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Research Paper

Establishing of institutional diagnostic reference level forcomputed tomography Skull scan with an Artificial Intelligence

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Abstract
Background*: Skull scans are the most frequently performed computed tomography (CT) examinations worldwide. However, there is growing concern over the probability of increased cancer risks among the exposed populations. Diagnostic reference levels (DRLs) identify radiation dose that is not commensurate with clinical objectives. The aim of this study was to establish DRLs for CT Skull procedures and estimate effective dose (ED).*

Material and Methods*:*
Three different scanners were used to acquire skull CT of 424 patients retrospectively within 2022. The 50th and 75th Percentile was computed using Python Machine learning and the Effective dose which gives the life time attributive risk was computed using the product of DLP and the constant factor 0f 0.021 for skull examination .And the result obtained was compared with internationally accepted standards.

Results:
The Computed Tomography Dose Index DRL and the Achievable dose this studies are 53.27milligray (mGy) and 48.11milligray (mGy) respectively While the Dose Length Product DRL and Achievable dose are 1374.14mGy centimeters (mGy-cm) and 1064.26 mGy centimeters (mGy-cm)respectively . The effective dose is 32.98.

Conclusion*:*
It is essential to understand CT configuration and develop a Diagnosticc Reference Level since doing so will enable end users to improve and optimize specific CT scanner settings and lower patient dose without sacrificing image quality.

Keywords: *Diagnostic Reference Level, Computed Tomography, Effective dose, Machine Learning, Artificial Intelligence,*

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I. Introduction

To better understand diseases and assist in patient diagnosis, computed tomography (CT) has become essential in clinical practice (1).Since its invention in the 1970s, computed tomography (CT) imaging has transformed medical imaging.The development of multi-detector CT (MDCT) scanners, which enable the quick capture of three-dimensional, higher-quality images, boosted demand for the CT modality(2). However, patients may experience side effects from a radiation dose that is so high that it raises their risk of getting cancer(3) . Calls for a reduction in CT dosages and a focus on patient protection from ionizing radiation are a result of the greater awareness of the risk of radiation-induced malignancies. The justification of the recommended examination serves as the foundation for patient radiation protection(4,5).The protection principle mandates that all CT dosages be optimized, which means that they must be maintained as low as possible and consistent with the clinical goal. The creation and application of diagnostic reference levels (DRLs) was suggested by the International Commission on Radiological Protection (ICRP) in order to achieve this goal. For some CT imaging methods, the use of DRLs makes it easier to identify patient doses that are unusually high or low. Because of this, the DRLs as a type of inquiry level can be thought of as an optimization tool (6).If the length of the anatomy covered (in cm) is too long, the dose would be doubled. Therefore, it is crucial to create scanning guidelines that limit investigation to what is actually necessary (8, 9,10).

Head CT scans are the most frequently examination worlwide.The first trick is that we refer to the results of CT scans as "densities," of which we must become familiar with three typical ones that are simple to identify. According to the CT scan, "In general, the greater the density, the whiter the appearance on the CT scan, and the lower the density, the darker the appearance on the brain CT scan." The brain, often the biggest part inside the skull, is the reference density (the one you compare with). The term ISODENSE refers to something with the same density as the brain and has the appearance of a dull, grayish white substance.So, the reference density is the brain. The skull is the clearest example of a hyperdense structure that can be seen in a typical brain CT scan. Anything that is denser (whiter) than the brain is referred to as HYPERDENSE. The thick, all-white ring that surrounds the brain, which is the skull, is easily recognized. Similar to how the term "brain density" is used, "hypodensity" refers to something with a darker tone and lower density (7).

Patient dosages have been the subject of numerous papers and investigations conducted abroad. In Rivers state and Bayelsa state, there are currently no CT DRLs in place or any such dose research. The institution's DRL will be periodically examined and modified in light of new information that reflects advancements in dose administration and technological application.According to the Popularity of Programming Languages (PYPL) Index, Python is one of the most extensively used computer programming languages in the world.It is well-liked in artificial intelligence, which is expanding rapidly thanks in part to its unique connection to data science.Extraction of knowledge from data is the goal of machine learning. (11).Predictive analytics or statistical learning are other names for the research area that lies at the nexus of statistics, AI, and computer science. In recent years, the use of machine learning techniques has proliferated throughout daily life.(12)

II. Materials And Methods

CT SYSTEMS

The institutional ethics committee evaluated this study, and after reviewing it, it decided to waive informed consent for it.The three multislice CT (MSCT) systems in the institution from the states of Rivers and Bayelsa provided data that was collected retroactively. Table 1 provides specifics on the CT systems. The CT Dose Index Volume (CTDIvol) and dose length product (DLP) of every CT scanner was frequently assessed and tested for quality assurance and quality control processes. Based on the 75th percentile of the dose dispersed over all patients, the institutional DRLs reported in this study.

