities, limited access to continuing education, and inadequate training in neuro-oncology. Many healthcare professionals in Sub-Saharan Africa have limited training in neuro-oncology, which can limit their ability to provide effective care to patients with brain tumors.<sup>25</sup> Haizel-Cobbina et al.<sup>17</sup> also highlighted insufficient funding and resources that limit the availability of training programs and continuing education opportunities.

Despite these challenges, the studies also identified several opportunities for addressing the workforce training and education barriers to access. For example, Servadei et al.<sup>47</sup> emphasized the importance of developing local and sustainable training programs to build capacity and improve access to care. They also highlighted the potential of international partnerships and collaborations to improve the region's access to specialized training and education.

Eighteen studies<sup>2,7,10–12,14,15,17,25,26,38,40,42,45,47,56,58,59</sup> discussed health policy barriers. These barriers included a lack of funding for healthcare, inadequate health insurance coverage, and limited access to essential medicines. For example, Kanmounye et al.<sup>25</sup> found that many countries in Sub-Saharan Africa have limited funding for healthcare, which can limit access to care for patients with brain tumors. Balogun et al.<sup>45</sup> also highlighted the challenges related to health policies, including the limited availability of health insurance coverage and the high out-of-pocket costs patients bear.

Despite these challenges, the studies identified several opportunities to address health policy barriers. For example, Gerstl et al.<sup>15</sup> mentioned the need for continued funding and development of neuro-oncological human resources in LMICs to address disparities that presently exist. Other researchers also highlighted the potential of international partnerships and collaborations to improve access to essential medicines and other resources in the region.<sup>2,59</sup> Several studies also discussed the potential of community-based health policies. For example, Stagno et al.<sup>38</sup> discussed the potential of involving community

leaders and traditional healers in developing health policies to improve trust and acceptance of modern health-care practices.

### Patient Experiences and Outcomes

Fifteen studies<sup>10,11,24,30,31,33,39,41,44,47,51,53,55,58,60</sup> discussed patient experience barriers (Supplementary Table 4). These barriers included a lack of awareness and knowledge about brain tumors, stigma and discrimination related to cancer, and limited access to psychosocial support. For example, Ogbole et al.<sup>55</sup> noted that patients in developing countries usually present for neurological evaluation after morphological changes associated with their tumors significantly impair their quality of life. Furthermore, Servadei et al.<sup>47</sup> mentioned that patients in LMICs often have to travel long distances to access care, face long waiting times, and may not receive appropriate care due to a shortage of trained healthcare professionals.<sup>47</sup> Ekpen et al.<sup>11</sup> highlighted that patients with intracranial tumors in Sub-Saharan Africa typically have delayed diagnosis due to late presentation, which has been reported to be 2 years on average, thus usually making prognosis bleak.

Despite these challenges, the studies also identified several opportunities for addressing the patient experience barriers to access for neuro-oncology in Sub-Saharan Africa. Chan et al.<sup>10</sup> emphasized the importance of developing patient-centered care models to improve access to care and support for patients with brain tumors. As explained in the review, patient-centered care involves understanding and addressing each patient's unique needs and preferences. This approach recognizes that patients are experts in their experiences and can provide valuable insights into their care needs. Several studies also discussed the potential of technology and telemedicine to address patient experience barriers. For example, Servadei et al.<sup>47</sup> highlighted the potential of telemedicine to provide psychosocial support and counseling to patients with brain tumors in remote areas, as well as the potential of using mobile health technologies to provide education and support to patients with brain tumors in LMICs.

Thirty-four studies<sup>6-8,11,12,14,15,20,24,25,28,30-34,36,38,41-44,46,48-54,57,58,61,62</sup> discussed patient outcome measures. These outcome measures included survival rates, treatment response rates, quality of life, and functional outcomes. The studies consistently demonstrated that access barriers in Sub-Saharan Africa have a negative impact on patient outcomes in neuro-oncology. For example, patients in Sub-Saharan Africa with limited access to neuro-oncology care had lower survival rates compared to patients in regions with better access.<sup>25</sup> Limited access to timely diagnosis, treatment, and follow-up care resulted in delayed initiation of treatment, suboptimal treatment options, and poorer treatment outcomes. Njami et al.<sup>62</sup> found that long delays before diagnosis were associated with poor visual outcomes in their Cameroonian patients. The authors also noted that early diagnosis and patient education on the need to rapidly consult whenever there is vision loss was important to improve outcomes.

