PERSPECTIVE ON RADIATION THERAPY IN ZAMBIA INVOLVING ALTERNATIVE TECHNOLOGIES

Abstract

Radiotherapy was not available in Zambia until 2006, and its citizens had to seek cancer treatment in neighbouring countries. This paper sheds light on the phased approach to developing a cancer control service at the national level involving alternative technologies with a perspective on experiences, potential pitfalls, and good practice recommendations.

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INTRODUCTION

Radiotherapy – a nuclear technology that is used in cancer treatment – was not available in Zambia until 2006, which at the time had a population of approximately 13 million people. Before 2006, Zambians had to seek cancer treatment in neighbouring countries. In response to this need, Zambia began constructing a cancer treatment facility at the University Teaching Hospital (UTH) in the capital city of Lusaka. It had been projected that the national cancer centre would be capable of treating some 1,200 patients per year, which would substantially cut healthcare costs and promote early diagnosis and treatment of the disease. Today, the Cancer Diseases Hospital (CDH), which was set up as an institution independent of UTH, exceeds this projection and sees about 3,200 new cancer patients per year, approximately 50-60% of whom receive radiotherapy as a treatment modality. Throughout the years, the CDH has gradually grown in patient numbers and service provision to the point of saturation, necessitating both expansion and decentralisation. To this end, good planning – as opposed to a haphazard approach - is essential, and scaling up service provision would be impossible without a proper vision and stakeholder buy-in. This paper sheds light on the phased approach to developing a cancer control service at the national level involving alternative technologies with a perspective on experiences, potential pitfalls, and good practice recommendations.

BACKGROUND

The massive funds spent by Zambian government to enable cancer patients to seek treatment outside the country was the impetus in establishing the country's first radiotherapy centre. In as much as treatment abroad was possible, only 350 of the 5,000 cancer patients were sent abroad between 1995 and 2004 with government support. Given the out-of-pocket cost of approximately 10,000 USD, only a privileged few could afford to access cancer treatment mainly in neighbouring countries like Zimbabwe or South Africa. Zambia began constructing a radiotherapy facility at the University Teaching Hospital in the capital city of Lusaka in 2003. Radiotherapy, a nuclear technology that is used in cancer treatment, was not available to the then-13 million Zambians until 2006. Zambia was cognisant of the need to have local access to radiotherapy, which is evidenced by political will displayed by the government: it agreed to obtain a loan from the OPEC Fund for International Development in 2001. Prior to that, in 1995, the International Atomic Energy Agency (IAEA) had approved a technical support project for Zambia with the objective of establishing a radiotherapy facility to treat the growing number of cancer patients locally.

SUMMARY OF THE PROJECT

The Cancer Diseases Hospital (CDH) came about due to the need in providing the Zambian population with local access to radiotherapy, which was at the top of the agenda for the Ministry of Health (MoH). In 2003, the foundation stone for the construction of the first radiotherapy facility in Zambia was laid. However, the facility was built without accommodating for bed space, which was hampering the quality of care and led to the inception of a CDH Phase II project. The main aim of this project was to equip and provide hospital accommodation for patients. The CDH expansion to include wards and extra radiotherapy equipment was completed in 2017. The two milestones of the CDH Phase I and II displayed strong commitment from professionals involved in the management of cancer patients. The span of 10 years from the official opening of the facility in July 2007 to 2017 when the hospital expanded in capacity had its share of challenges and lessons learned. Since its inception, the CDH has seen over 22,000 new cancer patients. Cancer registry Globocan estimated at least 13,381 new cancer cases in 2020. Of the new patients diagnosed with cancer in Zambia, an average of 3,500 access the CDH for treatment, implying the need to increase access to radiotherapy. Decentralising this service is imperative, which led to the conception of the CDH Phase III project seeking to address equity of access to radiotherapy for all Zambians, which is now ongoing.

