The Role of International Collaborations in Sustainable Neurosurgical Development in Nigeria

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OBJECTIVE: **Despite 6 decades of existence, neurosurgery is still in the developing stages in Nigeria. In this era of collaborative health system capacity-building in low- and middle-income countries, this article reviews past efforts and future prospects for collaborative neurosurgical development in Nigeria.**

METHODS: **A bibliometric review of the Nigerian neurosurgical literature and data from a structured survey of Nigerian neurosurgeons and residents provided details of current local and international collaborations for neurosurgical research, service delivery, training, and capacity building. These were analyzed to provide an overview of the role of collaborations in sustainable neurosurgical development in Nigeria and to recommend approaches to enhance neurosurgical capacity.**

RESULTS: **In 1023 peer-reviewed neurosurgery publications from Nigeria, there were 4618 authors with 3688 from 98 Nigerian institutions and 930 from 296 foreign institutions in 70 countries. While there were significant research collaborations amongst Nigerian institutions, the most common were with institutions in the US, United Kingdom, and Cameroon. From the survey, 62 of 149 respondents (41.6%) from 32 health facilities noted their institution's involvement in capacity-building neurosurgical**

Key words
- Advancements
- Capacity-building
- Collaborations
- Neurosurgery
- Nigeria
- Sustainability

Abbreviations and Acronyms
DGNN: Duke Global Neurosurgery and Neurology
LMIC: Low- and middle-income country
LUTH: Lagos University Teaching Hospital
NC: North Central
NW: North West
SANC: Swedish African Neurosurgery Collaboration
SE: South East
SS: South South
SW: South West
UCH: University College Hospital
UI: University of Ibadan
UK: United Kingdom
UNTH: University of Nigeria Teaching Hospital
US/USA: United States of America
WFNS: World Federation of Neurological Surgeons

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collaborations. These collaborations involved 22 Nigerian institutions and 13 foreign institutions in 9 countries and were mostly for training and workforce development (78.1%), and research and data management (59.4%). The majority of foreign institutions were from the US and United Kingdom.

CONCLUSIONS: **Current and previous neurosurgical collaborations have led to sustainable progress in Nigeria. Further local, regional, and international collaborations would enhance the capacity to address the needs and challenges affecting neurosurgery in Nigeria.**

INTRODUCTION

There is a significant lack of material, economic, and human resources for optimal neurosurgical service delivery in many low- and middle-income countries (LMICs), including Nigeria.[1,2] However, collaborative efforts with personnel and institutions in high-income countries have been shown to help to increase the capacity to solve the unmet needs and challenges with health care in such settings.[3-6]

The advent of modern neurosurgery in West Africa, through the pioneering work of Professor E. Latunde Odeku at the University College Hospital (UCH), Ibadan, Nigeria, in October 1962, resulted from a collaboration with the Rockefeller Foundation of New York.[7] This partnership was championed by the institution's then vice chancellor, Professor Kenneth Dike, and the medical school dean, Professor J. C. Edozien, along with Dr. John M. Weir of the Rockefeller Foundation.[7] The new neurosurgery unit began with 8 pediatric patients, and by October 1963, was averaging 28 patients at its weekly clinic with 18–20 admissions and 5–10 radiodiagnostic investigations.[7] The Rockefeller Foundation also furthered the training of Nigeria's second neurosurgeon, Professor Adelola Adeloye, as a Research Fellow in Experimental Teratology at the University of Cincinnati, Ohio, in 1972–73.[8,9] Both Odeku and Adeloye gave the first comprehensive description of the congenital inclusion subgaleal dermoid cyst over the anterior fontanelle, in 1971, eponymously named the Adeloye-Odeku disease.[8,10]

Five years after Odeku's return, a new neurosurgery unit was founded at the Lagos University Teaching Hospital (LUTH), Lagos, in 1968 by Dr. Colin da Silva, and subsequently at the University of Nigeria Teaching Hospital (UNTH), Enugu, in 1974 by Professor Samuel C. Ohaegbulam.[11] Since then, Nigeria has witnessed a steady growth of neurosurgery beyond the pioneering centers, some of which were achieved with other international collaborative efforts, including the Foundation for International Education in Neurological Surgery, the World Federation of Neurological Surgeons (WFNS), and the Korle Bu Neuroscience Foundation.[12-14] Besides these, the University of Toronto has been training certified neurosurgeons from LMICs, including Nigeria, in a 1-year neuro-oncology and skull base surgery fellowship since 2010.[4,6] The recently introduced Swedish African Neurosurgery Collaboration (SANC), in 2017, by the Swedish Neurosurgical Society in collaboration with UNTH Enugu, Nigeria, is another partnership of interest.[1,15] The SANC twinning model, International Neurosurgical Twinning Modeled for Africa, is focused on service delivery through surgical missions, workforce education/training, and equipment donation, in addition to supporting the establishment of the Association of West African Neurosurgeons.[1]

