EVALUATING THE MANAGEMENT AND MAINTENANCE PRACTICES OF LINEAR ACCELERATOR AND COBALT-60 CANCER TREATMENT MACHINES IN NIGERIA: A COMPREHENSIVE ASSESSMENT

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ABSTRACT

This research paper investigated the state of radiotherapy machines and their management in cancer treatment centers in Nigeria. The study aimed to identify the challenges faced by these centers and propose strategies for improvement. Through a comprehensive analysis of data collected from surveys and questionnaires, critical issues impacting the availability, reliability, and effectiveness of radiotherapy machines were highlighted. The findings revealed a significant shortage of radiotherapy machines across the nation, with Nigeria having less than 6% of the required number of linacs. This scarcity led to a high workload on the existing machines, resulting in long waiting lists and compromised treatment outcomes. Management challenges, such as the absence of preventive maintenance policies, inadequate personnel training, delayed spare parts delivery, and limited engagement of maintenance contractors, were identified. The research emphasized the need for supportive cancer treatment machines, including orthovoltage and superficial machines, to alleviate the burden on existing radiotherapy machines. However, most centers lacked these supportive machines, limiting their ability to provide comprehensive care to patients. Financial sustainability also emerged as a significant concern, as internal funds proved insufficient for maintenance and operations. The involvement of the government and the establishment of independent regulatory bodies were proposed to address these challenges. In conclusion, this study called for urgent action to address the gaps and challenges in radiotherapy machine management in Nigeria. It highlighted the importance of increasing the number of machines, implementing preventive maintenance policies, enhancing staff training, and securing adequate funding. By doing so, the quality of cancer care could be significantly improved, leading to better patient outcomes and a more robust healthcare system in Nigeria.

Keywords: *Cancer; Linear Accelerator; Cobalt-60 Machines; Maintenance*

1.0 INTRODUCTION

Cancer is a global health concern, representing a significant threat to humanity and causing substantial morbidity and mortality worldwide. It is characterized by the uncontrolled division and infiltration of abnormal cells into healthy tissues, resulting from DNA alterations within cells. In the United States, it ranks as the second-leading cause of death (Findlay-Shirras et al., 2021; Pilleron et al., 2021; American Cancer Society, 2016). Regrettably, data on cancer incidence in many sub-Saharan African countries remain scarce, despite its menacing impact (Curado et al., 2007; Ba et al., 2021). Alarmingly, cancer

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incidence continues to escalate globally, with projections indicating approximately 1.27 million new cases and nearly 1 million deaths by 2030 (Sylla et al., 2012). Therefore, it is crucial to take immediate and comprehensive measures, including effective policies within the healthcare sector, to combat the growing burden of cancer in the sub-Saharan African region.

Chemotherapy stands as the most widely used treatment for cancer, particularly in the early stages of the disease. It involves the administration of drugs to eradicate cancer cells. To effectively manage cancer, chemotherapy is administered on a regular schedule and adjusted when the disease becomes active again. Monitoring techniques such as imaging tests and blood tests are employed for diagnosis (Sun et al., 2021). The demand for cancer treatment has surged in recent years due to the growing number of cancer patients and the limited availability of radiotherapy machines. According to the World Health Organization (2008), an estimated 7.6 million people died from cancer in 2005, and the International Atomic Energy Agency (Bateman, 2007) warns that approximately 84 million people may succumb to the disease in the next decade if appropriate actions are not taken. Durosinmi-Etti et al. (2016) estimated that around 55% of new cancer patients require radiotherapy services at least once. The International Atomic Energy Agency reports that Nigeria faces the greatest shortage of radiotherapy machines, with only one machine per population of 19.4 million people. In contrast, Nwankwo et al. (2013) recommend one machine per 250,000 people, as seen in high-income countries. Additionally, Nwankwo et al. (2013) concluded that Nigeria needs at least 137 linear accelerators (linacs), highlighting a shortfall of over 129 linacs based on current assessments. In other words, Nigeria possesses less than 6% of the necessary megavoltage (MV) radiotherapy machines.

The lack of spare parts and expertise for maintenance has been identified as a leading cause of equipment breakdown (Ramere & Laseinde, 2021; Ochuokpa et al., 2022). Moreover, many technicians, engineers, and radiographers may not receive adequate training in equipment repairs, maintenance, and operations (Nwankwo et al., 2013). Due to the scarcity of required radiotherapy machines, patients in under-resourced countries often have to travel long distances for daily treatment (Anakwenze et al., 2017). Grau et al. (2014) examined the distribution of radiotherapy equipment in European countries and developed a model for health economic evaluation of radiation treatments at a European level. The study revealed significant variation in equipment availability across countries, with 2,192 linear accelerators, 96 dedicated stereotactic machines, and 77 cobalt machines reported in 27 countries. Only 12 countries had at least one cobalt machine in use. The number of MV machines (cobalt, linear accelerators, and dedicated stereotactic machines) per million inhabitants ranged from 1.4 to 9.5 (median 5.3), with an average of 0.9 to 8.2 (median 2.6) MV machines per department. The average number of treatment courses per year per MV machine varied from 262 to 1061 (median 419). While 69% of MV units were capable of IMRT, only 49% were equipped for image guidance (IGRT). A clear relationship was observed between the availability of radiotherapy equipment in countries and their socio-economic status, as measured by GNI per capita.

Yap et al. (2016) conducted a comprehensive study to estimate the global demand for and supply of radiotherapy megavoltage machines (MVMs) and analyze changes over the past decade. They utilized data from the International Agency for Research on Cancer Global Cancer Incidence, Mortality, and Prevalence (GLOBOCAN) database, extracting information on 27 cancer types across 184 countries. The Collaboration for Cancer Outcomes Research and Evaluation radiotherapy utilization rate (RTU) model was employed to estimate the number of patients in each country requiring radiotherapy for specific cancer types and determine the demand for MVMs. The findings revealed variations in RTU among different countries, with a global deficit of over 7,000 machines. Particularly in low-income countries, the gap between radiotherapy demand and supply has widened in the past decade. Despite approximately half of all cancer patients worldwide requiring radiotherapy, over 2 million individuals lack access to this vital treatment due to insufficient availability of MVMs. Low- and middle-income countries are disproportionately affected by this shortage.

