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HEALTH SERVICES RESEARCH

Emerging Use of Public-Private Partnerships in Public Radiotherapy Facilities in Nigeria

Chidinma P. Anakwenze Akinfenwa, MD, MPH[1]; Abiola Ibraheem, MD[2]; Kenneth Nwankwo, MD[3]; Nwamaka Lasebikan, MD[4]; Musa Ali-Gombe, MD[5]; Usman Malami Aliyu, MD[6]; Emmanuel Ikhile, MD[7]; Omobolanle Adegboyega, MD[8]; Adamu Abdullahi, MD[9]; Ann H. Klopp, MD, PhD[1]; Kathleen Schmeler, MD[10]; Lilie L. Lin, MD[1]; Anuja Jhingran, MD[1]; Brandi R. Page, MD[11]; Jim Leng, MD[12]; Surbhi Grover, MD, MPH[13]; and Atara Ntekim, MD[14]

PURPOSE Radiotherapy (RT) treatment at public hospitals in Nigeria is often interrupted by prolonged periods of machine breakdown because of insufficient funds for maintenance and repair. These delays have prompted the uptake of public-private partnerships (PPPs) to acquire and maintain RT equipment. This study aimed to understand Nigeria's current RT capacity and the impact of PPPs on RT availability and cost.

METHODS Eleven radiation oncologists, each representing one of the 11 RT centers in Nigeria (eight public and three private), were invited to complete a survey on the type, status, acquisition, and maintenance plan of existing RT equipment, cost incurred by patients for external-beam radiation (EBRT) and brachytherapy treatment, and number of patients treated per year on each machine. Type and status of equipment at nonresponding facilities were obtained through literature review and confirmed with the facility.

RESULTS A total of eight (81%) respondents completed the survey, all representing public centers, three of which reported PPP use. They reported 11 megavoltage units in total (seven linear accelerators [LINACs] and four Cobalt-60s) and 10 brachytherapy afterloaders. Of those, 57% (4/7) of the LINACs, 100% (4/4) of the Cobalt-60s, and 63% (7/11) of the afterloaders were in clinical use. All commissioned equipment supported by PPPs (three LINACs and one afterloader) were in operation. The public EBRT equipment were nonfunctional 35% of the year (resulting in 60% fewer patients treated per year). The PPP EBRT and afterloaders did not experience any periods of breakdown, but PPP costs were 338% higher than public equipment.

CONCLUSION This study characterizes the use of PPP as a more reliable method of RT delivery in Nigeria, albeit at higher costs.

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INTRODUCTION

With a population of 206 million, Nigeria is the seventh most populous country in the world.[1] The United Nations predicts that Nigeria's population will double by 2050, thereby surpassing that of the United States and becoming the third most populous country.[1] As life expectancy increases, cancer is posing an increasing challenge for Nigeria's health systems, which have historically focused on maternal and child health, and infectious disease. Although cancer cases are underreported, there are an estimated 124,815 new cancer cases diagnosed each year in Nigeria, representing 11% of all cancer cases in Africa.[2,3] Fifty-two percent of these patients will likely require external-beam radiation (EBRT) as part of their treatment regimen.[3] Unfortunately, Nigeria, which has one of the highest number of cancer cases in Africa, does not have the radiotherapy (RT) capacity for its growing cancer burden, with only < 2% of Africa's 397 megavoltage units.[4,5]

Nigeria has had a gradual increase in RT capacity over the past 50 years, with one RT center in 1973, to 11 centers with teletherapy and/or brachytherapy (eight public and three private) in 2020.[6] Despite this expansion, Nigeria still has the greatest gap between RT need and availability, with only one megavoltage unit per 29.4 million people.[1,5] The need is likely underestimated because of the frequent and prolonged periods of machine breakdown at underfunded government radiation oncology departments without active service contracts.[7] By contrast, privately funded RT centers in Nigeria are often functioning, with minimal interruptions in treatment because of machine faults.

These funding challenges and resulting treatment delays have prompted some public RT centers to explore the use of public-private partnerships (PPPs) to acquire and/or maintain RT equipment, without the reliance on limited government funding.[6] Under a PPP contract, the private sector partner or investor is

ASSOCIATED CONTENT

Appendix

Author affiliations and support information (if applicable) appear at the end of this article.

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CONTEXT

Key Objective

Nigeria, which has one of the highest number of cancer cases in Africa, does not have the radiotherapy (RT) capacity for its growing cancer burden. This study aims to understand Nigeria's current RT capacity and use of public-private partnerships for RT acquisition. Although public-private partnerships have been used to bolster laboratory services in lower-resource settings, its use in RT is not well documented in existing literature.

