Evaluation of radiotherapy facilities in Cameroon: case of the general hospital of Yaounde; how good are we?

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ABSTRACT
The increase in cancer incidence has led to an alarming increase in mortality rate worldwide. Africa and Cameroon especially as such necessitates the assessment and establishment of improved radiotherapy facilities for a better well-being and increase life expectancy. We carried out a retrospective, transversal, and quality study of facilities during a period of 29 years in the General Hospital of Yaoundé (GHY) using questionnaires and data sheets related to External Beam Radiotherapy and Brachytherapy. We used Epi info software to analyze the data. Our results show that no radiotherapy facility from the creation of the GHY until 2017 ever attained the normative score of 100%. The indicator related to the staff had 15 a normative score of 80.84%, equipment 18.18% and infrastructure 75%. The most represented staff specialty was radiotherapy technicians (RTTs) with 42.86%, each of the following were just 14.29%, radiation oncologists (RO), medical physicists (MP), and engineer. The staff was fairly knowledgeable on the major types of cancer, main causes and treatment methods. 28.58% of them had a mastery of radiotherapy, 28.57% knew the essential equipment needed for a brachytherapy unit and 46.67% for an external beam therapy. This calls for great need to improve radiotherapy facilities.

KEYWORDS
Radiotherapy; equipment; staffing; infrastructures

1. Introduction
The incidence of cancer is increasing, particularly because of the increase in life expectancy arising from worldwide improvements in standards of living. According to recent estimates of the International Agency for Research on Cancer (IARC) and World Health Organization (WHO), approximately 10 million new cases of cancer are being detected per year world-wide with slightly more than half of the cases occurring in developing countries (IAEA,Vienna 2008), with more than 6 million of dead recorded worldwide in year 2012. By the year 2015, this number is expected to increase to about 15 million cases of which two thirds will come from developing countries (IAEA,Vienna 2008). Worldwide, cancer already kills more individuals than HIV/acquired immune deficiency syndrome (AIDS), malaria, and tuberculosis combined, and these trends are projected to increase as populations in the developing world age and adopt western lifestyles (IARC,GLOBOCAN 2012). An estimated 500,000 individuals in Sub-Saharan Africa died from cancer in 2008 (IARC,GLOBOCAN 2012). While global cancer mortality is expected to increase by 104% by 2020, increases in death rates will be about 5-fold greater in the developing world, compared to the established market economies. Sub-Saharan Africa is unprepared to meet this growing disease burden if radiotherapy centers are not improved to meet demands. Knowing that in addition to the accumulating risks associated with diet, tobacco, alcohol, lack of exercise and industrial exposure, the developing world is already burdened by cancers some of which are attributable to infectious diseases. These disparities in cancer risk combined with poor access to epidemiological data, research, treatment, cancer control and prevention combine to result in significantly poorer survival rates in developing countries for a range of specific malignancies.

Among all cancers, lung, cervical, breast, colorectal, and prostate are by far the most common and treatment modalities include: radiotherapy, chemotherapy, hormonal therapy, adjuvant therapy, immunotherapy, and surgery. Radiotherapy being one of the methods of treatment is a specialty which uses complex equipment and ionizing radiation for the delivery of treatment of different types of cancers. It is estimated that approximately 3300 teletherapy machines are currently installed in developing countries. This figure is below the estimated needs of almost 5000 and about 15,000 machines by the year 2020 (IAEA,Vienna 2008). Taking this into account and in addition to the great need for trained and qualified professionals (radiation oncologists (RO), medical physicists (MP), radiotherapy technicians (RTTs),
radiation protection officers (RPO), dosimetrists (DM) and maintenance engineer (ME), the future development of teletherapy infrastructures for cancer treatment appears to be a substantial undertaking.

In Cameroon, a developing country in central Africa, there is actually one teletherapy machine and four radiation oncologists serving a population of 25 million, both of whom are based in the capital of Yaoundé and economic capital Douala. Efforts led by the Ministry of Health to subsidize generic chemotherapy and to screen for cancer have been seriously under-funded, so that many patients who are diagnosed with treatable cancers die unnecessarily. According to the Globocan estimate 2012, breast cancer is the most frequent cancer in women with an incidence of 35.25 per 100,000 in Cameroon (Sando, et al., 2015). Many low and middle income countries (LMIC), which face with this double burden of breast cancer and collar of uterus must put in practice combined intervention of a good report, cost/efficiency, and accessible to attack these diseases that can be foreseen (Sando et al., 2015; Calmon Teixeira, 1990). Breast and cervical cancers are the leading types of cancers related to morbidity and mortality in sub-Saharan Africa where they account for 45.4% of new cases of cancers among women in 2012 (Feelay, Shin, & Bray et al., 2008; Mathers, Bemand, & Ibug et al., 1999). This rapid increase in cancer incidence necessitates the establishment of standard and improved radiotherapy facilities for a better wellbeing of our society and increase life expectancy.