Al-Bashir et al. (2017) presented an enhancement process aimed at addressing the extensive downtime experienced by medical tools during maintenance work in Jordanian Health Hospitals. The study targeted the improvement of availability levels, which had been reported as unsatisfactory due to prolonged equipment downtimes resulting from time-consuming maintenance procedures within JPHS. The

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methodology employed standard corrective maintenance (CM) practices, gathering data on corrective maintenance from 689 different medical devices, encompassing 15 fault categories and 5203 work orders, during the study period from May 2002 to April 2009. By utilizing the Define Measure Analyze Improve Control (DMAIC) procedure, along with tools such as Fishbone Diagram (ISHIKAWA), Pareto analysis, regression analysis, and process capability analysis, factors influencing corrective maintenance times and subsequent downtimes were identified. The study concluded that applying the Six Sigma methodology "DMAIC" to Corrective Maintenance for medical equipment can reduce downtime and increase availability by establishing a high-quality correction process that fulfills customer needs. Additionally, a multiple regression model was developed to showcase the variables primarily affecting downtime and guide decision-makers in mitigating their impact. The model indicated that check time, decision time, and delivery time were the main factors influencing downtime, rather than the actual maintenance time. This shows that there is the need for the optimization of not only the process of patients access to the machines but also the availability (Samuel et al., 2022a; Samuel et al., 2022b; Alabi et al., 2022).
The purpose of this study is to assess the management and maintenance of external beam linear accelerators and cobalt 60 radiotherapy machines in Nigeria. The aim is to identify the challenges within the management and maintenance processes and provide a basis for developing mitigation measures.

2.0 METHODOLOGY

Research design

In this study, a cross-sectional descriptive observational research design was employed, incorporating a mixed methodology of quantitative and qualitative approaches. The objective was to evaluate the current management approach of Linear Accelerator and Cobalt-60 Machines in Nigeria. The research team conducted an inspection tour of two radiotherapy centers, specifically examining the linear accelerator machines at the National Hospital, Abuja, and the cobalt-60 machine at Ahmadu Bello University Teaching Hospital, Zaria. During the tour, staff members operating the radiotherapy machines were interviewed, providing valuable insights through oral interviews. Additionally, log books on quality analysis records and maintenance were reviewed at National Hospital, Abuja, and Usman Dan Fodio Teaching Hospital, Sokoto. To gather further data, well-structured questionnaires were prepared and distributed among various categories of staff working with radiotherapy machines in the seven radiotherapy centers across Nigeria. Secondary data from existing literature on external beam radiotherapy machines were also collected. The obtained data were analyzed using the Microsoft Excel program.

Population for Study

This research specifically targeted a population consisting of eight (8) teaching hospitals in Nigeria that currently possess radiotherapy equipment, including either linear accelerators or Cobalt-60 machines. The study population was further narrowed down to include radiographers/physicists, engineers responsible for operating and conducting routine maintenance/repairs on the radiotherapy machines, as well as the management team tasked with overseeing the logistics of procuring the machines and necessary repair parts as needed.

Sampling and Sampling Procedure

For this study, a total of seven (7) teaching hospitals were included in the examination process using the questionnaire. These hospitals are as follows: Lagos University Teaching Hospital, the University of Nigeria Teaching Hospital in Enugu, University College Hospital in Ibadan, University of Benin Teaching Hospital, Ahmadu Bello University Teaching Hospital in Zaria, Eko Hospital, and the National Hospital in Abuja. However, an oral interview was conducted with personnel from Usman Dan Fodio Teaching

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Hospital in Sokoto. The questionnaire was administered to a specific group of individuals within these hospitals. For each of the seven (7) sampled teaching hospitals, two (2) radiographers and one (1) engineer/technician were selected to provide the required information through the questionnaire. Additionally, four (4) physicists from the National Hospital in Abuja, as well as three (3) members from the management cadre of the same hospital, were chosen. These selections were made based on the relevance of the information they could provide, considering their roles in routine operations, maintenance, and logistics. It is worth noting that the National Hospital in Abuja played a significant role in this study, as it was the first institution to install a linear accelerator machine and simulator in Nigeria. Furthermore, the hospital possesses other supportive treatment machines such as superficial X-ray machines and the Renderplan machine. The selected health institutions and personnel were considered appropriate for this study as they represent the population of interest. These institutions are the only ones equipped with radiotherapy equipment in the study area, and the chosen personnel are directly involved in the routine operations and maintenance of these machines.

Sources of Data

In this study, both primary and secondary sources of data were utilized to address the research questions. The primary source of data involved the administration of questionnaires and conducting personal interviews with the individuals responsible for operating the linear accelerator and cobalt-60 machines. The questionnaires were designed in an organized and structured manner, while the interviews followed a semi-structured approach, allowing for the collection of comprehensive and relevant data. A total of twenty-seven (27) questionnaires were randomly distributed among the health institutions, and eighteen (18) were returned, representing a response rate of approximately 66.67%. The data collected through the questionnaires were analyzed using bar charts to facilitate interpretation. In addition to the questionnaires, personal interviews were conducted with key stakeholders in the field. These interviews provided valuable insights and supplementary information related to the management of the linear accelerator and cobalt-60 machines. The questionnaires were divided into three (3) sections, each addressing different aspects of machine management. The collection of secondary data involved gathering information from existing literature, including studies, textbooks, research papers, and journals. These secondary sources were accessed from libraries and the internet, allowing for a comprehensive review of relevant literature related to the topic of study.

Technique for Data Collection

For this study, three distinct sets of questionnaires were developed and utilized to gather information from different groups of respondents. Each set of questionnaires was tailored to the specific category of professionals involved, enabling a comprehensive understanding of the operation and maintenance of the equipment from various perspectives. The questionnaires designed for the management personnel focused on exploring their roles and responsibilities in equipment management. These questionnaires delved into areas such as decision-making processes, resource allocation, and overall coordination of the equipment. In addition to the questionnaires, oral interviews were conducted with the participants. The interview questions followed a similar format to the structured questionnaires but allowed for more detailed responses. These interviews provided an opportunity for the officers to share additional insights and elaborate on their understanding of the subject matter. Moreover, the interview sessions assessed the proficiency of the respondents in handling the equipment for both maintenance and operation, thereby providing valuable information on their level of expertise. By utilizing different sets of questionnaires and conducting oral interviews, this study aimed to gather comprehensive and detailed information on the management and maintenance of the equipment, considering the perspectives of various professionals involved.