CT DOSE QUANTIIES

Recent descriptions of the dose amounts and units frequently utilized to establish diagnostic levels were approved as reference dose values. A big (32 cm diameter) or small (16 cm diameter) plastic cylinder made of poly methyl methacrylate can be used to measure CTDIvol, a quantity that represents the radiation output of a CT system (PMMA) (13 and 14). A single estimate of the radiation dosage to that plastic cylinder was created by combining the dose measurements taken at the plastic cylinder's center and periphery. As a benchmark for adult CT in the skull, the CTDIvol was evaluated in the big phantom.

DATA COLLECTION

A committed and skilled radiographer and a radiologist who ensured the image quality of each case manually extracted all 424 examination data for successive adult skull exams completed within 2022 and age 18 and above and weight between 50 kg and 90 kg.

We were able to get information about the patient's gender, age, scan length , KV, mAs, pitch, scanner model, CTDIvol, and DLP.

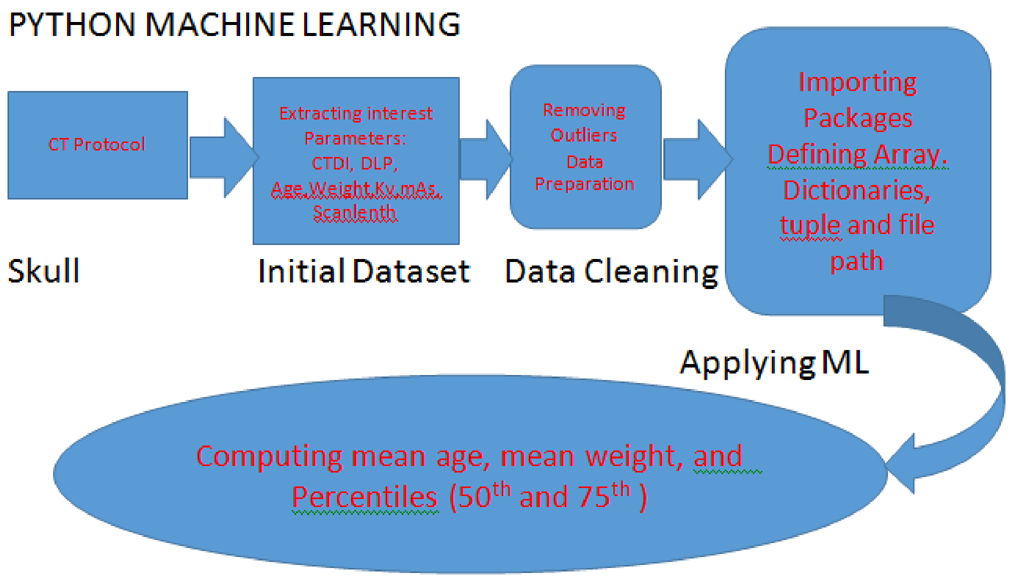

Fig 1: Methodology in establishing DRL using Artificial Intelligence

III. Results And Discussions

Table 1: Details of CT system Used in this study.

SCANNERS	MANUFACTURERS	MODEL	SLICE	YEAR OF INSTALLATION	MAX KV	MAX mAs
A	GENERAL ELECTRIC	OPTIMA 660	64	2014	600	800
B	GENERAL ELECTRIC	OPTIMA 660	64	2014	600	800
C	GENERAL ELECTRIC	HISPEED DUAL	2	2008	140	200

Three General Electric scanners were employed, as stated in Table 1 above. Optima models A and B had the same maximum Kv and mAs and 64 slices, but Hispeed model Scanner C had just two slices and lower Kv and mAs.

Table2. Showing Dose Length Products and their Effective Dose

SCANNERS	No of Patients	Mean Weight (Kg)	Mean Age (yrs)	50^{th} Percentile DLP (mGy-cm)	75^{th} Percentile DLP (mGy-cm)	Effetive Dose
A	190	Male=51.35 Female=54.19	M=50 F= 55	1180.91	1474.63	48.60
B	172	Male= 51.98 Female= 52.43	M=60 F= 58	1151.20	1381.63	25.55
C	62	Male= 57.48 Female= 43.79	M=64 F=57	230.85	258.99	5.57
Total	**424**					**32.98**

As seen in Table 2, a total of 424 patients took part in the study, with Scanners A, B, and C assessing at 190, 172, and 62 individuals, respectively. The 50th and 75th percentiles of the dose length products were obtained for Scanners A, B, and C as follows: 1180.91 mGy-cm and 1474.63 mGy-cm, 1151.20 mGy-cm and 1381.63 mGy-cm, 230.85 mGy-cm and 258.99 mGy-cm, respectively. The effective dose is 32.98.

