



Perspective

Neuroscience education and research in Cameroon: Current status and future direction

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ABSTRACT

Neurological disorders comprise 20% of hospital admissions in Cameroon. The burden of neurological disorders is increasing, especially in children and the elderly. However, there are very few neurologists, psychiatrists, gerontologists and neuropsychologists trained in the treatment of neurological disorders in Cameroon and there are very few facilities for training in basic and clinical neuroscience. Although non-governmental organizations such as the International Brain Research Organization (IBRO), International Society of Neurochemistry (ISN), and Teaching and Research in Natural Sciences for Development (TReND) in Africa have stepped in to provide short training courses and workshops in neuroscience, these are neither sufficient to train African neuroscientists nor to build the capacity to train neuroscience researchers and clinicians. There has also been little support from universities and the government for such training. While some participants of these schools have managed to form collaborations with foreign researchers and have been invited to study abroad, this does not facilitate the training of neuroscientists in Cameroon. Moreover, the research infrastructure for training in neuroscience remains limited. This is reflected in the low research output from Cameroonian universities in the field. In this review, we describe the burden of neurological disorders in Cameroon and outline the outstanding efforts of local scientists to develop the discipline of neuroscience, which is still an emerging field in Cameroon. We identify key actionable steps towards the improvement of the scientific capacity in neuroscience in Cameroon: (1) develop targeted neuroscience training programs in all major universities in Cameroon; (2) implement a thriving scientific environment supported by international collaborations; (3) focus on the leadership and the mentorship of both local and senior neuroscientists; (4) develop public awareness and information of policy makers to increase governmental funding for neuroscience research.

1. Introduction

The burden of neurological disease across Sub-Saharan Africa over the last half a century is increasing at an unprecedented rate amid changes in child mortality, increased lifespan, diet, lifestyle and environmental changes (Feigin et al., 2020). This increase has not been accompanied by a commensurate increase in training, research or effective care for people with neurological, neuropsychiatric or neuro-behavioral disorders. While there has been an increased interest in neuroscience research in Africa (Abd-Allah et al., 2015; Howells and Womersley, 2018; Patel et al., 2019; Womersley and Ripullone, 2017), there remains a shortage of neurologists and other trained clinicians. At

individual and institutional levels, efforts are being harnessed to address this disease burden within Cameroon and the Central African region. However, such efforts are hampered by lack of relevant and sufficient knowledge and skills training in both basic and clinical neurosciences. In addition, there is a lack of directed political will and funding for creating and supporting training and research environments in the brain and behavioral sciences. Compared to developed nations, Cameroonian (like most African) science institutions are decades behind, with many falling short of implementing the World Health Organization (WHO) Strategy on Research for Health, which includes strengthening the research culture (organization), focusing research on priority health needs (priorities), strengthening national systems for health research (capacity),

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promoting good practice in research (standards), and strengthening links between health research and health (translation) (Uthman et al., 2015).

Stepping in to mitigate this lack of neuroscience teaching and research training, a number of science-based non-profit organizations such as the International Brain Research Organization (IBRO), the International Society for Neurochemistry (ISN), the Pan African Association of Neurological Sciences (PAANS), the Society for Neuroscience (SfN), and the World Federation of Neurology, have supported African neuroscientists over the years and have helped them to build scientific capacity for sustainable education and research (Russell, 2017). Support from these organizations has included research infrastructural support; assistance to establish research institutes; and the establishment of training courses and workshops to introduce African scientists to powerful-yet-cost-effective experimental model systems. Several Cameroonians have benefited from these efforts. Other support has come from the promotion of scientific networking, public engagement and advocacy for improved neuroscience funding (Juliano, 2012; Karikari et al., 2016; Yusuf et al., 2014).

In the present review, we first focus on the current burden of neurological diseases in Cameroon and then examine the efforts of Cameroonian neuroscientists to study and treat these disorders. We detail the local efforts to increase neuroscience awareness, teaching and research in the country. Finally, we make actionable recommendations on how Cameroonian neuroscience research and teaching might best be supported in the future.

2. The burden of neurological disease in Cameroon

While reports on the global burden of neurological diseases provide a world-wide view of the most prevalent neurological disorders (GBD, 2016; Feigin et al., 2020), data specific to the prevalence of neurological disorders in sub-Saharan Africa and Cameroon are also available (Doumbe et al., 2015, 2019; Kompoliti et al., 2017). However, accurate epidemiological data on the prevalence of neurological diseases in Cameroon have been difficult to obtain. The available data are limited to outpatient urban settings, leaving data on close to half the population uncaptured. In a study to determine the pattern of neurological diseases in urban settings, the spectrum of neurological disorders presenting at a neurology clinic in Yaoundé, Cameroon was analyzed (Tegueu et al., 2013). Out of 4526 admissions, 912 patients (20.15%) were given a neurological diagnosis. The most frequent neurological disorders were headache (31.9%), epilepsy (9.86%), and intervertebral disc disorder (7.67%), followed by lumbar and cervical arthrosis, polyneuropathy, stroke, Parkinson disease, and dementia. Future studies must collect such data from the rural areas of the country.