Despite the progressive development of neurosurgery training and services, Nigeria still lacks the capacity to meet the neurosurgical needs of the population. This article describes collaborative partnerships in research and capacity building between Nigerian and international neurosurgical institutions and identifies areas that could benefit from future collaborations. The aim is to provide an overview of the progress of neurosurgery in Nigeria, understand the role of collaborations in sustainable neurosurgical development, and make recommendations on how to improve existing neurosurgical capacity through more collaborative efforts.

METHODS

Study Design and Setting

We conducted a bibliometric review of the neurosurgical literature from Nigeria, from inception in 1962 till December 2021 as described in the accompanying methods and bibliometrics manuscripts in this issue.[16,17] In addition, we distributed a structured online survey to all neurosurgeons and neurosurgery residents in Nigeria as described in the accompanying methods manuscript in this issue.[16]

Data Collection and Analysis

The bibliometric review was conducted using a three-stage blinded approach as already described.[16,17] The data of interest included the number, affiliations, and distribution of authors. The network of authorships was used as a proxy for neurosurgical research collaborations. Also, data from the structured survey of all Nigerian neurosurgeons and residents included questions on the availability and scope of local and international neurosurgical collaborations.[16] All relevant data from the bibliometric review and survey were descriptively analyzed on Google Sheets and visualized with R statistical package (The R Foundation for Statistical Computing, Vienna, Austria). The data provided details of local and international collaborations for neurosurgical research service delivery, training, and capacity building in Nigeria.

Registration and Approval

The bibliometric review was registered on the National Institute for Health Research International Prospective Register of Systematic Reviews [# CRD42021281283], while the survey was approved by the Duke Health Institutional Review Board (# Pro00110539) and the University of Ibadan (UI)/UCH, Ibadan, Ethics Committee (# UI/EC/22/0078). In addition, survey participants completed an online informed consent before responding to the survey questions.

RESULTS

Research Collaborations from Bibliometric Review

In 1023 full-text peer-reviewed journal publications included in the bibliometric review, there were 4618 authorship counts, with 3688 (79.9%) from 98 Nigerian institutions, and 930 (20.1%) from 296 foreign institutions in 70 countries. The most common Nigerian institutions were the UI/UCH Ibadan (991 author counts, 21.5%), University of Lagos/LUTH Lagos (293, 6.3%), and University of Nigeria, Nsukka/UNTH Enugu (275, 5.9%). The most common foreign institutions were Shinshu University School of Medicine, Matsumoto, Japan (63 author counts, 1.4%), the Association of Future African Neurosurgeons, Yaoundé, Cameroon (62, 1.3%), and the National Institute of Health Research Global Health Research Group on Neurotrauma, University of Cambridge, United Kingdom (UK; 42, 0.9%). The most common contributing countries were Nigeria (1018 papers, 99.5%), the United States (US; 48 papers, 4.7%), the UK (40 papers, 3.9%), and India (30 papers, 2.9%). The greatest number of foreign collaborating institutions were from the US (60), the UK (32), Italy (21), India (18), China (13), and Canada (10), while the most number of foreign collaborating authors were from the US (172), UK (149), Cameroon (82), Japan (66), and India (46).

Strong institutional research collaborations were identified between states and regions within Nigeria, mainly based on the frequency of author connections, as shown in red lines (Figure 1). The most significant was observed between Lagos and Abuja, but similar ties were also found between Lagos and Calabar, Lagos and Ibadan, Ibadan and Nnewi, Ibadan and Ile-Ife, Ibadan and Abuja, as well as Nnewi and Enugu (red lines). The next prominent collaborations are those between institutions in Lagos and Ilorin, Lagos and Benin, Lagos and Enugu, Enugu and Umuahia, Enugu and Abuja, Ilorin and Abuja, Abuja and Jos, Abuja and Sokoto, Sokoto and Kano, and Calabar and Bayelsa (thicker dark lines).