Knowledge Generated

The use of public-private partnerships to acquire RT equipment in Nigeria has increased. With these public-private partnership–acquired machines, fewer periods of breakdown are reported and more patients are treated per machine. However, the costs of patient treatment with a public-private partnership–acquired machine have increased up to four-fold.

Relevance

This study supports the need to further explore novel RT acquisition models, such as public-private partnerships, to improve access to RT treatment in lower-resource settings.

responsible for purchasing the equipment or maintenance contract, with expectations that their initial financial investment will yield returns over some time. Other forms of PPPs may include agreements between public and private sector entities to achieve a public health objective or service for the public good, without expectations of a return on investment. Although PPPs seem like a promising alternative to government-funded RT, there is a concern that this may lead to significantly increased treatment costs to remunerate the partnering private company. This may lead to increased costs to patients, who are largely uninsured and pay out of pocket for medical expenses.[7] This study thus aims to understand Nigeria's current RT capacity and use of PPPs and determine the impact of PPPs on RT availability and cost, and number of patients treated per year.

METHODS

This was a mixed-methods cross-sectional study across multiple centers in Nigeria conducted in February 2020. A Research Electronic Data Capture (REDCap) form was sent to a convenience sample of 11 radiation oncologists, representing one from each of the 11 RT centers in Nigeria, to collect information on existing RT equipment and the use of PPPs. Some respondents were employed at multiple centers (public and private centers), resulting in multiple responses from the same public center. Upon receipt of multiple responses from the same center, numerical values were averaged to generate mean values. Appendix Table A1 lists the RT centers that participated.

Respondents were asked at least 10 questions (Appendix Table A2) about the type and status of existing RT equipment, method of acquisition and maintenance (government or PPP), frequency and duration of machine malfunction, cost incurred by patients for EBRT and brachytherapy treatment, and number of patients treated per year on each machine. There was also an open-ended qualitative question to solicit general comments about PPP models for RT machine acquisition. The average number of months a machine was not functioning and the average number of patients treated per year for each funding type was calculated (excluding machines reporting 12 months of breakdown over the past year). The relative difference in patient costs between government-funded and PPP equipment was calculated. The relative difference in the average number of patients treated per year was also calculated. Machine-specific questions were repeated for each reported commissioned EBRT or brachytherapy machine. Details of type and status of equipment at nonresponding facilities were obtained through literature review and discussion with coauthors, and then confirmed with the facility. We also evaluated general sentiments toward PPPs for RT acquisition.

The form was sent by e-mail with a link to REDCap, a secure, web-based system for data collection. Responses were exported to Microsoft Excel software, and Jamovi Version 1.6.1.0 was used for statistical analysis. Descriptive statistics were calculated, and means were reported with standard deviations. We calculated the relative differences in treatment costs and number of patients treated by funding model. Treatment costs were reported in Naira (₦) and converted to US Dollars using an exchange rate of $357.14 on February 22, 2020. We also present the costs in terms of the 2018 purchasing power parity conversion factor of $135.14 to account for differences in the cost of living in Nigeria compared with the United States, presented as P$.[8] Shapiro-Wilk test and Q-Q plots were used to assess normality, and an independent-samples *t*-test was used to compare average costs by funding type. Two individuals who were blinded to the respondent's center coded the written responses and achieved consensus on the final reported themes by discussion. This study was reviewed and approved by the University of Ibadan/University College Hospital Ethics Committee.

RESULTS

Existing RT Equipment and PPP Use

A total of eight (81%) radiation oncologists completed the survey, representing seven out of eight public centers (87.5%; Appendix Table A1). At the time of the study, there were four Cobalt-60s, seven linear accelerators (LINACs; one of which is not yet commissioned), and 11 brachytherapy afterloaders (four of which are not yet commissioned) at the 11 RT centers in Nigeria (Fig 1). Of those, 57% (4/7) of the LINACs, 100% (4/4) of the Cobalt-60s, and 63% (7/11) of the brachytherapy afterloaders were in clinical use. Three of the seven responding public centers reported PPP use, with two LINACs acquired through a PPP at the Lagos University Teaching Hospital, one LINAC acquired by the federal government but maintained by a PPP at University of Nigeria Teaching Hospital, and one high-dose rate brachytherapy afterloader acquired by a PPP at University College Hospital (Fig 2, Appendix Table A1).