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Questionnaire Design

The survey questionnaires employed in this study encompassed three distinct operational dimensions: technical, managerial, and organizational factors. Each questionnaire was tailored to the specific group of professionals being surveyed, ensuring that information was obtained based on their areas of expertise and responsibilities. For the Radiographers/radiotherapists, the questionnaire focused on gathering information regarding the operational mode of the machines. This included assessing the workload on the equipment and evaluating its overall performance. The questionnaire for the Engineers, on the other hand, aimed to assess the maintenance state of the machines, specifically focusing on the maintainability of the equipment. This questionnaire explored the maintenance and repair approach employed, as well as any challenges encountered in the process. In the case of the management cadre, their questionnaire was designed to capture information related to the role of hospital management in the operation of the equipment. This encompassed areas such as funding, training, general administration, and any contributions from the government, if applicable. To ensure unbiased responses, the questionnaires intentionally omitted the collection of personal biodata. Each questionnaire consisted of 25 questions, specifically tailored to the respective group being surveyed. Section I of the questionnaire aimed to elicit information on the operational mode of the machines, including workload and overall performance. Section II focused on technical aspects, such as maintenance and repair approaches, as well as any challenges faced. Finally, Section III sought to gather insights into the role of hospital management, including funding, training, general administration, and potential contributions from the government. By utilizing these structured questionnaires, the study aimed to obtain comprehensive and detailed information on the operational, technical, and managerial aspects of the equipment, providing valuable insights from each professional group involved.

3.0 RESULTS AND DISCUSSION

Status of Radiotherapy Machines across the States of Nigeria

In the results presented in Figure 1, the relationship between the total number of installed external beam machines and the number of machines currently in operation is depicted. The findings reveal that out of the 6 installed linear accelerator machines, 5 are functioning properly, indicating a functional rate of 83.3%. Conversely, for the Cobalt-60 machines, only 2 out of the total 4 installations are currently operational, resulting in a functional rate of 50%. Furthermore, it is important to note that the non-functioning Cobalt-60 machines have been officially decommissioned due to their advanced age, confirming their inability to be restored to a functional state. This highlights the significance of addressing the challenges associated with outdated Cobalt-60 machines and emphasizes the need for strategic measures to ensure the availability and functionality of this equipment to meet the demand for radiotherapy services effectively.

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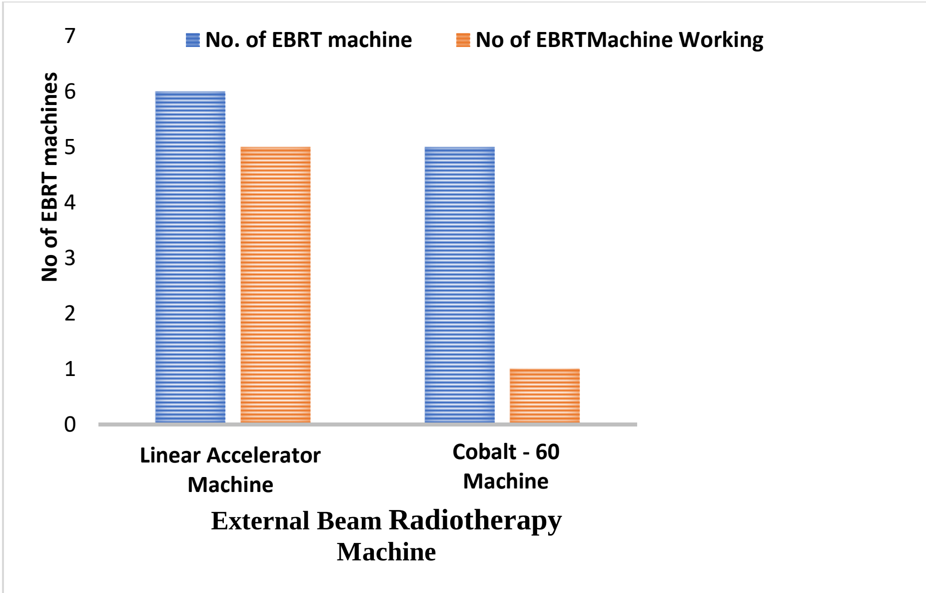

Figure 1: Total Number of External Beam Radiotherapy Machines in Nigeria and the total number of EBRT working

The findings from previous studies highlight the inadequate number of installed machines across Nigeria to meet the growing demand for cancer care. According to Nwankwo et al. (2013), Nigeria currently possesses less than 6% of the required number of megavoltage radiotherapy machines, with a shortfall of more than 129 linear accelerator machines out of the recommended 137. The recommended standard for machine density varies based on population density, suggesting the need for 1 radiotherapy machine per 450 patients or 1 machine per 183,000 population for linear accelerator machines, and 1 machine per 500,000 or 1,000,000 population for cobalt-60 machines (Slotman et al., 2005). The suggested optimal proportion of patients to be treated with radiotherapy for most cancers ranges from 60% to 76% (Ranganathan et al., 2021), underscoring the significant burden placed on the limited number of available machines. This overburdening is exacerbated by the fact that linear accelerator machines have an average lifespan of 10-12 years, while cobalt machines require source head replacement every 5.27 years (Ramanathan, 2021). Figure 2 presents the age distribution of the four cobalt-60 machines currently installed in Nigeria, highlighting the need to address the aging equipment and expand the number of radiotherapy machines to meet the increasing patient demand. Urgent measures are necessary to enhance the capacity and accessibility of radiotherapy services in Nigeria.