Furthermore, a rich network of collaborative research authorships was identified between Nigerian institutions and other institutions worldwide, with the most significant in red lines (Figure 2). Of these collaborations between Nigerian institutions and those in several countries globally, the most prominent are those with institutions in the US, UK, Cameroon, Japan, India, Canada, Italy, Pakistan, China, and South Africa.

Other Collaborations from the Online Survey

Sixty-two respondents from 32 institutions (9 in the South West [SW], 8 in the North Central [NC], 5 each in the North West [NW], South East [SE], and South South [SS], and none in the North East) indicated that their facilities were involved in neurosurgery collaborations (Table 1). These collaborations were between 22 Nigerian institutions and 13 institutions in 9 other countries (4 in the US, 2 in the UK, and 1 each in Canada, Ghana, India, Israel, Morocco, South Africa, and Sweden).

The most commonly reported collaborations were for training and workforce development (25 institutions), research and data

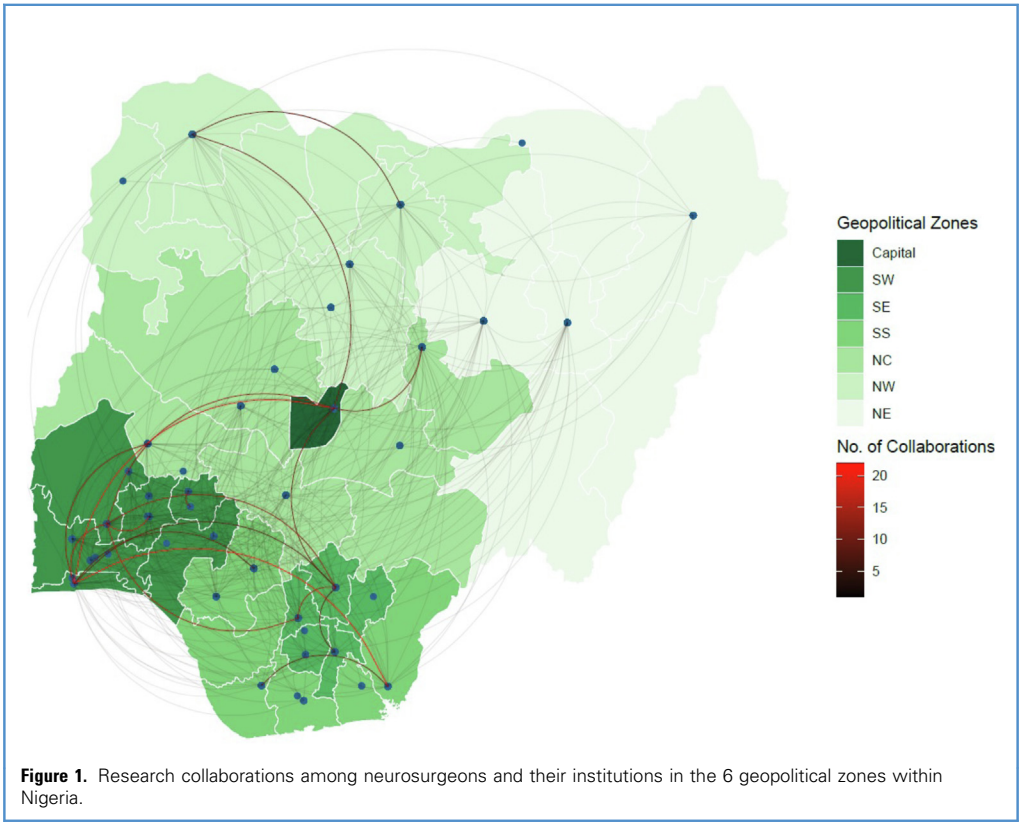

Figure 1. Research collaborations among neurosurgeons and their institutions in the 6 geopolitical zones within Nigeria.