Despite these challenges, the studies also identified several opportunities for improving patient outcomes in

neuro-oncology. These opportunities included the development of comprehensive and integrated care models, the establishment of multidisciplinary tumor boards, and the improvement of healthcare infrastructure and resources. The studies emphasized the importance of addressing the specific needs of pediatric patients with neuro-oncological conditions.<sup>51</sup> Elhassan et al.<sup>12</sup> discussed the challenges faced by children with brain tumors in Sudan, including limited access to specialized pediatric neurosurgical care and supportive services. The authors highlighted the need for tailored approaches to address the unique challenges faced by pediatric patients, including age-appropriate treatment options, psychosocial support, and long-term follow-up care.

## Discussion

### Challenges

This review reveals a complex landscape marked by significant challenges and promising opportunities. In Sub-Saharan Africa, the shortage of diagnostic tools significantly impedes neuro-oncology care, leading to delayed diagnoses and inadequate treatment choices. Financial, infrastructure, and geographical barriers further exacerbate the situation, hindering access to skilled personnel, proper training, and healthcare facilities. Insufficient health policies, patient awareness, and psychosocial support compound the challenges, contributing to lower survival rates for neuro-oncology patients compared to regions with better healthcare access.

In 2010, the average total health expenditure per person in African countries was US\$135, significantly lower than the US\$3150 spent in high-income countries.<sup>63</sup> Despite carrying 25% of the global disease burden, Africa's share of worldwide health spending remains below 1%.<sup>64</sup> Despite a commitment made in 2001 for African nations to allocate 15% of their budgets to healthcare, only 6 countries have fulfilled this pledge after 15 years, and even in those cases, access to quality healthcare remains a challenge.<sup>64</sup> The rising costs of treatments like chemotherapy, for instance in cases of malignant gliomas, further exacerbate the situation. The expense of care, such as adjuvant chemotherapy, can reach up to \$240 000 annually, far beyond the average African annual salary of approximately \$9549.<sup>65,66</sup> This stark disparity in healthcare access also persists within the Western world, disproportionately affecting marginalized communities and leading to heightened morbidity and mortality among diverse populations.

Although there has been an increase in the neurosurgical workforce, current projections indicate that LMICs might not achieve the neurosurgical workforce density target set by the Lancet Commission on Global Surgery for 2030. Sub-Saharan Africa, in particular, faces a scarcity of neurosurgical professionals, with Lesotho showing some positive developments.<sup>25</sup> In regions without neurosurgeons, there are high mortality and morbidity rates related to neurosurgical conditions. Meanwhile, in areas with neurosurgeons but insufficient equipment, delayed diagnoses and challenges in intensive care and neurosurgical

management impact outcomes and demand significant dedication from neurosurgeons. The absence of essential technological resources like diagnostic facilities and specialized instruments also adversely affects the skills of neurosurgeons and patient outcomes.<sup>67</sup> Technological advancements have transformed modern neurosurgery, revolutionizing planning, optics, robotics, devices, and minimally invasive techniques to provide tailored and effective treatments.<sup>68</sup>

## Opportunities

In spite of the formidable challenges outlined in this paper, the endeavor to improve access to neuro-oncological care in Sub-Saharan Africa is not a lost cause. Numerous opportunities exist to expand access and enhance patient outcomes in the region. However, the intricacies of the healthcare landscape in this region necessitate collaborative efforts among all stakeholders to bridge the gaps in care access. This section highlights a few such avenues with established track records.

To begin, any efforts to broaden healthcare access require robust governmental support. Health departments and ministries within Sub-Saharan African countries must acknowledge the existing deficits in access. Physicians, healthcare workers, and citizens should unite with a shared goal: persuading their leaders that the neurological care crisis within the region demands immediate attention rather than delay. This is particularly crucial given the complexity of governmental bureaucracies in the region. Once achieved, government and policy interventions become essential.

With governmental backing secured, substantial investments must be directed towards infrastructure and medical personnel. The issues highlighted in this paper, particularly the shortage of medical staff, can be addressed by expanding neurological and neurosurgical care training programs within the region. Subsequently, regional hospitals should be equipped with the necessary infrastructure, tools, and equipment to handle the demands of modern neuro-oncological care. While it is true that most hospitals may lack the capacity for such expansions, there can be innovations in streamlined transportation to hospitals in urban centers that can handle patient loads and provide specialized care.

