



Review Article

Access to brachytherapy treatment for cervical cancer management in Africa

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ABSTRACT

Background and purpose: Cervical cancer is an important public health issue with a high incidence and death rate in Africa. It is mostly treated with Brachytherapy as the gold standard but its access is limited. This study set out to investigate the distribution and accessibility of brachytherapy units in Africa for the treatment of cervical cancer, and to provide some recommendations for increasing the quantity and accessibility of such equipment throughout the continent.

Materials and methods: The International Atomic Energy Agency's Division of Human Health's Directory for radiotherapy Centers (DIRAC) was the principal source of data for this study. The number of brachytherapy equipment in the 54 African countries was obtained from the DIRAC database. The number of cervical cancer cases was obtained from the GLOBOCAN 2022 database, and country's income was calculated using the Gross Domestic Product (GDP) per capita from the global economics database. All of these searches were conducted in February 2024.

Results: Africa exhibited a greater number of cervical cancer cases. A total of one hundred (100) brachytherapy units were present across 84 radiotherapy centres spanning 20 African countries. Egypt and South Africa each possess 23 units, which accounts for 46% of the overall quantity. With just two brachytherapy facilities, Nigeria had the most cervical cancer cases. A significant quantity of brachytherapy unit was situated in countries of northern Africa. The quantity of these units varied among countries, from those without any to those with many, and was not only influenced by GDP per capita.

Conclusion: Due to the rising incidence of cervical cancer in Africa, the number of brachytherapy equipment was woefully inadequate. Consequently, Africa requires partnerships and financial support to facilitate the quantity and accessibility of brachytherapy services. This will enable the provision of thorough and holistic care to patients and enhance their quality of life.

Introduction

There is a huge health risk that affects women all around the globe, and that is cervical cancer [1]. There are over 500,000 women who are diagnosed with this illness every year, making it the third most frequent kind of cancer on the globe [2]. The majority of instances are found in less developed nations, which are characterized by a lack of effective screening and treatment methods [3–5].

Cervical cancer has been recognized as one of the most common

forms of cancer in sub-Saharan Africa, according to earlier findings [6,7]. It is the most prevalent kind of cancer among females in the majority of African nations, both in terms of the number of cases and the number of deaths [3]. Smoking, being human immunodeficiency virus (HIV) positive, having a compromised immune system, and human papillomavirus (HPV) infection are all risk factors for cervical cancer. Women who do not have access to health care are the ones who bear the burden of cervical cancer, and this is especially true in nations with low and intermediate incomes [8]. In Africa, the number of people

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diagnosed with cervical cancer is fast growing at an alarming rate. This could be attributed to inadequate treatment options, lack of awareness, and poor vaccination and screening programs. To achieve progress in reducing the number of cervical cancer in Africa and enhancing the overall health of women on the continent, it is possible to overcome the challenges associated with screening, immunization, and treatment, and to offer assistance for comprehensive cervical cancer preventive strategies [3,7].

An important segment of effective cervical cancer treatment programs is the capability to deliver effective and targeted treatment to women. The most effective treatment for locally advanced cervical cancer is the combination of external beam radiotherapy (with or without concurrent chemotherapy) with brachytherapy [9–11]. Brachytherapy is a specialized form of radiation therapy that comprises the careful placement of radioactive sources directly into or near the tumor [12,13]. This allows for targeted and localized radiation delivery, maximizing the effect on cancer cells while minimizing damage to surrounding healthy tissue. In contrast to surgery or external beam radiotherapy alone, brachytherapy given in addition to external beam radiotherapy has shown encouraging outcomes in the treatment of cervical cancer [12]. One study found that brachytherapy and external beam radiation therapy improved local tumor control and minimized toxicity to normal surrounding structures [11]. By enabling the safe escalation of radiation doses to the tumor, brachytherapy has the potential to enhance local control and achieve the goals of palliation in cervical cancer management. Moreover, brachytherapy has shown efficacy in the management of recurrent cervical cancer, a medical disease characterized by the limited effectiveness of other treatment modalities [9]. Additionally, the use of brachytherapy in cervical cancer management takes into account the quality of life of women with primary and recurrent cervical cancer [14,15].

