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# Evaluation of Dose to Patients Undergoing Head, Chest, and Abdomen Computed Tomography Scan Examinations at Specialist Hospital, Bauchi, Bauchi State, Nigeria.

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**Abstract:** X-rays are used to make images in the developing imaging technique known as computed tomography (CT), which is frequently employed in radiology practice to diagnose and monitor a variety of medical disorders. In this study, the dose to patients undergoing head, chest, and abdomen computed tomography scan examination at Specialist Hospital, Bauchi, Bauchi State, Nigeria was evaluated. The study used a quantitative and prospective approach to figure out how much radiation will be absorbed by patients getting an abdomen, chest, and head CT examination. A total of thirty patients (ten each) who underwent either head, chest, or abdomen scans were recruited for this study. The demographic details (age, gender, and weight), scan parameter (kVp, mAs, Pitch, scan length, thickness, and $CTDI_w$), and measured calculated dose parameters (MSAD, $CTDI_v$, DLP, and Effective dose) were determined. The mean $CTDI_v$, DLP, Effective dose, and MSAD are (81.76 mGy, 81.76 mGy, and 29.18mGy), (1326.03mGy.cm, 1417.47mGy.cm, and 1417.47mGy.cm), (3.05 mSv, 21.26 mSv, and 21.26 mSv), and (3.05 mGy, 4.34 mGy, and 9.67 mGy), for head, chest, and abdomen scan examination, respectively. The $75^{th}$ percentile, which is the local Diagnostic Reference Level (DRL) for $CTDI_v$ and DLP, is (112.4386mGy and 1451.63 mGy.cm), (37.84034mGy and 2008.08 mGy.cm), and (37.84034mGy and 2008.08 mGy.cm), for head, chest, and abdomen, respectively. These values are found to be within the ICRP reference level for $CTDI_v$ and DLP of (60 mGy and 1050 mGy.cm), (30 mGy and 650 mGy.cm), and (35 mGy and 780 mGy.cm), for head, chest, and abdomen, respectively. The CT scanner at the Specialist Hospital, Bauchi, investigated in this study was found to be operating slightly above the ICRP $75^{th}$ percentile value for $CTDI_{vol}$ and DLP. Effective dose and Multiple scan average are found to be within the acceptable level. The mean value of $CTDI_v$ and DLP for all the patients that underwent CT examination for Head, Chest, and Abdomen is found to be within the ICRP reference level. This implies that the CT examination taking place at the center is in accordance with the ALARA principle; however, regular monitoring is required.

**Keywords:** dose, computed tomograpy, thermoluminicense dosimeter.

## 1 Introduction

Since CT X-ray is the most well-known type, the term "computed tomography" (CT) is frequently used to describe it. However, there are a variety of different CT techniques, including positron emission tomography (PET) and single-photon emission computed tomography (SPECT). One type of radiography is X-ray tomography, which preceded computed tomography. There are numerous more tomographic and non-tomographic radiographic techniques based on the body structures' capacity to absorb the X-ray radiation. CT produces data that can be used to demonstrate various biological structures. Over the past two decades, CT use has substantially increased in several nations [1].
X-rays are used to make images in the developing imaging technique known as computed tomography (CT), which is frequently employed in radiology practice to diagnose and monitor a variety of medical disorders. One major restriction of CT is the rising concern over the cancer risk associated with greater X-ray exposure [2]. CT scanner usage is constantly growing [3]. Because they produce photographs of high quality in MPR and 3D perspectives [4], have an extremely quick acquisition time [5], high

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spatial resolution, low noise levels, and high contrast to distinguish between various tissue densities are the defining characteristics of the image quality [6]. Although the CT scan is regarded as a powerful modality, it regrettably accounts for the majority of the medical dosage that patients receive. According to the International Atomic Energy Agency (IAEA), CT scans made up around 25% of all radiological exams and generated between 60% and 70% of the total dosage from radiological exams [7]. Various imaging facilities may utilize different CT scanners and protocols, which could result in variable radiation exposure levels between institutions. It could be challenging to compare and benchmark radiation doses due to this lack of uniformity, which could also obstruct the development of best practices. Variations in the radiation exposure to patients may result from the lack of consistent guidelines for CT scan dose protocols for various anatomical locations, such as the abdomen, chest, and head. The safety of the patient and the precision of the diagnosis may be jeopardized as a result of potential overexposure or poor image quality. Healthcare practitioners must keep up with quickly changing CT technology and dosage reduction techniques, but this can be difficult. Hence, to guarantee that the most recent methods for optimizing patient dosages are effectively applied, ongoing education and training are required.

