Original Article

An Audit of Computed Tomography Services in Zambia

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ABSTRACT

Background: In Zambia, Computed Tomography (CT) has been available since 1994 as part of the healthcare delivery pathway. Radiographers undertake CT examinations of the body to diagnose diseases, injuries and to plan for radiotherapy.

Objective: The aim of this study was to audit CT services in Zambia.

Methodology: The study used a convergent parallel design in which quantitative and qualitative data were collected concurrently using an online questionnaire. Quantitative data were analysed using descriptive statistics, whilst qualitative data were analysed by themes.

Results: Out of the 23 facilities, a total of 22 responded. Results indicated that Western and Central provinces did not have CT scanners. Most CT facilities are in the Lusaka province. 59% (N=13) and 41% (N=9) were from the public and private sectors, respectively. In public hospitals, 46% (N=6) of CT scanners were functional with service contracts and 89% (N=8) were functional in the private hospitals with service contracts. 61.5 % (N=8) of public hospitals had maintenance schedules while 89% (N=8) of private hospitals had maintenance schedules. A total of 7 facilities reported having radiographers with a qualification in CT. 12 out of 22 facilities indicated having a radiologist with average patient waiting times for CT reports being 76 hours and 24 hours in public and private facilities, respectively.

Conclusion: This audit revealed an unequal distribution of CT scanners characterised by poor maintenance and lack of service contracts, especially in public hospitals. The audit also revealed longer waiting times for CT reports in public than in private hospitals.

INTRODUCTION

Since its introduction in 1972, Computed Tomography (CT) has evolved into an essential medical imaging tool for a continually increasing variety of clinical applications.[1, 2] Ehrlich and Coakes[3] define CT as a medical imaging modality that uses X-radiation to produce cross-sectional images of the human body. Improvements in technology leading to the introduction of multisectoral CT scanners has resulted in considerable benefits which include improved temporal and spatial resolution, increased concentration of intravascular contrast material, decreased image noise, efficient X-ray tube use, and longer anatomic coverage.[2-4] In medicine, CT is used for the diagnosis of life-threatening injuries, the diagnosis and staging of cancer, imaging of blood vessels, guidance for diagnostic and therapeutic interventions, orthopaedic works, investigation of injury in **paediatric suspected physical abuse, and planning** of radiotherapy treatment.[2,3] However,

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there is also potential for inappropriate use of CT.[5] This can happen when untrained personnel are used to operate the scanners and unjustified requests for CT examinations from medical practitioners.

While the benefits of CT have been well documented, medical radiation has become a major source of radiation exposure for the general population and its effects have become a public health issue.[6,7] CT is a high radiation dose imaging modality and large cohort studies of the cancer risk in people exposed to CT scans in childhood have provided evidence of the association between cancer risk and CT scans.[8] To minimise these possible effects of ionising radiation on humans during CT examinations, CT services must be provided in an organised and efficient manner through strict adherence to set standards and guidelines. One of the strategies used in radiology to ensure that the standards of imaging are maintained is through periodical clinical audits. Clinical audits act as tools designed to improve the quality of patient care, their experience, and outcomes through formal review of systems, pathways, and outcomes of care against defined standards.[5,9] The European Society of Radiology (ESR) [9] espouses that as part of sound clinical governance, healthcare facilities are accountable for continually assessing, and where possible, improving the quality of their service.

In Zambia, CT imaging services became available in 1994 when the first scanner was installed at Nkana Mine Hospital (now Sinozam Hospital).[10] Since then, several CT scanners have been installed across the country. CT services should be provided by a multidisciplinary team that is comprised mainly of radiographers, radiologists, nurses, and medical physicists. Each member of this team is supposed to be appropriately qualified and licensed to practice and therefore expected to operate in a manner that ensures patient safety and quality of care. The CT facilities and the staff working in them are supposed to be registered with the Radiation Protection Authority (RPA) for personnel dosimetry.[11] Radiographers, radiologists, and medical physicists are licensed for practice by the Health Professions Council of Zambia (HPCZ) while nurses are licensed by the Nursing & Midwifery Council of Zambia (NMCZ). The registration and licensing of the facilities and radiology staff to these regulatory bodies is a matter of statutory requirement and is therefore mandatory. The Radiological Society of Zambia (RSZ) is the professional body for healthcare workers that utilise ionising and non-ionising radiation in the diagnosis and treatment of diseases.