Based on these statistics, we thought it is wise to carry out an evaluation of teletherapy infrastructures in Cameroon so as to know our improvement level compared to the standards recommended by IAEA and other international organizations and committees become a necessity. This study is based on the use of external beam therapy and brachytherapy with the purpose to evaluate the improvement of the radiotherapy facilities in Cameroon from its creation until 2017. This focus on the identification of external beam therapy and brachytherapy users, the evolution of equipment and qualified staffing. The result of our investigations will be compared to the international recommended standards in equipment and in qualified staffing, to some European and African results. These results will help us to establish deficiencies in equipment and skilled personnel and the causes of such failures. These results will also serve as a useful baseline to be taken into account before the establishment of new radiotherapy departments in Cameroon.

This study was aimed at presenting to the Ministry of Public Health data or information which is very relevant in the improvement of radiotherapy facilities, knowing how good we are compared to the standards of IAEA, proposing recommendations regarding staff and equipment, to fight against increasing cancer incidence, help in the prevention of morbidity and mortality. The methodology and data analysis procedures used in this study were scientifically valid. During data collection, there was sufficient monitoring to remain scientific and maintain the quality of the data collected.

2. Materials and methods

This was a retrospective cross sectional hospital-based study (GHY) targeting administrative and technical staff of the radiotherapy unit alongside its infrastructure and equipment. Sampling was exhaustive involving those working in the therapy unit with at least 3 years of work experience and involved a total of 10 workers.

When the questionnaire and informed consent form were developed using the software Epi Info version 3.5.4, the data collection tools were pretested and validated. All these were then submitted to the ethical committee of the Department of Physics of the University of Dschang for ethical evaluation and approval. Also, an administrative authorization was obtained from the GHY. Collection was done by a single interviewer. All eligible participants who were willing to participate were enrolled in the study. The interviewer at the level of the hospital had to introduce himself, briefly described the aim of the study and the procedure of the data collection. With the approval and help of the chief of the therapy unit, eligible participants were identified and the information notice was explained to them and a questionnaire given to them individually.

During the conception of the data entry sheet, we introduced conditions, which prevented the entry of wrong data.

The data were double-entered, compared, and cleaned before analysis. For those who accepted to participate in the study, a questionnaire was administered to them face to face. Their general characteristics, socio-demographic and economic variables (age, sex, monthly revenue, working experience in domain of speciality, main types of cancer in Cameroon and possible causes, methods of treatment, types of treatment, essential equipment and staff required, knowledge of radiotherapy and cancer attitude vis-à-vis radiotherapy facilities in Cameroon, evaluation of staff and equipment level, problems encountered, and reasons for such a pace of radiotherapy facilities). Another data sheet was given to the chief of the unit for retrospective analysis of staff, equipment, and buildings since the creation up to 2016.

All the filled questionnaires were verified and validated by the field supervisor. These questionnaires were then transferred to the principal investigator (PI) for conservation. The data capturing or entry sheet was developed using Epi Info version 3.5.4 software.
The data from the validated questionnaires were double-entered, compared, cleaned and analyzed. The major analyses involved included calculation of frequency and their confidence intervals at 95% (for qualitative variables such as monthly revenue, working experience, type of cancers, essential staff and equipment), and mean or median (for quantitative variables such as age of participant).

3. Results and discussions

3.1. Characteristics of participants

Out of the 10 people contacted for the study, two persons indirectly denied to participate, giving us a non-response of 20%. We excluded one person who did not meet up our inclusion criteria.

The center received about 25 patients 2 years after its creation in 1989; this number rose to 150 in 1990, fluctuated from 1990 to 2001 and got to a deep in 2002. The number steadily rose from 2003 and got to its peak in 2008 with about 350 patients. The number gradually reduced until 2012 when the center was temporarily closed though patients kept coming after this said period (see Figure 1).

3.2. Results for the staff

In Figure 2, the curve in green indicates standard number of personnel for a center having an annual number of 1000 patients as prescribed by the IAEA. Since the GHY receives an annual number of about 350 patients, we therefore derived another standard for a center treating less than 400 patients per year, which is indicated in red. The blue curve indicates the number of personnel in the GHY.

