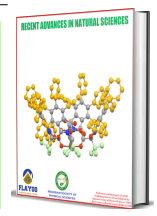
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Optimizing patient safety: an evaluation of computed tomography dose-length product variations across hospitals in Abuja, Nigeria

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ABSTRACT

The increasing use of computed tomography (CT) as a diagnostic tool in Nigeria raises concerns about high radiation doses and potential cancer risk. To address this concern, CT dose-length product (DLP) was evaluated at ten hospitals in Abuja, Nigeria, using polymethyl methacrylate phantoms, a 100 mm pencil ionization chamber, an electrometer, and a CT probe. The study assessed variations in radiation dose across the facilities by measuring DLP in mGy·cm for chest and head phantoms. Chest phantom DLP values ranged from 79.36 ± 0.001 mGy·cm at Hospital H to 677.40 ± 0.01 mGy·cm at Hospital D. Head phantom values ranged from 230.14 ± 0.004 mGy·cm at Hospital A to 1165.73 ± 0.3 mGy·cm at Hospital I. Most facilities recorded DLP values below the European diagnostic reference levels (DRLs) used for comparison. However, Hospital D exceeded the chest reference level of 650 mGy·cm, while Hospitals E and I exceeded the head reference level of 1050 mGy·cm. These findings indicate substantial variation in scanning protocols among the facilities. The study recommends routine quality control, equipment calibration, standardized protocols, and refresher training for CT operators to ensure doses administered to patients are As Low as Reasonably Achievable (ALARA) principle and reduce unnecessary radiation exposure.

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1. INTRODUCTION

Computed tomography (CT) is an imaging procedure that uses specialized X-ray equipment to produce cross-sectional images of objects [1, 2]. It plays an important role in patient diagnosis and is used in various medical imaging procedures because it provides clear images of bones, muscles, blood vessels, and different types of tissue when other imaging techniques provide limited image quality [3–6]. CT examinations can deliver higher radiation doses than conventional and mobile X-ray examinations. Research has shown that radiation exposure can be higher for head examinations than for body examinations.

This has prompted concerted efforts to ensure that CT examinations are monitored appropriately, with strict adherence to justification and dose-optimization protocols [7, 8].

In Nigeria, establishing local diagnostic reference levels (LDRLs) remains difficult. Scattered, decentralized audits have left a gap in knowledge regarding routine institutional exposure levels. These radiation doses are typically assessed using stan-

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Figure 1. CT head phantom (small) and chest phantom (large).



Figure 2. CT ionization chamber (left) and electrometer (right), PTW Type 30009 (Freiburg, Germany).

dard indices such as the volume CT dose index (CTDIvol), the weighted CT dose index (CTDIw), and the dose-length product (DLP). These metrics vary according to scanner design, scanning protocols, operator settings, and patient body size [9, 10]. To address these regional optimization gaps, this study establishes baseline CT radiation doses in Abuja hospitals. Dosimetry was performed by placing a calibrated PTW CT probe (Type 30009, Freiburg, Germany) inside standard polymethyl methacrylate (PMMA) head and chest phantoms. The measured charges were transmitted through a coaxial cable to a readout electrometer to establish dose records [11].

2. MATERIALS AND METHODS

2.1. DOSE-LENGTH PRODUCT (DLP) DETERMINATION

Dose-length product (DLP) values were assessed across ten clinical computed tomography (CT) facilities in Abuja, Federal Capital Territory (FCT). Dose measurements were taken with a 100 mm active-length pencil-shaped ionization chamber (PTW Type 30009, Freiburg, Germany) connected through a low-noise cable to a dosimetry electrometer. This chamber was used with standard CT polymethyl methacrylate (PMMA) dosimetry phantoms. The setup included a 32 cm diameter body phantom for adult chest examinations and a 16 cm diameter head phantom. Both phantoms were 15 cm thick along the z-axis and had 1 cm diameter holes for the probe. The holes were located at the geometric centre (C) and at a depth of 1 cm from the outer edge at the 0°, 90°, 180°, and 270° positions, which served as peripheral measurement sites.

Figures 1 and 2 show the phantoms and dosimetry equipment used in the study.