## 2 Experimental Section

### 2.1 Materials

A Computed Tomography scanner machine located at the study center, Data Collection Sheet, Thermoluminescence Dosimeter (TLD), and Microsoft Excel Package were used as materials for this research.

### 2.2 Study Design

The study used a quantitative and prospective approach to figure out how much radiation will be absorbed by patients getting an abdomen, chest, and head CT examination. The study required the use of numerical data, completed to ensure more trustworthy and valid data [8], and gathered from the computer archive system, where the dose report and exposure parameters are recorded. As a result, a quantitative design was necessary.

### 2.3 Method of Data Collection

CT radiographers, who are skilled in data collection and gathering, were involved in the data collection process. The participants' demographic data (such as age, gender, and weight), scan parameters (such as kVp, mAs, slice thickness, and pitch), dosage parameters (such as CTDI and DLP), and Thermoluminescence dosimeter values are the four sections of the data collection sheet that were utilized. It was adapted from the survey form for establishing reference values that was evaluated and validated by the International Atomic Energy Agency (IAEA). It also included information on the various CT scanners, such as detector configuration, year of manufacturing, make, and model. In this study, a total of 30 patients who underwent various CT examinations, including abdomen, chest, and head scans, are involved in this study. Based on the European Commission's suggested guideline for sample recruitment, which states that a minimum of 10 participants must be recruited for each body area being studied. Additionally, a sample will be more representative of the population from which it was drawn if it is larger [9]. All of the patients who accepted to participate in the study and completed the inclusion criteria had their weight checked to ensure they were within the range for patients of a standard size, which for the European population is $70 \pm 3\, kg$. Because a standard-size patient for the Nigerian population could not be located in the literature, the European weight limit was chosen to facilitate comparisons with published values.

### 2.4 Method of Data Analysis

The demographic details (age, gender, and weight) were included in the data. The scanning range (kVp, mAs, Pitch, and scanning parameters), as well as the dose parameters (CTDI & DLP) and TLD values. The descriptive analysis was used to summarize the data for this study; it is used to describe the data by identifying its locational measures (mean, median, and mode) and expressing its variability-related measures (range, standard deviation, and standard error). Microsoft Excel was used to analyze the data. The quartile value at the 75% confidence level and the mean standard deviation were used. The reported statistics from European nations with established DRLs were used to compare them with the measured dosages[10-12].

### 2.5 CT Dose Measurement Parameters

#### 2.5.1 Multiple Scan Average Dose (MSAD)

MSAD is the average radiation dose during a CT procedure that involves many parallel scans, as opposed to only the center scan. Only when the scan protocol employs more than a few concurrent scans can the MSAD provide information about the average patient dose. Similar to the CTDI, the MSAD is infrequently carried out and requires Thermoluminescent dosimeters for measurement. Morin *et al*. (2003) state that the MSAD for non-spiral scans can be calculated using the following equation, which takes the CTDI as input:

$$MSAD = \frac{NxT}{I}(CTDI) \quad (1)$$

where I is the distance between scans (mm), T is the nominal scan width (mm), and N is the total number of scans. N x T is the entire nominal scan width for the MSCT system, and I is the patient table movement during a single gantry rotation. Consequently, considering that pitch is defined as the table movement per gantry revolution, which needs to be collimated. Karthikeyan and Chegu's work indicates that the MSAD for spiral scans can be written as follows:

$$MSAD = \frac{I}{Pitch}(CTDI) \quad (2)$$

### *2.5.2 Volume Computed Tomography Dose Index ($CTDI_{Vol}$):*

Volume Computed Tomography Dose Index ($CTDI_{Vol}$) is stated as the mean dosage applied to the scan volume during a particular test. The CTDI is the source of delivery. Another new radiation dose metric that has been approved by the International Electrotechnical Commission is $CTDI_{Vol}$.For single-slice scanners, $CTDI_{Vol}$ is defined as follows by Morin et al. (2003):

$$CTDIvol = \frac{NxT}{I}(CTDIw) \quad (3)$$

When N is the number of scans, T is the nominal scan width (mm), and I is the distance between scans (AAPS). Also, $CTDI_{vol}$ for MSCT is defined as:

$$CTDIvol = \frac{I}{Pitch}(CTDIw) \quad (4)$$

In CT dosimetry, the CTDIVol is currently the recommended way to express radiation dose and is thought to be more helpful for comparing radiation dosage to important organs like the thyroid and lens during a CT examination of the neck.