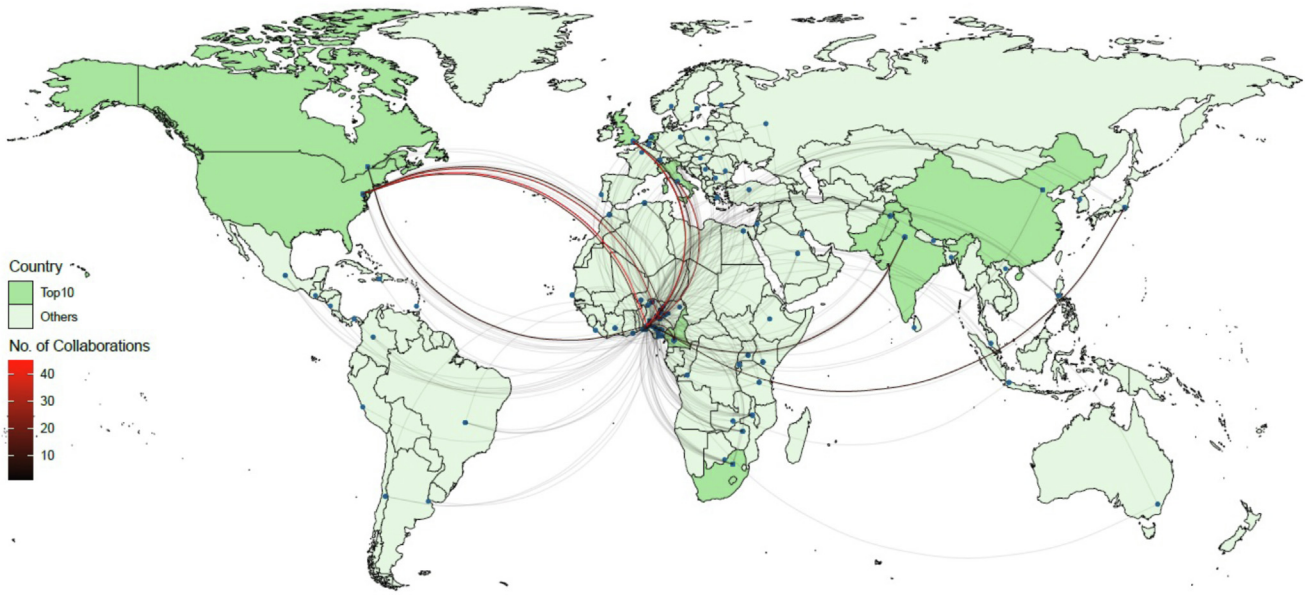

Figure 2. International neurosurgery research collaborations involving Nigeria.

management (19 institutions), service delivery (13 institutions), and equipment/technological transfers (12 institutions) (Table 2).

Collaborative connections were also e).vident between Nigerian institutions in different states and regions from the online survey (Figure 3). The strongest links were between Sokoto and Abuja, Enugu and Nnewi, and Ibadan and Abeokuta (red lines). Several inter-regional collaborative linkages exist, especially among institutions in the SW and those in the SE and SS regions.

The network of collaborations between Nigerian and foreign institutions as identified in the online survey is as shown in Figure 4, with the major collaborations involving the US, UK, and Morocco.

DISCUSSION

Role of Intra-Nigeria Collaborations

These results clearly depict significant collaboration among neurosurgeons within Nigeria (Figures 1 and 3) and internationally (Figures 2 and 4), both for academic research and for general capacity building (Table 3). Apart from academic research and training to develop the neurosurgery workforce in Nigeria as the main focus, it is interesting to note that some of these collaborative efforts involved technology and equipment exchange, and even funding assistance (Table 2). Within Nigeria, transregional and institutional research collaborations were highest in Ibadan and Lagos (Figure 1). Similar results were also reflected in the peer-reviewed literature from the bibliometric and systematic analyses in this issue, with both Ibadan and Lagos leading.[17,24-28] The most prominent Nigerian institutions were correspondingly in both locations too, UI/UCH in Ibadan and University of Lagos/LUTH in Lagos, and were closely followed by University of Nigeria Nsukka/UNTH in Enugu. These observations are likely a result of these 3 locations playing key foundational roles in the establishment of neurosurgery in Nigeria.[7,11] Apart from the several regional collaborative linkages involving institutions in the SW and those in the SE and SS regions, the strongest links identified for the NC and NW regions were Sokoto and Abuja (Figures 1 and 3). This is particularly noteworthy as 1 of the major neurosurgical pioneers in Nigeria, BB Shehu, was instrumental to establishing functional neurosurgical units at Usmanu Danfodiyo University Teaching Hospital Sokoto and National Hospital Abuja.[29] In addition, 1 of the benefactors of the WFNS Foundation and the Africa 100 project is based in Sokoto (Table 3) and has played a strong role in establishing and developing neurosurgery in NC, North East, and NW regions of Nigeria.[19,20]