There are also data on the global burden of pediatric neurological disorders (Newton, 2018) and the burden of neurodevelopmental disorders in Low and Middle Income countries (Bitta et al., 2017) including information on Sub-Saharan Africa. But once again, data on pediatric neurological disorders in Cameroon are scanty and limited to outpatient-population based studies. A study of pediatric neurological diseases from urban health care districts in Cameroon from 2012 to 2014, found that the most frequent neurological disorders were epilepsy (66.4%), headache (5.6%) and cerebral palsy (4.8%). Among infants (ages 0–2) and toddlers (ages 3–5), the most common neurological complaint was seizure (33.3% and 69.2% respectively) and the most common neurological diagnosis was epilepsy (33.3% and 84.6% respectively) (Doumbe, 2019). In a retrospective review of 114 children with neurological problems seen at a pediatric neurological clinic in a 2-year period in the North of Nigeria, the most common neurological disorders were cerebral palsy (55.3%), seizure disorder (26.3%) and postmeningitic complications (6.2%) (Wammanda et al., 2007). In a prospective study of 644 Nigerian children over a period of 20 months at the paediatric neurology clinic of the University College Hospital, Ibadan, Nigeria, the most frequent paediatric neurological disorders were

epilepsy (45.3%), cerebral palsy (36.0%), neuro-muscular disorders (4.5%), and mental retardation (4.5%) (Lagunju and Okafor, 2009). The pattern of paediatric neurological disorders in Cameroon is similar to that in Nigeria and other West African countries and points to the need for an increased number of paediatric neurological specialists and facilities for diagnosis and rehabilitation. There is also a need to diagnose and treat the neurodevelopmental sequelae of environmental toxins (Grandjean and Landrigan, 2014).

Finally, it is important to consider the pattern of neurological diseases and cognitive impairment related to aging in Cameroon (Callixte et al., 2015). Up to 50% of people age 55 and older are affected by age-related neurological diseases which are associated with a high risk for adverse health outcomes, including mortality, disability, institutionalization, and hospitalization. Several studies have been carried in Sub-Sahara African countries to demonstrate the burden of neurological diseases (Dewhurst et al., 2012; Birbeck et al., 2015) (Owolabi, 2020). However, little is known about the epidemiology and clinical pattern of neurological disorders of the elderly in Cameroon. Callixte et al. (2015) conducted a descriptive study in an outpatient neurology clinic in Yaoundé, Cameroon to understand the burden of neurological diseases of the elderly requiring treatment by Cameroonian neurologists and geriatricians. The records of all outpatient neurological consultations from May 2005 to December 2011 were collected at the Clinique Bastos, the sole clinic with adult neurological consultations during the study period in Yaoundé. Diseases were classified according to the 10th revision of the WHO International Classification of Diseases (ICD-10). Out of a total of 912 patients, 187 (20.5%) were aged 60 and older. The most common complaints of these patients were low back pain (19.7%), tremor and movement disorders (13.8%), pain in the lower limbs (10.6%), cognitive disorders (9.6%), and headaches (9.1%). The most commonly diagnosed neurological diseases of the elderly in this study were lumbar arthrosis (14%), dementia (Alzheimer's type & vascular; 12.4%), Parkinson's disease (10.2%), and polyneuropathy (9.1%).

As life expectancy of Cameroonians (now 60.3 years) increases, public health care for an aging population becomes even more important (Jaul and Barron, 2017). Although the population of Cameroon is in general, quite young today, these people will all age and the infrastructure for treating the neurodegenerative diseases of an aging population must be put in place before the burden of the elderly becomes overwhelming. As pointed out by Doumbe et al. (2019), “Based on recent estimates, it is predicted that by 2050 there will be 139 million people aged 60 and older living in Sub-Saharan Africa, with a subsequent increase in the prevalence and burden of neurodegenerative disorders”. The need for treating neurocognitive disorders, intellectual disability, mood disorders, and sensory motor dysfunction for patients of all ages, necessitates scientific and medical training in basic and clinical neuroscience, gerontology, psychiatry, and neuropsychology. In the last few decades, motivated scientists and physicians have started to tackle this neurological disease burden at the levels of both experimental research and clinical practice.