1. Cancer Diseases Hospital Phase I

Being a pioneer in the field of radiation therapy in Zambia would not have been possible without the pillars that transformed this "greenfield" facility into a regional resource. The decision to make radiotherapy available in Zambia was the beginning of a socio-economic benefit to the many Zambians who might not have otherwise had the chance to receive any form of treatment for cancer. In the early 2000s when the radiotherapy facility was in its infancy stages, the MoH's guiding principle was to ensure that all Zambians have "equal access to health as close to the family as possible". The country had a major diseases burden with cancer being a pressing issue alongside HIV, malaria, as well as a number of other communicable diseases. In 2002, the project was kickstarted with an approved loan from the OPEC Fund for International Development of 5.6 million USD in total given to Zambia, plus 400,000 USD from the Zambian Government through the MoH Project Coordination Office. The total project budget was 6 million USD. The components of the project covered training, civil works, equipment procurement, and cancer awareness programmes.

The International Atomic Energy Agency (IAEA) Technical Cooperation Project, ZAM 6010 - Establishing a Radiotherapy Facility provided support by awarding fellowships to 11 trainees, which were broken down as two radiation oncologists, four medical physicists, three radiation therapists and two biomedical engineers. Unfortunately, two of the four medical physicists could not complete the training. Local technical expertise in radiation therapy was absent at the time, and the IAEA-Technical Cooperation filled this gap to a large extent by providing technical experts in architecture and construction. The expert support was provided to advise on architectural design, progress review during construction, advice on bunker design, reinforcing shuttering and overall timing of the project to ensure all key milestones were

achieved in the final clinical operation of the facility. Clinical start-up meetings in which experienced radiation oncology experts provided advice to the government on the staff structure were required before beginning clinical operations. One major outcome of the clinical start-up meetings was that the MoH heeded the advice to establish the CDH as an independent grant aided institution rather than as an additional department to an already existing hospital.

For a newcomer country adopting radiotherapy, selecting the right equipment can be a daunting task, as the process might be biased or influenced by external factors. Thus, it is vital to draw attention to Zambia's approach to ensuring the first radiotherapy equipment was installed and functional in the country. Capital investment in equipment and sustainability thereof are crucial components. The choice of equipment was based on what the budget could accommodate and also on the fact that after securing a loan, the country had the liberty to select equipment that would be most suitable to address its particular needs. Zambia sought guidance from the IAEA. The CDH decided to acquire a Co-60 unit, a linear accelerator (LINAC), and an HDR brachytherapy device at the same time due to the various types of cancers that needed to be treated and the need to ensure that all patients received adequate treatment.

Figure 1: Linear Accelerator (LINAC) installed in 2006

Co-60 and the LINAC (6 and 10 MV photons plus electrons) machines are both external beam radiotherapy, while each have different penetrating abilities. Certain cancers, such as skin, head, neck, cervix, and prostate require LINAC radiotherapy, particularly if the patient is overweight. Cervix cancer requires both external beam radiotherapy and HDR brachytherapy. Thus, so far as cervix cancer was the most widespread in Zambia at the time (and continues to be), it was best to have all the recommended treatment options available. Treating larger patients on Co-60 machines results in high bowel toxicities, meaning there is a limit on the thickness (patient distancing from the source is measured according to the area to be treated). Higher LINAC photon energies deposit the dose deeper, making it possible to reduce side effects.

The first personnel representatives were trained when the country decided to set up a radiotherapy facility in the mid-1990s, and later they provided guidance on developing proposals and encouraging the government to pursue this project. By 2000, a project document had been submitted to the Ministry of Finance (MoF) and the funds for developing first architectural drawings, seeking trainees, and compiling a list of equipment were set aside.

The regulatory framework and infrastructure were replaced in 2005. This, in part, was driven by the introduction of radiotherapy into the health sector. The use of ionising radiation to treat

cancer was new, and as such, required appropriate laws to govern it as well as to ensure safety and radiological security. The owners of the radiotherapy facility had to be accountable and ensure public safety and that trained and qualified staff were operating the radiation emitting equipment for the benefit of patients. To this end, the Ionising Radiation Act of 1972 was replaced with the Ionising Radiation Protection Act No. 16 of 2005 with its amendment Act No. 19 of 2011. The push was also a result of the IAEA guiding the country to ensure the basics were in place prior to beginning treatment. The stringent licensing procedures for a radiotherapy facility must be complied with for safety and quality purposes.