The therapy center from its creation in 1987 had one medical physicist and was in conformity with the standard prescription until 1991 where it fell out of the norms and had no medical physicist. This situation remained level for the next 14 years, and only had a remedy in 2005 with the arrival of one medical physicist. This then continued until 2016 (See Figure 2).

The center started in 1987 with 2 RTTs and was operating below the norms until 1990. It later stepped above the norms in 1991 having 4 RTTs and remained constant for the next 8 years. The number dropped to the norms of three RTTs in 1999 and remained the same until 2011. In 2012, the number went out the standard prescription by reducing to 2 and finally got to 1 RTT in 2016 (see Figure 3, Figure 4 and Figure 5).

![Figure 1. Annual number of cancer patients at the GHY.](image1)

![Figure 2. Number of medical physicists.](image2)

![Figure 3. Number of RTTs.](image3)

![Figure 4. Number of oncology nurses.](image4)

![Figure 5. Number of dosimetrists.](image5)
There has been one oncology nurse from the creation of the center in 1987 until 2009. This number got to a peak of two oncology nurses in 2010 but dropped to one in 2011. From 2013 until 2016, the center did not have any oncology nurse.

There has never been any dosimetrist in therapy center of the GHY from its creation in 1987 until 2016.

The center operated under the norms of two ROs from 1987 to 2009. The number later reduced to one RO in 2011 and remained the same until 2016 (see Figure 6).

From 1987 to 2016, the center has had one engineer (see Figure 7).

### 3.3. Results for equipment

In Figure 8, the curve in red represents the standard equipment recommended by the IAEA for a center treating an average of 1000 patients annually while that in green represents the standards for a second tele-therapy unit. This second tele-therapy unit is to ensure workflow, avoid over-crowding and enhance efficiency. The curve in blue represents the number equipment in the GHY.

The center has been in conformity with the norms from 1987 to 2016 by having one sample clinical device (see Figure 8).

There has never been a single photon unit since the center was created (see Figure 9).

There has never been any CT-simulator since the creation of the center in 1987 (see Figure 10).

From 1987 to 1992, there was no orthovoltage unit. From 1993 to 1994, the center had one ortho-voltage unit thereby operating under standard prescriptions. This number fell back to zero in 1995 and continued until 2016 (see Figure 11).

From 1987 to 2004, there was no TPS. From 2005 until 2008, the center had one TPS thereby operating...
under standard prescriptions. This number fell back to zero in 2009 and continued until 2016 (see Figure 12).

The center has never had any patient immobilization device (see Figure 13).

From 1987 to 2016, there has been a cobalt-60 machine in the center. Norms respected (see Figure 14).

No linear accelerator machine from the creation to date as seen in Figure 15.

3.4. Results for buildings

There has been one mega-volt bunker from the creation of the center until 2016 as seen in Figure 19.

There has been one X-ray bunker from the creation of center until 2016 (see Figure 20).

There has been one simulation room from the creation of center until 2016 (see Figure 21).

There has been one dark room from the creation of center until 2016 (see Figure 22).

The therapy unit has had one dosimetry planning room from 1987 to 2016 (see Figure 23).

No HDR bunker from 1987 until 2016 as seen in Figure 24.
No mold room from 1987 to 2016 as seen in Figure 25.
The center has had one LDR bunker from its creation in 1987 until 2016 (see Figure 26).

3.5. Discussion

This study was designed to assess radiotherapy facilities in the GHY. More specifically, to evaluate the staff and their knowledge on radiotherapy, determine the evolution of equipment and staffing from the creation of the center until 2016, compare the level of the GHY to norms prescribed by international organization and see how good we are, give possible problems for such a pace and propose recommendations.

To respond to the above objectives, we carried out a cross sectional hospital-based study targeting administrative and technical staff of the radiotherapy unit of the general hospital of Yaoundé. A multistep cluster sampling method was used to select...
participants. This was to assure for the internal and external validity of our results.

Key results of this study indicate that most of the participants were above 50 years of age, probably driving toward retirement and arising needs to ensure continuity. The most represented specialty was the RTTs with 42.86%, each of the following were just 14.29%, RO, MP, and engineer. Results showed that all the participants were fairly knowledgeable on the major types of cancer in Cameroon, main causes of cancer, treatment method, but just 28.58% of participants could give a precise and concise definition of radiotherapy. This calls for great need of continuous training programs and seminars to enhance performances, which are scarcely attended by participants. It was amazing to notice that very few participants knew the essential equipment needed for a brachytherapy unit (28.57%) though some attempted those needed for an external beam therapy.