Role of International Collaborations

Internationally, the largest number of foreign collaborations for neurosurgical research and workforce capacity-building was with institutions in the US (Figures 2 and 4). Over time since the collaboration with the US-based Rockefeller Foundation led to the beginning of Nigerian neurosurgery, various other international collaborations have contributed to the steady growth and development of the neurosurgery specialty in Nigeria, as shown in Table 3. These include training of Nigerian neurosurgeons at the WFNS Training Center in Rabat, Morocco, under the auspices of the WFNS Foundation and the Africa 100 Project,[12,18-21] as well as the Neuro-oncology and Skull Base Surgery Fellowship of the University of Toronto at the Toronto Western Hospital which is a 1-year training program that exposes trainees to a wide range of procedures for intra-axial and skull base tumors.[4]

Table 1. Institutions Involved in Neurosurgery Collaborations in Nigeria

North-Central Region	North-West Region	South-East Region	South-South Region	South-West Region	Foreign Institutions
Asokoro District Hospital, Abuja	Ahmadu Bello University Teaching Hospital, Zaria	Federal Medical Center, Owerri	Apex Neurosurgery Clinic, Warri	Babcock University Teaching Hospital, Ilishan-Remo	Apollo Hospitals, Bangalore, India
Brain and Spine Surgery Consortium, Abuja	Aminu Kano Teaching Hospital, Kano	Federal Teaching Hospital, Abakaliki	Igbinedion University Teaching Hospital, Okada	EuraCare Specialist Hospital/RNZ Neuroscience, Victoria Island, Lagos	Duke University/Duke Global Neurosurgery and Neurology, Durham NC, USA
Federal Medical Center, Lokoja	Barau Dikko Teaching Hospital, Kaduna	Memfys Hospital for Neurosurgery, Enugu	Irrua Specialist Teaching Hospital, Irrua	Federal Medical Center, Abeokuta	Korle Bu Teaching Hospital, Accra, Ghana
Jos University Teaching Hospital, Jos	National Orthopedic Hospital, Dala, Kano	Nnamdi Azikiwe University Teaching Hospital, Nnewi	University of Benin Teaching Hospital, Benin City	Federal Teaching Hospital, Ido-Ekiti	London School of Hygiene & Tropical Medicine, London, UK
National Hospital, Abuja	Usmanu Danfodiyo University Teaching Hospital, Sokoto	University of Nigeria Teaching Hospital, Enugu	University of Uyo Teaching Hospital, Uyo	Ladoke Akintola University Teaching Hospital, Ogbomoso	McMaster University, Hamilton, Ontario, Canada
University of Abuja Teaching Hospital, Gwagwalada, Abuja				Lagos State University Teaching Hospital, Ikeja, Lagos	Ochsner Medical Center, New Orleans LA, USA
University of Ilorin Teaching Hospital, Ilorin				Lagos University Teaching Hospital, Idi-Araba, Lagos	Swedish Neurosurgical Society/Swedish African Neurosurgical Collaboration, Sweden
Wellington Neurosurgery Clinic, Abuja				Obafemi Awolowo University Teaching Hospital, Ile-Ife	Tel Aviv Medical Center, Tel Aviv, Israel
				University College Hospital, Ibadan	University of Cambridge, Cambridge, UK
					University of Cape Town, Cape Town, South Africa
					University of Minnesota, Minneapolis, MN, USA
					Vanderbilt University, Nashville TN, USA
					WFNS-Rabat Reference Training Center, Rabat, Morocco

WFNS, world federation of neurological surgeons.

Table 2. Types of Collaborations Amongst the Nigerian Institutions Involved

Type of Collaboration	Number of Institutions, n = 32 (%)
Training and workforce development	25 (78.1%)
Research/data management	19 (59.4%)
Service delivery	13 (40.6%)
Equipment/technological transfers	12 (37.5%)
Funding	3 (9.4%)

Persisting Challenges in Nigerian Neurosurgery

While the neurosurgery specialty in Nigeria has recorded tremendous progress in local training, especially over the last 2 decades, including training of female neurosurgeons, several challenges still exist.[1,2,12,17,29-33] These include the dearth of modern operative and diagnostic facilities and equipment for training and practice, lack of practice guidelines, lack of subspecialty fellowship training, inadequate gender balance, and financial constraints.[1,2,12,17,29-33] Much of the available training and practice is on general neurosurgery, with neurotrauma and spine surgery also being predominant.[17,24,25,29,32] Similar difficulties peculiar to other LMICs have recently been addressed through international collaboration with neurosurgery programs domiciled in high-income countries.[2,6,34-36] Nigeria, thus, has a good chance of additional benefit from further international collaborations to address the persisting challenges with expanding neurosurgery capacity despite past and present collaborative efforts.