Status of Commissioned Equipment

While all commissioned equipment supported by PPPs were in operation, three government-supported machines were nonfunctional at the time of the survey (Appendix Table A1). The government acquired and maintained EBRT equipment were nonfunctional 35% of the year (4.25 months ± 2.48 months), resulting in 60% fewer patients treated per year than PPP sponsored equipment (Fig 3, Appendix Table A1). By contrast, the PPP-acquired and -maintained equipment were functional year-round. The government-acquired brachytherapy afterloaders were not functioning 25% of the year (3 months ± 1.41 months). At the time of this survey, the PPP-acquired brachytherapy afterloader was not yet commissioned.

Treatment Costs

Overall, the PPP costs were higher than the government-funded equipment costs (P = .01; Table 1). The average cost of a 20-fraction course of EBRT from PPP RT equipment was $1810.67 ± $598.13 (P$4,785.16 ± $1,580.73, ₦646,666.67 ± ₦213,619.60), which represents a 335% increase when compared with EBRT from government-funded RT at an average cost of $416.50 ± $153.52 (P$1,100.71 ± $405.72, ₦148,750 ± ₦54,829.28). The average cost of PPP LINAC-delivered EBRT of $1,810.67 ± $598.13 (P$4,785.16 ± $1,580.73, ₦646,666.67 ± ₦213,619.60) represented a 308% increase when compared with a government-funded LINAC at a cost of $443.34 ± $176.16 (P$1,171.66 ± P$465.55; ₦158,333 ± 62,915). The costs of PPP-funded brachytherapy were also higher ($280.00 ± NA; P$739.97 ± NA; ₦100,000 ± NA), representing a 36% increase, from government-funded brachytherapy ($205.00 ± $116.57; P$542.64 ± $308.08; ₦73,333 ± ₦41,633.32).

General Sentiments

Direct quotations are in Appendix Table A3. All respondents felt that PPPs were generally good. Thematic analysis revealed that respondents reported PPPs led to improved availability of RT (Fig 4). The most frequent comment was that PPPs were the way forward (n = 6). However, there was also a comment that this was at increased costs to patients who struggle to afford cancer care (n = 1). Some respondents stressed the importance of reviewing the details of the partnership contracts very carefully to avoid exploitation by private companies and protect the interests of the governments and patients (n = 2). Another commented that PPPs help ensure that the oncology trainees had RT experience (n = 1).

DISCUSSION

Using cancer incidence data from 2008, the International Atomic Energy Agency estimated that Nigeria, which had seven machines, would need an additional 138 RT machines to care for its patients with cancer.[9] Since then, Nigeria added five megavoltage units to its supply of RT equipment, two of which were acquired through a PPP with the Nigerian Sovereign Investment Authority (NSIA). Since our data collection, a new private center (Marcelle Ruth Cancer Center in Lagos) has commissioned a LINAC. Notably, all the new megavoltage units are linear accelerators, which offer superior dosimetry to Cobalt-60 machines but have higher operational costs and requirements for stable power or backup power supplies, such as generators and inverters.[10,11] For these reasons, Cobalt-60 machines are thought to be more sustainable in lower-

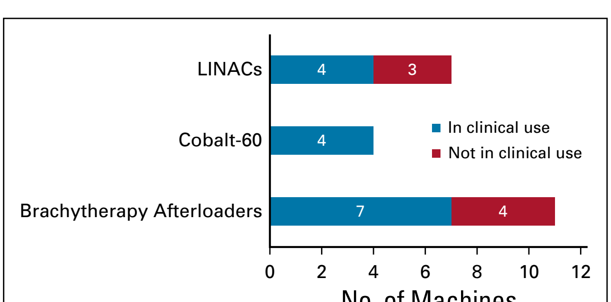

FIG 1. Census of existing radiotherapy equipment. LINACs, linear accelerators.

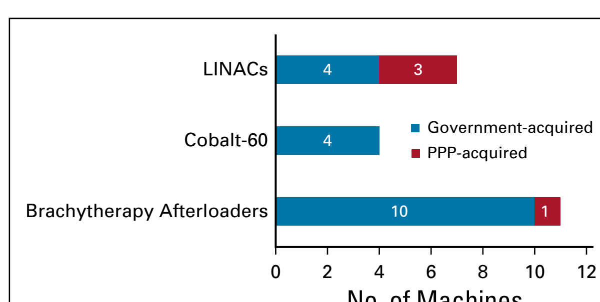

FIG 2. PPP use. LINACs, linear accelerators; PPP, public-private partnership.

