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Original Research Article

Establishment of National Diagnostic Reference Level for Adult CT Exams: Overview of Kenya, Ghana, Tanzania, Uganda, Nigeria, Egypt and Cameroon publications

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Abstract

A diagnostic reference level (DRL) is a form of investigation level used as a tool to aid in optimisation of protection in the medical exposure of patients for diagnostic and interventional procedures. It is used in medical imaging with ionizing radiation to indicate whether, in routine conditions, the amount of radiation used for a specified procedure is unusually high or low for that procedure. Diagnostic Reference Levels (DRLs) also corresponding to a set at the 75th percentile of the dose distribution from surveys conducted across a broad user base using a specified dose-measurement protocol, are recommended for radiological examinations. In This paper, we review the most common methodology that exist in the African literature because of our same socio-economic and demographic context. This paper put focus on providing a concise information overview to establish the DRLs. This overview can be useful for any on who project the study of DRLs. Overall, this paper provides valuable stapes to carry out, suggest possible future trends and research.

Keyswords: Diagnostic reference level (DRL), Volume-weighted Computed Tomography Dose Index (CTDIvol), Dose Length Product (DLP)

1. Introduction

In 1990, the International Commission on Radiological Protection (ICRP) recommended the use of DRLs for patients undergoing radiological examinations Medical exposure to ionizing radiation constitutes a significant exposure to the population in comparison to all the other sources *(Clarke R and al. 1990)*. A diagnostic reference level (DRL) is a form of investigation level used as a tool to aid in optimisation of protection in the medical exposure of patients for diagnostic and interventional procedures. It is used in medical imaging with ionizing radiation to indicate whether, in routine conditions, the amount of radiation used for a specified procedure is unusually high or low for that procedure *(ICRP 2017)*. Diagnostic Reference Levels (DRLs) also corresponding to a set at the 75th percentile of the dose distribution from surveys conducted across a broad user base using a specified dose-measurement protocol, are recommended for radiological examinations (*Erem and al. 2022*).

According to Requirement 34 of the International BSS, governments through regulatory bodies, professional bodies and health authorities have a responsibility to ensure that DRLs are established for the country *(GSR part 3).*

In Europe, DRLs were formally introduced in Council Directive 97/43/ EURATOM (EC, 1997), and Member States of the European Union were obligated to promote the establishment and the use of DRLs as a strategy for optimisation. This obligation was reiterated by the European Commission (*EC, 2013*), with a requirement for the establishment, regular review, and use of DRLs. The 2013 Council Directive also states that appropriate local reviews are undertaken whenever DRLs are consistently exceeded, and that appropriate corrective action, if required, is taken without undue delay. Several research programmes were launched by the European *(ICRP 2017).*

In Africa, the establishment of DRL has started in certain countries and the results of their work are known in the international community. Here we will present their result and analyze it in order to highlight the advantages and disadvantages of the methods used by the authors.

2. Methodology

To conduct our review of African papers about National Diagnostic Reference Levels (DRLs), we employed a comprehensive search strategy that involved the use of one database, research gate, focus on the approach uses by the authors to carry them studies and the scientific tools that also use.

3. Background

3.1 Approach's Proposes by some Africans authors to establish Diagnostic Reference Levels in their countries

Case of Kenya

In Kenya, the authors have firstly carry out a study to identified the CT scanners available throughout the territory *(Wambani and al. 2010).* Others studies have been done to determine patient doses using multidetector computed tomography scanners in Kenya (G.K. Korir 2012) and for actual quality management systems in radiology *(Korir and al. 2013).*

Then for conducting this study, the authors have received required data from 10 facilities (representing 33 % coverage of all facilities in the country) with respect to the 20 identified types of CT scanning procedures that were performed and are considered in the study. One structured questionnaire permit to collected the data that take in account theses following variables: Age , height and weight, Type of exam, Kv, mA, mAs per rotation, Effective mAs, rotation on time (s), total mAs, Dose modulation used, scan length, acquisition slice setting, Pitch, total DLP, mean CTDI.