3. Neuroscience research in Cameroon, who is doing it and what are they doing?

Neuroscience research can address a number of the neurological disorders of disease-endemic regions of Africa, such as neurotoxicity due to chemical pollutants (Anetor et al., 2008), infections, and behavioral brain disorders, including depression and addictions, by investigating the pathogenic mechanisms underlying these diseases. There is also the potential to develop new treatments for such disorders using novel drugs developed from unique African flora and fauna as described in recent issues of *Metabolic Brain Disease* (Howells and Womersley, 2018) and *Frontiers in Neuroanatomy* (Patel et al., 2019), which focus on neuroscience research in Africa. Cameroon has an abundance of medicinal plants (Mahomoodally, 2013; Ntie-Kang et al., 2013) and there is considerable interest in developing new drugs to treat neurological

disorders from these plants (Fokunang et al., 2020; Nsagha et al., 2020; Simoben et al., 2020).

In Cameroon, basic research in Neuroscience has primarily focused on better understanding how environmental pathogens and toxins lead to diseases of the nervous system specific to Africa (Angwafor et al., 2019; Millogo et al., 2019), which are largely neglected in Europe and America (Bentivoglio et al., 2014). In this regard, we would like to highlight research that targets epilepsy (Siewe et al., 2019) as Cameroon has one of the highest levels of epilepsy (4–6%) in the world (Burton, 2015). The extraordinarily high prevalence of epilepsy in Cameroon is the result of a complex interplay between genetic and environmental factors which include the endemic spread of onchocerciasis (River blindness) in some regions of the country (Chesnais, et al., 2018). The dedicated work of Njamnshi et al. (2010) has helped to better understand the clinical presentation of onchocerciasis-associated epilepsy in Cameroon (Angwafor et al., 2019; Boullé et al., 2019; Elliott et al., 2013; Njamnshi et al., 2010; Siewe Fodjo et al., 2018, 2019). While international multidisciplinary initiatives are important to facilitate research on onchocerciasis-associated epilepsy in Cameroon (Colebunders et al., 2018), there are also local initiatives to develop anti-epileptic drugs from Cameroonian medicinal plants (Ntie-Kang et al., 2013). Although the evaluation of the pharmacological properties and active ingredients of medicinal plants to treat epilepsy represents a real potential in the African context (Ketcha Wanda et al., 2015; Medugu et al., 2020; Moto et al., 2018), none of the antiepileptic drugs developed from such phytotherapy approaches has yet been transferred into clinical studies. The World Health Organization traditional medicine strategy (WHO, 2014) may facilitate such research in Cameroon and other sub-Saharan countries (Auditeau et al., 2019).

Other publications from Cameroonian neuroscientists involve epidemiological studies conducted on small samples of the population or relying on clinical surveys (Luma et al., 2013). These reports are neither inclusive nor conclusive, but they do provide valuable information on neurological disorders seen in urban health care facilities in Yaoundé and Douala. However, more than 50% of the Cameroon population dwell in resource-poor rural settings and do not have access to those facilities (Callixte et al., 2015; Kanmogne et al., 2010; Tianyi et al., 2019). There is a gap between the data reported in such studies and the reality of the disease prevalence in the country as a whole. We found few studies focusing on neurological diseases in Cameroon and these studies were limited to Yaoundé (Tegueu et al., 2013; Callixte et al., 2015, Shaha et al., 2015; Cubo et al., 2017; Doumbe et al., 2019). Other studies evaluated the prevalence of individual neurological disorders: meningitis (Fonkoua et al., 2001; Massenet et al., 2013); HIV-related neurological disorders (Dzoyem et al., 2012; Kanmogne et al., 2010; Njamnshi et al., 2008); stroke (Mapoure et al., 2014; Mapoure et al., 2017); or epilepsy (Elliott et al., 2013; Njamnshi et al., 2009, 2010). As stated earlier, the investigators of these localized studies limited their research to the population that visited urban healthcare facilities and do not provide information about patients living in remote areas who do not have access to health care facilities in the main cities. There is a need for community-based studies inclusive of both rural and urban settings (Kaddumukasa et al., 2016; Mpanya et al., 2014). One way forward may be through increased education and the cooperation of different health care professional: Neuro-cooperation (Delgado-Suarez et al., 2021).