In addition to government support, capacity-building and training initiatives are pivotal in enhancing healthcare access. These programs have seen significant growth in the region, strongly emphasizing forging enduring partnerships between foreign nations and neurosurgical centers in Sub-Saharan Africa. These initiatives facilitate the exchange of expertise and training, contributing to the development of local healthcare expertise. Prominent examples of such initiatives include the Foundation for International Education in Neurological Surgery, the World Federation of Neurosurgical Societies, the Korle-Bu Neuroscience Foundation, and the Global Brain Surgery Initiative.<sup>4</sup> In addition, the Society for Neuro-Oncology (SNO) Sub-Saharan Africa (SNOSSA), an organization endorsed and supported by SNO as a regional body for neuro-oncology, establishes collaborations with both local and intercontinental

partners with the aim of improving outcomes for adult and pediatric brain tumor patients in Sub-Saharan Africa. These programs have conducted numerous procedures and transferred valuable skills to local surgeons and residents while supplying essential medical equipment to hospitals. Expanding these existing programs and fostering more sustainable collaborations between countries and neurosurgical institutions can offer a temporary yet effective solution to address the urgent need for improved neuro-oncological care.

An underscored importance in enhancing infrastructure is the need for advanced diagnostic and early intervention measures for neuro-oncological conditions. These diseases have better prognosis and cure rates when detected early. Providing medical staff with up-to-date diagnostic tools can improve the detection of neuro-oncologic conditions, resulting in better outcomes. However, concurrent with early detection measures are community engagement and awareness. Sub-Saharan communities must be educated about neuro-oncology conditions, symptoms, and prognosis. We recommend focusing efforts and future studies on evaluating the availability of advanced diagnostic imaging, the equitable distribution of healthcare resources and personnel including the surgeon-to-patient ratio, the affordability of surgeries and materials, and the accessibility and quality of rehabilitation and palliative care. These factors are crucial metrics for assessing the state of neuro-oncological care in Sub-Saharan Africa (Table 2).

## Limitations

This literature review, while comprehensive in its scope, presented several inherent limitations. Our primary reliance on PubMed and Google Scholar databases might have inadvertently omitted pertinent studies on the subject, and the inherent nature of publication bias, where studies with negative or inconclusive results remain unpublished, could have skewed our findings. It is important to note that restricting our literature review to articles published after January 1st, 2003 may have inadvertently led to the exclusion of seminal works or studies offering valuable historical context on neuro-oncology in Sub-Saharan Africa. This temporal boundary might limit the comprehensive understanding of the evolution and foundational aspects of research in this area.

Furthermore, the representation of studies across Sub-Saharan Africa may not be uniform, leading to potential overrepresentation or underrepresentation of certain regions. Third, including diverse study designs, ranging from scoping reviews to case series, introduces variability, affecting the data's consistency and comparability. Several studies incorporated into this review exhibited a moderate to high risk of bias due to factors such as limited sample sizes or ambiguous methodologies, necessitating a cautious interpretation of the aggregated findings.

The vast and diverse landscape of Sub-Saharan Africa, with its myriad cultures, traditions, and healthcare paradigms, also presents an inherent limitation. While our review offers a panoramic view, the granularity required for specific countries or communities might be