Looking at the various advantages of brachytherapy treatment for cervical cancer, this study set out to investigate the availability and distribution of brachytherapy facilities in Africa and to provide actionable recommendations for increasing the quantity and accessibility of such equipment throughout the continent.

Materials and methods

All fifty-four (54) African nations were included in this study. A database was created and all necessary information and data was inputted. There were considerations made about the population of a nation, the gross domestic product (GDP) per capita, the number of general cancer and cervical cancer cases, and the number of brachytherapy machines. The information on GDP per capita was obtained from the database of global economics [16]. The data on cancer cases for each nation was obtained from the GLOBOCAN 2022 database, while the population data for each country was obtained from the Worldometer database [17]. The Database for Radiotherapy Centres (DIRAC), maintained by the International Atomic Energy Agency's Division of Human Health, was the source for brachytherapy equipment distribution across Africa. DIRAC is an electronic database that is centralized and regularly updated. DIRAC comprises the current and historical global data on radiotherapy centers, teletherapy machines, brachytherapy units, treatment planning systems, computed tomography systems, and simulators. DIRAC remains the world's most comprehensive database on radiotherapy resources. DIRAC is used worldwide for planning radiotherapy services, advocacy for equity in access to cancer treatment, investment in healthcare infrastructure, and benchmarking of radiotherapy resources [18]. All of these searches were carried out in February of 2024. For comparison, an estimation was made of the number of brachytherapy units per case of cervical cancer.

Statistics Analysis was performed with Microsoft Excel 2016 and the Statistical Package for Social Science (SPSS) version 26. Frequency distributive analysis was conducted to summarize the number of brachytherapy machines, number of cervical cancer cases recorded in

each country. Additionally, a basic linear regression was used to establish a correlation between the GDP per capita in each nation and the number of brachytherapy units per cervical cancer case.

Results

A total of 100 brachytherapy units were present across 84 radiotherapy centers spanning 20 African countries. Eight African countries had only one brachytherapy unit while 34 had none. Egypt and South Africa had the highest number of brachytherapy units, each possessing 23 units, which accounts for 46 % of the overall quantity. Most of the units could be located in Northern and Southern regions of the continent. According to the DIRAC database, the total number of brachytherapy units worldwide was 3336 [18]. Hence Africa's situation represents 3 % (100/3336) of the total global brachytherapy units as against a total of 125,615 cases of cervical cancer cases which were recorded in Africa.

There were 1,153,560 cancer cases in Africa which comprises 125,615 cervical cancer cases. Cervical cancer accounted for the leading cause of cancer death in the majority of these countries [19]. Cape Verde and Sao Tome and Principe had the lowest number of recorded cervical cancer cases, 46 and 14 respectively. Nigeria was the continent's most populated country and had the highest number of cervical cancer cases, accounting for 10.9 % (13,676/125,615). There was no cancer data available for Seychelles. Certain nations that possess just one or two brachytherapy units have a relatively low quantity of units per instance of cervical cancer. This is due to the elevated incidence of cervical cancer in these nations. Ethiopia has a solitary brachytherapy unit, although it exhibits a cervical cancer incidence rate of 8,168 instances (0.0001), in contrast to Tunisia's rate (Table 1).

GLOBOCAN has stated that by 2030, the number of cervical cancer cases is estimated to be around 174,000 in Africa [19]. That is an increase of 48,385 new cases from 2022. Assuming that the majority of these patients would require brachytherapy treatment, a rapid facility expansion project needs to be activated across the continent.

In Fig. 1, the scatter plot reveals a negative correlation between the two variables ($r^2 = 0.212$, $p\text{-value} = 0.124$). There was a trend to correlation between the GDP per capita and brachytherapy unit per cervical cancer cases as shown in Fig. 1. GDP per capita values were not available for six countries namely Sao Tome and Principe, Eritrea, Djibouti, Equatorial Guinea, Somalia, and Seychelles.