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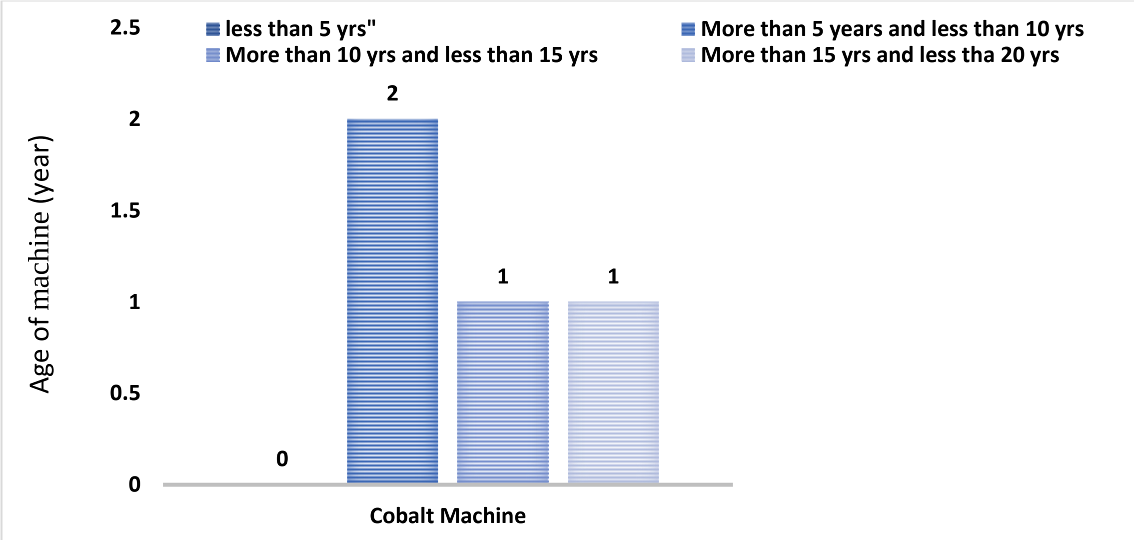

Figure 2: Age Distribution of the Cobalt-60 Machines

Based on the responses obtained from the survey participants, it was revealed that three out of the four cobalt-60 machines currently in use in Nigeria have exceeded the standard half-life of 5 years for the replacement of the cobalt-60 isotope head (Ramanathan, 2021). As a consequence, the activity of the source decays by approximately 1.09% per month (Rahman et al., 2022), leading to an increase in treatment time proportional to the decay rate. This deterioration directly impacts the quality of treatment and the capacity to accommodate a sufficient number of patients with these cobalt machines simultaneously. Figure 3 illustrates the installation years of the linear accelerator (linac) machines. Among the six Linac machines, two were installed less than 10 years ago, while the remaining four have been in operation for more than 10 years. Notably, the faulty Linac machine, installed 19 years ago at the National Hospital, Abuja, may have exceeded its specified lifespan. Most manufacturers recommend an active life of 10 years for linear accelerator machines and do not provide guarantees on spare parts, particularly for the software controls, beyond that timeframe (Kamen et al., 2019).

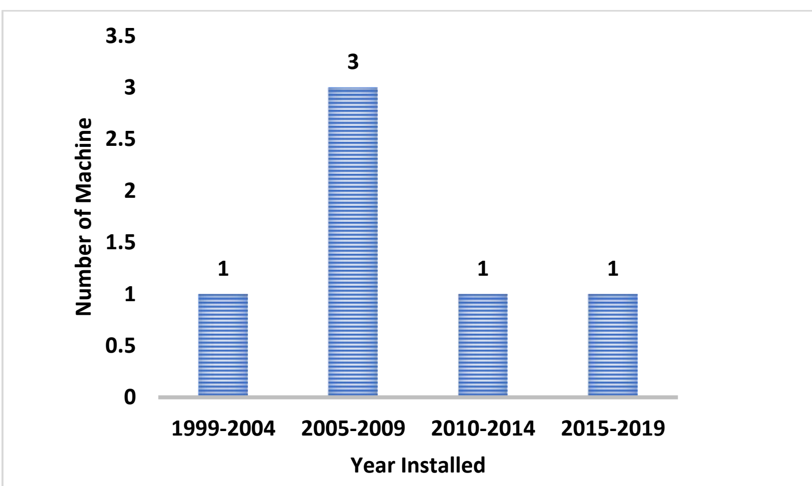

Figure 3: Year of installation of Linear Accelerator machines

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The under-provision of radiotherapy machines has been identified by the Royal College of Radiologists, resulting in several consequences. These include the presence of long waiting lists for radiotherapy, the inability to administer the most effective treatment, the inability to address potentially life-threatening treatment delays, and the inability to compensate for unscheduled gaps in therapy, ultimately leading to prolonged overall treatment times. To mitigate these challenges, each center needs to be equipped with more than one linear accelerator machine. Additionally, the installation of supportive machines capable of delivering less penetrating doses can effectively address superficial cancer cases, thereby reducing the burden on larger machines and optimizing resource allocation within the healthcare system.

Frequency of breakdown of machines and possible factors responsible

Figure 4.4 presents the distribution of responses regarding the frequency of breakdowns reported across different cancer centers. The data reflects the average duration of breakdowns observed on the linear accelerator machines, as reported by the respondents.

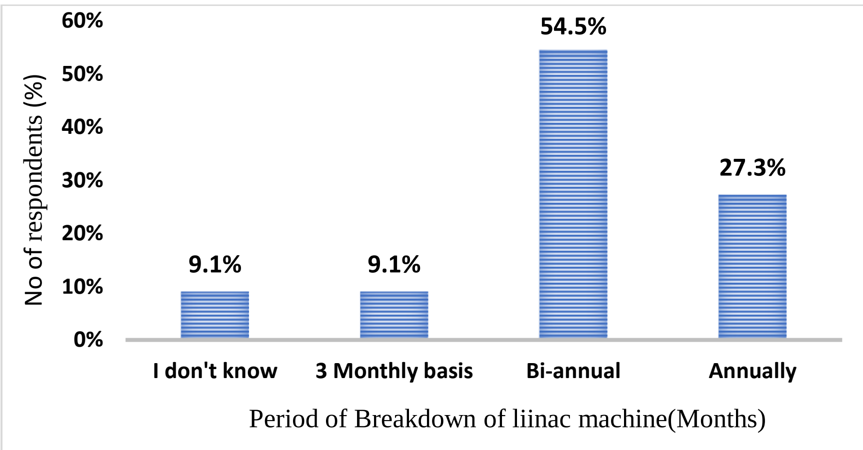

Figure 4: Average Number of Breakdowns of LINAC Machine

Among the respondents, 54.5% reported that the Linac machines experience an average of two breakdowns per year, while 27.3% indicated that the machines encounter an average of one breakdown every 12 months. It should be noted that these breakdowns encompass both minor issues, for which repair parts can be sourced locally, as well as major breakdowns that necessitate the importation of parts.

