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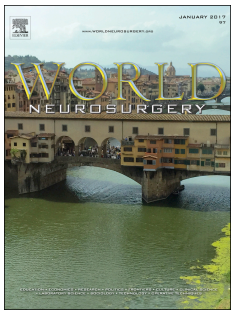

State of African neurosurgical education: An analysis of publicly available curricula

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NA: Writing - Review & Editing
CK: Writing - Review & Editing
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LJ: Writing - Review & Editing
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Abstract

Introduction

Africa bears more than 15% of the global burden of neurosurgical disease; however, it has the lowest neurosurgical workforce density worldwide. The past decade has seen an increase in neurosurgery residency programs on the continent. It is unclear how these residency programs are similar or viable. This study highlights the current status, interdepartmental and regional differences, with the main objective of offering a template for improving the provision of neurosurgical education on the continent.

Method

PubMed and Google Scholar were searched using keywords related to "neurosurgery," "training," and "Africa" from database inception to 10/13/2021. The residency curricula were analyzed using a standardized and validated medical education curriculum viability tool.

Results

Curricula from 14 African countries were identified. The curricula differed in resident recruitment, evaluation mode and frequency, curriculum content, and length of training. The length of training varied from four to eight years with a mean of six years. The Eastern African region had the highest number of examinations, with a mean of 8.5. Few curricula had correlates of viability - ensuring that the instructors are competent (64.3%), prioritization of faculty development (64.3%), faculty participation in decision making (64.3%), prioritization of resident support services (50%), creating a conducive environment for quality education (42.9%), and addressing student complaints (28.6%).

Conclusion

There are significant differences in the African postgraduate neurosurgical education curriculum warranting standardization. This study has identified areas of improvement for neurosurgical education in Africa.

Keywords

Africa, Curriculum, Education, Neurosurgery, Residency

Introduction

Traditionally, surgical residency has featured residents assuming total responsibility for patient care; however, the diverse training conditions caused significant variations in the quality, quantity, and breadth of surgical exposure among residents.[1] The variation in exposure and competency required reevaluation of postgraduate surgical education to ensure a minimum acceptable experience and guarantee the acquisition of technical competencies.[1] For example, the European Association of Neurosurgical Societies (EANS) decided to harmonize training across Europe.[1] In 1983, the EANS introduced oral assessments for its trainees and on completion of a training course.[1] These oral assessments were expanded to the European Examination in Neurosurgery organized by the Joint EANS/UEMS Examination Committee in 1992, and later by the European Board of Neurosurgery in October 2015.[1] Stakeholders of postgraduate education have stressed the importance of multidimensional harmonization; that is, harmonization beyond evaluations. As a result, the philosophy for postgraduate surgical education has changed from the historical "see one, do one, teach one" principle to the use of more holistic adult learning principles.[1]

Residency programs aim to impart physicians with technical and non-technical skills.[2] Cultivating these competencies requires contributions from attendings, multidisciplinary health personnel, and support from the hospital leadership.[1,2] Trainees equally play an important role in their education.[2,3] This model of postgraduate surgical education is the result of the reinvention of surgical training programs worldwide. In the United States, the American Board of Surgery (ABS) and the Residency Review Committee for Surgery (RRC-S) have spearheaded this revolution.[2]

There is little information about the current surgical education models in low- and middle-income countries (LMICs) - African neurosurgery in particular. Africa bears a significant fraction of the global burden of neurosurgical disease but has one of the lowest workforce density in the world.[3-5] Fortunately, the number of aspiring African neurosurgeons is on the rise with up to 7% of final-year medical students reporting an interest in the specialty.[6,7] However, their pursuit of a career in neurosurgery is hindered by multiple factors. Almost one-third of aspiring African neurosurgeons lack information on the entry requirements, cost, and the number of training programs in their home country and in other African countries.[8] There is also inadequate information on the length of training, curriculum, and resources available at African neurosurgery training programs. As a result, many aspiring African neurosurgeons do not consider training on the continent or give up on neurosurgical training altogether.[6,8] Recent studies have provided insight into the landscape of neurosurgical education in Africa. Twenty-two of the 54 (40.7%) African countries have neurosurgery training programs: 5 in Northern Africa (Algeria, Egypt, Libya, Morocco, and Tunisia),

6 in Western Africa (Burkina Faso, Côte d'Ivoire, Ghana, Niger, Nigeria, and Senegal), 1 in Central Africa (Cameroon), 6 in Eastern Africa (Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda), and 4 in Southern Africa (Malawi, South Africa, Zambia, and Zimbabwe).[9] It is not uncommon for aspiring neurosurgeons to train in countries other than their home country and return to their home country for practice.[10,11] It is unclear how similar or dissimilar the training programs' curricula are. The question on the similarity of African neurosurgery training programs is particularly important given variations in training length (range: 4 and 8 years).[9] Unsurprisingly, the lack of information on the homo-/heterogeneity in African training programs has caused issues with the credentialing of foreign-trained neurosurgeons.[5,10,11] Local stakeholders expect that these incidences will increase especially as African countries implement the free trade area agreement which will facilitate the movement of persons, goods, and services across borders.