The first LINAC was acquired in 2006 and remains the only one in the country. Furthermore, it has not been replaced. Phase I involved building only one LINAC bunker and two cobalt unit bunkers. The LINAC, which is a Siemens Primus, was one of the last machines of this model and is no longer manufactured. Together with other major and auxiliary radiotherapy equipment for quality assurance (QA) and dosimetry, the LINAC was under a service contract for repair, maintenance, and calibration. This contract also included a provision for radioactive sources. A local Siemens agent fulfilled all these functions. The auxiliary equipment was bought under the same purchase contract as the LINAC, Co-60 (MDS Nordion T789E), conventional simulator, HDR brachytherapy (Nucletron), dosimetry and QA equipment (through PTW, which is a global provider of QA).

2. CDH Phase II

The commissioning of radiotherapy equipment was done after assuring the safety and quality of radiotherapy services, which was the goal set right from the beginning. Ideas to expand the hospital appeared as early as 2009 when the OFID personnel encouraged Zambia to do so given the success of commissioning a radiotherapy facility that was steadily increasing in patient numbers. It was apparent that in-patient facilities were necessary as well as other pertinent services that were either done in a very small working area (thus limiting the number of patients seen per day) or were completely absent. The radiotherapy service value chain was established and the strengths drawn from Phase I of the project were used to propel the next phase. These strengths included equipment, infrastructure, capacity building, and strategic planning. The initial Phase I section of the hospital had empty bunkers (treatment rooms), which needed to be filled. Therefore, equipment was purchased to fit into the already existing bunkers, namely a Co-60 unit and a high dose rate brachytherapy unit. A computed tomography scanner and magnetic resonance scanner were installed much earlier in 2010 and were fully funded by the Government Health Infrastructure Funds.

By the end of 2015, the CDH was a fully functional hospital with an in-patient bed capacity of 256, a new laboratory, medical imaging and nuclear medicine equipment, as well as other auxiliary services. This set the stage for the hospital to offer other oncology services as a one-stop shop.

3. CDH Phase III

Whereas international organisations had provided inferred projections on the incidence of cancer in Zambia before, the existence of a local cancer treatment facility allowed for more accurate data on cancer incidence in Zambia, further enhancing the accuracy of the Zambia National Cancer Registry. The decision to expand was based on the experience of witnessing the steady increase in the numbers of patients at a single facility and the limits of that facility in terms of equipment and infrastructure to accommodate past a certain number of patients. The expansion plans include other locations within the country.

Second, the vision to become a Regional Centre of Excellence and a national hub for oncology services also informed the expansion plans in that it was decided that the CDH should function as a referral for the region by improving services offered. This demonstrates an improvement in trying to fit the planning to address specific local needs. The target of location, infrastructure, professional expertise, and service design were all drawn from a trend analysis of cancer type, province with the highest number of patients, existing hospital infrastructure, and a centrality of location in relation to other provinces. The locations chosen were towards the north and south of the country. These facilities would serve the northern and southern regions of the country and would house radiotherapy, nuclear medicine, medical imaging, chemotherapy, and other major support services.

Phase III – which was scheduled to commence in 2016 – began with needing to get governmental approval. This involved collecting the necessary documentation and obtaining the signatures from the MoF as the custodian and signatory to all national debt. The process turned out to be lengthy due to certain intricacies and ensuring that the loan requirements are satisfied. Clinical professionals, such as radiation oncologists, medical physicists, radiation therapists, oncology nurses, nuclear medicine physicians, and pharmacists were involved in the project's planning and execution phases. These professionals performed the final approval of the architectural design in order to ensure that the functionality is suitable for oncology and nuclear medicine services.