To collect the data, the adult chest phantom was placed flat on the patient couch and moved to the scanner isocentre so that its long axis aligned with the z-axis of the CT machine. The PTW pencil chamber was inserted into the central hole of the phantom. To align the phantom and ionization chamber, the horizontal room lasers were adjusted until they crossed at the probe midline. Adhesive tape was placed along the probe and on the phantom face to prevent movement during couch travel.

A scout scan (topogram) was performed first to determine the scan coverage area. CTDI quality-assurance measurements were then performed using the standard chest examination protocol, with three readings at the 90°, 180°, 270°, and 0° peripheral positions (P1, P2, P3, and P4) and the central position (C). The procedure was repeated using the adult head phantom under standard clinical head-scan settings. Charges recorded from the electrometer in charge mode were corrected for temperature and pressure and used to estimate CTDIw values. These values were compared with the CTDI values displayed on the scanner consoles, as were the displayed and calculated DLP values, using the following equations:

Table 1 lists the scanner specifications, and Table 2 gives the chest and head scan parameters.

$$k_{TP} = \frac{(273.2 + T)P_0}{(273.2 + T_0)P}, \tag{1}$$

$$C_{\mathrm{PMMA},100,c} = \frac{10}{NT} M_c N_{\mathrm{PKL},Q_o} k_Q k_{TP}, \tag{2}$$

$$C_{\mathrm{PMMA},100,P} = \frac{10}{NT} M_P N_{\mathrm{PKL},Q_o} k_Q k_{TP}, \tag{3}$$

$$\mathrm{CTDI}_w = \frac{1}{3}\left(C_{\mathrm{PMMA},100,c} + 2C_{\mathrm{PMMA},100,P}\right), \tag{4}$$

$$\mathrm{DLP} = \mathrm{CTDI}_{vol} \times \text{scan length}. \tag{5}$$

The volume CT dose index (CTDIvol) was derived from the computed weighted index (CTDIw) by accounting for the helical pitch factor (P) used in each hospital's clinical protocol:

$$\mathrm{CTDI}_{vol} = \frac{\mathrm{CTDI}_w}{P}. \tag{6}$$

Here, CTDIw was established from the measured central (C) and peripheral (Pn) phantom exposures using equation 4.

For axial sequence modes, where the pitch factor is not applicable, P was set to 1.0, giving CTDIvol = CTDIw.

In these equations:

T is the nominal slice thickness.

N is the number of tomographic slices exposed simultaneously (so the nominal irradiating beam width is NT).

k_{TP} is the correction factor for temperature and pressure.

T is the temperature measured in the study room.

P is the room pressure.

T_0 is the temperature at the reference condition.

P_0 is the air pressure at the reference condition.

Table 1. Technical specifications of CT scanners used at the selected hospitals.

No.	Hospital	Manufacturer	Scanner model	Tube settings	Model number
1	A	GE Model: light speed VCT64 Slice	GE light speed VCT64 Slice CT Scanner(D3162T)	80 to 120 kVp; 10 mA to 800 mA	D3162T
2	B	Toshiba Scanner Alexion Japan	Toshiba Scanner Alexion TSX-034A	120 kVp to 135 kVp (max); 260 to 300 mA (max)	3CC1532167
3	C	GE HANGWEI MEDICAL SYSTEMS CO., LTD, BEIJING 100176 CHINA/OCTOBER 2019	Revolution ACT (GE Revolution 16 Slice)	80 to 140 kVp; 200 mA	5492001
4	D	Siemens Medical Systems Germany 2010	Siemens 6 Slice Somatom Emotion	80 to 130 kVp; 20 mA to 345 mA	03815300
5	E	Toshiba Scanner Activion 16	TSX-031A	120 to 135 kVp; 260 mA to 300 mA	1CC11Z3354
6	F	WIPRO GE HEALTH CARE PVT.LTD, INDIA/APRIL 2017	Revolution ACT (GE Revolution 8 Slice)	80 to 140 kVp; 10 mA to 200 mA	17794BG9
7	G	GE HANGWEI MEDICAL SYSTEMS CO., LTD, BEIJING 100176 CHINA /OCTOBER 2017	Revolution ACT (GE Revolution 16 Slice)	80 to 140 kVp; 10 mA to 200 mA	489031HM5
8	H	GE Medical Systems MONTERREY MEXICO S.A de C.V/OCTOBER 2010	GE HiSpeed dual CT D3162T	80 to 140 kVp; 10 mA to 350 mA	2232785
9	I	Philips Health Care (Suzhou) Co., Limited, Republic of China/16th August,2018	Philips Access Scanner System.	80 to 140 kVp; 10 mA to 233 mA	PM 1103-218
10	J	Philips Medical Systems (Cleveland) Inc. Cleveland, Ohio 44143 USA/February,2015	Philips Brilliance CT Big Bore 16 Slice	90 to 140 kVp; 20 mA to 665 mA	SN 75014

Table 2. Scan parameters used for chest and head phantom examinations.