Analysis of the maintenance of the radiotherapy machines

Implementing a preventive maintenance policy is crucial in enhancing the availability and reliability of radiotherapy machines. Figure 5 illustrates the analysis of the percentage of radiotherapy centers that have implemented preventive maintenance (PM) policies based on the respondents' experiences. Approximately 44.4% of the respondents reported not having any preventive maintenance policy in place, while approximately 55.6% confirmed the existence of a PM policy.

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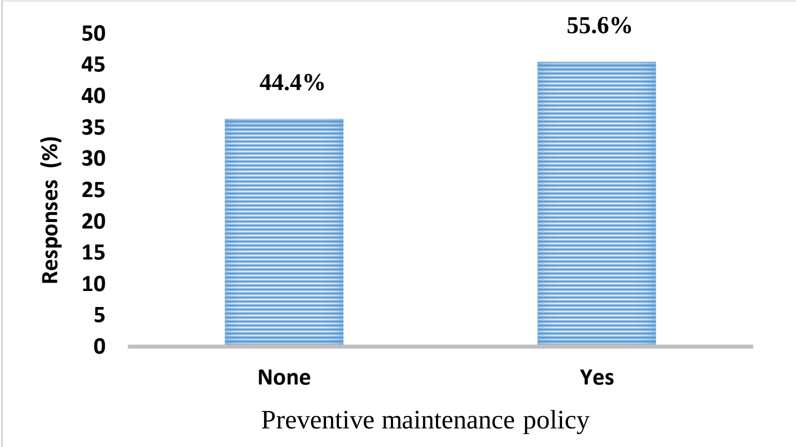

Figure 5: Preventive Maintenance Policy Available

The absence of a preventive maintenance policy can be attributed to several factors, including insufficient allocated funds, inadequate knowledge about machine operation, lack of proper training in machine maintenance, and misplaced priorities. Additionally, the time required for spare parts to arrive from the source after placing an order should be considered as part of the preventive maintenance policy. It is evident from the responses that a majority of the spare parts are sourced from overseas countries, including Europe, America, India, or South Africa, while only a small portion (primarily cobalt-60 machine boards) is procured within the country.

Figure 6 provides an overview of the different sources from which spare parts for radiotherapy machines are obtained. Approximately 90% of the spare parts are imported from overseas countries, while the remaining 10% are sourced domestically, with the majority consisting of cobalt-60 machine boards.

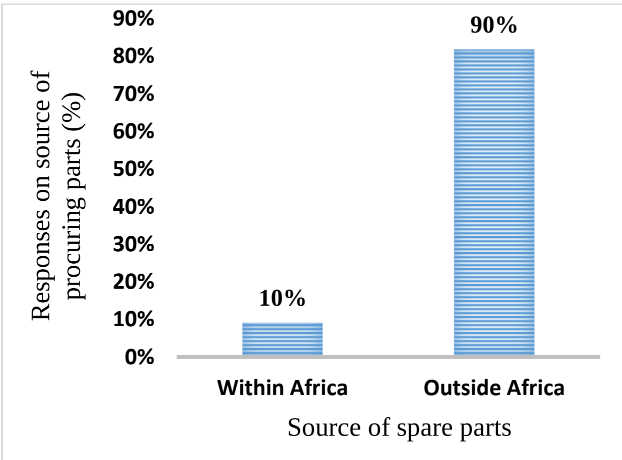

Figure 6: Source of Procuring Spare Parts

The procurement source of the parts, as depicted in Figure 6, has been found to have an impact on the delivery time. Various factors such as logistics, administrative processes, and customs clearance can cause delays in the delivery of parts. Figure 7 visually illustrates the responses regarding the time taken in weeks for the delivery of procured spare parts.

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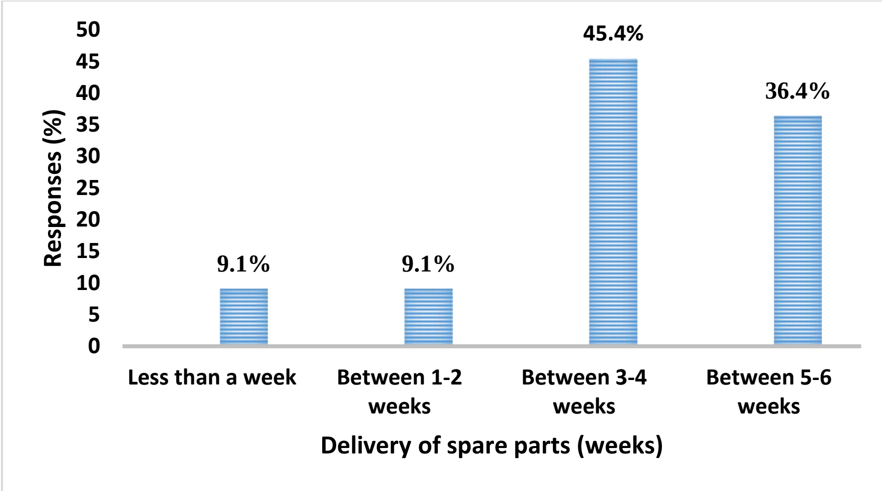

Figure 7: Average Time of Arrival of Spare Parts

Figure 7 illustrates the significant time lost as a result of delays in delivering ordered spare parts. Approximately 45% of the respondents reported a delivery time of 3-4 weeks, while 36.5% mentioned a delivery time of 5-6 weeks. However, a small percentage of respondents (9.1%) experienced shorter delivery periods of 1-2 weeks or even less than a week.
Figure 8 presents the availability of dehumidifiers at six cancer treatment centers in Nigeria, represented in percentage form.