They have also considered theses scanogram informations: Namely, scanner manufacturer and model, scan length, slice thickness/beam collimation, operating conditions, displayed patient doses, Projection, kV, mA, typical scan length, slice width, total mAs and number of scanograms. (*Goeffrey K and al. 2015)*

For the validation of the routinely displayed dose measurements of the CT facilities that provided patient dose survey data, the authors take in account the clinical protocols validated using T40027 CT head (16 cm diameter) and body (32 cm diameter) phantoms (PTW-Freiburg, Germany) with a calibrated Unfors Xi CTexternal detector instrument.

That validation was calculated using Equations for the determination of. The CTair kerma index (CTDI100) , The weighted CT dose index (CTDIw), The volume CT dose index (CTDIvol) and The CT

dose length product (DLP) for axial and spiral scanning for a complete CT examination. The Effective dose (E) is estimated using this formula:

$E = E_{DLP} \times DLP$

(Deak and al. 2010).

After that, they have compared with the values obtained from dose coefficient factors in references *(Huda and al. 2011)*. and for their previously study *(Korir and al. 2013).*

Effective dose coefficients or k-factors are used to convert DLP displayed on the CT console per examination to derive patient-effective doses. These effective dose conversion factors were derived from data averaged over many models of scanners thus being non-specific to a CT scanner. For the statistical analysis, the mean effective dose per examination type was used to calculate the collective effective dose in CT. The annual collective effective dose (S) from the CT scanning examination patient population was determined for each age group as a product of mean effective dose and the total patient population per examination type (*Korir and al. 2012)*. As a guideline for good practice, the third quartile (75^{th} percentile) patient dose values for each age group examination procedure irrespective of the hospital or CT scanner model were determined and proposed as the initial national diagnostic reference levels (NDRLs) for each CT procedure. (*Goeffrey K and al. 2015)*

Case of Ghana

Ghana approaches for establishment of NDRL for adult xray consist to select the most commonly used procedures. The surveys have been done in 22 CT facilities and data was collected using a structured questionnaire provided by the IAEA for each patient between 2016 and 2020. 22 CT facilities represents 54% of all the CT machines in Ghana and 69% of functional CT facilities in the country. In all, data was collected from twenty-six (26) CT facilities across Ghana both in private and public facilities. Finally, have collected and analysed 2,156 dose report from the image data of selected adult patients (weight between 80kg-120kg) undergoing CT scans of head, chest, abdomen and lumbar spine. A sample of 20 typical adult patients undergoing CT procedure.

The parameters collected include:

- patient data (Age and weight);
- protocol use;
- CTDIW;
- reference Phantom;

- DLP;
- image accepted or rejected;
- AEC used;
- scanning mode;
- kV;
- exposure time;
- pitch;
- Beam width;
- Scanning range;
- AP diameter ;
- and lateral width.

Statistical analysis take in account the median values of the $CTDI_{VOL}$ and DLP were then estimated and compared with a typical dose level of published DRLs for similar practice.

The upper quartile (Q3/4) values of the estimated median values were calculated as the estimated DRL value for a specific procedure of the facility.

Procedure Basic daily QC were performed on all the CT scanners, including (kVp accuracy, mA accuracy, exposure time, HVL and image noise assessment). The measured QC estimates were compared with the records of the equipment recorded over the time.

They have also make the validation of the clinical protocol of all the CT scanners. These parameters have been measured like we have already see in Kenyan (*Goeffrey K and al. 2015)*. (kVp accuracy, mA accuracy, exposure time, HVL and image noise assessment). The measured QC estimates were compared with the records of the equipment recorded over the time. The dose assessment ($CTDI_{VOL}$ and $CTDI_{W}$) using the head and body phantoms were performed.

The DLP was calculated by multiplying the CTDIvol and the scan length for each measurement of the head and body phantoms.

Other information that is found here is the characteristics of the CT scanners (manufacturer, year of fabrication, year of installation of devices, kvpmax, type of exposure control (AEC) systems protocols and varied or fixed tube current settings,number of slices ,detector *(Mary Boadu and al 2023)*.