Despite the availability of CT services in Zambia since 1994, no documented audit of the CT services was found during the review of literature and ministry documents. Audits must be conducted on these important clinical services. This will go a long way to improving patient care and outcomes by assessing the systems, processes, and outcomes of CT facilities against the established standards of practice. This study, therefore, aimed at auditing CT services in Zambia. The findings can help inform strategies that could improve CT service delivery in the country.

METHODOLOGY

The study used a convergent parallel design in which quantitative and qualitative data were collected concurrently using an online questionnaire. Before the commencement of the audit, an application was made, and an ethical waiver was obtained from the National Health Research Authority of Zambia (reference no: NHRA0003/04/2021). Permission was also sought and obtained from the Heads of the Radiology department at the participating CT sites. The audit did not seek health workers' or patients' personal information. The population and sample for this audit were all medical facilities (N=23), both public and private, offering CT services in the country. These medical facilities with CT services were identified through the registry of RPA (Table 1). One CT facility was not on the list provided by RPA.

Table 1: CT facilities in Zambia

No	Name of the CT imaging centre	Province	Category
1	University Teaching Hospitals	Lusaka	Public
2	Cancer Diseases Hospital-Diagnostic	Lusaka	Public
3	Cancer Diseases Hospital-Therapeutic	Lusaka	Public
4	Levy Mwanawasa University Teaching Hospital	Lusaka	Public
5	Maina Soka Military Hospital	Lusaka	Public
6	Ndola Teaching Hospital	Copperbelt	Public
7	Kitwe Teaching Hospital	Copperbelt	Public
8	Livingstone Teaching hospital	Southern	Public
9	Chipata Central Hospital	Eastern	Public
10	Mansa General Hospital	Luapula	Public
11	Kasama General Hospital	Northern	Public
12	Chisali General Hospital	Muchinga	Public
13	Kansanshi Mine Hospital	North-Western	Private (Mine)
14	Medland Hospital	Lusaka	Private
15	Victoria Hospital	Lusaka	Private
16	Advance Diagnostic Centre	Lusaka	Private
17	Care for Business	Lusaka	Private
18	Forest Park Specialised Hospital	Lusaka	Private
19	Coptic Church Hospital	Lusaka	Private (church)
20	PHILABS-Lusaka	Lusaka	Private
21	PHILABS-Ndola	Copperbelt	Private
22	Lusaka Trust Hospital	Lusaka	Private

Data for this audit were collected in April 2021 using a structured questionnaire. The questionnaire was developed based on the literature [2,5] and the experiences of clinical auditors as diagnostic radiographers. It contained questions on the category of the medical facility, equipment, radiography workforce, reporting system, radiation protection, quality assurance (QA), and suggestions on how to improve the delivery of CT services. Two radiographers with experience in CT and clinical audits validated the questionnaire. Furthermore, the questionnaire was piloted on two CT radiographers based in the Lusaka and Copperbelt provinces. They were asked to complete it and provide comments regarding the wording, length, and structure. There were no major comments provided by pilot respondents to warrant alterations.

The data collection procedure involved first contacting the Heads of Radiology departments, who were the gatekeepers, by telephone to explain the purpose of the audit. The ethical waiver and audit information sheet were sent by electronic mail to the Head of Radiology department with a link containing the online questionnaire. Each facility was requested to complete one questionnaire as per the objective of this audit. The respondents were given approximately two weeks to complete and submit a completed questionnaire. Due to poor responses from private CT facilities, the main author sent a reminder a week following the administration of the questionnaire. The quantitative data were analysed using descriptive statistics with appropriate graphs and tables, whilst qualitative data were analysed by themes.

RESULTS

Profile of the facilities that participated in the audit

The enquiry from RPA indicates that there are a total of 22 CT facilities registered in Zambia (Table 1). In this audit, a total of 23 questionnaires were sent out because one facility was not on the list provided by RPA. The response rate was 95.7% (N=22). Lusaka had the most responses 68.1% (N=15). From the responses obtained, 59% (N=13) were public facilities while the remaining 41% (N=9) were from the private sector. Only Lusaka and North-western provinces had privately owned facilities (Figure 1).