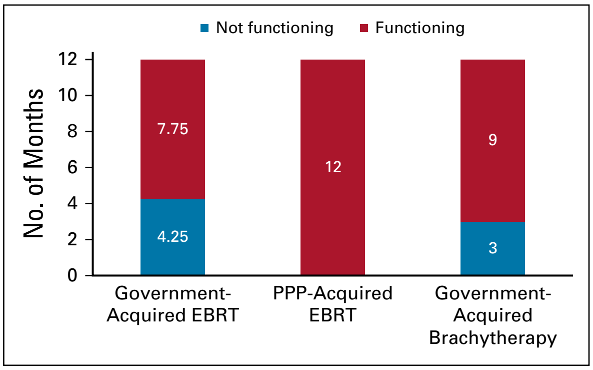

FIG 3. Status of commissioned equipment. EBRT, external-beam radiation therapy; PPP, public-private partnership.

resource settings, but local needs, conditions, and resources have to be factored into these decisions. Nigeria has also added high-dose-rate brachytherapy machines for multiple centers, including one through a PPP with the NSIA. Although these incremental gains in machines pale compared with the estimated need, the shift from relying on government funding for machine maintenance and acquisition is noteworthy. For years, RT machines purchased by the federal government or donated by other entities have become old and often break down, with significant delays in repair.[12,13] By contrast, the privately funded RT centers in Nigeria have had minimal interruptions in treatment because of machine faults, despite high patient volumes. It is also important to note that the currently published DIrectory of RAdiotherapy Centres (DIRAC) reports seven existing RT centers and seven megavoltage machines, whereas our findings indicate 12 centers with 12 megavoltage units.[5] This discrepancy between the DIRAC and our findings underscores the importance of ground-level reassessment of current cancer treatment capacities.

Although PPPs offer innovative solutions for purchasing RT equipment, they can also be used to creatively acquire maintenance contracts. University of Nigeria Teaching Hospital in Enugu established a PPP to purchase a vendor service contract for its government-acquired megavoltage unit, ensuring timely and consistent maintenance independent of government funding. Although these partnerships have not been commonly used in low-resource settings, they are attractive because they allow governments to take advantage of private-sector expertise to improve the management and quality of services and leverage private funding for infrastructure and equipment provision.[14-16] For example, McIntosh et al[14] demonstrated that a PPP-managed network in Lesotho achieved higher patient volumes and more efficient care (lower average lengths of inpatient stays and lower rates of emergency room visits). Similarly, we demonstrate that RT centers in Nigeria using PPPs maintain higher patient volumes and less machine downtime. However, it is important to note that this association with higher patient volumes and less frequent machine downtime does not indicate causality. There may be unmeasured confounding factors such as referral pattern changes, staffing shortages from strikes, or political or economic changes that may contribute to differences in patient volume. However, based on coauthor feedback, the higher number of patients treated per month in PPP centers were treated under standard staffing levels and referral patterns. The coauthors also note that PPP arrangements have reduced radiation treatment waiting periods from six months to less than eight weeks because more treatments are delivered each month using the functioning PPP supported equipment. There may also be greater financial incentive for PPP-funded RT centers to maintain their equipment to increase revenue and service their debt. Future work should focus on exploring causality and the impact of PPPs on machine functionality and patient volumes.

The scope and sustainability of RT PPPs in Nigeria are beyond this manuscript's purview, but are being further explored in an ongoing study. However, there are examples of PPPs being used successfully in oncology. In Botswana,

TABLE 1. Average Cost of Radiotherapy in Nigeria

Equipment Type	Government-Acquired, $ {P$} (₦) [No.]	PPP, $ {P$} (₦) [No.]	Percent Increase
EBRT	$416.50 ± $153.52 {P$1,100.71 ± $405.72} (₦148,750.00 ± ₦54,829.28) [n = 4]	$1,810.67 ± $598.13 {P$4,785.16 ± $1,580.73} (₦646, 666.67 ± ₦213,619.60) [n = 3]	335.73
LINAC	$443.34± $176.16 {P$1,171.66 ± P$ 465.55} (₦158, 333.30 ± 62,915.00) [n = 3]	$1,810.67 ± $598.13 {P$4,785.16 ± $1,580.73} (₦646, 666.67 ± ₦213,619.60) [n = 3]	308.42
Cobalt-60	$336.00 ± NA {P$887.97 ± NA} (₦120,000.00 ± NA) [n = 1]	NA	NA
Brachytherapy	$205.00 ± $116.57 {P$542.64 ± $308.08} (₦73, 333.33 ± ₦41,633.32) [n = 3]	$280.00 ± NA {P$739.97 ± NA} (₦100,000.00 ± NA) [n = 1]	36.36
All equipment	$326.00 ± $170.46 {P$861.54 ± $450.47} (₦116, 428.60 ± ₦60,876.53) [n = 7]	$326.00 ± $170.46 {P$3,773.86 ± $2,399.31} (₦510, 000.00 ± ₦324,242.70) [n = 4]	338.04

Abbreviations: ₦, Nigerian Naira; $, US Dollar; P$, cost in US Dollar adjusted for purchasing power parity; EBRT, external-beam radiation; LINAC, linear accelerator; NA, not available; PPP, public-private partnership.