Case of Tanzania

Tanzanian authors have done a preliminary study to investigate the need and urgency to establish national reference dose levels from CT examinations. With this knowledge, it would be easy to identify practices in need of immediate intervention in order to reduce radiation harm to patients undergoing CT

examinations in Tanzania. *(J E Ngaile and al. 2006)*.

The data been collected from eight hospitals in Tanzania with CT scanners.

The informations used in this study were routine CT examinations of head, chest, abdomen, lumbar spine and pelvis. The selected investigations used in this study represent over 90% of the total CT examinations conducted in Tanzania at the time of study.

In order to investigate, the exposure related parameters (kilovoltage (kV), tube current (mA), exposure time, slice thickness, table increment and number of slices), the patient doses, and devices characteristics of typical exposure parameters were collected from each hospital participating in the study. Patient data were collected from a minimum number of ten adult patients for each selected CT examination and scanner.

CT dose measurements

For interest of this study, the determination of patient dose from CT examinations using the reference dose quantities proposed by the EC. However, these quantities cannot be determined without the knowledge of CT dose index (CTDI). In theory, the CTDI, as a measure of dose from single slice irradiation, is defined as the integral along a line parallel to the axis of rotation (*z*) of the dose profile, *D(z)*, divided by the nominal slice thickness, *t*, given by *(EC (1999), Jessen et al (1999))*

$$CTDI_{\infty} = \frac{1}{t}\int_{-\infty}^{+\infty} D(z)dz \quad \textbf{(1)}$$

CTDI was obtained from a measurement of dose, *D(z)*, along the *z*-axis made in air and phantoms using a special pencil-shaped ionisation chamber (Diados, type M30009, serial No. 0254, PTW-Freiburg) with a volume of 3.14 cm3. The chamber was connected via a 2.5 m cable to a radiation-measuring device (Diados, type 11003, serial No. 1394, PTWFreiburg).

The calibration of the ionization chamber is traceable to the standards of the German National Laboratory (PTB), and was calibrated according to the International Electrotechnical Commission Standards (IEC) (IEC 1999). The overall accuracy of ionisation chamber measurements was estimated to be ?}5%. Since the sensitive length of the pencil ionisation

chamber is 100 mm, the above expression was modified to read (EC 1999, Jessen *et al* 1999)

$$CTDI_{100} = \frac{1}{t}\int_{-50}^{+50} D(z)dz \quad \textbf{(2)}$$

Measurements of CTDI in air *(*$CTDI_{100,air}$*)* and in the cylindrical polymethyl

methylacrylate (PMMA) phantoms *(*$CTDI_{100,phantom}$*)* of diameters 16 cm (head) and 32 cm (body) were made as recommended by EC guidelines based on the typical patient and exposure related parameters obtained from each hospital *(EC 1999).* Unfortunately, the $CTDI_{100,air}$ and $CTD_{100,phantom}$ for CT scanner model Tomoscan M-EG from RMC were not determined due to malfunction of the scanner. Hence, the missing reference dose quantities for this particular hospital were estimated using normalised CTDI values already established by the ImPACT group (ImPACT 2000).

Determination of reference dose quantities

The weighted CTDI (CTDIw) to the selected CT examinations in this study was estimated from measurements of CTDI in PMMA phantoms described in the previous section at the centre ($CTDI_{100,centre}$) and at the periphery ($CTDI_{100,periphery}$). For the sake of simplicity, from here on, the $CTDI_{100,air}$, $CTDI_{100,centre}$ and $CTDI_{100,periphery}$ will be abbreviated by CTDIair, CTDIc and CTDIp, respectively. Based on the assumption that higher radiation dose is delivered at the peripheral rather than the central region of the phantom, the *(*CTDIw*)* was then estimated using the relationship *(Shrimpton et al 1998),* Jessen *et al* 1999)

$$CTDI_w = \frac{1}{3}CTDI_C + \frac{2}{3}CTDI_P \quad (3)$$

where CTDIp represents an average of measurements at four different locations around the

periphery of the phantoms. In order to take into account non-contiguous exposure along the

z-axis, the CTDIw was either divided by pitch (for helical) or multiplied by a packing factor

(for axial) to obtain the volume CTDI (CTDIvol). For helical CT scanners, CTDIvol is given by McNitt-Gray (2002), NRPB (2005)

$$CTDI_{vol} = CTDI_w \frac{1}{pitch} \quad \textbf{(4)}$$

where pitch is the ratio between table increment per rotation, *I*, and beam width, *t* [15].