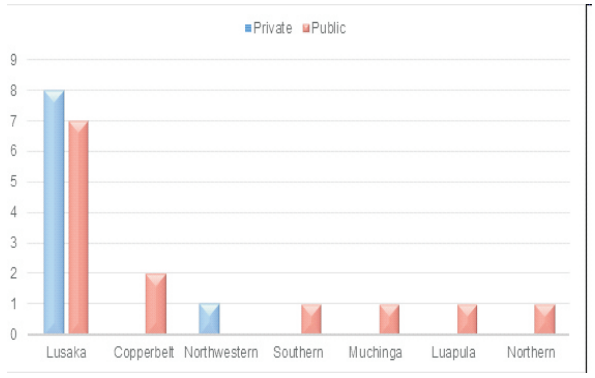

Figure 1: Provincial distribution of responding facilities

In the Zambia health sector, public facilities are arranged hierarchically with level three (III) being the highest referral hospital. The private sector utilises categories with 'A' being the highest category facility. In this audit, almost all private facilities were category A, whilst most of the public facilities were level III facilities as highlighted in Table 2. There was only one private facility outside Lusaka that responded to the questionnaire.

Table 2: Profile of facilities audited

			N	%
Categories of the level of care	Private	Category A	8	36
		Category B	1	5
	Public	Level II	3	14
		Level III	10	45

Equipment

Table 3 shows the distribution in terms of manufacturers. Furthermore, the table highlights the service history for the previous two years before data collection. The number of functional CT scanners at the time of the audit were considerably less in the public sector (46%) compared to the private sector (89%). The downtime for the CT scanners in the public sector averaged 1.8 years (21.6 months).

Table 3: Equipment profile

		Private	Public
Machine manufacturer	Philips	1	2
	Neusoft	-	4
	Siemens	5	3
	Toshiba	2	4
	GE	1	-
Average number of years since installation		4.44 (SD 1.94)	5.31 (SD 4.93)
Functional status		8 (89%)	6 (46%)
Availability of maintenance schedule		8 (89%)	8(61.5%)
Average downtime (Years)			1.78 (1.63)
Average number of services in the 24 months		3.75 (SD 1.28)	2.38 (SD 3.5)
Facilities with a service contract		8 (89%)	6(46%)

Radiography workforce

Regarding the radiography workforce, the public facilities had a median of 3 (IQR 2-6) radiographers with bachelor's degrees and a median of 5 (IQR 4-6) with a diploma qualification only. The private facilities had a median of 1 (IQR 1-1) radiographer with a bachelor's degree and a median of 2 (IQR 2-2) with a diploma qualifications only.

The total number of facilities that had CT application training was 13 (6 private and 7 public). The rest of the radiographers had on-the-job training from others. Figure 2 below shows the range of highest CT specialised qualifications of radiographers operating the CT scanners in the facilities audited.

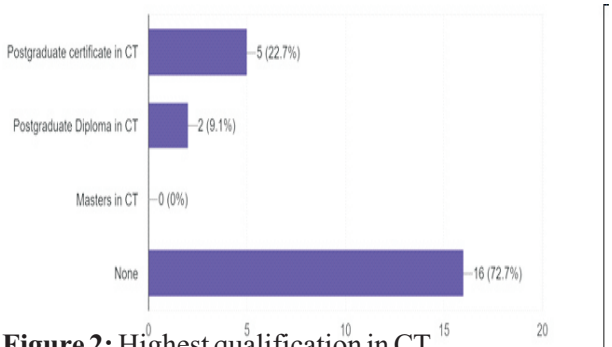

Figure 2: Highest qualification in CT

CT reporting

One section of the questionnaire elicited information on CT reporting. The information requested included the availability of radiologists in their respective radiology departments, facilities utilising teleradiology, and the average time for a patient getting a written diagnostic report. Table 4 shows the results of the CT reporting system.