As of 2021, the project has begun, and a project consultant has been contracted. Zambia is in the phase of the site and equipment selection, approval of the drawings, and personnel training. The construction has not yet commenced. Phase III will transform the CDH into a centre of excellence with the addition of an extra bunker and new equipment.

The equipment list will include linear accelerators, which require specific bunker designs. Such a decision has been made, because the CDH is confident in its ability to provide the maintenance of LINACs locally. The CDH had planned to replace the existing LINAC as part of Phase III, however the phase did not begin on time. Had it gone according to the plan, the LINAC would have been replaced in 2018. Previously, there had been a debate organised among physicists, radiation oncologists, and radiation therapists, after which the involved professionals agreed not to support purchasing additional Co-60 machines. This was due to the recent global tendency to phase out Co-60 units. However, then the India-made Bhabhatron entered the market. CDH became the third hospital in Africa that will receive such a Co-60 teletherapy unit. Zambia will probably continue to use Co-60 machines for another 5-

10 years. The updated plan is to replace one only if the technical specifications are favourable (shielding and footprint).

PROJECT ORGANISATION

Placed under the auspices of the Ministry of Health, a project implementation unit (PIU) was appointed comprising various stakeholders from both government ministries and civil society as well as international organisations based in Zambia. The PIU had the task of overseeing the individual project phases from start to completion (progress reporting to the MoH and funders, conducting the procurement processes based on the Zambia Public Procurement Authority procedure, monitoring of trainees through reports received and visitation to training sites). It reported to a director who in turn reported to the permanent secretary. As the end-user ministry, the MoH held the executive role of managing the contractor and triggering payment milestones through the MoF. Also part of the project organisation were cancer awareness campaigns, which were put together with the help of civil society organisations involved in this issue. The objective of the awareness campaigns was to inform citizens of the new cancer treatment facility and to encourage screening. Medical personnel were also educated on the referral process to the CDH once operational and also to make them aware that such a facility was being constructed and therefore other services should be ready to take up the increase in service demand.

Figure 2: CDH in-patient (Phase

REGULATORY AUTHORITY

The Zambia regulator, the Radiation Protection Authority, as it is known today, had to complete its part of the task when the radiotherapy centre (CDH Phase I) was nearing completion and official opening. The CDH was the first radiotherapy facility that the Radiation Protection Authority had to license in the country, meaning that there was a need to ensure the necessary legal infrastructure and framework was available and conformed with the international standard to allow for the licensing, importation of radiation sources, and provision of guidelines. The Ionising Radiation Act of 1972 was repealed and replaced by the Ionising Radiation Protection Act No. 16 of 2005 and its amendment No. 19 of 2011.

There was a symbiotic but independent relationship between the regulator and the radiotherapy facility (more so at the time of its transitioning from being a project into being a functional hospital). The regulator's role was clear and set in the legislation: to issue an operational license to the facility as long as all required conditions were fulfilled. The conditions, among others, included ensuring that the staff operating the radiation emitting equipment were qualified, adequate equipment shielding was confirmed, the equipment was

correctly calibrated, pre-installation requirements were met, and that the right documentation was in place (such as quality assurance and quality control procedures).

Rigorous work had to be done in order to have the right legal framework for construction and eventual operation of the radiotherapy facility. The IAEA Department of Technical Cooperation provided experts for many radiation safety consultations. This meant that the IAEA would be a source of suitable experts. Zambia just had to file a formal request to the Agency and take the necessary actions to ensure the experts could be present during construction. Towards the completion of the construction and eventual installation of equipment, the PIU hired the medical physicist who was first to return after training and took up the role to ensure the hospital would become functional. The medical physicist's primary role was to ensure all the regulatory requirements were met, to oversee the final works during construction, to observe the installation process, and to perform acceptance testing of the equipment.

