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Developing a modern radiotherapy department in a rural hospital in Cameroon: The Mbingo experience

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A B S T R A C T

Although radiotherapy is critical for cancer cure and palliation, access to such expensive and sophisticated technology is very limited in low- and middle-income countries (LMIC). Cancer incidence in Africa is currently 1.5 million case per year, thus urgent and innovative solutions are required to build necessary infrastructure needed to address this global health challenge. We describe our approach and challenges as a faith based non-government organization in setting up a modern radiotherapy department in a rural hospital in Cameroon to mitigate this unmet need. We highlite our engagement with international bodies and individuals for fund raising and volunteerism, local radiotherapy workforce development and training (radiation oncology, dosimetrists, radiation therapist and medical physicists) and the expertise required for construction of the bunker and installation of the Linac machine.

Introduction

Radiotherapy constitutes a major component of comprehensive cancer treatment when combined with surgery and systemic therapies. Approximately 50 % of cancer patients will require radiotherapy, either for cure or to palliate symptoms during their treatment [1]. Radiation therapy contributes an estimated 40 % improvement in survival in cancer patients. However, access to radiotherapy in low and middle-income countries (LMICs) is severely limited with Africa having only 34 % of its optimal radiotherapy capacity [2]. This significantly contributes to the disparities in survival rates observed between LMICs and HICs, where access to radiotherapy is more readily available. In 2020, the International Atomic Energy Agency (IAEA) reported that only 28 of the 54 African countries have external beam radiotherapy facilities, many of which are outdated Cobalt units [3]. This situation is particularly concerning given the growing cancer burden in Africa.

According to GLOBOCAN 2020 report, 1.1 million cases and 711,000 related deaths were reported in Africa [4]. At that time, there were 430 megavoltage units in place (54 % of which were in Egypt and South Africa), representing a significant shortfall, with an estimated deficit of 1018 megavoltage units [3]. This deficit was calculated as megavoltage units per million people, and this varied from 0.02 in Ethiopia to 2.37 in Mautitius. Furthermore, in 2020, only 21 African countries had access to brachytherapy, with a total of 102 installations; 60 % of these being concentrated in South Africa, Egypt and Algeria. Also of concern, the projected incidence of cancer in Africa is expected to rise by 1.5 million cases per year by 2030, with a potential doubling of the death rate [5]. This data underscores the urgent need for increased investment and partnership in cancer treatment infrastructure across the continent.

Cameroon, with a population of about 28 million people, has only two radiotherapy facilities both located in its economic capital, Doula. These consist of a Cobalt unit in a state hospital, and a Varian™ linear accelerator (LINAC) machine in a private centre. No brachytherapy is available in the country. Most cancer patients in Cameroon face challenges in accessing these facilities due to prolonged wait times, frequent machine downtimes, and high cost of treatment, travel and accommodations, for a largely rural population [6].

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Mbingo Baptist hospital (MBH)

Mbingo Baptist Hospital (MBH) (Fig. 1) is located in a rural setting in the Northwest region of Cameroon. It currently has a 278-beds inpatient capacity. It also functions as a post graduate training facility for General Surgery, Head and Neck Surgery, Internal Medicine and Public Health through the co-located Baptist Institute of Health Sciences (BIHS).

In 2003, cancer management began with the commencement of a childhood cancer program supported by World Child Cancer organization. In 2007, the Women's Health Program (WHP) was initiated focusing on breast and cervical cancer screening. By 2010, a pathology laboratory was established and is currently manned by 2 on-site pathologist and externally supported by a telepathology program. Adult medical oncology services were introduced in 2017.

Currently, MBH assessed approximately 1000 new cancer cases annually, many of whom present with locally advanced or metastatic disease, necessitating multimodal therapies. The most common adult cancers seen at Mbingo are breast, prostate and cervical cancer (Table 1). The most common pediatric cancers are Burkitt's lymphoma, NonHodgkins lymphoma, Wilms tumor and brain cancers. While the hospital can provide surgery and chemotherapy, patients requiring radiotherapy are referred to Douala. Few patients can afford to access this service. MBH also offers a Palliative Care program for the terminal care of those with incurable disease.

The focus of this report is the development of a radiotherapy unit at Mbingo hospital.

Table 1
Cancer Statistics from Mbingo Medical Records Incident cases by year.