A correlation between GDP per capita and the number brachytherapy units among the countries revealed a positively weak and insignificant association indicating that regardless of the GDP of a country, access to brachytherapy facility should be given priority. GDP per capita among countries without any brachytherapy unit ranges from 1690 USD to 28,817 USD, compared to 2,604 USD – 27,147 USD for countries with at least one. The majority of countries were found to have a GDP per capita of less than 5000 USD. Regardless of the high GDP per capita of Eswatini and Libya, they had no brachytherapy facilities compared to Madagascar which has a low GDP per capita but has one unit installed. Gabon has the highest GDP per capita on the continent but despite this, there was no brachytherapy unit compared to that in South Africa and Egypt which have the highest number of machines. There are some variations observed in the linear regression model. There may be other factors that could account for the differences in the availability of brachytherapy units across countries. The overall population, screening programs in each country, the number of cervical cancer cases, and the availability of diagnostic tools are some examples of factors that could account for the variability [20].

Discussion

Access to brachytherapy facilities is very scarce in Africa. Comparing the present situation in Africa with an earlier study conducted in 2020, it is evident that no absolute improvement has been achieved in terms of

Table 1

A table showing variables with their statistics for the 54 African countries.

Countries	No. of Cancer cases	No. of cervical cancer cases	Population	GDP per capita /\$	Total Number of Brachytherapy machines	Brachytherapy machine per cervical cancer cases
ALGERIA	63,306	1799	45,606,480	12,997	13	0.0072
ANGOLA	24,085	2823	36,684,202	11,231	1	0.0004
BENIN	7365	701	13,712,828	5,329	0	–
BOTSWANA	2222	454	2,675,352	23,639	1	0.0022
BURKINA FASO	14,308	988	23,251,485	3,352	0	–
BURUNDI	7873	1457	13,238,559	1,264	0	–
CAMEROON	19,260	2525	28,647,293	5,379	0	–
CAPE VERDE	423	046	598,682	9,216	0	–
CENTRAL AFRICA REPUBLIC	2656	295	5,742,315	1,690	0	–
CHAD	10,141	1111	18,278,568	2,529	0	–
COMOROS	599	163	852,075	4,089	0	–
CONGO (BRAZAVILLE)	2717	397	6,106,869	6,055	0	–
COTE D'IVOIRE	21,083	2360	28,873,034	8,847	0	–
DJIBOUTI	787	071	1,136,455	–	0	–
DR CONGO	52,049	8705	102,262,808	2,180	0	–
EGYPT	148,639	1302	112,716,598	18,936	23	0.0177
EQUATORIAL GUINEA	910	127	1,714,671	–	0	–
ERITREA	2403	196	3,748,901	–	0	–
ESWATINI	1073	417	1,210,822	14,980	0	–
ETHIOPIA	77,790	8168	126,527,060	3,690	1	0.0001
GABON	1842	271	2,436,566	28,817	0	–
GAMBIA	1192	325	2,773,168	3,712	0	–
GHANA	27,054	3072	34,121,985	8,940	3	0.0010
GUINEA	8558	2551	14,190,612	4,503	0	–
GUINEA-BISSAU	1141	224	2,150,842	2,882	0	–
KENYA	44,065	5845	55,100,586	6,930	4(1)	0.0009
LESOTHO	1969	598	2,330,318	3,807	0	–
LIBERIA	3796	717	5,418,377	2,293	0	–
LIBYA	8099	278	6,888,388	28,749	0	–
MADAGASCAR	20,693	4060	30,325,732	2,604	1	0.0002
MALAWI	19,475	4701	20,931,751	2,112	0	–
MALI	14,842	2436	23,293,698	4,226	0	–
MAURITANIA	3202	468	4,862,989	7,893	1	0.0021
MAURITIUS	2795	136	1,300,557	27,147	1	0.0074
MOROCCO	63,110	2644	37,840,044	11,054	10	0.0038
MOZAMBIQUE	25,741	5456	33,897,354	1,901	0	–
NAMIBIA	3222	350	2,604,172	12,898	1	0.0029
NIGER	11,263	624	27,202,843	1,957	0	–
NIGERIA	124,735	13,676	223,804,632	9,333	2	0.0001
RWANDA	6966	866	14,094,683	3,390	0	–
SAO TOME AND PRINCIPE	143	014	231,856	–	0	–
SENEGAL	11,561	2064	17,763,163	5,489	1	0.0004
SEYCHELLES	0	0	107,660	–	0	–
SIERRA LEONE	1915	486	8,791,092	2,956	0	–
SOMALIA	10,423	1167	18,143,378	–	0	–
SOUTH AFRICA	100,897	10,532	60,414,495	19,331	23	0.0022
SOUTH SUDAN	6737	749	11,088,796	7,089	0	–
SUDAN	28,076	1234	48,109,006	7,089	0	–
TANZANIA	44,070	10,868	67,438,106	4,181	4	0.0004
TOGO	5292	511	9,053,799	3,209	0	–
TUNISIA	20,095	414	12,458,223	14,154	4	0.0100
UGANDA	35,539	6938	48,582,334	3,320	1	0.0001
ZAMBIA	15,037	3640	20,569,737	5,609	2	0.0005
ZIMBABWE	17,312	3520	16,665,409	4,275	2	0.0006
TOTAL	1,153,560	125,615	1,458,571,408	387,253	100 (99 + 1)	0.0008