Table3. Showing Computed Tomography Dose Index

SCANNERS	NUMBER OF MALE PATIENTS	NUMBER OF FEMALE PATIENTS	MEAN AGE (Yrs)	50th Percentile CTDI (mGy)	75th Percentile CTDI (mGy)	MEAN WEIGHTS (Kg)
A	84	106	M=50 F= 55	49.59	55.28	Male=51.35 Female=54.19
B	100	72	M=60 F= 58	49.48	54.30	Male= 51.98 Female= 52.43
C	29	33	M=64 F=57	13.69	15.34	Male= 57.48 Female= 43.79
Total	**213**	**211**				

According to Table 3, there are 424 patients, 213 of whom are male and 211 of them are female. Furthermore, Scanner A, B, and C's CTDI's 50th and 75th percentiles are as follows. respectively 49.59 mGy and 55.28 mGy, 49.48 mGy and 54.30 mGy, 13.69 mGy, and 15.34 mGy

Table4. Showing findings of this studies compared to internationally accepted standards

Examination	ARPANSA DRL(mGy)	EC DRL (mGy)	UK DRL (mGy)	DRL(mGy) This Work (mGy)
SKULL	47	60	66	53

CT- computed tomography, EC- European commission, UK- United Kingdom
ARPANSA-Australian radiation protection and nuclear safety agency. (15)

According to Table 4, the 53mGy skull computed tomography diagnostic reference level used in this investigation was compared to the globally recognized norms set by the European Commission, the Austrian radiation protection and safety agency, and the United Kingdom.

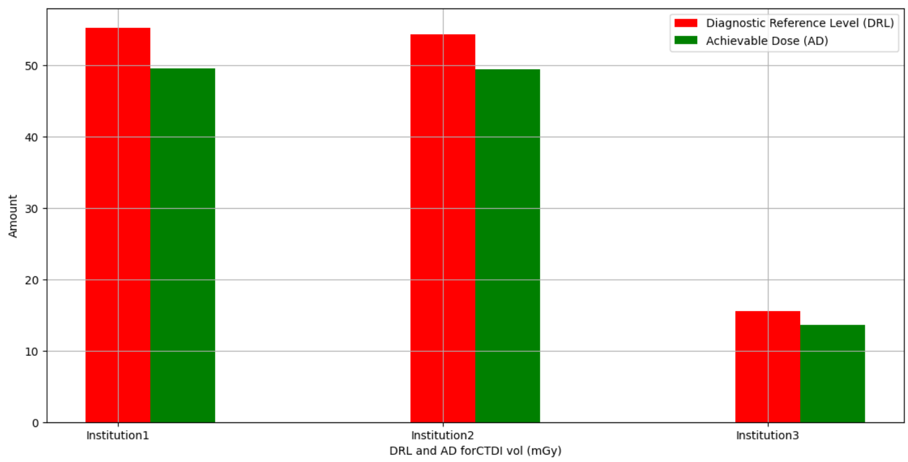

Fig 2.CTDI DRL and AD for the three scanners

The Fig. 2 above shows that the three centers vary. Diagnostic Reference Level and Achievable Dose