Example of a Successful Collaborative Approach that can be Adapted to Nigeria

One such collaborative program is the Duke Global Neurosurgery and Neurology (DGNN) program which began in 2007 and formalized as an organization in 2014.[5,6] The DGNN utilizes a 4-fold strategy, namely technology, twinning, training, and top-down in developing neurosurgical capacity in Uganda, an East African country.[5,6] 'Technology' involves the supply of operative and postoperative care equipment to build capacity for the provision of safe anesthesia, proper execution of neurosurgical procedures, adequate intensive care to ensure optimal recovery after surgery, and biomedical service required for efficient

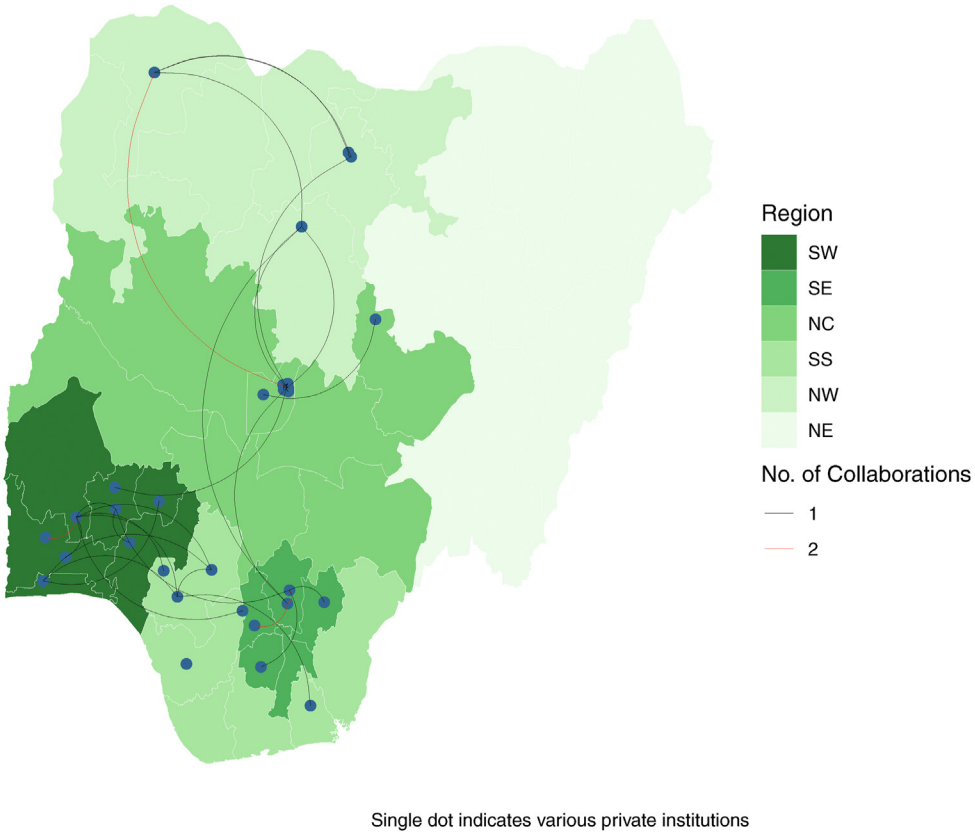

Figure 3. Neurosurgery capacity-building collaborations between Nigerian institutions.