	2017	2018	2019	2020	2021*	2022
All	846	872	570	2038		1920
Prostate	84	101	221	154		
Breast	265	204	211	417		
Cervix	39	37	80	70		
Burkitts Lymphoma	56	47	44	78		
Leukemia			14	18		
Other	402	483		1301		

*CBC decision to change the way cancer statistics are collected across their 10 institutions.

History of the project

The pursuit toward a comprehensive Cancer Care program at MBH began in earnest with the visit of two radiation oncologists in September 2016. This visit, which included meetings with officials in Cameroon's capital city of Yaounde (this included the Prime Minister and faculty from the University of Yaounde 1). In assessing the status of radiation therapy in Cameroon, it was clear that with only one publicly available unit based on cobalt technology at Doula further access to radiation therapy was needed. The discussions recognized that the Mbingo site was strategically situated for access to treatment for those in the country's north and that a reliable hydroelectric power source was in development. The conclusion of this mission was that a radiation therapy program at MBH was feasible, and the decision was made to proceed.

In 2017, an international multidisciplinary volunteer advisory group was formed to spearhead the development of the radiotherapy program at MBH. This group comprises a diverse team of experts, including on-site specialists, and remote contributors such as civil/structural engineers, radiation oncologists, medical physicists, nuclear medicine specialists and radiation therapists. The collaboration and planning process is facilitated through monthly videoconferences, where updates on the program's needs, developments, challenges, and priorities are shared and discussed. This approach ensures a cohesive and well-coordinated effort in establishing the radiotherapy program at MBH, a crucial step in enhancing care in the region.

By 2021, the 350 kVA hydroelectric power plant funded by USAID, the North American Baptist Convention and Cameroon Baptist Convention (CBC) was completed (Fig. 2). The plant now provides a

Fig. 1. Aerial view of Mbingo Baptist Hospital.

Fig. 2. Hydroelectric power dam and power station.

consistent and stable power supply essential for operating sophisticated equipment like a linear accelerator.

Bunker shielding, design, and construction: The development of the radiotherapy bunker at MBH has been a collaborative effort involving the voluntary services of two civil engineers and two medical physicists. Their expertise was crucial in designing the bunker with its radiation shielding in compliance with the guidelines specified in the National Council on Radiation Protection Report No. 151 [7,8] (Fig. 3). The radiation shielding report and design were submitted to the Cameroon Radiation Safety office in Yaounde in September 2019. Permission to proceed with construction was granted.

A site visit in January 2020 assessed the availability of necessary construction materials and facilitated a topographic survey of the bunker site. The detailed structural concrete design follows the Canadian Standards Association CSA A23.3 "Design of Concrete Structures" [9].

Key considerations in the civil design which started in 2018 and was completed in 2022 include:

–Roof loading based on peak rainfall accumulation during the 8-month wet-season.

– Earthquake risk assessment, with historic data revealing two quakes in the vicinity of magnitude 4.8 and 4.2 in 1987 and 2005. The magnitude 4.8 quake occurred 250 km east of Bamenda, 45 km from MBH.

–Stringent dimensional tolerances for walls, ceiling heights and floor levels with acceptable differential settlement after alignment of the Linac equipment set at < 0.2 mm over 10 m per year.

–Revisions to the concrete mix design to avoid the use of expensive admixtures while retained concrete workability and strength. Local civil and geotechnical engineering and material testing firm GeoStruct provides material testing for backfill and concrete to confirm compliance to the design specifications.