### *2.5.3 Effective Dose*

A partial body exposure's effective dose is the amount of risk that a whole body exposure would be equivalent to. When using this phrase, one must consider the kind of radiation and the tissues' susceptibility to ionizing radiation. The effective dose in CT is represented as follows, according to Ling (2009):

$$E = E_{DLP} xDLP \quad (5)$$

Where E = Effective dose
EDLP = Normalized effective dose
DLP = Dose Length product

## 3 Results and Discussion

### *3.1 Data Analysis*

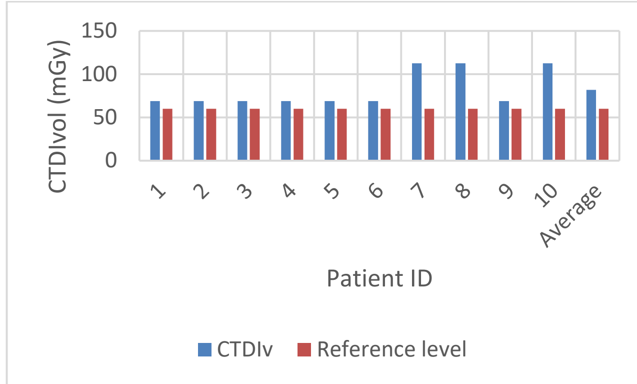


**Fig.1:** Comparison of $CTDI_{vol}$ and ICRP Reference level for Head examination.

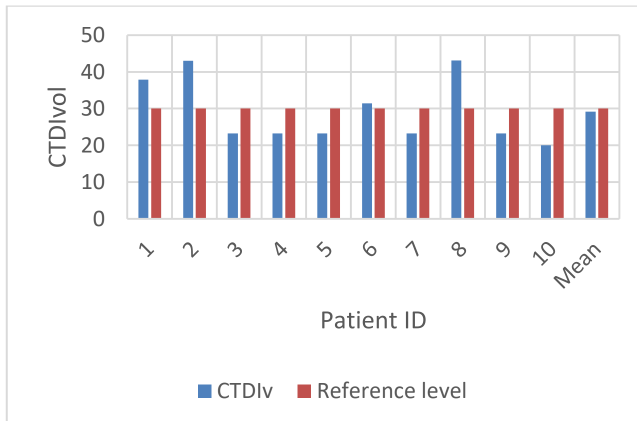


**Fig. 2:** Comparison of CTDI $_{vol}$ and ICRP Reference level for Chest examination.

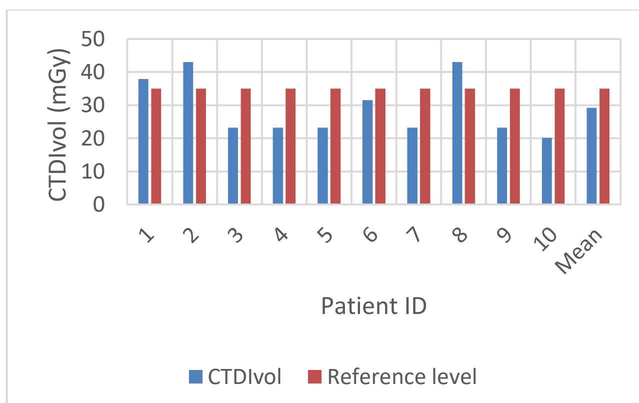


**Fig. 3:** Comparison of CTDIvol and ICRP Reference level for Abdomen examination.

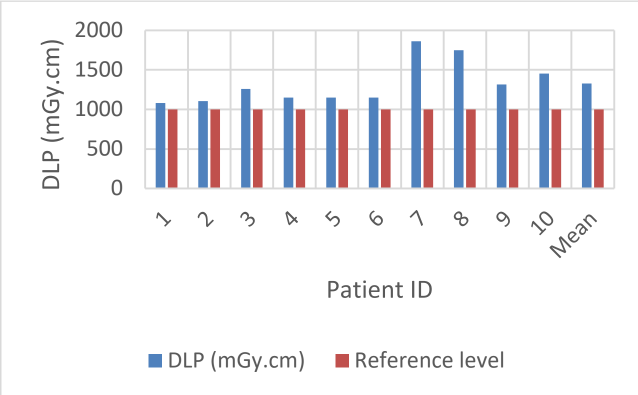


**Fig.4:** Comparison of DLP and ICRP Reference level for Head examination.

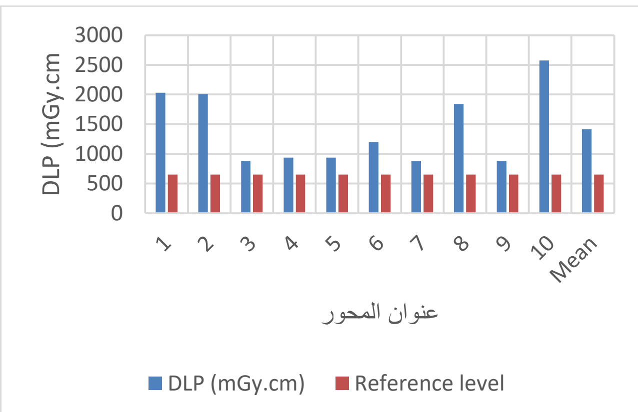


**Fig.5:** Comparison of DLP and ICRP Reference level for Chest examination.

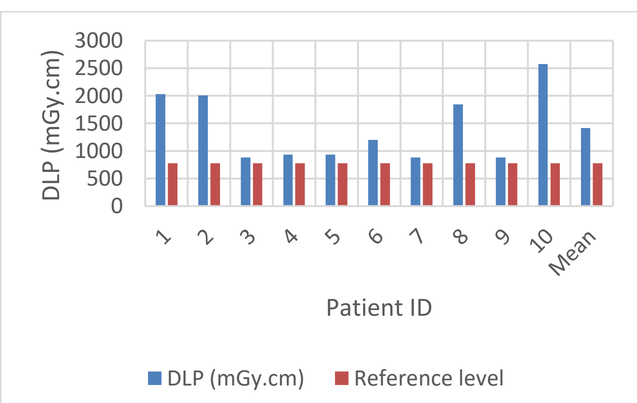


**Fig.6:** Comparison of DLP and ICRP Reference level for Abdomen examination.

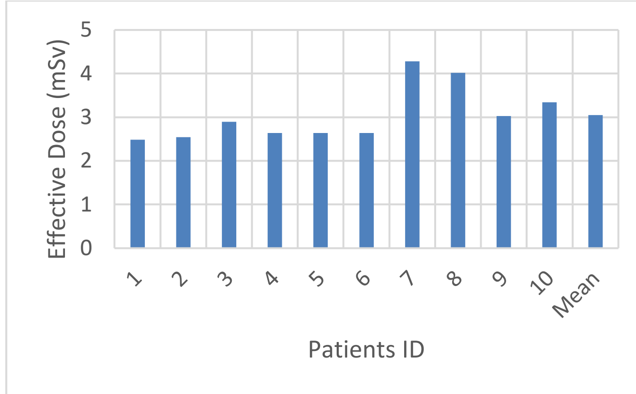


**Fig. 7:** Bar chart of Effective Dose for Head examination.

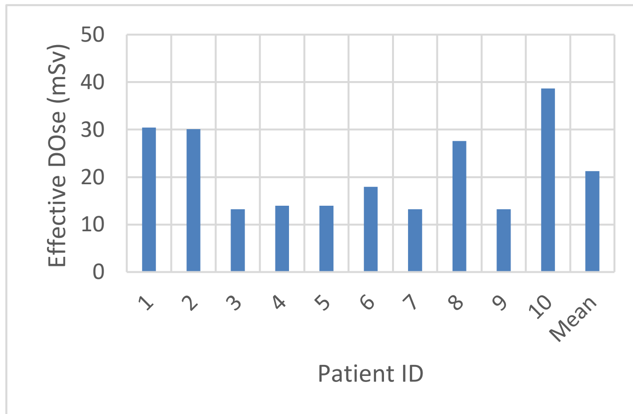


**Fig. 8:** Bar chart of Effective Dose for Chest examination.

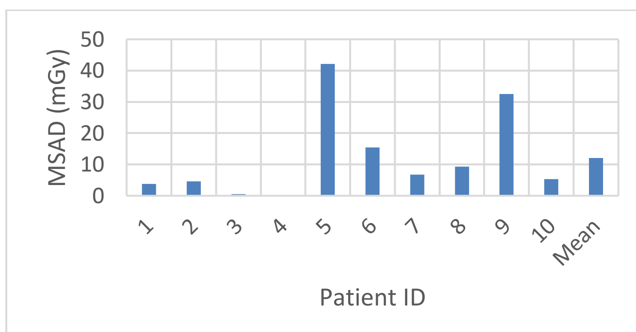


**Fig. 9:** Bar chart of MSAD for head examination.

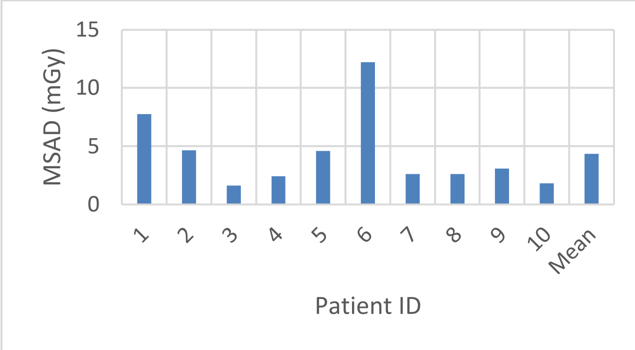