One of the major hurdles in collecting information on neuropsychiatric disorders in Cameroon is the fact that there is a stigmatization and mystery is attached to mental illness. For example, Yongs (2016) reported that “Stigma against mental illnesses remains rampant in Cameroon, constituting a significant barrier to successful treatment, reducing key life opportunities, and predicting poor outcomes over and above the effects of mental illness per se”. This cultural factor accounts for the limited number of consultations for psychiatric disorders in health care facilities. Like most Africans, Cameroonians first seek help from herbalists and spiritual centers before going to a hospital or clinic. Thus, they remain out of the reach of researchers. The case of how

parents treat infant seizures provides a good example. Chiabi et al. (2018) interviewed mothers who brought their children into the General Pediatric Unit of the Yaounde Gynaeco-Obstetric and Pediatric Hospital, in Cameroon, over a period of 6 months (March to August 2014) about their attempts to treat the seizures before they came to the hospital. The results are quite revealing: Most parents (74%) had tried to stop the seizure using some form of home remedy, including inhalation of a strong odor or smoke from burnt clothes (13.4%); putting an object into the child’s mouth (8.7%); auto-medication (6.3%); giving the child traditional medicines (5.5%) or prayers with anointed water (5.5%) or forcing the child’s head inside the latrine (5.5%). Despite these harmful methods to stop the seizures, 98% of the mothers still brought their children to the hospital afterwards. It is clear that public education is required in order that patients with neurological disorders are not treated in ways that are inappropriate and harmful before they arrive in medical clinics. Oddly enough, the COVID-19 pandemic has focused attention on mental health in Cameroon and may result in increased facilities to treat neuropsychological problems (Mviena et al., 2020).

It is also important to acknowledge the effort of many biologists, biochemists and scientists who, despite their limited facilities, tackle questions related to the brain and neurobiological disorders at the basic science level using mouse or rat models (Fanta Yadang et al., 2019; Fotsing et al., 2017; Mbiydzennyuy et al., 2018; Moto et al., 2018; Ngoupaye et al., 2018; Tankeu et al., 2016). Until now, no studies have made use of cheaper and readily available animal models like *Caenorhabditis elegans*, *Drosophila melanogaster* or the zebrafish (Maximino et al., 2015). Promotion of the use of these models would not only reduce research costs but also make it easy for genetic, molecular and developmental studies to be performed. Encouragingly, international organizations, especially TREND in Africa (<https://trendinafrica.org/>), have engaged in effective training schools to implement the use of these genetically modifiable and affordable model species in African laboratories.

The total number of medical publications from Cameroon between 1996 and 2019 was 6994 according to the SCImago Journal and Country ranking system, with Cameroon ranking 79th globally and 10th in Africa (SCImago, 2019). From these medical publications, neuroscience and neurology-related publications accounted for 2.1%, with clinical neuroscience contributing 61% and basic neuroscience 39% of these publications (Fig. 1). Cameroon ranked 95th in the world and 12th in Africa for neuroscience research (SCImago, 2019). The data on the output of neuroscience publications in Cameroon might be incomplete

Neuroscience publication from Cameroon by sub-areas

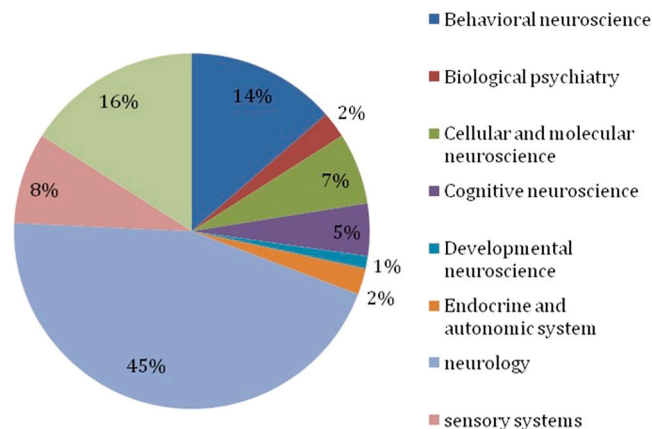


Fig. 1. Neuroscience publications between 1996 and 2019, from Cameroon by sub-areas. (source SCImago, 2019).

as several publications are not indexed on international search platforms such as Pubmed or Web of Science because they are university reports or national journals (such as the Journal of Cameroon Academy of Sciences). In addition, many Cameroonian researchers are not referenced on Google Scholar, Research Gate or other online platforms dedicated to scientific researchers. In this regard, Cameroonians and other African French-speaking researchers often suffer from a lack of visibility and are under-represented in a publishing environment that is dominated by English. Because of this language barrier, they also struggle to publish as first or senior authors in international journals (Roca et al., 2019).