brachytherapy capability [21]. Similarly when compared to the brachytherapy capability of western Europe (834) and North America (819), Africa lags behind with a total of 734 and 719 respectively [18].

The current number of brachytherapy units does not match up with the need for brachytherapy services, steered by the increase in population and a high cancer burden on the continent. If no action is taken, this consequence might potentially lead to a significant increase in cancer-related mortality [15,22]. The geographical accessibility to brachytherapy services is also clearly not uniform as seen in Fig. 2.

Highly populated regions in western and central Africa had very few centers, while the majority of brachytherapy units are located in the northern and southern parts of Africa. Many countries remain without

any brachytherapy unit in Africa. Considering the significance of cervical cancer in the region, the limited availability of brachytherapy resources will have a detrimental effect on cancer treatment results. Brachytherapy is in high demand in countries with low and middle-income levels due to the prevalence of locally advanced disease in 60 % of cervical cancer cases [23].

The cost of a brachytherapy machine purchase and installation can vary depending on the type of equipment and the manufacturer. Prices for brachytherapy equipment range widely more than \$200,000, with leading manufacturers offering different options [24]. A machine can last many years and treat many patients, making it an extremely cost effective cancer therapy compared to new drugs such as immunotherapy

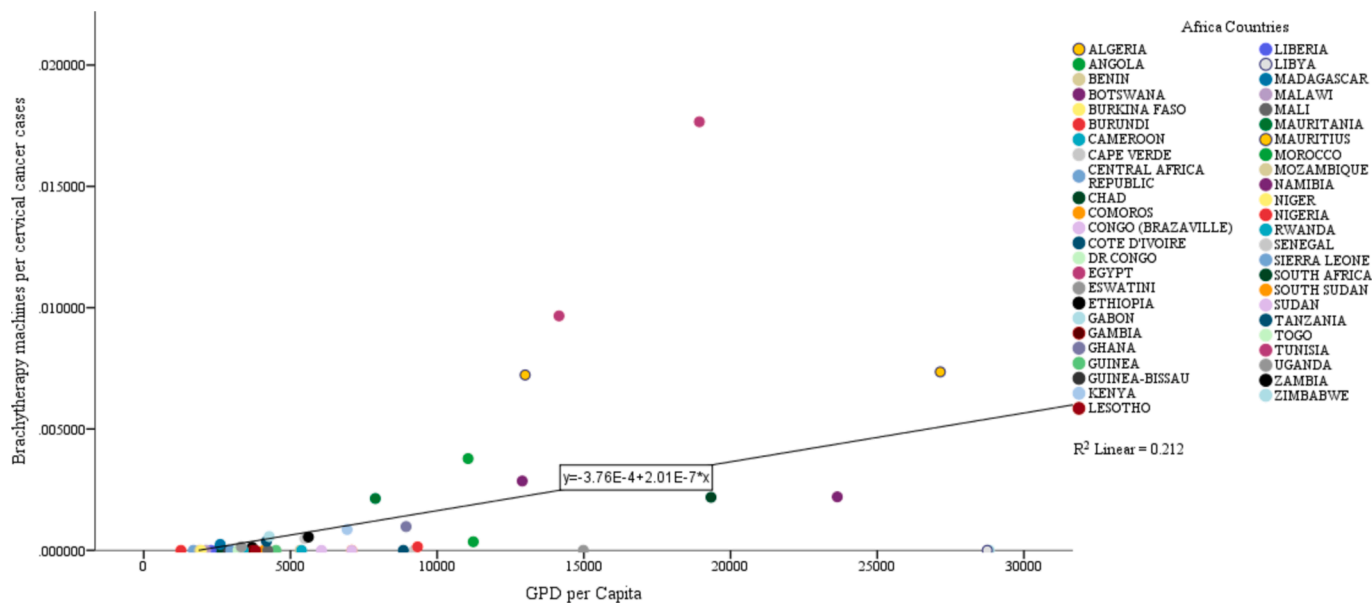


Fig. 1. A scatter plot of brachytherapy machine per cancer cases by GDP per capita by the 54 African countries.