In this study, the DLP (in mGy cm) for the selected CT examinations per hospital was determined by multiplying the values of CTDIw or CTDIvol obtained according to equations (3) and (4), respectively, by scan length, *L*, defined elsewhere *(Shrimpton et al 1991*). For a body region of *i* scan sequences, each with scan length *L*, the DLP

could be calculated from the relationship (EC 1999, Jessen *et al* 1999):

$DLP = \sum_{i=1}^{N} CTDI_{voli} L_i$ **(5)**

In order to evaluate how well the hospitals under study are performing in terms of minimization of risks associated with CT imaging, it was further useful to compare mean effective dose to patients among scanners. This was done by estimating the effective dose using the normalised values of effective dose for DLP (*E*DLP), defined as the quotient E/DLP, given by EC *(1999)*

$E = (E)_{DLP} \times DLP$ **(6)**

where *E*DLP is the normalised value appropriate to general regions of the patients (head, neck, chest, abdomen, pelvis and trunk) provided by EC (1999), Jessen *et al* (1999). The mean estimated effective doses per CT examination per hospital using *E*DLP values were further compared with previous estimated effective doses using CTDIair measurements and conversion coefficients (NRPB-R250) derived from Monte Carlo (MC) techniques (Jones and Shrimpton 1993, ImPACT 2000).

2.4. Comparisons of mean CTDIw and DLP among hospitals and European guidelines

In order to evaluate how well the hospitals in Tanzania are performing in terms of radiation dose to patients undergoing CT examinations, it was useful to compare CTDIw, DLP and *E* for the entire country. This was done by determining CTDIw, DLP and *E* of selected CT examinations for different hospitals. This will enable comparison of performance of individual hospitals in relation to proposed RDLs (EC 1999). In order to estimate the reference dose levels as recommended by EC guidelines, it was necessary to determine the country third quartile values for CTDIw, DLP and *E* for each examination (EC 1999) [15].. The country mean and third quartile values for CTDIw, DLP and *E* were obtained using descriptive statistics from the mean values of CTDIw, DLP and *E* per hospital. The country mean of CTDIw, DLP and *E* for five selected CT examinations will enable comparison between Tanzania and the proposed RDLs.

In addition, in order to compare the extent of the scan length per examination among nations, the mean values of scan length per examination in this study were determined and compared with published values from two European countries. *(J E Ngaile and al. 2006).*

Case of Uganda

A retrospective cross-sectional study have been carry out in Uganda where recruitement of patients from seven facilities in Uganda *(Geoffrey K. Korir and al 2015)*. The selection of participants have been doing by systematic random sampling were recruited for common studies like routine head, chest, abdomen and lumbar spine CT scan examinations. Considering the IAEA requirements, a minimum of 10 patients and a maximum of 20 adult patients per radiation center in describing CT dose characteristics. Finally, a total of 574 adult patients data were obtained during one year from seven hospitals with 25 CT scan machines in Uganda.

Data was collected from the CT scan console using a piloted data collection tool. Piloted data was manually extracted from the CT scan console and entered into the data collection tool. Authors mentioned that any radiation dose management systems and software have been established in Uganda.

The quantitative data were entered into the Epi-Info database for analysis. None of the facilities had size specific dose estimate (SSDE) capabilities.

Study variables

The study variables were kVp, mAs, reference mAs, examination mAs, total mAs, slice thickness, scan length, scan time, DLP, CTDIvol Effective dose for head, chest, abdomen and lumbar spine exams per study site.

The Effective dose was computed as a product of the Dose Length Product (DLP) and different conversion factors denoted the k-factor for the different tissues and anatomical regions.