Hospital	Chest thickness (mm)	Chest slices	Head thickness (mm)	Head slices	Chest kVp	Chest mAs	Head kVp	Head mAs
A	5	27	2.5	48	120	124.5	120	200
B	10	16	5	30	100	224	120	200
C	5	29	5	30	120	147	120	270
D	10	15	6	24	110	88	110	250
E	5	28	5	28	120	98	120	196
F	5	30	5	28	120	156.8	120	120
G	5	29	5	30	120	156.8	100	320
H	3	51	3	52	120	100	120	100
I	5	67	4.8	36	120	120	120	350
J	5	66	5	37	120	150	120	200

NPKL, Qo is the dosimeter calibration coefficient in terms of the air-kerma length product; kQ corrects for differences between the dosimeter evresponse at the calibration quality and at the measurement quality Q of the clinical X-ray beam.

Mc and Mp are the mean dosimeter readings from the central and peripheral bores of the standard phantom, respectively.

C_{PMMA}, 100, C and C_{PMMA}, 100, P are the PMMA computed tomography dose indices at the central and peripheral chamber bores, respectively.

Tables 3, 4, and 5 present the displayed, calculated, and measured DLP values, respectively.

The hospital and phantom baseline framework utilized in this study corresponds to the cohort described in our 2022 work; however, while the previous study evaluated CTDI measurements, this manuscript presents a distinct evaluation focusing strictly on Dose Length Product (DLP) metrics.

3. DISCUSSION

The dose-length product (DLP), measured in mGy·cm, is an important metric in this study. DLP is a CT radiation dose index derived from CTDIvol and scan length; however, it is not a direct measurement of the total energy deposited in an individual

Table 3. Dose-length product displayed by CT scanners in Abuja hospitals.

Hospital	CT scanner	Body phantom (mGy·cm)	Head phantom (mGy·cm)
A	GE light speed VCT 64 slice	177.22±0.01	230.12±0.004
B	Toshiba Scanner Alexion	217.6±0.004	888.4±0.03
C	GE Revolution 16 Slice	165.39±0.01	577.55±0.02
D	Siemens 6 Slice Somatom Emotion	1245.3±0.01	527.08±0.02
E	Toshiba Scanner Activion 16	123.00±0.01	1170±0.90
F	GE Revolution 8 Slice	148.77±0.002	455.72±0.001
G	GE Revolution 16 Slice	139.43±0.01	597.09±0.1
H	GE Hispeed dual CT	81.60±0.0007	597.75±0.1
I	Philips Access CT Scanner System	449.46±0.32	1165.75±0.3
J	Philips Brilliance CT Big Bore 16 Slice	76.6±0.002	469.8±0.001

Table 4. Calculated dose-length product of CT scanners in Abuja hospitals.

Hospital	CT scanner	Body phantom (mGy·cm)	Head phantom (mGy·cm)
A	GE light speed VCT 64 slice	141.75±0.01	230.16±0.004
B	Toshiba Scanner Alexion	172.8±0.004	747±0.03
C	GE Revolution 16 Slice	138.77±0.01	577.5±0.01
D	Siemens 6 Slice Somatom Emotion	109.5±0.01	527.04±0.02
E	Toshiba Scanner Activion 16	88.2±0.01	980±0.90
F	GE Revolution 8 Slice	133.95±0.002	422.52±0.001
G	GE Revolution 16 Slice	115.28±0.01	597.15±0.1
H	GE Hispeed dual CT	77.11±0.0007	600.91±0.1
I	Philips Access CT Scanner System	426.79±0.32	1165.71±0.3
J	Philips Brillance CT Big Bore 16 Slice	424.05±0.002	384.8±0.01

Table 5. Measured dose-length product for CT scanners in Abuja hospitals and European diagnostic reference levels.