**Fig.10:** Bar chart of MSAD for chest examination.

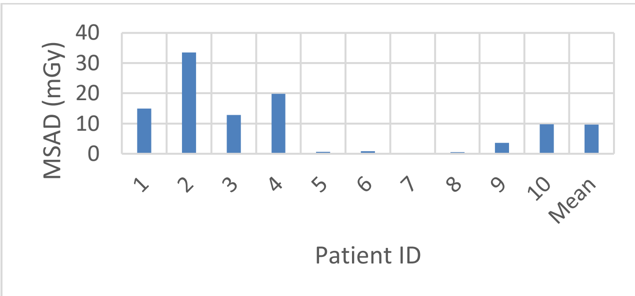


**Fig.11:** Bar chart of MSAD for Abdomen examination.

### *3.2 Discussion of Findings*

The Volume Computed Tomography Dose Index of patients that underwent Head, Chest, and Abdomen examination ranged from 68.59 mGy to 112.45 mGy with a mean value of 81.76 mGy, 20.07 mGy to 43.05mGy with a mean value of 81.76 mGy, and 20.07 mGy to 43.05mGy with a mean value of 29.18mGy, respectively. The Dose Length Product of patients that underwent Head, Chest, and Abdomen examination ranged from 1079.11 mGy.cm to 1859.30mGy.cm with a mean value of 1326.03 mGy. cm.cm, 884.08 mGy.cm to 2575.26mGy.cm with a mean value of 1417.47mGy.cm, and 884.08 mGy.cm to 2575.26mGy.cm with a mean value of 1417.47mGy.cm, respectively. The Effective Dose of patients that underwent head, chest, and abdomen examination ranged from 2.48 mSv to 4.02 mSv with a mean value of 3.05 mSv, 13.2622 mSv to 38.6289 mSv with a mean value of 21.26 mSv, and 13.26 mSv to 38.63mSv with a mean value of 21.26 mSv, respectively. The Multiple Scan Average Dose of patients that underwent head, chest, and abdomen examination ranged from 0.18 mGy to 32.46mGy with a mean value of 3.05 mGy,1.62 mGy to 7.75mGy with a mean value of 4.34 mGy, and 0.25 mGy to 33.46mGy with a mean value of 9.67 mGy.

The ICRP has recommended that DRLs be established, considering these factors, and that local or regional DRLs should equal the national benchmark (ICRP, 2007). The current work provides the DRLs for head, chest, and abdomen CT examinations. The results indicate wide variations in dose in the center. The variations in $CTDI_{vol}$ and DLP for head CT examinations were less compared to chest and abdomen examinations.

The current study is not without limitations: DRLs are often established using average-sized patients, and weight restriction criteria were applied for data collection across all centers, as most of the Centres do not record such information. Although the mean weight reported in our work is an estimate and falls within the 70 kg ±3 recommended by ICRP. Therefore, the reported doses and DRL values are representative of CT facilities and practices in the Specialist Hospital, Bauchi, Bauchi State. The findings of this study provide a benchmark for CT doses and should facilitate optimization strategies to reduce the dose burden from CT examinations in the centre [13-14].

## 4 Conclusions

It is of interest to quantify the radiation dose received by a patient undergoing a CT examination, and national surveys generally show that this imaging technique is the dominant contributor to medical radiation exposure. The CT scanner at the Specialist Hospital, Bauchi, investigated in this study was found to be operating slightly above the ICRP 75$^{th}$ percentile value for CTDIvol and DLP. Effective dose and Multiple scan average are found to be within the acceptable level. The mean value of CTDIv and DLP for all the patients that underwent CT examination for Head, Chest, and Abdomen is found to be within the ICRP reference level. This implies that the CT examination taking place at the center is in accordance with the ALARA principle, but regular monitoring is required.

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