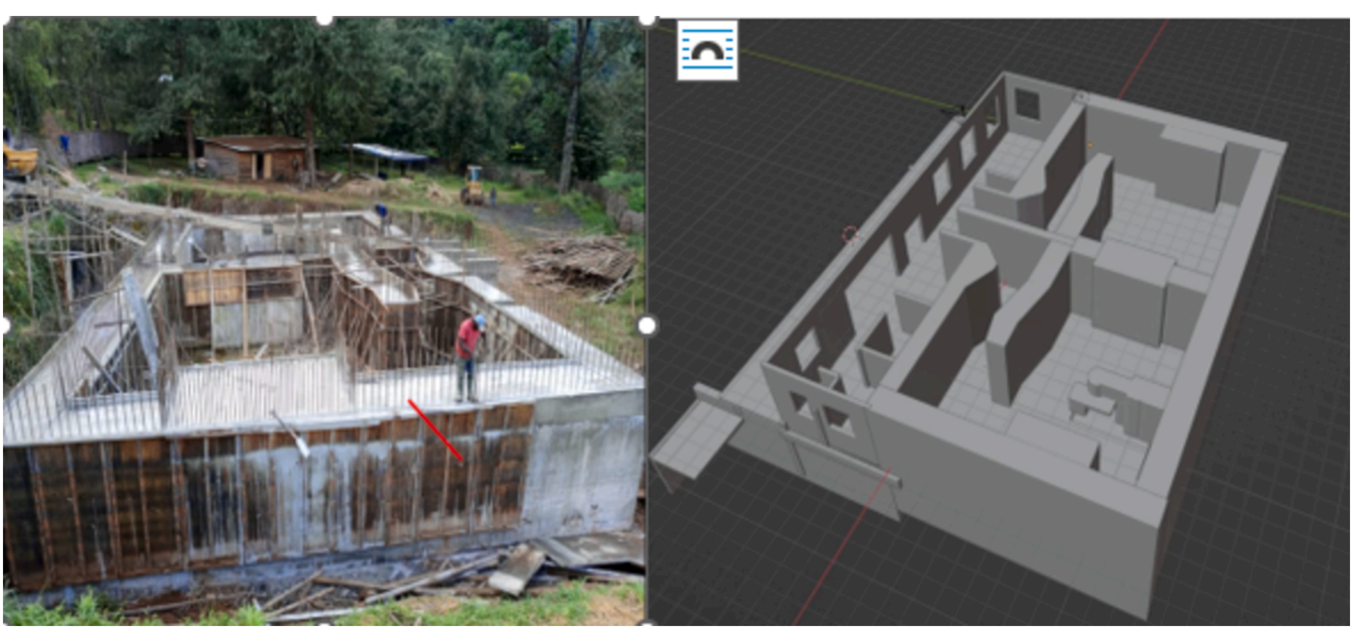

Fig. 3. Vault foundation and design.

–Cooling system design tailored to address the local humid and hot climate.

Construction began in January 2023 with weekly construction site meetings held to discuss scheduling and site conditions. The completion of the bunker is anticipated in early 2025.

Radiotherapy Equipment: A linear accelerator was donated to MBH radiotherapy treatment project (a used Varian 2100 Linac machine). This machine had been decommissioned and replaced in Wales, UK. It is ideal for several reasons.

–Though the IAEA now expects all linear accelerators to have a minimum clinical lifespan of 15 years, the donated machine had had relatively low use, and has a complete service history, having been meticulously maintained since installation. All manufacturers' updates were completed during its time at the donor centre, as it had been under a full parts and labor contract.

– In older series machines, the process to return to service after unexpected power outage is less complicated unlike the latest series of linear accelerators which are more software dependent.

–It was understood that there would be limited (or inexperienced) on-site technical support initially. With an older machine, the technical knowledge required to troubleshoot problems will be available, possibly even remotely, as the more common faults and resolutions are already known.

–One of the biggest problems with donated medical equipment is preventive and emergency maintenance. The WHO Guidelines for Medical Device Donations states that best practice is for spare parts to be available for up to 10 years after donation. Fortunately, spares for this machine are readily available, and many parts were shipped with the machine.

Education and Training Provision of Staff: Key positions required for a good functioning radiation oncology program include: a radiation oncologist, a medical physicist, a dosimetrist, and at least two radiation therapists. As there are currently no formal education and training programs for any of the radiotherapy disciplines in Cameroon, training needs to be established locally. To date, individuals who undertake training travel out of the country and have little incentive to return due to low salaries and limited employment opportunities.

Radiation Oncologist: One locally trained internal medicine physician was sent to Stellenbosch University in South Africa and has now finished training and returned to Cameroon as a medical and radiation oncologist (NAT).

Dosimetrist: Dosimetry can be done remotely, and this is quite common in the United States. Initially, this is the simplest solution and the dosimetrist will be paid according to the number of plans that are done, controlling cost.

Radiation Therapists: With the global development of online education, course work for radiation technicians/radiotherapist can be undertaken locally. The co-located BIHS as the academic structure and recognition to supervise students and provide the facilities, including internet to make this possible. The involvement of appropriate external resources remains to be procured and funded. An onsite Instructor is also needed to make such a scheme credible. Without a Cameroon national education structure for the radiotherapy workforce, the IAEA curricula and guidance provides the default standard of educational content. Until the linear accelerator has been commissioned, the practical experience for these trainees needs to be made available whether in country or internationally.