Hospital	CT scanner	Body (mGy·cm)	Head (mGy·cm)	Chest DRL (mGy·cm)	Head DRL (mGy·cm)
A	GE light speed VCT 64 slice	159.49±0.01	230.14±0.004	650	1050
B	Toshiba Scanner Alexion	195.20±0.004	817.70±0.03		
C	GE Revolution 16 Slice	152.08±0.01	577.53±0.02		
D	Siemens 6 Slice Somatom Emotion	677.40±0.01	527.06±0.02		
E	Toshiba Scanner Activion 16	105.60±0.01	1075.00±0.90		
F	GE Revolution 8 Slice	141.36±0.002	439.12±0.001		
G	GE Revolution 16 Slice	127.36±0.01	597.12±0.1		
H	GE Hispeed dual CT	79.36±0.001	599.33±0.1		
I	Philips Access CT Scanner System	438.13±0.32	1165.73±0.3		
J	Philips Brillance CT Big Bore 16 Slice	250.33±0.002	427.30±0.001		

patient during a CT scan. Whereas other technical settings characterize the X-ray beam at a given point, DLP accounts for the radiation dose index over the length of the body scanned. This makes DLP a practical tool for comparing hospitals, auditing radiation safety practices, and assessing dose optimization. Tracking DLP helps identify facilities with comparatively high dose indices and evaluate the balance between diagnostic imaging and radiation protection.

The results obtained from the ten hospitals in Abuja show substantial differences in DLP, which may be attributed to a lack of uniformity in CT protocols [12]. For chest scans, values ranged from 79.36 ± 0.001 mGy·cm at Hospital H to 677.40 ± 0.01 mGy·cm at Hospital D. Head scan values ranged from 230.14 ± 0.004 mGy·cm at Hospital A to 1165.73 ± 0.3 mGy·cm at Hospital I. Compared with the European diagnostic reference levels (DRLs) used in the study, most centres remained below the reference values, but some exceeded them. Hospital D exceeded the chest reference level, as shown in Figure 3, while Hospitals E and I exceeded the head reference level, as shown in Figure 4. These discrepancies may have resulted from differences in phantom size, scanning parameters, measurement uncertainty, or scanner calibration [13]. This pattern is consistent

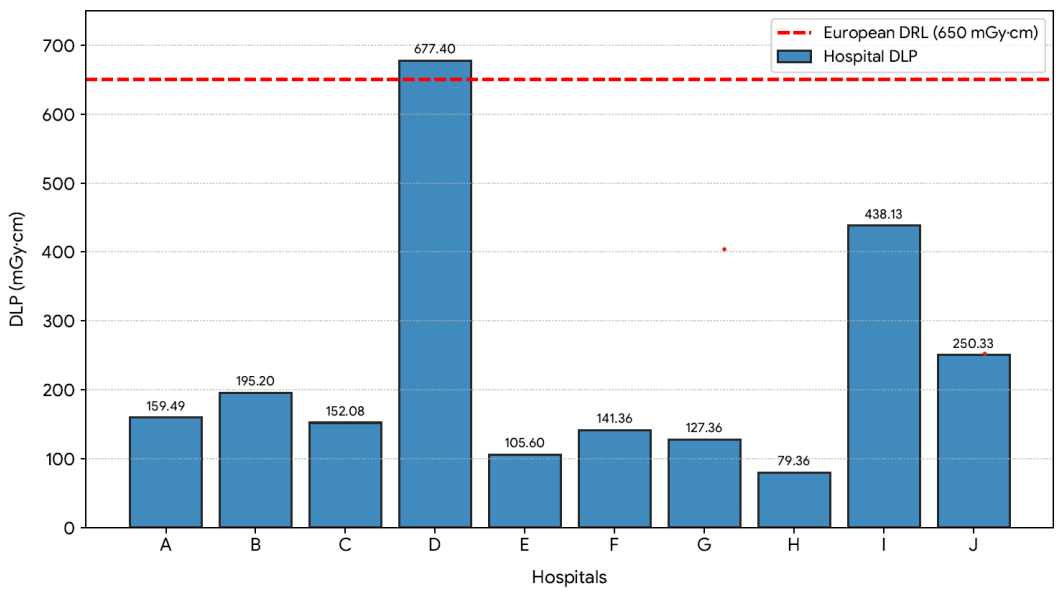


Figure 3. Dose-length product for chest phantom.