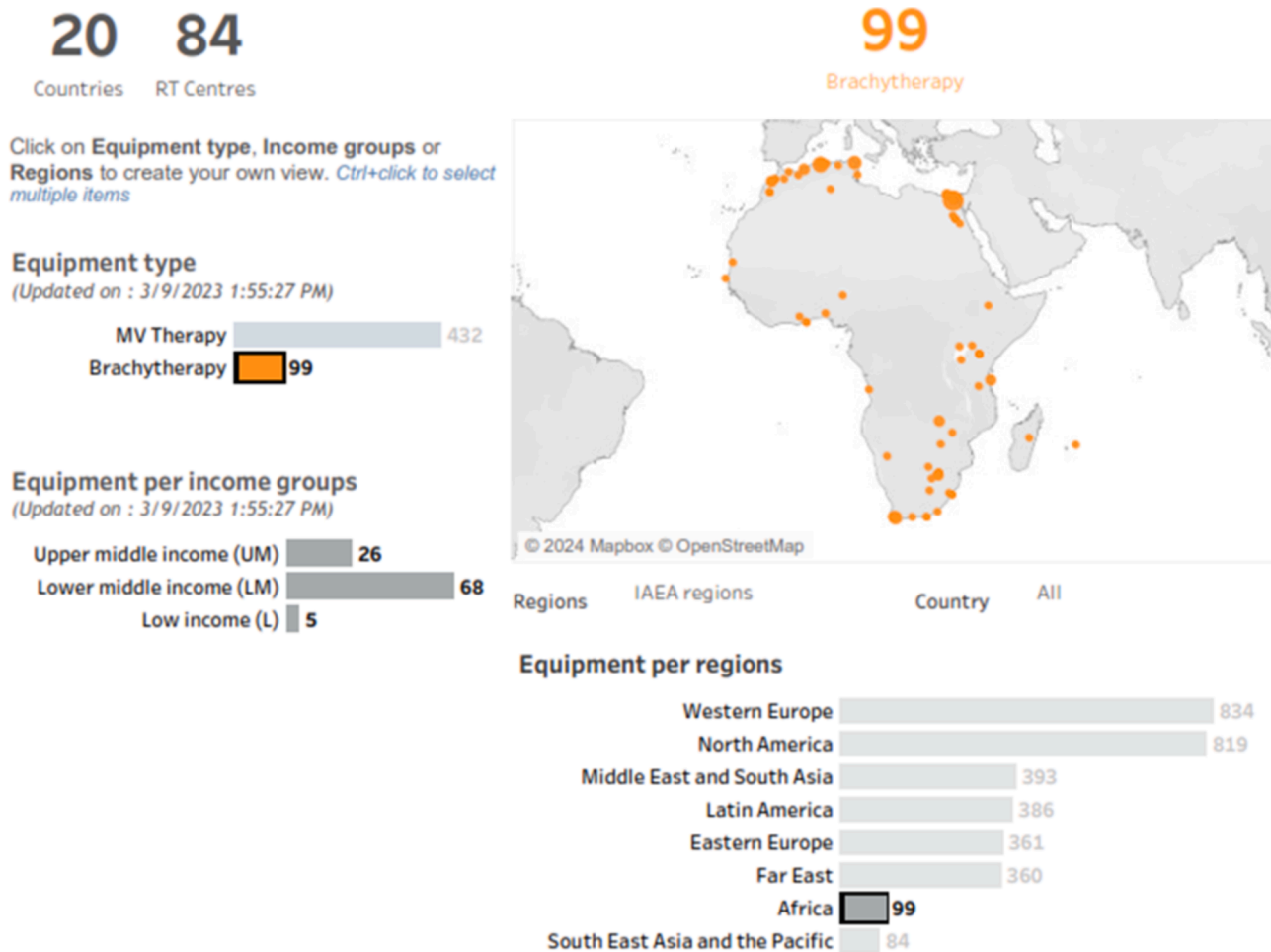


Fig. 2. Geographical location and number of brachytherapy Units in Africa.

[9,25]. The acquisition and commissioning of brachytherapy units constitute a significant initial capital investment. Both the expenses associated with equipment maintenance and the training and retention

of personnel have equal significance [26]. The correlation between a country's GDP and the availability of brachytherapy units per cervical cancer cases suggests that a country's income predicates availability but

might not be the only precondition for access. Countries with low income and without access to brachytherapy facilities need the implementation of methods aimed at including it into fundamental healthcare packages through universal healthcare coverage. These techniques would effectively mitigate the occurrence of catastrophic out-of-pocket expenses and promote the long-term viability and growth of the services [20]. The findings in this study could be used to inform the development agenda for 2030. Making progress towards achieving target 3.4 of the third United Nations Sustainable Development Goal which states that by 2030, one-third of premature mortality from non-communicable diseases of which cancer is part will be reduced through prevention and treatment to enhance mental health and well-being. Hence, every country is expected to put in place new policies to reduce cancer deaths to achieve the target by 2030 [27,28].

The achievement of these targets by all countries will partially rely on sufficient and enduring availability of brachytherapy machines and well-trained professionals [15]. The worldwide plan to expedite the eradication of cervical cancer as a public health issue, together with its corresponding objectives and targets for the years 2020–30, was endorsed by the World Health Assembly in 2020, highlighting the significance of cervical cancer in Africa. The objective of this worldwide approach is to achieve a 90 % rate of treatment accessibility for women diagnosed with cervical cancer [29,30].

Additionally, the African First Ladies Organization has implemented many measures for the reduction of cervical cancer on the continent. A network of oncologists has been developed by the African Cancer Coalition around the continent, while the African Union has organized advocacy events on cancer in conjunction with their annual conference [31]. Therefore, it is crucial to guarantee that this emphasis and promotion can be put into action via cancer control strategies that are strong and supported by data [32].

Aside from the cost of brachytherapy machines being the major gap in access to brachytherapy treatment, a lack of unique and quality procedural skillsets, and a lack of specialized training for physicists, oncologists, oncology nurses, therapy radiographers amongst others contribute to the gap created in the access of brachytherapy treatment in the African setting [33].