Regulatory obligations had to be met. The environmental project brief for the construction of the CDH outlined that the construction of the facility, importation, exportation, transportation, and use of the radiation sources would be in accordance with the provisions set out in the Act and statutory instrument No. 171 of 1992 and the regulations of 1992. There were a number of shortcomings in the law that necessitated an update, something that had been consistently highlighted in the feedback from IAEA experts and during bilateral meetings. Subsequently, the law was updated in 2005 and 2011.

STAKEHOLDERS AND PARTNERS' COORDINATION

The OPEC Fund for International Development (OFID) gave Zambia two loans for facilities during Phase I and II. Co-financiers of Phase I and II were the OFID, IAEA, and the Government of the Republic of Zambia. Phase III is funded by the Arab Bank for Economic Development in Africa (BADEA) and is currently underway. The project budget is 25 million USD with the government putting up 3 million USD and BADEA 22 million USD.

The responsibility for coordinating the project lies with the MoH and the MoF. As a signatory to the loan, the MoF processed all fund disbursements through the Project Coordination Unit, which was responsible for bilateral and multi-lateral cooperation, for approval by the OFID. The OFID has particular interest to see the project completed and the radiotherapy centre functional. Progress reports were provided on a quarterly basis with respect to construction progress, training schedules, equipment procurement, and clinical implementation. The equipment was procured following the Zambia Public Procurement procedure, and the 'no objection' to proceed was obtained from the OFID at each milestone during both construction and equipment procurement.

The University Teaching Hospital was overseeing the clinical implementation of the project. It identified and coordinated the selection of candidates for training, assisted in CDH Phase I design, and conducted awareness campaigns in collaboration with civil society organizations.

The IAEA supported training and civil works through fellowships and expert missions respectively under the technical cooperation ZAM 6010 project. Bi-annual progress report were submitted to the Project Management officer at the IAEA. The TC project was an IAEA funded project that was approved in 2003 and ran for four years. The contribution of the IAEA through ZAM 6010 is estimated to be approximately 1,120,900 Euro, which covered the expenses of fellowship training and traveling costs of sending experts to Zambia. Through this project, the MoH Radiotherapy PIU was able to receive expert advice in various aspects, in particular for civil works and clinical implementation for CDH Phase I.

There has been progressive improvement in terms of infrastructure and capacity building of the CDH. The motivation has been to gain experience and skills to further improve on what already exists. The CDH had three developmental phases, which culminated in a desire to have a 'hub-and-spoke' kind of service (the CDH in Lusaka becoming the main referral hospital and regional Centre of Excellence). To support this approach, the MoH endorsed the ImPACT Mission by the IAEA, and a National Cancer Control Strategic Plan 2016-2021 was one of the outputs. This has been a guide towards a number of activities aimed at addressing the cancer burden in the country from screening to treatment.

OPERATIONAL CHALLENGES

The MoH project implementation unit consisted of a project coordinator, architect, quality surveyor, civil engineer, and accountant as key members. The project coordinator was responsible for overseeing and managing the timely delivery of the project. The timeframe of the project had to be adjusted due to certain considerations that were technical in nature but that were beneficial to the final outcome of the project. For instance, the construction of radiation bunkers required expertise that was not readily available within the country, meaning that these experts had to be sourced outside of the project budget and a justification provided. The result was not detrimental but contributed to the project's delayed completion. The choice of equipment was also based on what the budget could accommodate at the time, and no extra budget was allocated at the time of executing Phase I. However, in 2010, the Government funded the purchase of a computed tomography scanner and a magnetic resonance scanner, both of which complemented the equipment purchased under Phase I.

Phase II experienced challenges to project implementation that were related to policy changes. The introduction of a statutory instrument required prices to be quoted in the local currency, which then in turn had a negative impact. Any delays in payment resulted in losses on the foreign exchange level as the majority of the equipment was purchased from outside the country and can impact on profit margins or even change drastically change (usually increment) the cost of acquiring a particular equipment.