This study aims to analyze the publicly available neurosurgical curricula in Africa. The study findings will be valuable in standardizing the curriculum of neurosurgical education on the continent and in facilitating the accreditations of neurosurgeons trained in other African countries.

Method

Data collection

Four authors (OED, GBM, PDM, CBM) conducted a PubMed and Google Scholar search using keywords related to "neurosurgery," "training," and "Africa" from database inception to 10/13/2021. The articles were screened for relevance. Data was extracted and stored in an Excel spreadsheet (Microsoft, WA, USA). Next, a supplementary hand search was performed using Google search (Google Inc., CA, USA) to identify relevant gray literature. The authors used the keywords "neurosurgery," "residency," and each country. The search was performed in English and the country's official language. The results from the supplementary hand search were added to the Excel spreadsheet. Also, the search results were validated by contacts in each country. When no relevant data relating to a particular country was noted after the three data collection rounds, the first author (OED) contacted local neurosurgeons directly. When these contacts failed to respond, the first author (OED) contacted the local neurosurgeon a second time (two weeks later) and then a third time (four weeks later). In the event the local neurosurgeon did not respond after three attempts, a second contact was identified.

Inclusion and exclusion criteria

African countries with neurosurgery training programs were included and data relating to their neurosurgical curricula were collected using a standardized tool.[12]

Curriculum analysis

The residency curricula were analyzed using a standardized and validated medical education curriculum viability tool which also tones with the world federation of medical education (WFME) standards.[13] This tool was framed out of a scoping review by Khan et al., to help in assessing curriculum quality standards so as to contribute to its improvement and innovation.[12] "Education strategy", "Students", "Faculty", "Assessment", "Educational and working environment", "Curriculum communication", "Technology" and "Leadership" are the areas covered by this framework.[12] These areas are similar to the elements of the curriculum outlined by some studies,[14-16] and they also support the curriculum mapping procedure.[17]

Statistical analysis

Summary descriptive statistical analyses were computed using SPSS v.26 (IBM, WA, USA).

Results

Data was found on 14 African countries (Cameroon, Egypt, Ethiopia, Ghana, Kenya, Libya, Morocco, Nigeria, Senegal, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe) with a neurosurgery training program, representing 63.6% (n=14/22) of the total countries within Africa with a neurosurgery training program. Of the 54 countries in Africa, 32 did not have an existent training program at the time of data collation. Most training programs had English as the primary language of instruction (n=9/14, 64.4%), while French was the second most frequent language of instruction (n=3/14, 14.3%). Most countries required a thesis or dissertation on completion of their training (n=13/14, 92.9%). Training duration varied between regions (Northern, Southern, Eastern, Western), with the longest training program being in the Western region with a mean of 6.00 years (SD ±1.00) and the lowest being in the Northern region with a mean duration of 3.67 years (SD ±2.309), the number of examinations was highest in training programs located in East Africa with a mean of 8.50 (SD ±4.43) and lowest in training programs located in North Africa with a mean of 1.33 (SD ±1.15). (**Table 1**)

Table 1: Training Program Structure

Category	**Regions**	**Mean**	**Standard Deviation**
Training Duration (years)	Eastern Region	5.00	1.33
	Northern Region	3.67	2.31

	Southern Region	5.00	0.00
	Western Region	6.00	1.00
Number of Examinations	Eastern Region	8.50	4.43
	Northern Region	1.33	1.15
	Southern Region	2.33	0.57
	Western Region	2.67	1.15
Educational Strategy	Eastern Region	0.95	0.10
	Northern Region	0.46	0.41
	Southern Region	1.00	0.00
	Western Region	0.86	0.11
Residents	Eastern Region	0.70	0.40
	Northern Region	0.26	0.46
	Southern Region	0.63	0.32
	Western Region	0.23	0.20
Faculty	Eastern Region	0.75	0.50
	Northern Region	0.26	0.46
	Southern Region	0.86	0.32
	Western Region	0.40	0.20
Assessment	Eastern Region	0.87	0.25
	Northern Region	0.33	0.57
	Southern Region	0.83	0.28
	Western Region	0.50	0.50
Educational and Working Environment	Eastern Region	0.75	0.50
	Northern Region	0.25	0.43
	Southern Region	0.83	0.28
	Western Region	0.75	0.43
Communication	Eastern Region	0.75	0.50
	Northern Region	0.33	0.57
	Southern Region	0.50	0.50