$E = k \times DLP$

where k is the DLP to effective dose conversion factor (mSv /mGy.cm). The conversion factors used were 0.0021 and 0.014 respectively [16] Image quality assessment was also done using a 5-point scale International Atomic Energy Agency (IAEA) tool.

Analysis plan

The software STATA version 15 were use for analysing Data. Here, baseline characteristics were summarised using means for numerical variables that were normally distributed and medians for numerical variables that were not normally distributed, and frequency and proportions for categorical variables and presented in the form of tables. CT scan variables for different facilities were compared for each of the examinations by comparing their

means, medians and proportions depending on the variable types these were also presented in the form of tables.

To determine the DRLs, three variables were considered namely; volume-weighted CTDI, DLP and effective dose. The reference levels were obtained by calculating the median (2nd quartile) and 3rd quartiles of the radiation doses per study site by anatomical region to determine the LDRLs. The NDRL was determined by computing the 75th percentiles of the median values of the LDRLs and presented in the form of tables.

Quality control

This was ensured using the following measures: The respective unit radiographers conducted daily, weekly and monthly dose calibrations. The fact is that, in Uganda the regulatory agency, namely, the AEC, requires the quality control, these tests to be conducted and documented for every CT scan facility. The regulator however performs yearly review assessment (enforcement) control tests on the machines. The data collection tool was also pre-tested and adjustments were made accordingly; data were collected and edited before entry into the software. Data sets were backed up regularly and stored, at the end of the study; the original data, data directory, final database and study analysis have been archived. *(Erem et al. 2022)*

Case of Nigeria

Data collection

The method used in Nigeria for data collection had been firstly to obtain the consent of the radiographers working in the centers for their participation. The authors adapted a dose survey sheet from the United Kingdom CT dose survey booklet was used for data collection. The sheet was designed to extract patient anthropometric characteristics such as:

- age,
- height weight,
- and gender.

It also allows for collection of information related to imaging parameters such as:

- scan mode,
- CT Dose Index volume (CTDIvol);
- Dose-Length-Product (DLP);
- tube potential (kVp),
- tube current and time (mAs),
- gantry rotation time,
- pitch, slice thickness,
- type and reconstruction algorithm.

The data for adult patients were collected (18 years or older). There was one survey

sheet per CT scanner for each participating centre. Dose data were extracted from patients' digital examination folders. For this study, dose data of the three common CT examinations (head, chest and abdomen/pelvis) and 20 randomly selected data patients per exams were extracted.

Statistical analysis

The authors have analysed the data using the Statistical Package for Social Sciences (SPSS) v22.0 (IBM Corp. Armonk, NY) Corp). The median values of CTDIvol and DLP for head chest and abdomen/pelvic CT examinations were calculated as recommended by the ICRP publication 103 (ICRP 2007). The National Diagnostic Reference Levels (nDRLs) for each of these examinations was then calculated based on the 25th, 50th and 75th percentiles. Effective doses (E) for these examinations were estimated using the k conversion factor as described in the ICRP publication 103:

$$E_{DLP} = k \times DLP$$

Where k = tissue weighting factor (head: 0.0021; chest: 0.014; abdomen/pelvis: 0.015) *(Ernest Ekpo and al. 2018)*

Case of Egypt

Egypt have elaborated the NDRL like a National project in consequence of the International Atomic Energy Agency (IAEA) regional meeting and training on ''Establishment and Utilisation of Diagnostic Reference Levels". So, the design and the Excel sheets for data collection were provided by the IAEA. Egyptian DRLs steering committee was established and was constituted by 30 persons from the field of radiology, medical physic and IAEA.

This project was conducted from September 2014 to February 2016 and included 24 meetings of the steering committee, 14 face to face and 10 teleconferences. Analysis of this data and the final interpretation of the results were performed from February 2016 to May 2016.

For the DRL study, the eligibility criteria were:

- Readiness to participate in the establishment of national DRLs after clarification of project's importance.
- Registered for more than 5 years with the regulatory authority, the Executive Office of Radiation Protection, Ministry of Health.
- Having a workload of more than 100 CT examinations/month.