Therefore, the seeming under-representation of Cameroonian and other Francophone African researchers in global publication output also suffers from the above-mentioned bias. Consequently, researchers in francophone countries are at a disadvantage of receiving very little research funds globally as high publication output is usually a prerequisite to funding acquisition. Recently, open preprint repositories are changing the climate of scholarly publishing, via the promotion of open source, open standards and citations of research work in progress or in many languages. This is a great opportunity for African researchers to become more visible. Among those repositories, AfricArxiv is a non-profit platform that offers the possibility to upload working papers, preprints, accepted manuscripts (post-prints), presentations, and data in languages other than English as well as in several African languages including Swahili, Sesotho, Igbo, and Zulu (<https://info.africarxiv.org/languages/>). There is a need to improve awareness of these Open Science initiatives within Africa in order to increase communication and foster scientific cooperation among these under-represented and financially challenged communities.

4. Support of neuroscience development in Cameroon by non-profit organizations

The first efforts of IBRO to improve neuroscience education and research in Cameroon began in 2007, when the first IBRO-sponsored neuroscience school entitled “Infections and Brain Dysfunctions: sleep, epilepsy and behavior” was held at the University of Yaoundé I, Yaoundé, Cameroon. This school focused on how infectious agents interact with the nervous system to cause brain dysfunctions, which manifest as sleep disturbances, epilepsy or behavioral changes. An important aspect of this school was to highlight the crucial role that basic science research plays in understanding the pathogenesis of the neurological diseases that burden the country and the Central African region in general. This first school stimulated the initiation of scientific interest in Neuroscience as a stand-alone discipline in the country.

A successful outcome of this IBRO School was that many participants used the contacts they formed at the IBRO School and previous neuroscience training courses in Cameroon to form lifelong collaborations. These opportunities have strengthened the commitment of Cameroonian students to neuroscience research locally and have given them the opportunity to travel to countries where they can learn more advanced techniques in neuroscience (Karikari et al., 2016). The increased attention to research in neurosciences led to the organization of another IBRO school in 2017. This IBRO-ARC, ISN School, which was also supported by the Company of Biologists, was organized at the Faculty of Medicine and Biomedical Sciences in Yaoundé and was focused on basic neuroscience research in small animals. At the technical level, basic techniques such as immunohistochemistry, Western blotting and RT-PCR analyses (Fig. 2) were taught. Equipment was donated by TRéND in Africa and the Institut de Pharmacologie Moléculaire et Cellulaire-CNRS in France.

Through this sponsorship, the biochemistry and physiological science laboratory at the school of Medicine was equipped to conduct research at molecular levels to study structural neuronal changes and examine protein expression. Currently there are four PhD students at this laboratory whose studies have incorporated immunohistochemistry, western blotting and RT-PCR to investigate the effects local



Fig. 2. Hands-on on Western blotting procedures at the 2018 IBRO school in Cameroon.

phytochemicals and nutraceuticals on different models of Parkinson’s disease and stroke. As a result of the IBRO schools, one of the authors has been able to obtain a laboratory placement to conduct bench work in a top university in South Africa. Through networking with IBRO faculty, one of the participants obtained an NIH grant and a laboratory bench placement for PhD study on Parkinson’s disease at the Department of Molecular & Clinical Pharmacology, Faculty of Medicine, ICBM, University of Chile, resulting in improved quality publications (Ngoungoure et al., 2019a, 2019b). While the numbers may seem low, the ramifications of one empowered scientist for the development of neuroscience in Cameroon are indescribable.

Since the first IBRO schools, many Cameroonian students have been involved with other neuroscience training programs in Africa, such as the IBRO teaching tools workshop, which is a “train the trainer” program that helps lecturers from different branches of neuroscience in Cameroon universities learn how to improve their teaching in neuroscience (Juliano, 2012). This has resulted in Cameroonians, who were once participants in IBRO schools, becoming faculty members at subsequent schools. This approach facilitates the confidence of Cameroonian graduate students to become professors in neuroscience. However, as important as these short IBRO schools and workshops are for advancing neuroscience education and research in Cameroon, there has yet to be a visible increase in the number of neuroscience research and training programs in Cameroon. There have also been difficulties in developing collaborative neuroscience teaching and research projects with universities in other African countries (Chu et al., 2014), something that might be facilitated by the Society of Neuroscientists of Africa (SONA). In addition, neuroscientists in Cameroon must become involved in the domain of public engagement and advocacy for improved neuroscience funding.

5. Local efforts to improve neuroscience education and neurology awareness in Cameroon

To overcome the burden of neurological disorders in Cameroon, efforts are being invested in advancing the public awareness of brain function and neurological diseases as well as in the training of basic and clinical neuroscientists. In 2013, a group of neuroscience researchers created the Cameroon Association for Neurosciences (CAMANE) in Ngaoundéré (Cameroon). Affiliated with SONA and IBRO, the mission of CAMANE is popularization of all areas of neuroscience in Cameroon. Its objectives are to (1) better understand the functioning of the nervous system and the physiopathology of brain diseases for better treatment strategies; (2) foster neuroscience research and education in the national

territory of Cameroon; (3) promote collaborations between clinicians and basic neuroscientists; (4) share the results of neuroscience research with the general public and the community. In Yaoundé in 2020, CAMANE organized its second conference entitled “Boosting the nervous system’s awareness and science communication to foster development in Cameroon” that brought together faculty and postgraduate students for oral and poster presentations to share their research findings (Fig. 3).