	Western Region	0.83	0.28
Technology	Eastern Region	0.62	0.43
	Northern Region	0.25	0.43
	Southern Region	0.50	0.50
	Western Region	0.08	0.14
Leadership	Eastern Region	0.75	0.50
	Northern Region	0.40	0.40
	Southern Region	0.80	0.34
	Western Region	0.66	0.23
Total Score (Average)	Eastern Region	0.75	0.39
	Northern Region	0.31	0.43
	Southern Region	0.74	0.24
	Western Region	0.48	0.11

Variation of Training curricula among training programs

Africa is a mosaic continent where the colonial history, culture and climate deeply influenced national organizations including the healthcare system. From the data collected, the following lines detail and contrast the different training programs according to the geographic area. In northern Africa, the WFNS Rabat training center (RTC) was established in 2002 after an agreement between the Mohamed 5 University (M5U) and the WFNS Foundation. The WFNS RTC, after its accreditation by the WFNS, offered a clear standardized teaching curriculum in neurosurgery with well elaborated clear teaching objectives. This partnership converted the Moroccan center into an excellent place for African neurosurgical training.

The curriculum in neurosurgery included rotations in 3 main hospitals in Rabat, all part of the Ibn Sina teaching hospital network affiliated to the M5U of Rabat, which later extended to several other cities. Residents undergo a 5-year training in Neurosurgery including a 6 months rotation in neurology and 1 year of training abroad (France, Belgium, Canada, or USA).[4] This is done in the senior years or immediately after their residency completion. During the residency program, the trainees were exposed to the full spectrum of neurosurgical pathologies (general neurosurgery, vascular neurosurgery, neurosurgical oncology & skull base surgery, functional neurosurgery, spine, and pediatric neurosurgery); also to multidisciplinary team management, including neurologists, endocrinologists, ophthalmologists, neuropathologists, neuroradiologists, neuro-oncologists, and radiation oncologists. Ref Additionally,

attendance at national and international scientific meetings and scientific publications was mandatory. Residents were assessed yearly and did two exams at the end of the first year and the end of the 5th year. Altogether, the 5-year training program led to a university specialization diploma in neurosurgery after successfully passing the board examinations, and a WFNS fellowship certificate was granted to each trainee.ref

The College of Surgeons of East Central and Southern Africa (COSECSA) accepts trainees into a 6-year neurosurgery program. The first two years are designed for basic surgical skills, after which trainees undergo a 4-year specialty dedicated training in neurosurgery. The basic surgical learning period covers a minimum of six months each of general and orthopedic surgery. Trainees also attend required surgical skills courses, complete some online modules, and maintain an electronic case log.ref Trainees who certify the above requirements at the end of the two-year period of training are qualified to take the membership examination consisting of written and oral components. The successful trainees then obtain Member of the College of Surgeons (MCS) status and are qualified to apply to core neurosurgical training under COSECSA also known as the College's fellowship program. ref In addition to rotating in any neurosurgical accreditated medical center in the COSECSA region during this training period, trainees can spend about six months at an approved international training site.ref The fellowship examination requires that trainees complete a number of virtual modules and maintain an electronic case log, having performed a minimum of 500 cases.ref Trainees are also mandated to submit at least a peer-reviewed journal article in the course of their fellowship. A trainee's regular schedule incorporates clinical conferences such as didactic sessions, journal clubs, and morbidity and mortality meetings, and culminates in the fellowship examination after four years of service and the satisfaction of all requirements. ref Similar to the MCS level, Fellow of the College of Surgeons (FCS) status demands that trainees successfully complete both written and oral examinations after which are designated by the post-nominal letters FCS-ECSA (Neuro) and graduate with qualifications to practice neurosurgery in any of the COSECSA region.ref The number of member countries, graduates, and robust international collaboration showcase the strength of the COSECSA program. However, inadequate faculty and resources remains a challenge to the program. ref

In Western Africa, the local training of Neurosurgeons has been led by countries such as Senegal and Nigeria for French and English-speaking physicians respectively. In Senegal, the training program is managed by 12 faculty who recruit on average 10 local and regional neurosurgeons yearly. The program offers a 5-year training program in general neurosurgery with students spread in 4 different hospitals in the country. Similar to WFNS RTC, trainees in Senegal are exposed to general neurosurgery, vascular and skull base surgery, neuro-oncology, pediatric, and spine. Milestone theoretical knowledge and operative

skills are assessed yearly through written exams and surgery supervision. At the end of the 5-years program, trainees spend 2 to 4 semesters abroad for Fellowship in partnership with hospitals in France or Belgium. Among the weaknesses of the program are the lack of local expertise in functional neurosurgery, and access to cadaveric laboratories, and lack of sponsorship for foreign trainees.