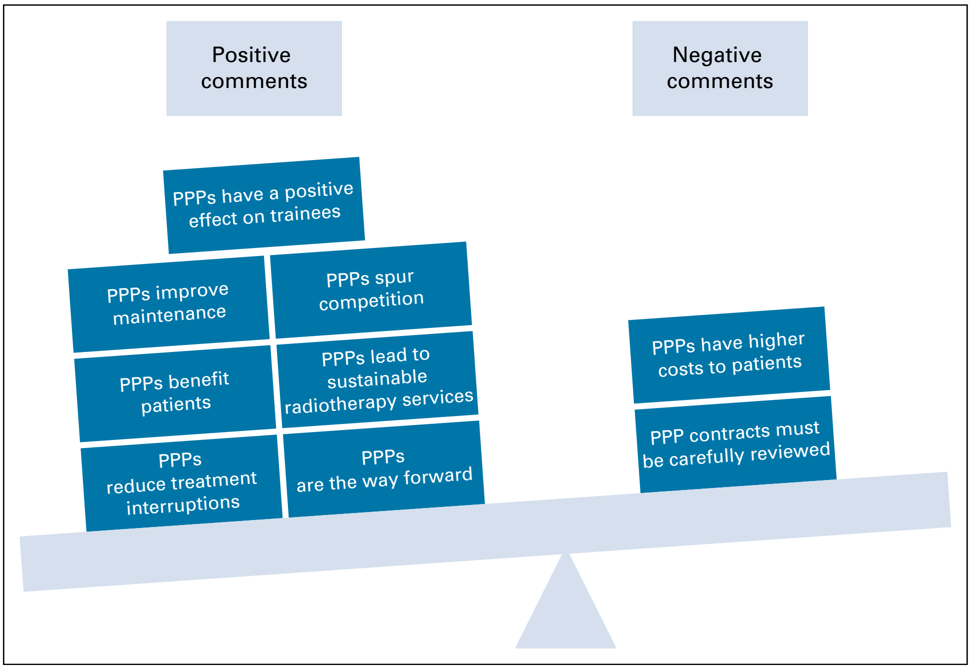

FIG 4. Most common comments on PPPs. PPP, public-private partnership.

the private sector treated its first RT patients at the Gaborone Private Hospital in 2000. Since then, the Botswana government is fully supporting RT costs, and public-sector patients now compose > 90% of the radiation-treated population.[17] Another example of a successful oncology PPP is My Child Matters, a project of the Sanofi Espoir Foundation, which has funded more than 55 pediatric cancer projects in low- and middle-income countries.[18] Its projects have catalyzed improvements in cancer care and complemented government and private sector efforts to sustain and scale improvement in cancer care. One such project expanded and renovated a pediatric oncology ward in Senegal to accommodate more beds and new outpatient areas, which improved access to timely hospital admission and chemotherapy administration.[18] The My Child Matters project also funded a project to expand satellite clinics across Paraguay and implemented electronic patient registration and follow-up systems, which allowed for timely rescheduling of missed appointments. This increased patient volume from 81 patients in 2009 to 884 patients in 2015.[18] These PPP projects not only had direct effects on patient care, but also indirect effects by catalyzing other government- and private-led improvements in health care. Factors that led to sustainability of these projects were involvement of leadership across disciplines, community and international engagement, training, and ongoing involvement of the government. Factors that may lead to failure of PPPs include poor involvement of broader institutional systems and inefficient operational processes—Ghana and Nigeria, for example, have experienced delayed government payments for contractors, which can both deter future investors and make banks reluctant to provide loans for PPP ventures.[19]