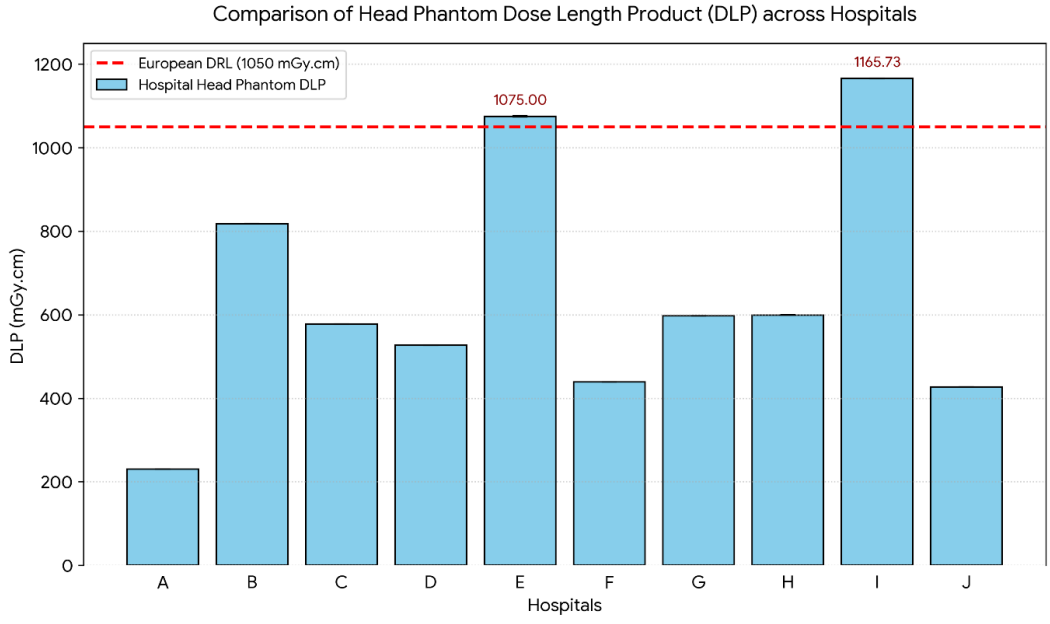


Figure 4. Dose-length product for head phantom.

with regional surveys in Nigeria reporting wide dose disparities associated with nonstandardized clinical practices [7], [14], [15], [16]. Consequently, patients undergoing similar examinations at different facilities may be exposed to substantially different radiation dose indices.

The variations in radiation exposure observed across the facilities are attributed primarily to the technological generation of the CT scanners and the acquisition protocols used. Older systems, such as the 6-slice scanner at Hospital D, may produce higher dose-length product (DLP) values because of beam geometries needed to achieve adequate diagnostic image quality [6]. Conversely, modern multidetector platforms, such as the 64-slice scanner at Hospital A, incorporate hardware configurations and automated exposure-control software that may reduce radiation exposure while maintaining image quality [5]. Furthermore, the data indicate that nonstandardized scan profiles influence dose. In particular, an excessive number of slices or narrow slice thicknesses may extend scan time and increase cumulative DLP [17].

Beyond equipment age and baseline protocols, clinical factors such as motion artefacts requiring repeat acquisitions and multiphase scanning protocols can increase cumulative patient exposure. The findings also suggest inadequate patient-size optimization, whereby failure to adjust tube current and voltage parameters for smaller patients may increase radiation exposure. These variations indicate a need for better protocol optimization to limit

unnecessary cumulative exposure and associated long-term radiation risks [17, 18].

4. CONCLUSION

The findings demonstrate that phantom-based CT dose measurements for comparable clinical protocols vary significantly across radiological facilities in Abuja, Nigeria. Using dose-length product (DLP), a dose index derived from the volume computed tomography dose index (CTDIvol) and scan length, the study identified a lack of protocol standardization in diagnostic imaging. Although most assessed facilities recorded values below the international reference levels used in this study, notable outliers indicate substantial protocol variation. Hospital D, for body examinations, and Hospitals E and I, for head examinations, recorded elevated dose indices, suggesting differences in operating practices and potential unnecessary radiation exposure.