Unlike Senegal, Nigeria offers a 6-year neurosurgery training program that consists of two parts. The first part, which is allocated a minimum of 200 credit units, demands that trainees complete rotations within a minimum period of 30 months. The rotation covers general surgery (9 months), Trauma (6 months), urology (3 months), orthopedics (3 months), anesthesia (3 months), rural posting (3 months), and elective (3 months). On completing the rotations, trainees become eligible to take the part 1 fellowship examination. Successful trainees in the part 1 fellowship examination then undergo a 4-year dedicated specialty training in Neurosurgery. Within this period, trainees acquire in-depth knowledge in general principles of neurosurgery, neurotrauma, infections in neurosurgery, vascular surgery, pituitary surgery, brain tumors, skull base surgery, spinal surgery, pediatric neurosurgery, pain management, stereotactic surgery, and principles in research. Unlike part 1 fellowship examination, eligibility for the part 2 fellowship examination requires that trainees acquire a minimum of 340 credit units and submit a dissertation within a minimum of 48 months period. Successful trainees are then awarded fellow of the West Africa College of Surgeons (FWACS) in Neurosurgery or Fellow of the Medical College of Nigeria (FMCN) in neurosurgery. Although Nigeria is the third country with the highest number of training programs, the number of successful trainees does not meet the population's yearly demands. Also, most programs do not have a robustic molecular lab.

Educational strategy

Over 70% (n=13) of countries had explicit mentions of their mission, objectives, curriculum design, training length, implementation guidelines, and review of instructional material (Table 2). The curricula varied in their acknowledgment of the importance of student support services (n=7/14, 50%), addressing student complaints (n=4/14, 28.6%), and creating an environment that is conducive of quality education (n=6/14, 42.9%). Many programs did not have the appropriate tools and media (n=6/14, 42.9%), or did not have reliable technology resources for educational support (n=5/14, 35.7%). Leadership participation was evident within the curricula as leadership played a role in resource allocation (n=8/14, 57.1%), achieving internal and external objectives (n=10/14, 71.4%) (**Table 2**).

Table 2: Neurosurgery Curriculum Viability within African Countries

Category		Frequency (%) N=14
Educational Strategy	Development of relevant mission and objectives	12 (85.7%)
	Curriculum Design	10 (71.4%)
	Length of Program	13 (92.9%)
	Implementation guidelines	13 (92.9%)
	Review of instructional material	11 (78.6%)
Residents	Perception of teaching	8 (57.1%)
	Perception of teachers	7 (50%)
	Perception of atmosphere	6 (42.9%)
	Academic self perception	9 (64.3%)
	Social self perception	5 (35.7%)
	Student support services	7 (50%)
	Student engagement with faculty, staff and administration	9 (64.3%)
	Active learning techniques	9 (64.3%)
	Clear analysis of audience	8 (57.1%)
Faculty	Ability to perform multiple roles	7 (50%)
	Competence of instructors	9 (64.3%)
	Staff involvement in organizational decision making	9 (64.3%)
	Faculty development	9 (64.3%)
	Respect diverse ways of learning	9 (64.3%)
Assessment	Prompt feedback	8 (57.1%)
	Measurement and Evaluation	11 (78.6%)
Educational and working environment	Flexible people oriented culture	9 (64.3%)
	Presence of various cultures	9 (64.3%)
	Climate of trust and shared understanding	10 (71.4%)
	Learner centered environment	10 (71.4%)
	Communicating policies and strategies	9 (64.3%)

Category		Frequency (%) N=14
	Communication/information for quality	9 (64.3%)
Technology	Document technology plan	5 (35.7%)
	Appropriate tools and media	6 (42.9%)
	Reliability of technology	5 (35.7%)
	Resources and information of technology	8 (57.1%)
Leadership	Create partnerships	9 (64.3%)
	Influence people management	11 (78.6%)
	Achieving internal/external standards and goals	10 (71.4%)
	Procuring resources for optimal institutional functioning	10 (71.4%)
	Allocate resources	8 (57.1%)

Discussion

This study is the first to evaluate similarities in surgical curricula across Africa. Fourteen of the 22 countries with neurosurgery training programs had publicly available curricula. There are great disparities in the length and content of curricula. Of note, we found significant regional differences.