Table 4: CT reporting

Item	Private	Public
Facilities with radiologists available	4(44.5%)	8(61.5%)
Utilising teleradiology	6(75%)	2(15%)
Average time (hours) for patients to get reports	24	76 (SD 50)

Radiation protection, quality assurance, and patient satisfaction surveys

In one section of the questionnaire, participants were asked questions on radiation protection and QA issues related to CT services in their departments. Furthermore, participants were asked to indicate if patient satisfaction surveys regarding CT services are conducted in their respective radiology departments. The responses are shown in Table 5.

Table 5: Radiation protection, QA, and patient satisfaction surveys

	Private	Public
Pre-authorisation acceptance and commissioning testing	8 (89%)	13(100%)
RPA authorisation	8 (89%)	13(100%)
Personal dosimeter	8 (89%)	13(100%)
Availability of diagnostic reference levels (DRLs)	4(44.5%)	1(7%)
Availability of QA programme	8 (89%)	7(53.8)
Availability of patient satisfaction survey	1 (12.5%)	0(0%)

Improvement efforts

The last question solicited participants' suggestions on ways to improve the delivery of CT services in their respective departments and the country in general. Following thematic analysis, eight suggestions emerged and are summarised in Table 6.

Table 6: Suggestions to improve the delivery of CT services in Zambia

	Suggestions	Frequency
1	Establishment of a postgraduate CT course and CPD learning activities in CT	7 (31.8%)
2	Appointment of CT clinical specialists to head each CT facility	2 (9.1%)
3	Increase in the availability of CT consumables, such as contrast media	2 (9.1%)
4	Reduction of CT user fees to make it affordable to most of the patients	2 (9.1%)
5	Increase in the number of CT scanners to cover all the provinces of Zambia	3 (13.6%)
6	Increase in the number of radiologists and their availability in each CT facility	4 (18.2%)
7	Establishment of QA programme and increase in the number of medical physicists	4 (18.2%)
8	Establishment of servicing and maintenance programme and availability of local CT engineers	7(31.8%)

DISCUSSION

This audit has provided useful baseline data for CT imaging services in Zambia. There is a total of 22 registered CT facilities in Zambia against a population of 18 million. A lack of CT scanners affects most African countries due to costs in terms of purchasing and maintenance. For example, an audit conducted by Kiguli-Malwadde *et al.*[12] found 25 CT scanners in Uganda serving a population of 44 million. Our audit further revealed that 8 out of 10 provinces have CT scanners, with most of them located in the Lusaka Province. This unequal distribution of specialised imaging equipment between urban and rural areas has been reported in Africa as a barrier to the delivery of equitable healthcare services.[12-15] To achieve the aim of the Ministry of Health (MOH) of providing effective quality healthcare services as close to the family as possible, it is necessary to instal CT scanners in all 10 provinces of Zambia.

Imaging equipment requires maintenance and servicing to ensure maximum efficiency and availability. At the time of our audit, a total of 36.4% (N=8) CT scanners were not working with considerably more non-functional units in the public facilities compared to the private facilities. The challenge of non-functioning specialised imaging equipment was also reported in an audit conducted in Nigeria by Ekpo and others.[13] This disrupts imaging services and can negatively affect the experiences of healthcare professionals and patients. Literature has identified poorly planned procurement patterns and planned preventive maintenance as some of the reasons for equipment breakdowns.[13,16] These were also the main reasons reported in our audit for the frequent breakdown of CT scanners. Our audit found 14 [89% (N=8) in private and 46% (N=6) in public)] CT facilities with service contracts. To overcome this problem, participants proposed the need to have local engineers, and the inclusion of service contrast during procurements.

In Zambia, there is a good number of radiographers to manage CT services. At the time of writing, there were a total of 707 diagnostic radiography professionals registered with HPCZ. However, the main challenge revealed in our audit is a lack of specialised radiographers to manage CT services in each department. In addition, 72.7% (N=16) of the radiography workforce managing CT imaging services have not received a postgraduate qualification in CT. For this reason, participants in our audit suggested the establishment of a local postgraduate CT course and CT clinical specialist posts. In a study by Sichone *et al*.[17] it was found that diploma radiographers in Zambia had inadequate technical competencies. Therefore, additional and specialised training is the best approach to improving CT imaging services management.[2,5, 10] **CT, being a** specialised imaging modality, should be operationally managed by a radiographer with a postgraduate qualification in CT.