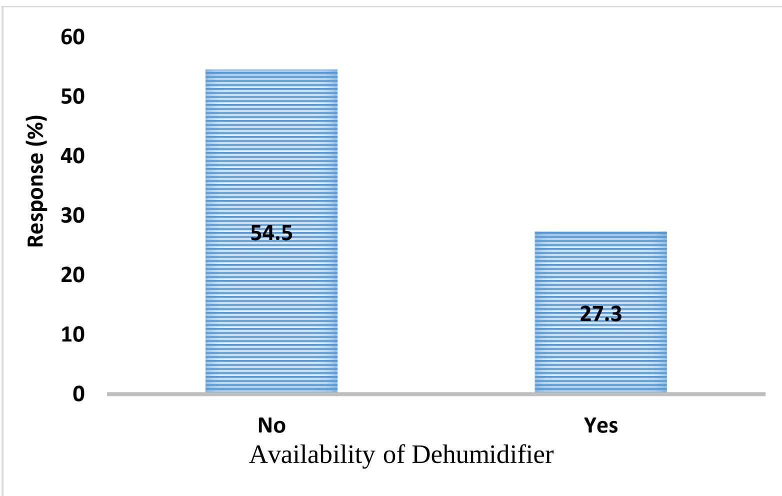

Figure 8: Dehumidifier Installed

Based on the data presented in Figure 8, approximately 61.5% of the surveyed cancer treatment centers do not have dehumidifiers installed. The absence of dehumidifiers has a direct impact on the humidity levels within the treatment room, leading to premature deterioration of the ion chamber.

The workload on the Radiotherapy Machines

The workload can be quantified by considering the number of courses of treatment or exposures administered. Courses of treatment may vary in terms of the number of attendances, fractions, and

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exposures involved (Greaves, 2018). The number of fractions and exposures administered is directly influenced by the number of patients in need of treatment. Figure 9 presents the respondents' perspectives on the daily patient workload required for treatment, taking into account their understanding of the established standards.

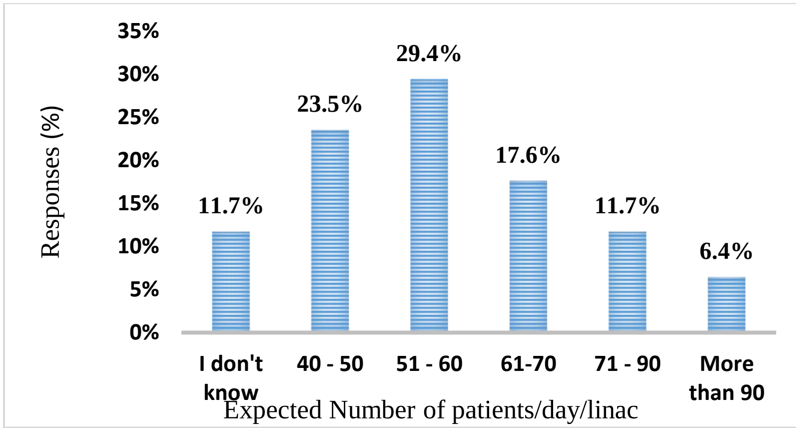

Figure 9: Expected Number of Patients for Treatment/day/Linac Machine

Approximately 23.5% of the respondents indicated that the specified standard for daily patient attendance should fall within the range of 40-50 patients, while 29.4% suggested that the required number should range between 51-60 patients per day. These figures align reasonably well with the recommended range of 40-50 patients, considering an average treatment time of 15-20 minutes per patient. Figure 10 presents the actual patient records currently being treated daily across the various centers. The data provided by the respondents regarding the actual number of patients treated per day allows for an assessment of the workload placed on the radiotherapy machines, in comparison to the information obtained in Figure 9.

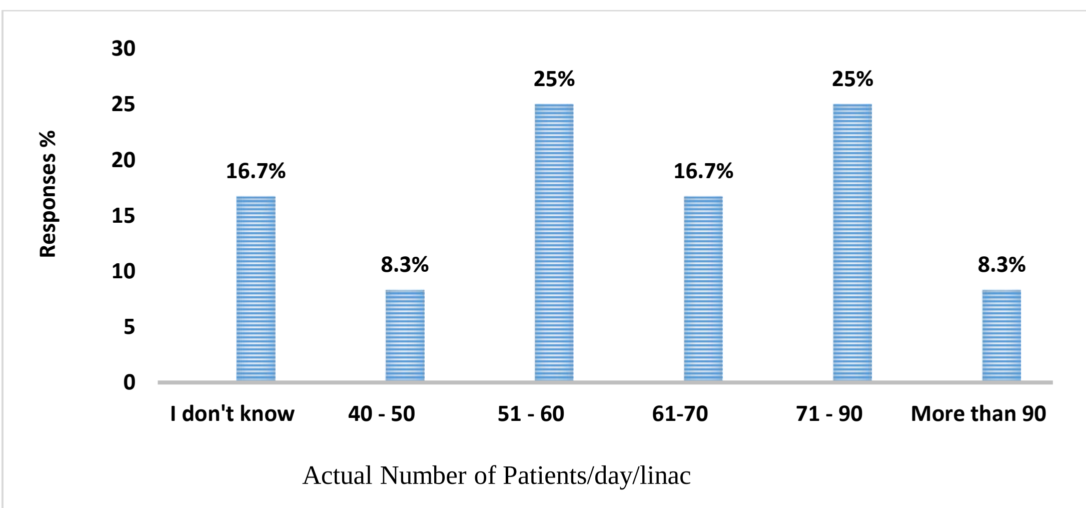

Figure 10: Actual Number of Patients/day/Linac Machine

The responses obtained from the respondents representing different centers indicate that the number of patients being treated surpasses the recommended capacity, placing an additional burden on the existing

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radiotherapy machines. This finding highlights the necessity of installing additional radiotherapy machines, as the workload on the current ten machines, based on available records, is substantial.

Analysis of Management Problems

Significant management issues were identified and comprehensive data were collected and analyzed to propose potential solutions. Ngwa et al. (2022) recommend the development of a training plan for personnel, which should be completed before the equipment installation. However, it was observed that some radiotherapy centers do not fully adhere to this recommendation. Figure 11 illustrates the percentage of responses regarding the level of personnel training on the radiotherapy machines.