The current African neurosurgery curricula mirror the training duration-adjusted curriculum proposed by the Foundation for International Education in Neurological Surgery (FIENS). Although there exists variation in the duration of neurosurgical training within the continent, the FIENS curriculum has served as the foundation for multiple African training programs including South Africa and Ethiopia.[18] The FIENS curriculum is organized around six core competencies: patient care, medical knowledge, practice-based learning, interpersonal relationships and communication, professionalism, and system-based practice.[18] Concerning patient care, the curriculum evaluation found that African neurosurgical residents are trained to provide contextually-appropriate and effective care. However, we noted most African neurosurgery training programs did not leverage technology as much as they could. For example, a handful of programs did not have electronic operative logbooks and medical records and even fewer used more sophisticated technological innovations such as operative models, artificial, and virtual intelligence. These technological solutions can improve the acquisition of technical skills especially when operative time and access to cadaveric dissections are limited. The first West African neurosurgical skills laboratory was established

recently in Cote d'Ivoire[19] and there are no skills laboratories in Central Africa. Mindful of this, training programs in Cameroon (Central Africa) and Ethiopia (East Africa) partnered with UpSurgeon, to pilot hyperrealistic simulators of neurosurgical approaches and intracranial scenarios.[20,21] It is essential that more programs adopt technological solutions to improve their residents' skills and patient care.

Medical knowledge and practice-based learning require residents to have a mastery of established and evolving clinical and practical skills in neurosurgery. The latter is to be acquired through conferences, clinical experiences, journal clubs, review courses, hands-on simulations, and self-directed courses. The methods for assessing theoretical knowledge differed among programs. Some programs such as Senegal and RTC organize yearly written exams, unlike the others. Although African faculty involvement was high, we found it could be further improved. In some training programs, faculty involvement has been bolstered through partnerships with organized neurosurgery societies such as the Continental Association of Neurological Societies (CAANS), the Regional College of Surgeons of East, Central and Southern Africa (COSECSA), and the West African College of Surgeons.[22,23] Some training programs are partnering with US-based institutions such as the Duke Global Neurosurgery and Neuroscience program and the Weill Cornell Tanzania Neurosurgery Project to increase the faculty-to-resident ratio and the resident experience.[19,20]

State of sponsorship of training programs

Through the sponsorship from the Foundation for International Education in Neurological Surgery (FIENS) and the World Federation of Neurosurgical Societies (WFNS), students interested in neurosurgery can continue their education through various surgical and clinical rotations while gaining opportunities to travel abroad to further their education. FIENS and WFNS afforded students to have the chance to travel and participate in research while contributing to the scientific literature with a focus on neurosurgery. Curriculums within African neurosurgery training programs have modeled the proposed training structure that WFNS and FIENS have suggested creating a format rooted in developing core competencies, improving productivity within research, and increasing exposure to different neurosurgical subspecialties. Upon completion of training, students are exposed to the breadth and depth of neurosurgery topics to be active participants while pushing forward the field of neurosurgery. Through continued partnership and innovation, inadequacies in the availability of technology can be improved to provide students with increased training opportunities and technological tools. Yet, these sponsorship opportunities seem less known by African physicians. As reported in Kanmounye et al, 5 out of 23 recipients of FIENS and Clack Fellowships so far are African trainees (ref).

Future steps

The variation in the neurosurgical residency curricula across Africa may be a reflection of the lack of involvement of key stakeholders in the development of continent-wide guidelines. Collaboration is crucial in forming a consensual approach to said guidelines and in increasing its awareness and uptake after its development.[24-26] Stakeholders that should be involved are, but not limited to, i) faculty members of neurosurgical programs, ii) faculty members of specialties that work closely with neurosurgeons, iii) residents, and iv) patients and the public.[19,27] It is essential that these stakeholders be engaged from the outset of the change process to get multifaceted perspectives and secure buy-in.[19,20] This should be done by involving faculty members from all African countries to ensure there is equal representation of perspectives from across the continent in creating guidelines that are realistic, effective, and sustainable for service delivery in all countries. Moreover, given the multidisciplinary team approach in managing neurosurgical conditions, it is critical to include faculty members outside of the neurosurgical specialty when designing future guidance. Involving residents would be of great benefit as they are directly affected by changes to the program curricula. Residents can provide input from the perspective of an end-user of the teaching delivered. This can include providing feedback on areas that are not taught adequately and how to ensure adequate training is provided for them to be confident and competent in managing patients.[22,28,29] Aside from the technical aspects of the curricula, residents can also provide their input on the structure of the training program; this includes working hours, flexibility in the training program, and the ability to pursue unique opportunities for personal or professional development (e.g. sporting commitments, academia, or leadership roles).[30-32]

Also, it is important that the curriculum be tailored after commonly seen neurosurgical pathologies among the African population. This practical aspect of training is crucial for strengthening the workforce capacity in the continent. We have to acknowledge that the level of neurosurgical expertise varies largely among countries. While some countries are advancing in subspecialties, the vast majority of African countries still need to build a solid foundational neurosurgical care with general neurosurgeons. The logical step forward will be to achieve basic neurosurgical care in every country while more advances might develop poles of specialties to deal continentally with complex cases, therefore reducing the need for transferring neurosurgical patients overseas.