In addition, CAMANE conducted two successful Brain Awareness Weeks, one in March 2019 in Dschang and the other in March 2020 in Dschang and in Buea (Fig. 4). These activities targeted secondary and high school students, with the goal of introducing them to basic topics in brain science and inspiring them to pursue career paths in STEM. Educational resource materials and other needs for these outreach activities were kindly donated by the Dana Alliance for Brain Initiatives (https://www.brainawareness.org/partner_report/cameroon-association-for-neuroscience-camane/). While much has been done at the level of public awareness and the dissemination of research findings through conferences, the engagement with media as well as legislators and policymakers about the importance of neuroscience education and research is still lacking.

The activities of CAMANE are supplemented by the Brain Research Africa Initiative (BRAIN) founded by Alfred Njamshi, a Professor of Neurology and Chair of the Neuroscience Laboratory at the Faculty of Medicine and Biomedical Sciences at the University of Yaoundé 1-Cameroon (<https://brainafrica.org/>). While celebrating the “World Brain Day”, this initiative is also involved in “Brain week in Cameroon”, which informs students and academics about various brain health issues and also educates people on the importance of keeping their brains healthy. The aim of this initiative is to develop partnerships for brain health and generate interest in neuroscience careers among students. During the 2020 Brain Awareness Week, BRAIN organized a national online COVID-19 survey, with free neurology consultation and continuous medical education under the theme “COVID-19 and chronic brain diseases”. BRAIN has mentored several high school students to delve into the field of medicine as well as medical interns in clinical neurosciences.

6. The importance of developing new training programs in neuroscience in Cameroon

At the university level, training programs in neuroscience are still a rarity in Cameroon. Despite the fact that there are over 15 public and private registered higher education institutions in Cameroon, only one clinical neuroscience program and one basic neuroscience graduate degree program are offered in the whole country (neurology and basic neuroscience at the University of Yaounde 1). This severely limits the



Fig. 4. CAMANE organized Brain Awareness Week.

number of scientists and clinicians receiving advanced training in neuroscience who could improve biomedical research and healthcare delivery in the country (Karikari and Aleksic, 2015). Only five accredited institutions train medical, biomedical and other paramedical personnel: Bachelor of Medicine and Bachelor of Surgery (MBBS), pharmacy, nursing science, and medical laboratory sciences which are available at most of the public and private universities. However, none of these universities has a neuroscience program or a neuroscience specialty, even though students are introduced to basic knowledge in neuroscience in Anatomy, Physiology, Biochemistry, and Pharmacology and to clinical neuroscience in Neurology, Psychology, and Psychiatry. It was not until 2017 that the University of Yaounde 1, started a Master of Science program in Neuroscience. However, this program has been plagued by an inadequate curriculum, lack of trained lecturers, limited funding, inadequate research infrastructure, and absence of career development programs and lack of access to teaching tools. As of 2019, 11 neurologists (two from the Democratic Republic of Congo [DRC] and nine from Cameroon), five neurosurgeons, and six psychiatrists (one from DRC) have been trained in the residency programs established at the School of Medicine in the University of Yaoundé I. They are now able to serve Cameroon and the outlying regions. Through the leadership of Professor Alfred Njamshi, BRAIN and the University of Yaounde 1, are engaging the Cameroon government at policy level to increase funding support for researchers and to improve on advanced clinical neuroscience equipment, infrastructure and foreign exchange programs.

Currently, the government of Cameroon sends resident doctors on foreign exchange programs each year for neurological specialization to



Fig. 3. Poster presentation at the 2nd Cameroon Association for Neuroscience conference in Yaounde, 13th – 15th October 2020.

institutions in Switzerland, Belgium and France. The Cameroonian government has also signed partnerships with European countries in which Cameroonians are sponsored to undertake PhD studies every year. The Cameroon government is also responding to the global health challenge of neurological disorders, by recruiting qualified PhD holders at home and abroad to offer direct health care services and to improve the quality of training programs in brain science, neurological and neurocognitive diseases in Cameroonian universities. This step was taken by the President of the Republic of Cameroon early in 2020 and has since taken effect. While the impact of this initiative might not yet be evident, and new degree programs in neuroscience might not be immediate, universities are integrating a neuroscience specialty into existing undergraduate and graduate programs in Medicine, Basic Science and Psychology.