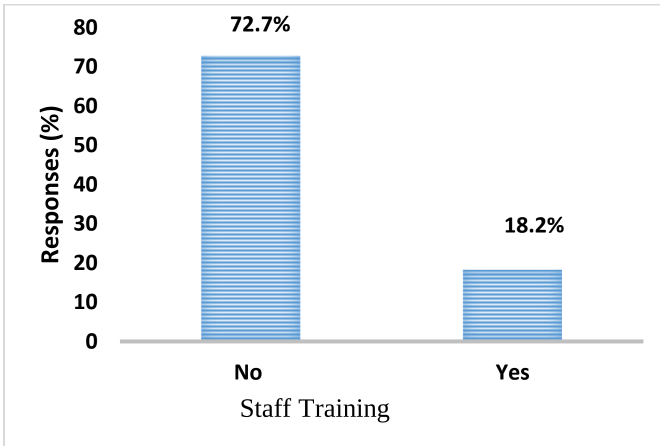

Figure 11: Staff Adequately Trained

Based on the data presented in Figure 11, it is evident that 72.7% of the respondents indicated a lack of sufficient training for personnel. This suboptimal management approach can lead to decreased productivity levels. It is crucial to ensure that maintenance engineers and radiographers receive adequate training to enhance the overall quality of service delivery. Figure 12 provides a percentage breakdown of the engagement levels of maintenance contractors at the radiotherapy centers in Nigeria. It is noteworthy that the majority of hospitals in Nigeria exhibit a low level of engagement with maintenance contractors, as indicated by the presence of maintenance contracts in their facilities.

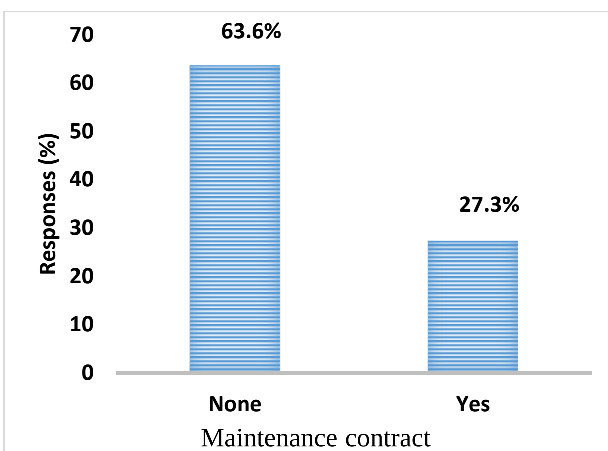

Figure 12: Operative Maintenance Contract at the moment

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Based on the responses received, it was found that approximately 63.6% of the respondents do not currently have an active maintenance contract with the manufacturer's representative. In contrast, about 27.3% of the respondents reported having such a contract in place. The findings, presented in Figure 13, reflect the opinions of various radiotherapy centers regarding the necessity of increasing the number of installed radiotherapy machines across Nigeria. The analysis of the respondents' feedback reveals that approximately 72.7% of them support the idea of hospitals acquiring additional units of radiotherapy machines. However, it is worth noting that approximately 18.2% of the respondents, potentially due to already having multiple radiotherapy machines installed in their hospitals (as observed in the cases of the National Hospital, Abuja, and Eko Hospital, Lagos), do not favor this proposal.

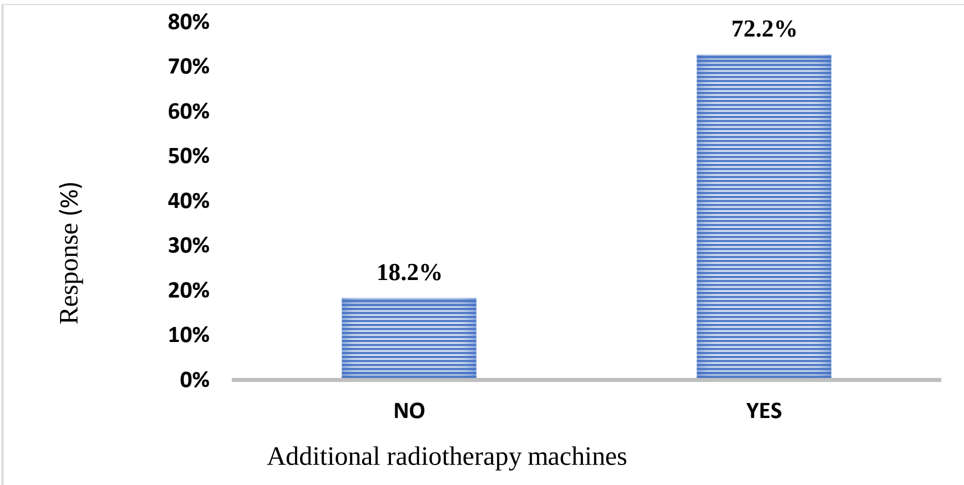

Figure 13: Installation of Additional Radiotherapy Machines

The inclusion of additional supportive cancer treatment machines can effectively alleviate the workload on the existing external beam radiation therapy (EBRT) machines. It is noteworthy that, apart from the National Hospital, Abuja, and University College, Ibadan, which possesses Brachytherapy and Orthovoltage machines respectively, the remaining hospitals lack other supportive treatment machines that can help alleviate the strain on the limited number of installed radiotherapy machines. This is significant considering that not all cancer cases require deep penetration treatment, as some are superficial. Figure 14 provides an overview of the availability of superficial or orthovoltage machines at the cancer centers in Nigeria, highlighting the current status of such equipment in the respective facilities.

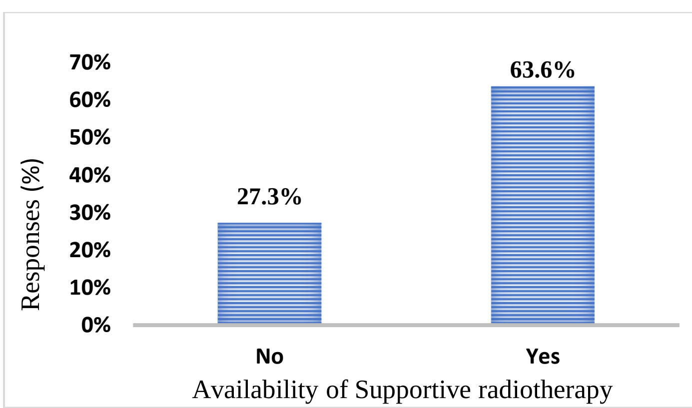

Figure 14: Superficial or Othovoltage Machine Installed

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According to the responses obtained, it was found that 63.6% of the participants indicated that their cancer centers lack any installed supportive cancer treatment machines, such as orthovoltage or superficial machines, which can help alleviate the workload on the linear accelerator or cobalt-60 machines. Conversely, 27.3% of the respondents confirmed the presence of such supportive treatment machines in their respective centers. Figure 15 illustrates the level of staff involvement in the procurement process of radiotherapy machines. The data, presented in percentages, revealed that 100% of the respondents acknowledged that the staff responsible for operating the radiotherapy machines are not involved in the procurement process of these machines.