Last but not least, getting patient and public involvement ensures that the service provided is continuously updated to meet contemporary expectations and needs. This can instill the confidence of the patients and the public in the care received across the continent.[30]

In conclusion, the involvement of these stakeholders in the creation of guidelines is important in ensuring that training across Africa is delivered in a systematic, holistic, structured, patient-centered manner that prioritizes the learning needs of the residents. Such guidance will enable residents to meet a set standard of clinical competencies by the time they reach the end of their training, whilst empowering them to pursue other areas of their personal or professional development.

Limitations

Only data from 14 countries were included and this limits the generalizability of our study findings. The paucity of data was a major challenge. Notwithstanding, we tried to improve data collection by running searches in multiple languages and triangulating the extracted data by verifying their accuracy with local contacts. We believe this manuscript succinctly describes and evaluates African neurosurgical curricula.

Conclusion

There is grave importance in periodic review of neurosurgical residency curriculum to standardize medical education so that specific requirements are met. This will allow for competent future neurosurgeons who deliver quality patient-centered care. Analysis of curriculum allows us to keep up pace with the rapidly developing field of Neurosurgery. The neurosurgical curriculum in Africa differs depending on the region but certain overarching themes echo. The importance of leadership, faculty participation in decision making, and competent faculty members were of great importance amongst the different regions. These factors seemed to play key roles in building strong and sustainable curriculums. Moreover, intercommunication between global associations such as CAANS, COSECSA, DUKE Global Neurosurgery, and Neuroscience program, AFAN, and FIENS helps to bridge gaps in the neurosurgical curriculum. These organizations working together is of paramount importance to ensure continual improvement.

Declarations

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References

1. Rohrich RJ. "See one, do one, teach one": an old adage with a new twist. *Plast Reconstr Surg*. Jul 2006;118(1):257-8. doi:10.1097/01.prs.0000233177.97881.85

2. Schneiderhan J, Guetterman TC, Dobson ML. Curriculum development: a how to primer. *Fam Med Community Health*. 2019;7(2):e000046. doi:10.1136/fmch-2018-000046

3. Sachdeva AK, Bell RH, Jr., Britt LD, Tarpley JL, Blair PG, Tarpley MJ. National efforts to reform residency education in surgery. *Acad Med*. Dec 2007;82(12):1200-10. doi:10.1097/ACM.0b013e318159e052

4. Dewan MC, Rattani A, Fieggen G, et al. Global neurosurgery: the current capacity and deficit in the provision of essential neurosurgical care. Executive Summary of the Global Neurosurgery Initiative at the Program in Global Surgery and Social Change. *J Neurosurg*. Apr 1 2018:1-10. doi:10.3171/2017.11.JNS171500

5. El Khamlichi A. African neurosurgery: current situation, priorities, and needs. *Neurosurgery*. Jun 2001;48(6):1344-7. doi:10.1097/00006123-200106000-00034

6. Kanmounye US, Lartigue JW, Sadler S, et al. Emerging Trends in the Neurosurgical Workforce of Low- and Middle-Income Countries: A Cross-Sectional Study. *World Neurosurg*. Oct 2020;142:e420-e433. doi:10.1016/j.wneu.2020.07.067

7. Howington JU, Hopkins LN, Piepgras DG, Harbaugh RE. Training standards in endovascular neurosurgery. *Neurosurg Clin N Am*. Apr 2005;16(2):445-9, xi. doi:10.1016/j.nec.2004.08.008

8. Maddalena V, Pendergast A, McGrath G. Quality improvement in curriculum development. *Leadersh Health Serv (Bradf Engl)*. Oct 1 2018;31(4):409-412. doi:10.1108/LHS-09-2017-0053

9. Stienen MN, Netuka D, Demetriades AK, et al. Neurosurgical resident education in Europe--results of a multinational survey. *Acta Neurochir (Wien)*. Jan 2016;158(1):3-15. doi:10.1007/s00701-015-2632-0

10. Kanmounye US, Temgoua M, Endomba FT. Determinants of Residency Program Choice in Two Central African Countries: An Internet Survey of Senior Medical Students. *International Journal of Medical Students*. 04/30 2020;8(1):20-25. doi:10.5195/ijms.2020.470

11. Karekezi C, El Khamlichi A, El Ouahabi A, et al. The impact of African-trained neurosurgeons on sub-Saharan Africa. *Neurosurg Focus*. Mar 1 2020;48(3):E4. doi:10.3171/2019.12.FOCUS19853

12. Khan RA, Spruijt A, Mahboob U, van Merrienboer JJG. Determining 'curriculum viability' through standards and inhibitors of curriculum quality: a scoping review. *BMC Med Educ*. Sep 5 2019;19(1):336. doi:10.1186/s12909-019-1759-8

13. Tackett S, Grant J, Mmari K. Designing an evaluation framework for WFME basic standards for medical education. *Med Teach*. 2016;38(3):291-6. doi:10.3109/0142159X.2015.1031737