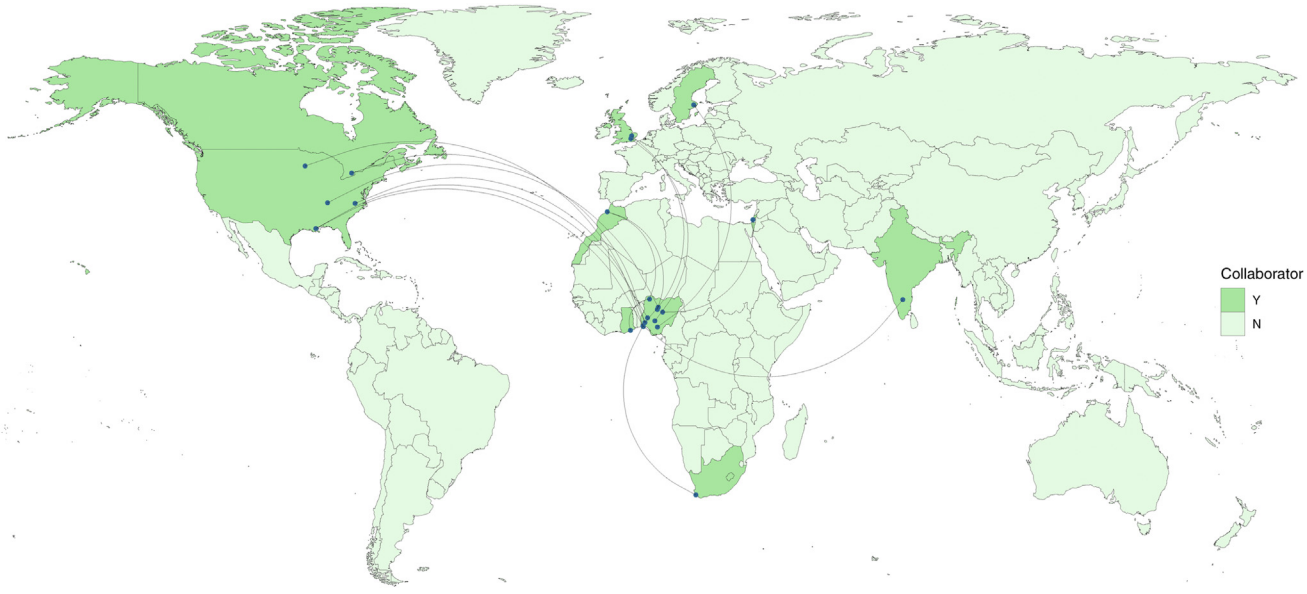

Figure 4. International neurosurgery capacity-building collaborations.

maintenance and repairs when required.[6] 'Twinning' and 'Training' had to do with collaborations between the neurosurgical departments at the involved LMICs and the Duke University Health system to augment the local formal residency training program, as well as further training of local biomedical staff for adequate maintenance of the supplied equipment.[6] 'Twinning' also took the form of surgical camps, which allowed direct interaction between local staff and visiting DGNN neurosurgeons, anesthetists, nurses, operating and recovery room staff, as well as intensive care unit nurses, and biomedical engineers.[6] 'Top-down' had to do with system-wide enhancement of other surgery-related disciplines in clinical care and academic training.[5,6] Over time, evidence has proven the efficiency and efficacy of these strategies since implementation at the Mulago National Referral Hospital, Kampala, and Mbarara Regional Referral Hospital[1], both in Uganda.[5,6,34]

Applicability in the Nigerian Context

With slight modifications, these strategies have great prospects in the Nigerian setting with less effort for a few reasons. The Ugandan collaboration involved only 2 centers,[5,6] whereas Nigeria already has multiple functional neurosurgery centers in all 6 geopolitical zones.[30,31] Second, Uganda had no training center when the DGNN started operations in 2007,[5,6] while Nigeria currently has training centers in 5 of the 6 geopolitical zones.[1,2,12,30,32,37-39] Third, it was the combined efforts of the Duke Neurosurgery training program director with the neurosurgery faculty at Mulago National Referral Hospital that led to the formal establishment of the Ugandan East African training program,[6] but Nigeria already has an established training curriculum by the National Postgraduate Medical College of Nigeria in addition to the training program by West African College of Surgeons[2,29,40] In view of these differences, modifications of DGNN's 4-fold model could be helpful in further improving the existing research, workforce, and infrastructural capacity in Nigeria.

Other Avenues for Collaboration

Besides the DGNN, other opportunities that could be further explored, include InterSurgeon, a platform designed to increase global partnerships and collaborations in neurosurgery to facilitate international education and training, clinical guidance, and research, not only by direct physical interaction but also virtually.[41] Since its inception, Nigeria currently ranks fourth with 14 members after the US, UK, and India.[41] Safe, affordable, and sustainable delivery of advanced subspecialty neurosurgical services can be made possible through enrollment of more Nigerian neurosurgeons in countries where training in highly specialized neurosurgical subspecialties is readily available.[41]