**Table 2.** Overview of Challenges, Interventions, and Key Stakeholder Engagement in Neuro-Oncological Access and Care

Domain	Challenges	Recommendations	Target stakeholders
Diagnostic tools	Limited access to diagnostic tools such as current MRI equipment were consistently highlighted as significant barriers	Improved access can be achieved through development of health-care infrastructure, regional referral networks, equipment maintenance, and telemedicine mobile health technologies	<ul style="list-style-type: none"> <li>- Pharmaceutical and biotechnology companies</li> <li>- Regulatory and policy-making bodies</li> <li>- Healthcare institutions and cancer centers</li> <li>- Insurance providers and payers</li> <li>- Healthcare technology and data analysts</li> </ul>
Patient outcomes	Limited access negatively impacted patient outcomes in neuro-oncology	Improved outcomes could be achieved through comprehensive and integrated care Models, multidisciplinary tumor boards, and addressing the specific needs of patients	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Nursing and rehabilitation staff</li> <li>- Patients and caregivers</li> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Healthcare institutions and cancer centers</li> </ul>
Patient experiences	Lack of awareness and knowledge, stigma, and limited psychosocial support were barriers to positive patient experiences	Patient-centered care models, community-based education, and technology/telemedicine were identified as opportunities for improvement	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Nursing and rehabilitation staff</li> <li>- Patients and caregivers</li> <li>- Patient advocacy groups and nonprofit organizations</li> </ul>
Health policies	Lack of funding, inadequate health insurance coverage, and limited access to essential medicines posed challenges	Developing policies and programs, international partnerships, and community-based health policies were opportunities for improvement	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Researchers and academics</li> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Regulatory and policy-making bodies</li> <li>- Insurance providers and payers</li> </ul>
Workforce training and education	Limited training opportunities, lack of access to continuing education, and inadequate training in neuro-oncology were barriers	Local and sustainable training programs, international partnerships, technology, and e-learning were highlighted as potential solutions	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Regulatory and policy-making bodies</li> <li>- Healthcare institutions and cancer centers</li> <li>- Insurance providers and payers</li> </ul>
Human resources	Shortage of trained health-care professionals, uneven distribution, and limited access to specialized resources and care were prominent barriers	Developing local training programs, international partnerships, and task-shifting/ task-sharing were identified as opportunities for improvement.	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Researchers and academics</li> <li>- Regulatory and policy-making bodies</li> <li>- Healthcare institutions and cancer centers</li> </ul>
Treatment modalities	Limited access to treatment modalities such as radiotherapy and chemotherapy was a major challenge	Opportunities for improvement included developing local and sustainable treatment options, international collaboration, and technology transfer	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Researchers and academics</li> <li>- Pharmaceutical and Biotechnology Companies</li> <li>- Regulatory and policy-making bodies</li> <li>- Healthcare institutions and cancer centers</li> <li>- Insurance providers and payers</li> <li>- Healthcare technology and data analysts</li> </ul>
Palliative care	Access was consistently low due to financial barriers, inadequate healthcare infrastructure, and sociocultural factors	Opportunities for improvement included regional referral networks, telemedicine, and community engagement i.e. involving traditional healers, community leaders, family members	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Nursing and rehabilitation staff</li> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Regulatory and policy-making bodies</li> <li>- Healthcare Institutions and Cancer Centers</li> </ul>
Financial	High cost of treatment and limited insurance coverage posed significant challenges to access	Developing affordable and sustainable treatment options, public-private partnerships, and social health insurance schemes were identified as opportunities for improvement.	<ul style="list-style-type: none"> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Pharmaceutical and biotechnology companies</li> <li>- Regulatory and policy-making bodies</li> <li>- Insurance providers and payers</li> </ul>
Health infrastructure	Limited access to imaging and diagnostic services, lack of trained personnel, and inadequate funding were major infrastructure barriers	Opportunities for improvement included telemedicine, international collaborations, technology transfer, and knowledge sharing	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Nursing and rehabilitation staff</li> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Pharmaceutical and biotechnology companies</li> <li>- Regulatory and Policy-making bodies</li> <li>- Healthcare Institutions and Cancer Centers</li> <li>- Insurance providers and payers</li> <li>- Healthcare technology and data analysts</li> </ul>

**Table 2.** Continued

Domain	Challenges	Recommendations	Target stakeholders
Geography and transportation	Limited access to healthcare facilities, lack of transportation infrastructure, and long travel distances posed challenges	Telemedicine, mobile health technologies, and community-based interventions were identified as opportunities for improvement	<ul style="list-style-type: none"> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Regulatory and policy-making bodies</li> <li>- Insurance providers and payers</li> <li>- Healthcare technology and data analysts</li> </ul>
Sociocultural	Stigma, fear, and mistrust of the healthcare system were significant sociocultural barriers	Community-based education, involvement of traditional healers and community leaders, and patient-centered care were potential solutions	<ul style="list-style-type: none"> <li>- Medical professionals and specialists</li> <li>- Patients and caregivers</li> <li>- Patient advocacy groups and nonprofit organizations</li> <li>- Regulatory and policy-making bodies</li> </ul>

lacking—especially given the absence of primary data collection and reliance on secondary data from extant studies. Although we designed this review to include as many non-English articles within our study criteria, our search strategy might have inadvertently excluded seminal works published in non-English languages, introducing a potential language bias. In light of these limitations, readers are advised to interpret the findings with circumspection. Future studies might benefit from primary data collection, an expanded search purview, and the inclusion of a broader spectrum of study design to foster a more holistic understanding of the neuro-oncologic landscape in Sub-Saharan Africa.

## Conclusion

While the challenges to neuro-oncology access in Sub-Saharan Africa are significant, the opportunities for improvement are equally substantial. A multifaceted approach that addresses the various barriers to access and leverages the identified opportunities is needed to improve neuro-oncology care in the region. Future research should focus on implementing and evaluating these strategies to determine their effectiveness in improving neuro-oncology access and patient outcomes in Sub-Saharan Africa.

## Supplementary material

Supplementary material is available online at *Neuro-Oncology* (<https://academic.oup.com/neuro-oncology>).

## Keywords

brain tumors | neuro-oncology | Sub-Saharan Africa

## Funding

None.

## Conflict of interest statement

None.

## Authorship statement

Conceptualization: W.E.Y.. Supervision: T.T. and M.B.. Data Extraction: W.E.Y., K.D., and V.B.. Data Analysis: W.E.Y., K.D., and V.B.. Writing—Original Draft Preparation: W.E.Y., K.D., and V.B.. Writing—Review & Editing: W.E.Y., K.D., V.B., T.T., and M.B..

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