14. Harden RM. Ten questions to ask when planning a course or curriculum. *Med Educ*. Jul 1986;20(4):356-65. doi:10.1111/j.1365-2923.1986.tb01379.x

15. Maccarrick G, Kelly C, Conroy R. Preparing for an institutional self review using the WFME standards - an international medical school case study. *Med Teach*. 2010;32(5):e227-32. doi:10.3109/0142159X.2010.482396

16. Chen BY, Kern DE, Kearns RM, Thomas PA, Hughes MT, Tackett S. From Modules to MOOCs: Application of the Six-Step Approach to Online Curriculum Development for Medical Education. *Acad Med*. May 2019;94(5):678-685. doi:10.1097/ACM.0000000000002580

17. Harden RM. AMEE Guide No. 21: Curriculum mapping: a tool for transparent and authentic teaching and learning. *Med Teach*. Mar 2001;23(2):123-137. doi:10.1080/01421590120036547

18. Bagan M. The Foundation for International Education in Neurological Surgery. *World Neurosurgery*. 2010/04/01/ 2010;73(4):289. doi:https://doi.org/10.1016/j.wneu.2010.03.007

19. Konan ML, Diaby R, Ghomsi NC, et al. ESTABLISHING THE FIRST NEUROSURGICAL SKILL LABORATORY IN WEST AFRICA: AN INITIATIVE FOR AN AFFORDABLE REGIONAL

EDUCATION CENTER. *World Neurosurgery: X*. 2022/03/29/ 2022:100122. doi:https://doi.org/10.1016/j.wnsx.2022.100122

20. Nicolosi F, Rossini Z, Zaed I, Kolias AG, Fornari M, Servadei F. Neurosurgical digital teaching in low-middle income countries: beyond the frontiers of traditional education. *Neurosurg Focus*. Oct 2018;45(4):E17. doi:10.3171/2018.7.FOCUS18288

21. Olson AL, Woodhead J, Berkow R, Kaufman NM, Marshall SG. A national general pediatric clerkship curriculum: the process of development and implementation. *Pediatrics*. Jul 2000;106(1 Pt 2):216-22.

22. Dada OE, Karekezi C, Mbangtang CB, et al. State of Neurosurgical Education in Africa: A Narrative Review. *World Neurosurg*. Jul 2021;151:172-181. doi:10.1016/j.wneu.2021.05.086

23. Prideaux D, Teubner J, Sefton A, Field M, Gordon J, Price D. The Consortium of Graduate Medical Schools in Australia: formal and informal collaboration in medical education. *Med Educ*. Jun 2000;34(6):449-54. doi:10.1046/j.1365-2923.2000.00568.x

24. Kanmounye US, Zolo Y, Tsopmene MRD, et al. Understanding the motivations, needs, and challenges faced by aspiring neurosurgeons in Africa: an E-survey. *Br J Neurosurg*. Dec 22 2020:1-6. doi:10.1080/02688697.2020.1862053

25. Kato Y, Liew BS, Sufianov AA, et al. Review of global neurosurgery education: Horizon of Neurosurgery in the Developing Countries. *Chinese Neurosurgical Journal*. 2020/05/19 2020;6(1):19. doi:10.1186/s41016-020-00194-1

26. Scheiner AP. Guidelines for medical student education in community-based pediatric offices. American Academy of Pediatrics Council on Pediatric Education Subcommittee on Medical Student Curriculum. *Pediatrics*. Jun 1994;93(6 Pt 1):956-9.

27. Bridges D, Davidson RA, Soule Odegard P, Maki IV, Tomkowiak J. Interprofessional collaboration: three best practice models of interprofessional education. *Medical Education Online*. 2011/01/01 2011;16(1):6035. doi:10.3402/meo.v16i0.6035

28. Gadjradj PS, Matawlie RHS, Harhangi BS. The neurosurgical curriculum: Which procedures are essential? *Interdisciplinary Neurosurgery*. 2020/09/01/ 2020;21:100723. doi:https://doi.org/10.1016/j.inat.2020.100723

29. Ikwuegbuenyi C, Adegboyega G, Nyalundja AD, et al. Public Awareness, Knowledge of Availability, And Willingness to Use Neurosurgical Care Services in Africa: A Cross-Sectional E-Survey Protocol. *Int J Surg Protoc*. 2021;25(1):123-128. doi:10.29337/ijsp.149

30. Kanmounye US, Zolo Y, Tétinou F, Nguembu S, Nathalie G, Takoukam R. Planning to succeed: Career development resources for future African neurosurgeons. 10/06 2020;25

31. Gopakumar G, Dusart-Gale D, Akgunduz A. CREATING FACULTY BUY-IN: LEADERSHIP CHALLENGES IN IMPLEMENTING CEAB GRADUATE ATTRIBUTES. *Proceedings of the Canadian Engineering Education Association*. 06/17 2013;doi:10.24908/pceea.v0i0.4850

32. Kuo AA, Slavin SJ. Clerkship curricular revision based on the Ambulatory Pediatric Association and the Council on Medical Student Education in Pediatrics guidelines: does it make a difference? *Pediatrics*. Apr 1999;103(4 Pt 2):898-901.