3.6. Staff

The number of staff actually involved in the operation of a radiotherapy service can vary between centers, often depending on the number of available qualified professionals. For a basic radiotherapy center treating up to 1,000 patients a year with two megavoltage teletherapy machines, a high-dose rate brachytherapy unit and other standard equipment (a conventional or computed
**Figure 22.** Number of dark rooms.

**Figure 23.** Number of dosimetry planning rooms.

**Figure 24.** Number of HDR bunkers.

**Figure 25.** Number of mold rooms.

**Figure 26.** Number of LDR bunkers.
tomography simulator), immobilization devices, shielding devices, a TPS, and physical dosimetry tools; the IAEA recommends a staffing of around 20 (4–5 radiation oncologists, 3–4 medical physicists, 7 radiation therapy technologists, 3 radiotherapy nurses, and a maintenance engineer), (Campbell, Arowojolu, Akinlade, Adenipekun, & Babarinsa, 2000). In more detail, this team consists of a radiation oncologist-in-chief, one staff radiation oncologist per 200–250 patients, one radiation physicist for every 400, one dosimeters or physics assistant per 300 patients, one mold room technician per 600 patients, four RTTs per megavoltage unit treating up to 50 patients per day, 2 RTT-simulation for every 500 patients simulated annually, and RTT-brachytherapy as needed, as well as a nurse for every 300 patients, a social worker, a dietician, a physiotherapist, and a maintenance engineer or electronics technician (Abdel-Wahab et al., 2013). The staff requirements will increase if special or advanced techniques such as three-dimensional treatment planning or conformal radiotherapy are employed as indicated in Figure 27.

From our results summarized in Figure 29, the significant insufficiency in terms of special personnel and auxiliary staff of the GHY had a conformity rate of 77.78% relative below the ideal norms of 100% from 1987 until 1990. The arrival of additional two RTTs in 1991 boasted up the conformity rate to 88.89% and remained the same until 1998. During this period, there was neither a MP nor a DM thereby adding more work load on the RO. In 1999, the number of RTTs dropped to three consequently reducing the conformity rate to 77.89%. This remained constant until 2004. In 2005, arrival of a MP rose the rate back to 88.89% until 2010. From 2011, there was a gradual decrease in the conformity due to the absence of the ON and reduction in the number of RO. This rate finally got to 55.56% in 2016. Despite this fluctuation, the staffing of the GHY has never achieved the norms and never for ones been effective. A therapy center is considered complete and efficient when it has at least one of the required specialists. However from our results, there has never been a dosimetrist in the GHY indicating that dose calculations has never been effectively done and consequently mounted extra work on the MP. Multi-function obviously reduces efficiency. This situation became worse in 1992 because there neither a dosimetrist nor a medical physicist in the therapy unit. As such treatment planning was sure based on assumptions and obvious to increase rate of mortality due to inefficiency. The arrival of a medical physicist in 2005 was a necessary condition but not sufficient to remedy the situation because sooner than later there was no oncology nurse to cater and follow up patients after treatment. This indicates massive need of personnel. Unfortunately, meeting the staff requirements for a radiotherapy clinic is difficult as the world faces a shortfall of 4.3 million trained health workers and countries are currently experiencing a health care workforce crisis, leaving health systems everywhere with insufficient staff available to meet the needs of their patients (Levin, El Gueddari, & Meghzifene, 1999). As stated earlier, many cancer clinics across the world are short of specialists, particularly medical physicists and oncology nurses. This is the case for most of Africa, and a significant number of countries in Asia, Latin America and even Eastern Europe considering the number of new patients and the required staffing. Lack of well-trained staff results in inappropriate or underutilization of the scarce radiotherapy facilities in most LMIC. Staffing requirements vary greatly depending on case-mix, type, and complexity of the techniques, research, and teaching commitments. Given the complexities of today’s modern radiotherapy clinics, rather than give fixed recommendations for staff numbers, the current approach is to use an algorithm that will provide the number of staff needed for a department, according to the activities implementation and training should begin at least a year before the establishment of the therapy center.