Radiologists play an important role in the delivery of CT services by reporting on images. They also provide consultancy to both radiographers and referring medical practitioners. However, this audit revealed a shortage of radiologists. Out of the 22 CT facilities that participated in this audit, only 12 reported having a radiologist in their department. The remaining facilities depend on teleradiology for CT diagnostic reports. The average time for patients to get diagnostic reports was 24 hours for private and 76 hours for public facilities. In this audit, a lack of immediate diagnostic reports due to a shortage of radiologists was identified as a barrier in the provision of quality imaging services. For this reason, respondents proposed the need to have resident radiologists in each CT facility. The other solution to this challenge is the establishment of reporting radiographers to report on general radiographic images and limited CT examinations.

Radiographers have a duty to keep radiation doses as low as reasonably practicable, consistent with the intended diagnostic purpose.[2,18] This is known as dose optimisation. Vital to the optimisation process

is the development and use of diagnostic reference levels (DRLs). The International Commission of Radiation Protection (ICRP)[19] defines DRLs as a specific radiation dose for a given imaging examination that is not expected to be exceeded. This means that DRLs are essential for high-quality practice and valuable tools in identifying excessive radiation doses to patients. [5] However, our audit found 5 out of 22 CT facilities had DRLs. As CT is a high dose modality, it is essential that other facilities develop DRLs.

In Zambia, it is a legal requirement under the Ionising Radiation Protection Act of 2011 that all imaging equipment utilising ionising radiation must be registered with the RPA.[11] This ensures that users, patients, and members of the public are protected from the harmful effects of radiation. During their work, imaging professionals are exposed to ionising radiation from either the primary beam or scatter.[20,21] For this reason, both local and international regulations recommend the monitoring of imaging professionals from radiation by using personal dosimeters.[11,21] In Zambia, this service is provided by the RPA. However, our audit found one private CT facility did not provide CT radiographers with personal dosimeters.

The safe use of imaging equipment requires QA programmes in place.[18, 22] The International Atomic Energy Agency (IAEA)[23] states that the increasing complexity of CT scanner operation and application requires QA to ensure that appropriate examination conditions exist and that procedures are optimised for diagnostic quality and patient dose. Generally, QA activities are undertaken by medical physicists in conjunction with radiographers. The pre-authorisation acceptance and commissioning testing of the imaging equipment is part of the QA. The acceptance testing occurs immediately after the installation of the equipment to make sure that the facility is getting the equipment and performance that was specified in the purchase agreement.[23] On the other hand, commissioning testing involves the establishment of clinical operation procedures for the equipment, such as scan protocols for a CT scanner.[23] Our audit found non-availability of QA programmes in 7 CT facilities audited. This may be attributed to a shortage of medical physicists and lack of quality control (QC) training for radiographers. In Zambia, there are currently 5 medical physicists working in the public sector.[22] For this reason, participants in our audit suggested an increase in the number of medical physicists and the training of radiographers in QC to enhance QA activities in Zambia.

Patient satisfaction surveys are important and commonly used indicators for measuring the quality of healthcare services provided to patients.[24] In other words, they help policymakers to understand how patients interact with the healthcare system and their experiences. However, only one private facility reported the availability of satisfaction surveys to CT imaging services. To improve the quality of CT and other imaging services, there is a necessity to conduct periodical patient satisfaction surveys in other facilities.

CONCLUSION

This audit revealed a marginal increase in the number of CT scanners in Zambia. The increase is due to the government of the Republic of Zambia and the private sector investment in healthcare services in the last decade. However, most of the CT scanners are in the Lusaka province. The audit also revealed several challenges which are hindering the delivery of quality CT services. It is recommended that the schools of radiography, RSZ, and the Ministry of Health (MOH) target five main areas: establishment of a local CT training programme and establishment of clinical specialist posts, increase in the availability of imaging consumables, increase in the number of CT scanners to cover all the provinces, increase in the number of radiologists and medical physicists, and the establishment of QA and servicing programmes.

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