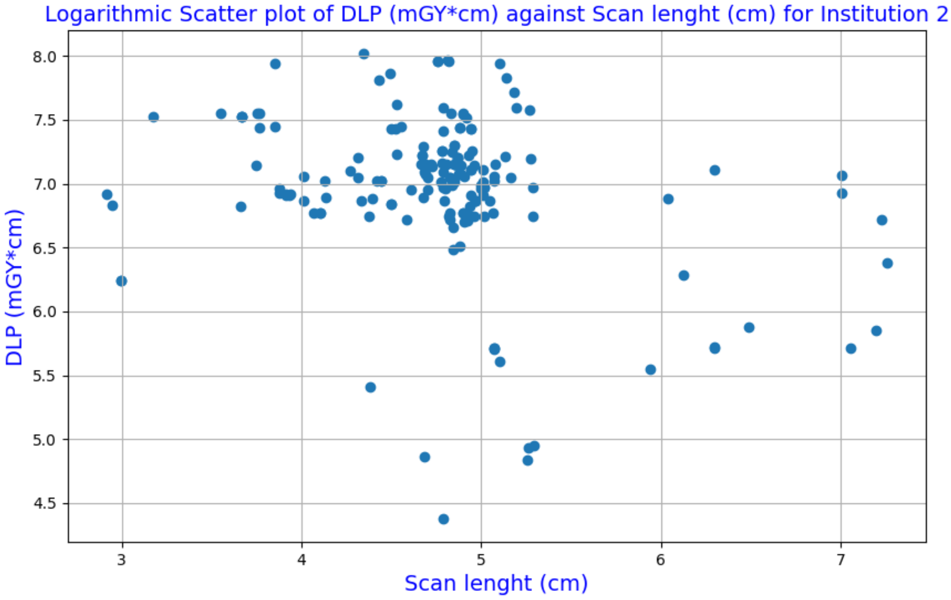

Fig 3. Logarithmic scatter plot of DLP against ScannerB

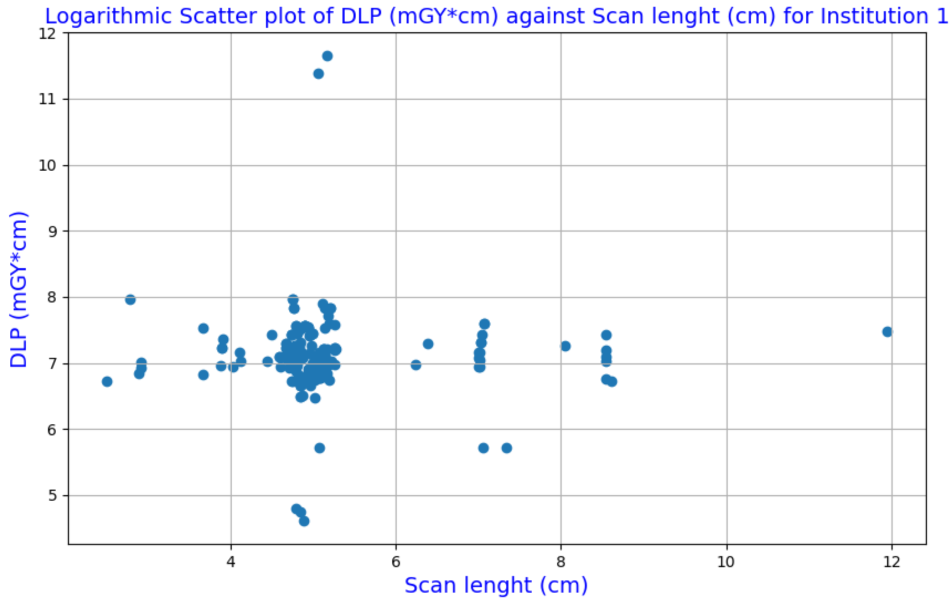

Fig 4.Logarithmic scatter plot of DLP against ScannerA

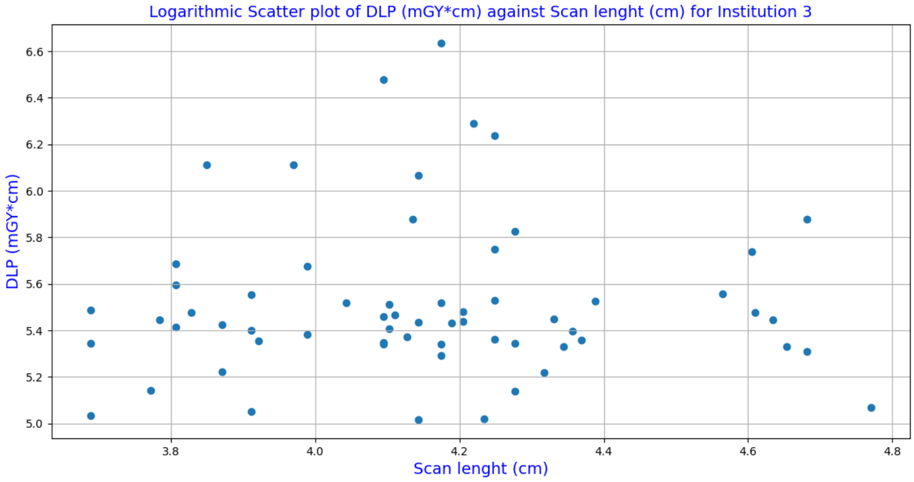

Fig 5.Logarithmic scatter plot of DLP against ScannerC

The fig3,4,and 5 indicate that the image quality Skull CT of the 424 patient indicate Dose and image quality are interdependent variables. Typically, dosage rises to improve image quality.

IV. Conclusion.

Adult skull CT scans for the 424 population have DRLs of 53.27milligray (mGy) and the Dose Length Product DRL is 1374.14mGy centimeters (mGy-cm). The effective dose is 32.98. Because they are better at optimization, centers with relatively low CTDI values should keep them. If a frequent dose audit is conducted, a DRL in south-south region of Nigeria that is exactly comparable to worldwide norms is possible.

V. Recommendation

For CT operations, the Nigerian Nuclear Regulatory Authority (NNRA) may want to develop diagnostic reference levels in order to lessen dose administration arbitraryness. Additionally, it would be ideal for Africa to work together on dose reporting and monitoring.

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