Although these partnerships appear to be a promising and perhaps sustainable mechanism for RT equipment acquisition and maintenance, they resulted in up to a four-fold increase in costs to patients. The cost of brachytherapy and external-beam treatments using a PPP represents 15% and 97%, respectively, of the $4,928.90 reported as the average Nigerian resident annual gross national income per capita in purchasing power parity.[8] For reference, the US income per capita is $62,521.[8] These cost increases are largely because of the higher costs of newer linear accelerators and the influence of the partnering private company or bank, which has a set timeline for repayment. There are also additional costs for active maintenance contracts, which the government-funded equipment do not have as they have employed engineers available for repairs. Unfortunately, these cost increases have pushed the brunt of inadequate government health investment onto the largely uninsured patient population, which is untenable, given that 80% of patients reported requiring financial assistance from friends and family pre-PPP at the University College Hospital in 2015.[7] Presently, Nigeria does not have universal health insurance coverage, but federal government employees are covered by the National Health Insurance Scheme, which only recently started covering cancer treatments. Beyond the National Health Insurance Scheme for federal employees, which only covers about 5% of the population, the majority of patients pay out of pocket for treatment and a minority have private health insurance.[20] For PPP-sponsored RT to increase RT access and availability, we need to ensure minimal cost increases through regulation or government subsidization of cancer care.

Another risk of PPPs is that there may be low competition levels to obtain these contracts, which does not allow for robust negotiations between government hospitals and private entities, thus increasing the risk of inflated contract prices. This risk is likely to be more severe in low- and middle-income countries than in higher-income countries because investors may require additional margins for political risks.[21] Moreover, once contracts are signed, the government entity must establish a rigorous monitoring program to ensure that agreed-upon outputs are received. In the most recent report from the Economic Intelligence Unit, Nigeria received a score of 36.8 out of 100 for its capacity to undertake PPP projects.[19] The Economic Intelligence Unit reported the largest barrier in achieving successful PPPs in Nigeria was the gap between what should happen based on Nigeria's strong set of fair and transparent laws on settling disputes and the level of contract enforcement.[19]

Although PPP use in sub-Saharan Africa is limited, they have most successfully been used for years within the utility sectors of high-income countries, where service quality can be clearly specified, measured, and guaranteed.[22] These partnerships in high-income countries have now been broadened to support health care infrastructure, including buildings, large technology systems, and services.[22] In Africa, health care PPPs have most often been facilitated by international partners that donate products or services to enhance treatment and prevention infrastructure.[23] One such example is the Becton Dickinson–US President's Emergency Plan for AIDS Relief PPP, which helped boost sustainable laboratory systems and develop laboratory workforce skills in four African countries.[24] Although these PPPs have made a tremendous impact and should be encouraged, health care PPPs with indigenous or African-based private sector partners, such as the NSIA, are promising and may allay the uncertainty regarding abrupt budget cuts from international partners during administration changes.[25,26]

This study identifies the RT equipment capacity in Nigeria and characterizes PPP use as a viable RT acquisition and maintenance method, albeit at a higher cost to patients. This shift from the reliance on government assistance in public hospitals presents an opportunity for national and international organizations to construct clear legal and regulatory frameworks that can aid in the development of RT-focused PPPs in a way that protects vulnerable public hospitals from exploitation and ensures patients will have equitable access to affordable cancer care. If this proves to be a successful RT provision model, then we will need to learn how changes in RT delivery resulting from PPPs can be leveraged to improve leadership and management practices in other underfunded or inoperative public RT departments and how international bodies like the International Atomic Energy Agency can help facilitate or support the formation of PPPs. While our sample size is small and the data are just preliminary, future larger-scale studies will characterize the acquisition and maintenance of PPP-acquired RT equipment and evaluate and compare the cost and long-term sustainability of RT delivered through government- versus PPP-funded RT equipment.

AFFILIATIONS

[1]Division of Radiation Oncology, The University of Texas, MD Anderson Cancer Center, Houston, TX
[2]Section of Hematology Oncology, University of Chicago, Chicago, IL
[3]Department of Radiation Medicine, College of Medicine, University of Nigeria, Nsukka, Nigeria
[4]Department of Radiation Medicine, University of Nigeria Teaching Hospital, Enugu, Nigeria
[5]Radiology Department, Gombe State University, Gombe, Gombe State, Nigeria
[6]Department of Radiotherapy and Oncology, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Sokoto State, Nigeria
[7]Department of Radiation Oncology, University of Benin Teaching Hospital, Benin, Edo State, Nigeria
[8]Lagos University Teaching Hospital, Lagos, Lagos State, Nigeria
[9]Department of Radiotherapy and Oncology, Ahmadu Bello University Teaching Hospital, Zaria, Kaduna State, Nigeria
[10]Gynecologic Oncology, The University of Texas MD Anderson Cancer Center, Houston, TX
[11]Department of Radiation Oncology and Molecular Radiation Sciences, Johns Hopkins University School of Medicine, Baltimore, MD
[12]The University of Chicago Pritzker School of Medicine, Chicago, IL
[13]Department of Radiation Oncology, Abramson Cancer Center, University of Pennsylvania, Philadelphia, Pennsylvania; Botswana-UPENN Partnership, Gaborone, Botswana
[14]Department of Radiation Oncology, College of Medicine, University of Ibadan, Ibadan, Oyo State, Nigeria

CORRESPONDING AUTHOR

Atara Ntekim, MD, Department of Radiation Oncology, College of Medicine, University of Ibadan, Ibadan, Nigeria, P.M.B 5017 G.P.O Ibadan, Oyo State, Nigeria; e-mail: kimata2000@hotmail.com.