The findings indicate an association between elevated dose indices, hardware limitations of older imaging systems, and non-standardized acquisition profiles. Scanner generation may influence patient dose; for example, the older 6-slice system at Hospital D recorded a higher DLP, potentially because of differences in beam alignment and scatter compared with modern multislice systems.

Conversely, modern multidetector platforms, such as the 64-slice scanner at Hospital A, may reduce radiation exposure through integrated dose-reduction software while maintaining diagnostic image quality. However, operational factors, including unoptimized slice configurations, unnecessary multiphase scans, and inconsistent protocol management by CT operators, may also contribute to elevated dose indices.

Ultimately, this study underscores the need to integrate the As Low as Reasonably Achievable (ALARA) principle into routine clinical workflows in radiological departments across the region. The variation in dose indices among the evaluated centres indicates that diagnostic protocols should not depend solely on operator habits or uncalibrated equipment. To reduce these discrepancies and align practice with international reference benchmarks, facilities should implement routine quality-control audits and staff training. Continuous dose tracking and regular equipment calibration may help reduce unnecessary exposure and improve the standardization of diagnostic imaging in Abuja.

4.1. RECOMMENDATIONS

To address the safety gaps identified in this study and align radiological practices with international standards, hospitals in Abuja should establish routine quality-control programmes for all CT scanners. Medical physics teams or external regulatory bodies should periodically calibrate each unit, particularly at Hospitals D, E, and I, where measured dose indices exceeded the reference values. Regular audits can help ensure that tube voltage, beam alignment, and dose output remain stable over time. Furthermore, radiological departments should implement standardized scanning protocols that minimize variation in operator-selected settings. Senior radiographers should establish consistent protocols for common head and body examinations based on diagnostic reference levels. Operators should adjust tube current and slice configurations according to patient size rather than using the same settings for every adult. Hospital management should also restrict unnecessary multiphase examinations and minimize repeat scans associated with preventable patient-motion artefacts.

Finally, sustained professional development and institutional accountability are needed across the local healthcare sector. Hospitals should organize regular practical refresher courses for CT operators, focusing on radiation safety, dose-length product monitoring, and the application of the ALARA principle. Healthcare authorities could use the baseline data established in this study to support a national diagnostic reference level registry. Routine reporting of mean patient dose indices would facilitate performance monitoring and ongoing efforts to reduce unnecessary medical radiation exposure in Nigeria.

DATA AVAILABILITY

All relevant data and measurement values underlying the findings of this study are fully included within the manuscript and its accompanying figures.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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References

[1] H. Mohammad, J. T. Iortile, I. Garba & M. A Suwaid. ‘‘Knowledge of radiation and its effects among Doctors in Makurdi, North Central Nigeria’’, International Research Journal of Basic and Clinical Studies, **1**(7) (2013) 103. http://www.interesjournals.org/IRJBCS.

[2] H. Mohammad, J. T. Iortile, T. T. Bitto, E. O. Eje-Ejum & B. I. Jayeoba. ‘‘Social-Demographic Characteristics and Awareness of Radiation Hazards among Radiology Technicians and Sub staff of Radiology Units in Benue State’’, Nig Hosp Pract, **14** 2014 28. http://www.ajol.info/index.php/nhp.

[3] J. T. Iortile, L. Alumuku & I. D. Shagu, ‘‘Comparative review of conventional computed tomography and photon counting detector-based computed tomography systems’’, FUAM Journal of Pure and Applied Science **5** (2025) 82.

[4] L. Alumuku, J. T. Iortile & T. Daniel, ‘‘Analysing spectral imaging at different photon energy bins for breast lesion contrast visualisation from computed tomography images’’, Nigerian Journal of Physics **33** (2024) 127. https://doi.org/10.62292/njp.v33i4.2024.321.

[5] J. T. Iortile, L. Alumuku & A. Shaanika, ‘‘Radiation dose optimization in computed tomography examinations: A comparative analysis of body and head phantoms in some radiological units of Abuja hospitals’’, FUAM Journal of Pure and Applied Science **5** (2025) 36. Available online: https://www.researchgate.net/publication/390607605_Radiation_Dose_Optimization_in_Computed_Tomography_Examinations_A_comparative_Analysis_of_Body_and_Head_phantoms_in_some_Radiological_Units_of_Abuja_Hospitals.