The main challenge throughout the years was paying the high cost for service and maintenance contract which can take its toll over the years. During the first five years CDH did not face a major problem. The next five years became a bit more challenging and major breakdowns started occurring. CDH had to replace the LINAC magnetron in 2015 and then

again in 2020. Physical protection in the Co-60 bunkers was installed at no cost for the hospital with the support of the US Department of Energy through the Pacific Northwest National Laboratory. The Zambian Radiation Protection Authority organised the process.

SUSTAINABILITY AND LOOKING TO THE FUTURE

The CDH Phase I was designed to house two high-dose rate Iridium 192 brachytherapy units, two Co-60 teletherapy units, one linear accelerator, an orthovoltage, a conventional simulator, and a CT scanner. Later, a magnetic resonance room was added as an extension to the existing building. Initial equipment that was purchased included a HDR brachytherapy unit, orthovoltage, Co-60 unit, linear accelerator, conventional simulator, and mammography machine.

The CDH had been aware of the need to prepare for the repatriation of the Co-60 source to the country of origin, which occurred through a service contract for the radiotherapy machines. A provision for purchase of a new source was incorporated into a five-year service and maintenance contract. In the seventh year of operation, the Co-60 source was changed out for the first time, and the used source taken away. Part of the conditions for the use and possession licence requires a commitment from the source supplier that the source will be taken back at the time of a source exchange.

Figure 3: Cobalt 60 source exchange at CDH

The CDH has continued to have service and maintenance contracts with the local representative of the machines housed in the hospital, which has enabled the hospital to continually provide this service to patients for nearly 15 years. The only drawback of the equipment is that some of the machines were being phased out of production, and as a result, maintenance support for these became a challenge and increased downtime. The CDH is now in the process of using a phased approach in replacing all the equipment that is older than 10 years. The first cobalt 60 unit Theratron T780E will be decommissioned by December 2022, the process has already been initiated.

Figure 4: A training session taking place with an expert

Capacity building has helped strengthen skills and has been a motivating factor for the radiation oncology team. Over the years there, has been continuous mentoring from institutions in high income countries. There was a need to continually improve the quality of radiotherapy delivery, and various strategies were employed to do this. Some examples of strategies undertaken include didactic training, exchange programmes, and a proof-of-concept type of project on compensator intensity modulated radiation therapy.

The hospital has also managed to establish local training programmes in radiation therapy and clinical oncology. This will ensure local capacity building is done at a much lower cost, allowing more people to be trained. Because the expansion of radiotherapy services requires trained labour, the CDH Training College is receiving teaching assistance from institutions in the USA and UK via online teaching.

RECOMMENDATIONS

Figure 5: Architectural drawing of one of the new radiotherapy facilities under Phase III

- ✓ **Leveraging Political Will**

  The connection between human health and governance cannot be delinked. Health plays a vital role in keeping the social economic aspects in check and preserving a tenacity of hope in a nation of people who hold on strongly to values and traditions. Having a robust infrastructure for cancer management and urging governments to view nuclear technology as a sustainable development investment must be done with the utmost care and a full trajectory of how, what, why, when, and for whom. At the helm of any nation's human health is knowing that there is a solution, that political leadership has a will to implement it, and to use its power as a vital tool.

- ✓ **Human Capital Investment**

  Any good investment will fail to attain its intended goal without the right human skill base, technical know-how, and self-motivation. The reality is that the pursuit of good return on investment lies in the human input and a match to the level of technology. There is little good when a highly skilled professional is given an outdated tool to work with as it limits potential capabilities. Internationally training personnel are exposed to the value of proper and sound investment with the aim to deliver a holistic sustainable service that can stand the test of time.

- ✓ **Endorsement by Stakeholders and Partners**

  The support from international and local organisations, world-renowned international cancer hospitals, experienced health professionals, and global funding agencies is priceless. They are shaping the future of Zambian oncology and creating a solid foundation for the proper transfer of skills, knowledge, and experience. The goal is to maintain continuity, and it is not always turn-key solutions that work but buy-in into the national strategic vision and aspirations that provides sustainability. A national vision must be established and this can then be used to leverage support.