7. Research facilities for neuroscience in Cameroon

One of the major reasons for the limited research output by university faculty in Cameroon is the poor research infrastructure. A survey of published papers from Cameroonian authors shows that very few of them employ advanced microscopic or molecular biology techniques. Maina et al. (2019) reported that in Nigeria there was no functional Transmission Electron Microscope or Confocal Microscope available, and the same can be said of Cameroon. During the preparations for the 2018 IBRO-ARC basic neuroscience school using small animals in Yaounde, part of the hands-on session could not be completed because of lack of specific antibodies and other consumables. Other demonstrations were difficult because there was no running water in the laboratory building. These examples highlight the difficulties encountered by the average neuroscience researcher in Cameroon. The supply of reagents and consumables is not only limited by a lack of funding, but also by a lack of storage. Either storage facilities having the required specifications are not available or the power supply is unreliable. Despite having a research environment which is detrimental to encouraging neuroscience research in Cameroon, researchers have still found ways to make modest contributions to the body of clinical and basic neuroscience literature. To further improve the quantity and the quality of neuroscience research output in Cameroon, it is essential that there is a financial investment in infrastructure capacity and technical training of neuroscientists in order to enable them to conduct scientifically sound research (Yusuf et al., 2014). To this end, universities are engaging in various public-private partnerships to strengthen training and research. For example, the University of Buea has established several partnerships with national and international academic institutions, business enterprises, industry, NGOs, and Civil Society organizations to enrich programs of study in terms of links with the business world. This is instrumental in maintaining national and international standards and the recognition of the importance of the university to train its graduates in the knowledge required to compete at the cutting edge of the global workforce. Through the corporate social responsibilities of pharmaceutical companies and international agencies, some laboratories at the university have been established and this improved research infrastructure is going a long way to support the efforts of Cameroonians to develop solutions to the neurological and nervous system-related diseases that are plaguing Africa.

8. The future of neuroscience in Cameroon

Neuroscience can become a critical tool for driving social and economic growth if public and private sectors invest in education and research (Yusuf et al., 2014). IBRO and other not-for-profit organizations have been at the forefront for decades now, building scientific capacity for sustainable neuroscience research and education in Africa, by funding training and workshops. Cameroon has benefited from IBRO schools in 2007 and 2018. In 2015, a tele-education training was organized in Douala on Parkinson's disease management (Cubo et al.,

2015). To meet the demands of the many passionate students and faculty in need of high-quality training, there is a need for IBRO teaching tools workshops and train-the-trainer programs that make it possible for lecturers from the various branches of neuroscience to learn how to organize their teaching for their students (Juliano, 2012). Building upon the 2018 IBRO neuroscience school, the Faculty of Medicine and Biomedical Sciences signed a Memorandum of Understanding with the Teaching and Research in Neuroscience Development (TReND) in Africa which saw material donation for this school. Both the university and the country of Cameroon benefit from this collaboration which will promote the hands-on training programs organized by TReND in Africa. This will improve capacity and strengthen the neuroscience program offered at the university as has occurred in the Faculty of Health Sciences, Kampala International University through its Institute of Biomedical Research. TReND in Africa introduced creative ways of using cheap and readily available models to conduct cutting edge research in neuroscience, while working with the faculty at the School of Health Sciences at KIU to develop a multidisciplinary M.Sc. program in neuroscience (Yusuf et al., 2014). With engagements in several of these African schools, not only are the resumes of faculty and students improved, but professional interactions visiting faculty enable Cameroonian students to attend high-level neuroscience courses at international institutions such as the Marine Biology Laboratory in Woods Hole, Massachusetts USA, the Cold Spring Harbor Laboratory on Long Island, New York USA, or the Federation of European Neuroscience Societies (FENS) summer schools. Future IBRO schools should be organized in Cameroon which is the driving country among the sub-Saharan Francophone countries in the field of Neuroscience. Using Cameroon as a hub for neuroscientists of the central African region will not only encourage excellence in neuroscience and neurology within the country but also sow the seeds for further initiatives in the surrounding regions.