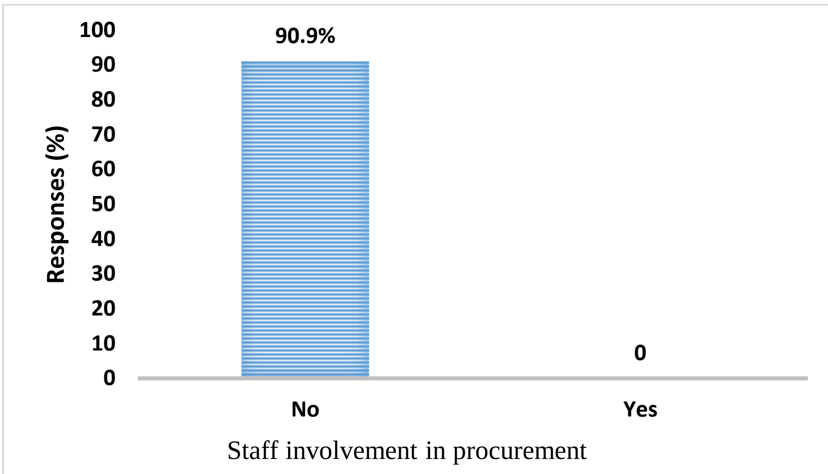

Figure 15: Level of involvement in the process of procuring machine

In contrast to the ideal procurement process for radiotherapy machines, which involves professional inspection before purchase to ensure proper assessment and adherence to standards, it was observed that this practice is not common in Nigeria. To further explore the source of financing for radiotherapy centers, an investigation was conducted using questionnaires, and the findings are presented in Figure 16, illustrating the percentage distribution of responses regarding the sources of financing for the radiotherapy centers.

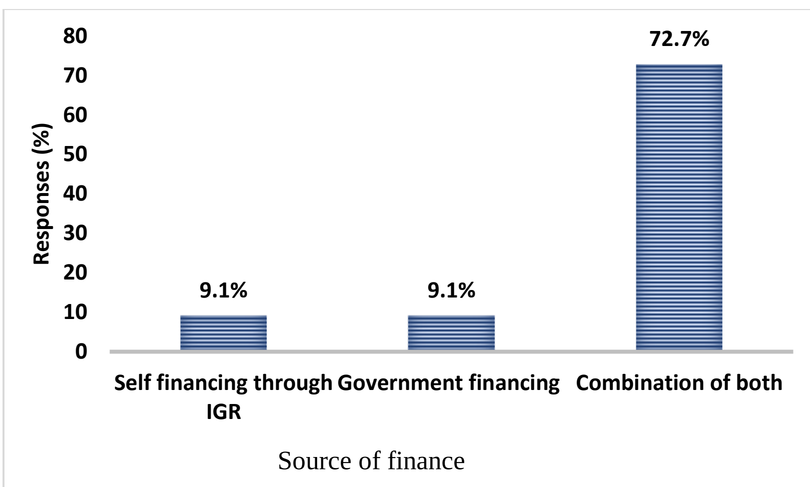

Figure16: Source of financing for the maintenance of the machines

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The analysis presented in Figure 16 highlights the insufficiency of internally generated funds from the operation of radiotherapy centers to effectively maintain and manage these facilities. Consequently, there is a critical need for government involvement in financial management, particularly regarding the maintenance of these machines. As depicted in Figure 16, funding sources for the maintenance of treatment machines are sourced from both the government and internally generated revenues, accounting for 72.7% of the total. Therefore, the government must play an active role in monitoring the various radiotherapy centers and ensuring the delivery of services following established standards by establishing independent regulatory bodies.

4.0 CONCLUSION

In this study, we have examined the current state of radiotherapy machines and their management in cancer treatment centers across Nigeria. The findings have shed light on several key issues that need urgent attention to improve the quality of cancer care in the country.

i. Analysis of the data revealed a significant gap between the number of installed radiotherapy machines and the growing demand for cancer treatment. Nigeria is facing a severe shortage of both linear accelerator machines and Cobalt-60 machines, with only a fraction of the required number available. This shortage has led to a high workload on the existing machines, resulting in longer waiting times for patients and compromised treatment outcomes.
ii. Furthermore, various management challenges that contribute to the inefficiency and suboptimal performance of radiotherapy centers were identified. These challenges include the lack of a preventive maintenance policy, inadequate training of personnel, delayed delivery of spare parts, and insufficient engagement of maintenance contractors. Addressing these issues is crucial to ensure the availability, reliability, and effectiveness of radiotherapy machines.
iii. The study also highlighted the need for additional supportive cancer treatment machines, such as orthovoltage and superficial machines, to alleviate the burden on the existing radiotherapy machines. Currently, most centers lack these supportive machines, limiting their ability to provide comprehensive and tailored treatment options for patients.
iv. Financial sustainability emerged as a significant concern, with internally generated funds being inadequate to meet the maintenance and operational needs of the radiotherapy centers. Government involvement and support are crucial in bridging the financial gaps and ensuring the provision of quality cancer care services. Establishing independent regulatory bodies can help enforce standards and monitor the adherence of radiotherapy centers to established protocols.

In conclusion, the findings of this study underscore the urgent need for strategic interventions in the management and provision of radiotherapy services in Nigeria. The government, healthcare institutions, and relevant stakeholders must work collaboratively to address the identified challenges and implement sustainable solutions. Increasing the number of radiotherapy machines, improving maintenance practices, enhancing staff training, and ensuring adequate funding are essential steps toward achieving optimal cancer care and improving patient outcomes in Nigeria. For further studies, a longitudinal study to assess the long-term impact of the proposed interventions on the availability, reliability, and effectiveness of radiotherapy machines can be conducted.

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