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AUTHOR CONTRIBUTIONS

Conception and design: Chidinma P. Anakwenze Akinfenwa, Usman Malami Aliyu, Adamu Abdullahi, Anuja Jhingran, Brandi R. Page, Atara Ntekim
Administrative support: Chidinma P. Anakwenze Akinfenwa, Ann H. Klopp, Kathleen Schmeler
Provision of study materials or patients: Chidinma P. Anakwenze Akinfenwa, Kenneth Nwankwo, Emmanuel Ikhile, Omobolanle Adegboyega, Adamu Abdullahi, Ann H. Klopp
Collection and assembly of data: Chidinma P. Anakwenze Akinfenwa, Kenneth Nwankwo, Nwamaka Lasebikan, Musa Ali-Gombe, Usman Malami Aliyu, Emmanuel Ikhile, Omobolanle Adegboyega, Adamu Abdullahi, Ann H. Klopp, Atara Ntekim
Data analysis and interpretation: Chidinma P. Anakwenze Akinfenwa, Abiola Ibraheem, Nwamaka Lasebikan, Adamu Abdullahi, Ann H. Klopp, Kathleen Schmeler, Lilie L. Lin, Anuja Jhingran, Brandi R. Page, Jim Leng, Surbhi Grover, Atara Ntekim
Manuscript writing: All authors
Final approval of manuscript: All authors

Accountable for all aspects of the work: All authors

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

Omobolanle Adegboyega
Employment: Lagos University Teaching Hospital
Honoraria: Lagos University Teaching Hospital
Travel, Accommodations, Expenses: Sanofi, I'pace maker

Kathleen Schmeler
Patents, Royalties, Other Intellectual Property: UpToDate

Lilie L. Lin
Research Funding: Astrazeneca
Travel, Accommodations, Expenses: AstraZeneca/MedImmune

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APPENDIX

TABLE A1. Respondent Organization and Radiotherapy Status Listed by Private Versus Public Center[a]

Center and City Location	Respondents	Years of Treating With Radiation	Machine Type	No. of Machines—Manufacturer (PPP or GF)	Months of Breakdown in the Last 12 Months[b]	No. of Patients Treated in the Past Year	Cost
Public							
Lagos University Teaching Hospital (LUTH), Lagos	1	40+	LINAC	2—Varian (PPP)	0	1,972 1,787	$2,156.02 (₦770,000)
			Cobalt-60				
			Brachytherapy	1 HDR (not yet commissioned)	Not yet commissioned		
University College Hospital (UCH), Oyo	1	33	LINAC				
			Cobalt-60	1—Bebatron (GF)	6	350	$336.00 (₦120,000)
			Brachytherapy	2 HDR—Bebig (1 PPP, 1 GF; GF not yet commissioned)	Not yet commissioned	PPP: 150	PPP: $280.00 (₦100,000) GF: $168.00 (₦60,000)
National Hospital Abuja (NHA), Abuja	—	—	LINAC	2 (1 not yet commissioned)	Not yet commissioned		—
			Cobalt-60				
			Brachytherapy	2 LDR (status unknown) 1 HDR (not yet commissioned)	Not yet commissioned		—
Ahmadu Bello University Teaching Hospital (ABUTH), Zaria	1	24	LINAC				
			Cobalt-60	1—CIRUS of France (GF; decommissioned)	Not functional		—
			Brachytherapy	1 LDR—Cis-Bios International (GF)	2		$112.00 (₦40,000)
University of Nigeria Teaching Hospital (UNTH), Enugu	2	10	LINAC	1—Elekta (GF, but maintenance by PPP)	2.5	900	GF: $280.00 (₦100,000)[c] PPP: $1,120.01 (₦400,000)
			Cobalt-60				
			Brachytherapy	1 (GF; not yet commissioned)	Not yet commissioned	—	—
University of Benin Teaching Hospital (UBTH), Edo	1	4	LINAC	1—Elekta (GF; not functional)	Not functional	1,047[d]	$420.00 (₦150,000)
			Cobalt-60				
			Brachytherapy				
Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto	1	11	LINAC	1—Elekta (GF; not functional)	Not functional	1,000[d]	$630.01 (₦225,000)
			Cobalt-60				
			Brachytherapy	1 HDR—Bebig (GF; not yet installed)	Not installed	—	—
Federal Teaching Hospital Gombe, Gombe	1	10	LINAC				
			Cobalt-60				
			Brachytherapy	1 HDR—Varian (GF)	4	74	$336.00 (₦120,000)
Private							
Eko Hospital, Lagos	—	—	LINAC				
			Cobalt-60	1			
			Brachytherapy				
La' Newton Oncology Clinic, Edo	—	—	LINAC				
			Cobalt-60				
			Brachytherapy	1—Prostate Seeds			
Radiotherapy Center Ikeduru Hospital, Imo	—	—	LINAC				
			Cobalt-60	1			
			Brachytherapy				
Average (±standard deviation) or total	8	NA	LINAC	7	0.83 ± 1.44	1,553 ± 573.03	$1,296.41 (₦463, 000)± $824.80 (₦294, 567.48)
			Cobalt-60	4	6 ± NA	350 ± NA	$336,00 (₦120,000) ± NA
			Brachytherapy	11	3 ± 1.41	112 ± 53.74	$224.00 (₦80, 000) ± $102.24 (₦35, 614.84)