3.7. Building

The therapy unit of the GHY has had a conformity rate of 75% from its creation in 1987 to present, 2016, being slightly below the norms of 100%. It has had a mega-volt bunker, X-ray bunker, simulator room, dark room, dosimetry planning room, and a LDR bunker. All these found in a single apartment with separate rooms of which some of them are also used as offices. This environment lacks ventilation and most often machines get hot and slow down treatment processes as well as place workers under

Figure 27. Total number of staff per year.
uncomfortable working conditions. There has always been limited accommodation consequently. There is always overcrowding of patients who are usually sent back home with incomplete treatments. Mortality rate is bound to be in a rise regarding such situations. However, this shortage of infrastructure will soon be resolved because the construction of an entire and well-structured therapy unit is going on at present in GHY, so hopefully GHY might get to the norms in terms of buildings (see Figure 28).

3.8. Equipment

A basic radiotherapy center aiming at treating an average of 1000 patients/year should be equipped with at least a single-photon energy teletherapy unit, an auto-voltage unit, a brachytherapy after loader (ideally for high dose-rate brachytherapy), an X-ray c-arm, full range of applicators, a simulator, preferably a CT simulator, a computerized treatment planning system (TPS), film processing equipment, patient immobilization devices, and mold room equipment, beam measurement, and quality assurance (QA) equipment.

This has never been the case in GHY since its creation. From our results (see Figure 29), we are tempted to say there has never been a therapy center in GHY. This is because the only machines from 1987 to 2016 has been a cobalt-60 machine and its accessories having a lot of short comings, an ortho-voltage unit, which operated just for 2 years (from 1993 to 1994), a TPS, which operated for 4 years (from 2005 to 2008), and a sample clinical space. This insufficiency in equipment in the GHY had a conformity rate of 18.18% from 1987 to 1992 and completely below the mean norms of 50% and ideal norms of 100%. In 1993, this rate slightly rose to 27.27% due to the arrival of an ortho-voltage unit but lasted just for 2 years. It went back to 18.18% in 1995 and persisted like this until 2004. It temporarily rose again to 27.27% from 2005 to 2008 due to the arrival of TPS. It then leveled off from 2009 to 2016 at 18.18%. A second teletherapy unit may become necessary to expedite workflow and for back-up. Procurement of new equipment has to be implemented through a transparent tendering process. Since technological developments in radiotherapy occur much faster than the economic lifetime of a linear accelerator, larger radiotherapy centers, which replace one or more machines every few years, enable the introduction of new technology at a faster rate (Eduardo Rosenblatt, 2014). This is indicated by curve in green. However, the center has been unable to meet up with the basic standards talk less of setting a second therapy unit. This leads to overcrowding and more to that, the machines available are not adapted to the treatment of types of cancers, has a single energy of 1.25eV, which does work for obsessed patients. This shortage of equipment (for example CT-simulator) has not only affected the radiotherapy unit but also affects the radiology unit because the staff of therapy unit constantly moved there for scans and analysis of results leading to inefficiency. There has never been a well-trained maintenance engineer to repairs faults as such center at times goes for weeks without being functional. What then happens to patients during this period if not to die?

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**Figure 28.** Total number of buildings per year.

**Figure 29.** Total number of equipment per year.
4. General conclusion

Radiotherapy today remains one of the best available strategies in the fight toward reducing the rate of mortality and morbidity. This study was designed to evaluate radiotherapy facilities in GHY from its creation until 2017 and compared to the norms prescribed by international organizations to see how good we are.

From our results, we can conclude that:

- No radiotherapy facility has ever attained the normative score of 100% from 1987 to 2016. The indicator related mainly to the staff had an average normative score of 80.84% while equipment and buildings, respectively, had scores of 18.18 and 75%.
- The staff have never been complete, the limited number of personnel trained in oncology is further compounded by the lack of enthusiasm on the part of young medical officers and nursing staff or oncology.
- Equipment never got to the standard level talks less of a second therapy unit, definitely leading to overcrowding and inefficiency.
- Cancer treatment centers are still very few since only Yaoundé and Douala have presumed centers.
- Rate of mortality and morbidity will continue to be in a rise if radiotherapy facilities are not improved.

In conclusion, we can say that there are so many things yet to be done such as; qualified and trained staff, modern equipments and technology, standard infrastructures to improve radiotherapy facilities at the GHY and meet up with standard norms prescribed by international organizations.

Highlights

- Quality control of the staff based on radiotherapy as a whole.
- Investigating the improvement of radiotherapy facilities in Cameroon.
- Comparison of radiotherapy facilities to the norms set by international organizations.
- The staff had a normative score of 80.84%, equipment 18.18%, and infrastructure 75%.
- Optimize measures to reduce mortality rate and increase life expectancy.

Disclosure statement

No potential conflict of interest was reported by the authors.

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