Table 1: Training Program Structure

Category	Regions	Mean	Standard Deviation
Training Duration (years)	Eastern Region	5.00	1.33
	Northern Region	3.67	2.31
	Southern Region	5.00	0.00
	Western Region	6.00	1.00
Number of Examinations	Eastern Region	8.50	4.43
	Northern Region	1.33	1.15
	Southern Region	2.33	0.57
	Western Region	2.67	1.15
Educational Strategy	Eastern Region	0.95	0.10
	Northern Region	0.46	0.41
	Southern Region	1.00	0.00
	Western Region	0.86	0.11
Residents	Eastern Region	0.70	0.40
	Northern Region	0.26	0.46
	Southern Region	0.63	0.32
	Western Region	0.23	0.20
Faculty	Eastern Region	0.75	0.50
	Northern Region	0.26	0.46
	Southern Region	0.86	0.32
	Western Region	0.40	0.20
Assessment	Eastern Region	0.87	0.25
	Northern Region	0.33	0.57
	Southern Region	0.83	0.28
	Western Region	0.50	0.50
	Eastern Region	0.75	0.50
	Northern Region	0.25	0.43

Educational and Working Environment	Southern Region Western Region	0.83 0.75	0.28 0.43
Communication	Eastern Region Northern Region Southern Region Western Region	0.75 0.33 0.50 0.83	0.50 0.57 0.50 0.28
Technology	Eastern Region Northern Region Southern Region Western Region	0.62 0.25 0.50 0.08	0.43 0.43 0.50 0.14
Leadership	Eastern Region Northern Region Southern Region Western Region	0.75 0.40 0.80 0.66	0.50 0.40 0.34 0.23
Total Score (Average)	Eastern Region Northern Region Southern Region Western Region	0.75 0.31 0.74 0.48	0.39 0.43 0.24 0.11

Table 2: Neurosurgery Curriculum Viability within African Countries

Category		Frequency (%) N=14
Educational Strategy	Development of relevant mission and objectives	12 (85.7%)
	Curriculum Design	10 (71.4%)
	Length of Program	13 (92.9%)
	Implementation guidelines	13 (92.9%)
	Review of instructional material	11 (78.6%)

Category		Frequency (%) N=14
Residents	Perception of teaching	8 (57.1%)
	Perception of teachers	7 (50%)
	Perception of atmosphere	6 (42.9%)
	Academic self perception	9 (64.3%)
	Social self perception	5 (35.7%)
	Student support services	7 (50%)
	Student engagement with faculty, staff and administration	9 (64.3%)
	Active learning techniques	9 (64.3%)
	Clear analysis of audience	8 (57.1%)
Faculty	Ability to perform multiple roles	7 (50%)
	Competence of instructors	9 (64.3%)
	Staff involvement in organizational decision making	9 (64.3%)
	Faculty development	9 (64.3%)
	Respect diverse ways of learning	9 (64.3%)
Assessment	Prompt feedback	8 (57.1%)
	Measurement and Evaluation	11 (78.6%)
Educational and working environment	Flexible people oriented culture	9 (64.3%)
	Presence of various cultures	9 (64.3%)
	Climate of trust and shared understanding	10 (71.4%)
	Learner centered environment	10 (71.4%)
	Communicating policies and strategies	9 (64.3%)
	Communication/information for quality	9 (64.3%)
Technology	Document technology plan	5 (35.7%)
	Appropriate tools and media	6 (42.9%)
	Reliability of technology	5 (35.7%)
	Resources and information of technology	8 (57.1%)
Leadership	Create partnerships	9 (64.3%)

Category		Frequency (%) N=14
	Influence people management	11 (78.6%)
	Achieving internal/external standards and goals	10 (71.4%)
	Procuring resources for optimal institutional functioning	10 (71.4%)
	Allocate resources	8 (57.1%)

Abbreviations

European Association of Neurosurgical Societies (EANS)
American Board of Surgery (ABS)
Residency Review Committee for Surgery (RRC-S)
Low- and Middle-Income Countries (LMICs)
World Federation of Medical Education (WFME)
Foundation for International Education in Neurological Surgery (FIENS)
Continental Association of Neurological Societies (CAANS)
College of Surgeons of East, Central, and Southern Africa (COSECSA)
Association of Future African Neurosurgeons (AFAN)

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