According to the World Health Organization, 2017 mental health profile (Mental Health Atlas 2017 Member State Profile; Cameroon [<https://www.ecoi.net/en/file/local/2002736/CMR.pdf>]), there is no reported data on the number of psychiatrists, non-psychiatrist medical doctors, occupational therapists, psychologists or social workers for Cameroon. However in 2011, the World Health Organization reported that Cameroon had 0.03 psychiatrists per 100,000 persons and 0.15 mental health nurses per 100,000 persons (World Health Organization, 2011). The mental health policy for Cameroon was first developed in 2014, but the lack of commitment of the policy makers has translated to a weak healthcare system. The result is a lack of knowledge on the demographic distribution of mental and neurological disorders, the genetic and molecular basis of nervous systems-related disorders, psychotropic therapeutic options and their effectiveness as well as the socioeconomic implications of these diseases (Quansah and Karikari, 2015). A consequence of this lack of commitment to mental health care is reflected in the training curricula of medical and biomedical science institutions, the lack of research infrastructure and funding and unregulated programs for training students how to deal with the disease burden overwhelming the fragile healthcare system. Co-ordinated and effective advocacy programs should be implemented to educate and raise the awareness of the policy makers about the frequency and the cost of brain related disorders in Cameroon. Additionally, the government should promote a thriving environment for a private sector educational system that will foster healthy public-private partnerships to strengthen education and make it relevant to industry. The private sector, especially biotechnological, information technology and pharmaceutical companies have an important role to play in the growth of neuroscience in Cameroon. There is little data indicating the existence of research collaborations between pharmaceutical companies and universities in Cameroon. Although different herbal remedies have been proven to be effective in managing several neurological diseases in animal models, there is limited funding and technical capacity to improve such findings and proceed to clinical trials. Pharmaceutical and biotechnological companies could provide grants and laboratories where scientists can access quality products to

carry out their research; in return, the scientific discoveries would be made into commercial products by the industries which are marketed locally and globally (Fokunang et al., 2020; Ntie-Kang et al., 2013). Such collaborations will advance the field by improving the impact of the quality of education and research.

Neuroscience training is of increasing importance in the 21st century and there are a number of ways that this training could be facilitated in Cameroon. The development of neuroscience programs in universities can be facilitated through interdepartmental cooperation within universities (Akil et al., 2016; Miller and Brown, 2016) and the ability to use open-access publications, on-line resources, and open source tools for teaching and laboratory research will facilitate the development of these programs (Freeman, 2015; Latimer et al., 2018; Pearce, 2020; Ravindran, 2020). Rather than depending on the standard rat and mouse models for the experimental study of neurobehavioral disorders, there is the opportunity to develop new models of human neurological disorders in Cameroon using native African animals (Manger et al., 2008). Given the recent attention to the need for species diversity in neuroscience (Hale, 2019; Juntti, 2019; Keifer and Summers, 2016; Striedter, 2019), and the wide range of African mammals, birds and fish native to Cameroon and other areas of Africa (Agha et al., 2018), there are opportunities to develop neuroscience research projects on a number of native animals. For example, it is possible to conduct basic neuroanatomy and neuromorphology studies on African species (Herculano-Houzel et al., 2014; Jacobs et al., 2014; Nguyen et al., 2020; Oosthuizen, 2017). Last but not least, there is enormous opportunity to advance neuroscience research in Cameroon through the use of invertebrate species (Balogun et al., 2018a, 2018b).

9. Conclusion

In this review, we have indicated that neuroscience is still an emerging field in Cameroon. While showing the efforts of local scientists to engage in teaching and research in this discipline, we emphasize the urgent need to improve the scientific capacity in neuroscience and suggest avenues for doing this. Research in neuroscience worldwide is enjoying a rapid expansion in scope, coupled with the remarkable development of innovative concepts, tools and clinical applications. As the understanding of normal and pathologic brain function is progressing rapidly, African neuroscientists are challenged to keep abreast of recent knowledge and research. Failure to develop more appropriate academic programs, models of training and career development in the neurosciences will slow down our efforts to develop local scientific capacity to address the increasing neurological burden which severely impacts the socioeconomic status and quality of life in Cameroon. There is therefore an urgent need for long-term strategic planning to establish neuroscience education in Cameroon as well as to develop the means to leverage expertise to support that education. The successful implementation of these initiatives will benefit not only the country but also the neighboring countries, especially those that are Francophone. Without undermining the efforts already accomplished, we believe that policy makers, academics, industries, scientific societies, private foundations, and other public and private sector contributors, must be actively engaged in achieving this goal.

Ethical Statement

Hereby, I Ngala Elvis Mbiydzennyuy consciously assure that for the manuscript “Neuroscience education and research in Cameroon: Current status and future direction” the following is fulfilled:

- 1) This material is the authors’ own original work, which has not been previously published elsewhere.
- 2) The paper is not currently being considered for publication elsewhere.

- 3) The paper reflects the authors’ own research and analysis in a truthful and complete manner.
- 4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
- 5) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
- 6) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

I declare that this submission follows the policies of IBRO Neuroscience Report as outlined in the Guide for Authors and in the Ethical Statement.

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Conflicts of Interest

The authors declare no conflict of interest.

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