[6] American Association of Physicists in Medicine (AAPM), ‘‘AAPM Computed Tomography Radiation Dose Education Slides’’ (2013). http://www.aapm.org/pubs/CTprotocol.

[7] T. A. Mahmood & S. R. Hassan, ‘‘Optimization of CT radiation dose: Insight into DLP and CTDIvol as scanner output metrics’’, Future Health Journal, **11**(3) (2024) 204. https://futurehealthjournal.com/optimization-of-ct-radiation-dose-insight-into-dlp-and-ctdi/.

[8] J. T. Iortile & T. A. Ige, ‘‘Measurement of computed tomography dose quantities at some radiological units of Abuja hospitals’’, African Journal

of Medical Physics **4** (2022) 48. https://www.researchgate.net/publication/376720806_Number_1_48_FAMPO_Federation_of

[9] B. Maidamma, I. Maina, O. W. Olasoji, A. M. Tijjani, B. F. Namq, O. A. Adeyeba, M. Mujahid, U. Rilwan, M. I. Sayyed & T. Y. Wais, ''Computed tomography procedures and current dose practice determination in Sokoto State CT centres'', Research Square preprint (2025). https://doi.org/10.21203/rs.3.rs-7273866/v1.

[10] J. T. Iortile & L. Alumuku, ''The significance of medical physicists in ensuring regulatory adherence and facility architecture in medical diagnostics'', Savanna Journal of Basic and Applied Sciences **7** (2025) 202.

[11] J. D. Zira, C. C. Nzotta & J. D. Skam, ''Diagnostic reference levels (DRLs) for computed tomography (CT) examinations in north eastern Nigeria'', Pakistan Journal of Radiology **27** (2017) 364. https://pakjr.com/index.php/PJR/article/view/750.

[12] American College of Radiology, ''Radiation dosimetry: CT (revised 4 June 2025)'', ACR Accreditation Support (2025). https://accreditationsupport.acr.org/support/solutions/articles/11000056198-radiation-dosimetry-ct.

[13] E. Samei, D. Bakalyar, K. L. Boedeker, S. Brady, J. Fan, S. Leng, K. J. Myers, L. Popescu, J. C. Ramirez Giraldo, F. Ranallo, J. Solomon, J. Vaishnav & J. Wang, ''Performance evaluation of computed tomography systems: Summary of AAPM Task Group 233'', Medical Physics **46** (2019) e735. https://doi.org/10.1002/mp.13763.

[14] E. U. Ekpo, T. Adejoh, J. D. Akwo, C. E. Owujekwe, A. M. Ali, M. Abba, K. A. Adesina, D. O. Omiyi & U. H. Chiegwu, ''Diagnostic reference levels for common computed tomography (CT) examinations: Results from the first Nigerian nationwide dose survey'', Journal of Radiological Protection **38** (2018) 525. https://doi.org/10.1088/1361-6498/aaaaf8.

[15] A. Ajetunmobi, T. W. David, A. T. Talabi, S. K. Alausa, A. P. Ejiwunmi, O. J. Odogboro & E. B. Peter, ''Estimation of effective dose for patients undergoing computed tomography scans from selected diagnostic centers in southwestern Nigeria'', FULafia Journal of Science and Technology **10** (2026) 197. https://doi.org/10.62050/fjst2026.v10n2.384.

[16] W. Igoniye, M. A. Briggs-Kamara, I. Cookey, F. B. Sigalo & C. F. Njeh, ''Establishing local diagnostic reference levels for computed tomography in a Nigerian metropolis: A retrospective analysis of clinical practice and radiation dose optimization'', Egyptian Journal of Basic and Applied Sciences **12** (2025) 567. https://doi.org/10.1080/2314808X.2026.2624216.

[17] I. Yemisi, T. H. Okafor, I. Pada, O. O. Samson, A. Abdul-Jamiu & S. H. Sarki, ''Optimization of patient radiation protection and dose levels in some Nigerian CT facilities using OSL dosimetry'', American Journal of Physics and Applications **14** (2026) 32. https://doi.org/10.11648/j.ajpa.20261403.11.

[18] M. Arfat, A. Haq, T. Beg & G. Jaleel, ''Optimization of CT radiation dose: Insight into DLP and CTDI'', Future Health **2** (2024) 148. https://doi.org/10.25259/FH_45_2024.