Abbreviations: GF, government-funded, HDR, high-dose rate; LDR, low-dose rate; LINAC, linear accelerator; NA, not available; PPP, public-private partnership.

[a]Information was collected in February 2020 and, thus, does not include a new private center (Marcelle Ruth Cancer Center in Lagos), which commissioned a LINAC after initial data collection.

[b]Not reported for machines deemed nonfunctional (broken for 12 months or longer).

[c]Cost before the maintenance PPP contract.

[d]Excluded from average since this machine was nonfunctional at the time of reporting.

TABLE A2. Questions Asked of Radiotherapy Centers

What is the name of the center for which you are providing information?
For how many years has your center treated patients with radiation?
How many commissioned external-beam or teletherapy machines are at your center (including nonfunctioning machines)?
How many commissioned brachytherapy machines are at your center (including nonfunctioning machines)?
For each radiotherapy machine, answer the following questions
1. Who is the manufacturer of the machine?
2. What kind of machine is it (Cobalt-60 or LINAC; low-dose-rate or high-dose-rate or both)?
3. State whether this machine was acquired through government or a public-private partnership.
4. State whether the maintenance is through government or public-private partnership.
5. Is the machine currently working?
6. How many times was the machine not working in the past year, and, on average, for how long was the machine not working?
7. How many patients has this machine treated in the past year (if machine was commissioned after January 2019, please specify when machine was commissioned)?
Does your center have a public-private partnership for external-beam radiation?
What is the cost (in Naira) of a 4-week course of external-beam treatment (Monday-Friday, 5 days a week, for a total of 20 fractions) from a public-private partnership–acquired machine?
Does your center have a government-funded external-beam radiation machine?
What is the cost (in Naira) of a 4-week course of external-beam treatment (Monday-Friday, 5 days a week, for a total of 20 fractions) from a government-acquired machine?
Does your center have a public-private partnership for brachytherapy?
What is the cost (in Naira) of brachytherapy treatment for cervical cancer from a public-private partnership–acquired machine?
Does your center have a government-funded brachytherapy machine?
What is the cost (in Naira) of brachytherapy treatment for cervical cancer from a government-acquired machine?
What is your general feeling about public-private partnership?
What are your general comments, if any, about public-private partnership models for radiotherapy machine acquisition?

Abbreviation: LINAC, linear accelerator.

TABLE A3. Selected Direct Quotations

"PPP is the way to ensure sustainable radiotherapy services."
"In my opinion, I believe public-private partnership is the way to tackle the current problem of radiotherapy practice in Nigeria as it gives wealth of avenue for maintenance of these equipment. This will not only provide working and sustainable radiotherapy machines but will also spur competition obviously across different centers, leading to rapid development of radiotherapy practice across the country at the most benefit of patients with cancer in Nigeria."
"That is the way to go." "…public-private partnership [is] a way to reduce radiotherapy treatment interruptions in Nigeria."
""…contract agreements must be closely looked into to meet expectations on both sides."
"PPP is the way out though at the expense of high cost of treatment."…"[A] Proper memorandum of understanding should be signed at inception to address those issues."

Abbreviation: PPP, public-private partnership.