Some guidelines to improve brachytherapy equipment accessibility in Africa

To enhance the availability and accessibility of brachytherapy equipment in Africa, the following practical guidelines can be implemented:

Establish Brachytherapy Infrastructure Plan: Each country should develop a comprehensive infrastructure plan to establish adequate facilities for brachytherapy across regions in the country, focusing on areas with the greatest need. Cost analysis should be included. It is important to also take into account the costs related to the development, implementation, operation, and decommissioning [26]. The costs associated with development and implementation include fixed expenses such as construction, staff training, procurement of the necessary equipment and supplies, as well as safety and quality assurance measures. These expenses will cover any extra costs for enhancing security. Security costs should be carefully considered during the development stage, as they can be quite significant. Operational costs encompass a range of expenses involved in delivering services, such as utilities, personnel, sourcing new supplies, disposing of used materials, patient-specific equipment like catheters, regular checks, ongoing staff training, and maintenance costs. As the unit gets older, it is expected that the expenses for maintenance will rise. At the end of the unit's lifespan, there is the decommissioning cost. This occurs when the unit is no longer operational or supported by the manufacturer, and proper disposal of the equipment and sources is necessary [23].

Collaborative Efforts: Foster collaboration between governments and manufacturers to expand access to brachytherapy equipment in the sub-regions would be beneficial. Partnership is one of the pillars to accelerate development according to the United Nations Sustainable Developmental Goals 17 [34]. Partnerships between not only national governments but non-governmental agencies such as universities and private sector businesses can be essential for the implementation and maintenance of brachytherapy machines and clinical services in Africa, both financially and in terms of technical expertise. Countries without existing facilities should adopt the development of models for partnerships [35]. One such organization is the International Atomic Energy Agency (IAEA). The IAEA has been instrumental in assisting many countries in acquiring radiotherapy and brachytherapy facilities across the world [20].

Training and Capacity Building Programs: The human resource needs are also very important. Professionals such as radiation oncologists, medical physicists, radiation therapists, biomedical engineers, and oncology nurses need to be trained in advance or trained concurrently with the plan to execute a brachytherapy facility [33]. Implementation of training programs for already existing healthcare professionals on the safe and effective use of brachytherapy equipment to ensure optimal treatment outcomes and patient safety should also be thought of. Investing in capacity-building initiatives to support the installation, maintenance, and utilization of brachytherapy machines in healthcare facilities across Africa, particularly in countries with limited access [36]

Guidance Publications: Technical guidance publications and technical reports from organizations like the World Health Organization (WHO), the American Brachytherapy Society, the European Society for Radiotherapy and Oncology (ESTRO), the American Association of Physicists in Medicine (AAPM) and the International Atomic Energy Agency (IAEA) can be utilized to inform the procurement, installation, and maintenance of brachytherapy equipment in alignment with international standards [11,26,37].

Regional Support: Countries with brachytherapy treatment experience such as South Africa, Egypt, Morocco, and Ghana need to provide targeted support to countries with limited access to brachytherapy services, such as Tanzania, by mentoring in the procurement and installing brachytherapy machines and facilitating exchange training for healthcare professionals [38]. This can be done through a team effort whereby highly trained specialists organize webinars, conferences, symposiums, and others to equip the less developed African countries. Subsequently, these specialists can travel to these nations to assist in the management and treatment of cervical cancer cases.

Limitations of the study

There are some limitations to this study. Firstly, it might be challenging to ensure that these facilities are operating efficiently due to the high frequency of equipment breakdowns in Africa and the lengthy maintenance periods caused by a lack of local experience. Secondly, due to the self-reporting nature of the DIRAC database, it may sometimes be challenging to verify the accuracy of the data. New Brachytherapy unit installations might be ongoing in some countries and this might go unreported for some time. Also, we did not take into account the different types of brachytherapy units and radionuclides used. The GLOBOCAN figures are approximations since many African nations do not have excellent population-based cancer registries. Because of this, certain estimates of the incidence and mortality of cervical cancer may be inflated.

Conclusions

There is a severe shortage of brachytherapy equipment even though cervical cancer is becoming more common in Africa. Thus, to increase

access to brachytherapy treatments and foster its expansion, Africa needs collaborations and financial support. Patients will be able to get all-encompassing treatment, which will improve the quality of management and treatment of cervical cancer cases amongst women in the African continent and eventually increase the chance of survival. By implementing these guidelines, African countries especially those without any brachytherapy units can work towards improving the availability and accessibility of brachytherapy equipment, ultimately enhancing cancer treatment outcomes and reducing disparities in healthcare access across the continent.

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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