Medical Physicist: This need remains outstanding. The historic and continuing contribution of volunteers at MBH has been foundational to what has been accomplished until now. This kind of humanitarian service will continue to be needed for many years and is encouraged by the patron organization of MBH, the Cameroon Baptist Convention (CBC). The global attention to cancer services in underserved populations makes this project a timely and relevant undertaking.

Integration into the national cancer strategy

In the early 2010 s, the Government of Cameroon invited an inspection of the nation's readiness to undertake the development of radiotherapy services. In 2014 a team of senior international radiation safety experts from International Atomic Energy Agency (IAEA) undertook to review the regulatory framework for radiation safety in the Republic of Cameroon. Deficiencies in the administrative status of the National Radiation Safety Authority were highlighted and efforts commenced to rectify the situation. By 2019, the legal and administrative structures were in place and in the same year, authorization was given to commence the construction of the bunker.

The Government of the Republic of Cameroon has established a working group to advise in the setting up of a radiotherapy strategy for the nation. CBC is in the process of participating in meetings of this working group. It is through the participation in the national strategy that the resources of the IAEA become available to a private institution. Amongst other advantages, the IAEA has both resources and advice regarding the establishment of accredited training for the necessary personnel required for safe radiotherapy.

Conclusion

The development of radiotherapy facilities at MBH in rural Cameroon is a critical component of providing comprehensive cancer care, complementing the existing medical and surgical oncology services. The plans include construction of adequate patient accommodations, training for essential personnel, and enhancement of both inpatient and outpatient access. Developing partnerships for staff education, engaging volunteer specialists for supervision, validating quality outcomes, present future exciting opportunities for enhancing cancer care in this underserved region.

Funding

Despite the critical role of radiation therapy in national cancer control programs, there is at present no dedicated budget from the Ministry of Health towards the development of radiotherapy facilities in the country. Consequently, non-government organizations (NGOs) embarking on radiotherapy projects must rely on external funding sources.

An estimated 10 million USD is required to establish a radiotherapy unit. This budget would cover the construction of the radiation bunker, procurement of a dedicated CT scanner system and a Linac machine (along with necessary service/maintenance contracts). The purchase of planning software and other ancillary dosimetric equipment/software needed for safe delivery of radiotherapy are also a priority. To date, sufficient funds have been raised to commence construction of the radiotherapy bunker, construction of patient accommodations and some of the costs of training the essential staff. By 2022, adequate funding was secured to commence construction.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, et al. Expanding global access to radiotherapy. Lancet Oncol 2015 Sep;16(10):1153–86.

[2] Ige T, Lewis P, Shelley C, Pistenmaa D, Coleman CN, Aggarwal A, et al. Understanding the challenges of delivering radiotherapy in low- and middle-income countries in Africa. J Cancer Policy 2023 Mar;35:100372.

[3] Elmore SNC, Polo A, Bourque JM, Pynda Y, van der Merwe D, Grover S, et al. Radiotherapy resources in Africa: an International Atomic Energy Agency update and analysis of projected needs. Lancet Oncol 2021 Sep;22(9):e391.

[4] Sharma R, Aashima NM, Fronterre C, Sewagudde P, Ssentongo AE, et al. Mapping Cancer in Africa: A Comprehensive and Comparable Characterization of 34 Cancer Types Using Estimates From GLOBOCAN 2020. Front. Public Health 2022 Apr;25 (10):839835.

[5] Larkin HD. Cancer Deaths May Double by 2030 in Sub-Saharan Africa. JAMA 2022 Jun 21;327(23):2280.

[6] 120-cameroon-fact-sheets.pdf [Internet]. [cited 2023 Dec 18]. Available from: https://gco.iarc.fr/today/data/factsheets/populations/120-cameroon-fact-sheets.pdf.

[7] National Council on Radiation Protection and Measurements. AAPM Publications Report No 151 http://www.aapm.org/pubs/ncrp/detail.asp?docid=27 Accessed 2Jan2024.

[8] NCRP-151: Linac Vault Shielding/Oncology. https://oncologymedicalphysics.com/vault-shielding-ncpr-151/ Accessed 2Jan2024.

[9] CSA A23.3 Design of concrete structures GlobalSPec https://standardsglobalspec.com/std/13372740/CSA%20A23.3 Accessed 2Jan2024.