Possible Hindrances to International Collaborations

Finally, various barriers mitigating against global neurosurgery collaborations have been well documented.[35,36] Some of these challenges could pose a major setback, especially for personnel from the collaborating countries. While high rates of infectious diseases and access to safe food and clean water supply may no longer be significant problems in most parts of Nigeria, the persistence of insurgency and terrorism remain a major concern.[35,42-44] Providing pretravel education and advisory on prone areas, ensuring adequate planning, and taking extra security measures could all help to address this limitation.[35] In addition, utilizing the strategy of weekly collaborative virtual educational

Table 3. Established International Collaboration Programs Involved in Training Nigerian Neurosurgeons and Developing Neurosurgery in Nigeria

Program/ Collaboration	Location	Facilitator(s)	Objectives	Activities/Requirements	Year Established	Benefactors/Successes
WFNS Foundation[12,18-21] and The Africa 100 project[19]	African WFNS training center in Rabat, Morocco	Dr. Abdelsalam El Khamlichi[18-21]; Prof. Majid Samii,[19] respectively	To increase the number of qualified neurosurgeons in Africa[18-21]	Candidates from any African country with a well-developed neurosurgery program.[18-21]	2002[18-21] and 2015,[19] respectively	Dr. Ismail Nasiru became the second trainee to join this program. He returned to Sokoto, Nigeria, after 3 years of training to become the chief of his department, managing associates and several residents. He and his team have significantly contributed to training several neurosurgeons in Nigeria.[19,20] Total of 6 Nigerian trainees[19,20]
Neuro-oncology and Skull Base Surgery Fellowship[4]	Division of Neurosurgery of the University of Toronto, Canada	Mark Bernstein[4]	1-year training program, that exposes trainees to a wide range of procedures for intra-axial and skull base tumors.[4]	A comprehensive academic program at the University of Toronto where the fellows have the opportunity to exchange experiences with other neurosurgeons and participate in clinical research projects.[4]	2010[4]	27 neurosurgeons from different countries have been trained in the program, among them Nigerians[4]
Korle-Bu Neuroscience Foundation (KBNF)[14,22]	Affiliated to the University of British Vancouver (UBC) and Vancouver General Hospital.[22]	Marjorie Ratel, David Fairholm[22]	Canadian charity/non-profit society enhancing delivery of quality neurosurgical care and training in West Africa.[14]	No formal training program. Committed to supporting neurosurgical training and education, research developments, and public outreach activities.[22]	2000[22]	KBNF has performed hundreds of neurosurgical procedures in West Africa; trained more than 2100 personnel; supported 19 hospitals in 4 West African countries (Ghana, Nigeria, Liberia, Sierra Leone)[14] — including the Neurosurgery unit of the University of Benin Teaching Hospital in Nigeria.[14]
Collaboration for formal training of neurosurgery residents from Memfys Hospital for Neurosurgery, Nigeria.[23]	Department of Neurosurgery, Shinshu University School of Medicine, Matsumoto Nagano, Japan[23]	Prof. Samuel Ohaegbulam (Nigeria), Prof. Kazuhiro Hongo (Japan).[23]	6-month postings for training in Neurosurgery and research[23]	A comprehensive 6-month academic and operative neurosurgery exposure at the Shinshu University School of Medicine in Japan.[23]	2013[23]	Not less than 12 Nigerian neurosurgery residents from Memfys Hospital have benefitted from this formal arrangement.[23]

WFNS, world federation of neurological surgeons.

programs and other forms of online training, as was recently established between SANC and the neurosurgery division at UNTH Enugu, in place of travel for personnel would further offset the security risk.[15]

Limitations

There are a number of limitations present in this study. These include those inherent in bibliometric and systematic review methodologies. Secondary analysis of existing data limits the researcher's control of the quality of included articles, thus introducing bias. While a broad range of research databases were used for the literature review, there remains a possibility of not including research articles from journals that are not indexed in the major databases or widely distributed. Also, some collaborations may have been missed, especially if they had no publications or research output. Additionally, using the survey introduces selection bias, as not all neurosurgery consultants and residents in the country responded. This selection bias may skew the data based on the information provided by the respondents, potentially resulting in an inability to capture all collaborative efforts. Despite these limitations, this study represents the most comprehensive and updated evaluation of neurosurgical collaborations in Nigeria.

CONCLUSION

Collaborative efforts have significantly impacted the neurosurgery specialty in Nigeria leading to tremendous and sustainable growth. This steady progress indicates that more local, regional, and international collaborations would further enhance the country's capacity to meet her neurosurgical needs and address persisting challenges. The recommendations from this study would go a long way in helping to achieve these goals.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

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