- Readiness to implement the basic quality control measures.

Fifty facilities (representing 20%) met the eligibility criteria.

They covered all of the 27 Governorates, with higher participation from three governorates (Cairo, Giza and Alexandria) representing a higher number of CT facilities per population and considered referral cities for the nearby larger rural areas. The study included facilities from university, military, governmental and private sector.

It must be noted that medical service in Egypt is largely practiced on private basis (70%). This was considered in selecting target facilities. In this study 64% of the included facilities were private hospitals. The distribution of the CT facilities in governorates is shown in Fig. 1. Twenty-eight (56%) of the participating facilities were from rural areas while 22 facilities (44%) were allocated to urban territories; consistent with the demographic distribution

report made by the Central Agency for the Public Mobilization and Statistics in 2013 [20].

2.3. Data collection

According to the statistics of the General Directorate of Radiology at the Ministry of Health, the most frequent six CT examinations were identified. These are CT of head, chest (high

resolution), abdomen (for liver metastases), abdomen-pelvis, Fig. 1. chest-abdomen-pelvis and CT angiography (aorta and both lower limbs).

All facilities were instructed to restrict data collection to adults and to measure the body mass (weight) of each patient. The information collected included: type of the equipment, number of detector rows and detector width of the CT scanner, tube voltage (kVp), average tube current when modulation was switched on, rotation time (s), helical/axial scanning, helical pitch, number of phases, use of tube current modulation, as well as the volume computed

tomography dose index, CTDIvol (mGy) and dose length product, DLP (mGy.cm). Although the intent was to collect data from 20 patients per examination in each facility, some centers provided data for 18 only. To maintain similarity, a decision was made to keep a consistent figure of 18 for each type of examination for each location. No attempt was made to restrict to a defined body weight to reflect an actual practice. Data were collected prospectively by

individual facilities in the paper form. The data was then transferred to Excel sheets.

2.4. **Statistical analysis**

Statistical analysis was performed using SPSS v. 18.0 (PASW, Chicago, IL). Quantitative variables are expressed as arithmetic mean (denoted further as mean), median (50th percentile), first quartile (25th percentile), third quartile (75th percentile), and mode (or modal value, that is the value that appears most often in a dataset).

The CT data were analyzed using descriptive statistics. For multi-phase studies, average CTDIvol per sequence and total DLP per examination were calculated as representative values used for further analysis. Median DLP and CTDIvol data from each site were used to estimate the typical dose in each facility. The national DRLs for Egypt were set based on the rounded third quartile values of distributions of medians for the CTDIvol and DLP values from contributing facilities. The third quartile of the CTDIvol was rounded to 1 mGy and that of the DLP was rounded to

5 mGy.cm. From the same distribution of medians, the median value of the CTDIvol per sequence and DLP value per examination was proposed as ‘‘achievable dose”. The results were compared with international DRL data. *(Salama and al 2017)*

Case of Cameroon

In Cameroon, in year 2017 a pilot study have been carry out for four commonest CT-scans examinations of adults in five radiology department 03 regions of Cameroon (Center, Littoral and West).

The methods use by the authors was a descriptive cross-sectional study during 06 months in medical imaging services. The sample randomly selected at least 30 acquisitions (minimum require is 20 acquisitions) for each of the four commonest CT examinations: cerebral, chest, abdominopelvic and lumbar spine. All acquisitions were helical mode. The variables were:

- The dosimetric quantities recorded (the Dose Length Product (DLP) in mGy·cm (milliGray.centimeter) and the Volumetric CT Dose Index (CTDIvol) in mGy (milliGray);
- patients age and sex;
- type of CT-scan examination (cerebral, chest, abdomino-pelvic, lumbar spine);
- Used of IV contrast (IV−/IV+);
- acquisition length;

- time of tube rotation;
- voltage (kV);
- mAs;
- pitch;
- and thickness of slices.

Statistical Analysis has been done with SPSS software version 2.0. The recommended Diagnostic Reference Levels for each protocol was the 75th percentile of the doses for this examination in the entire sample. *(Moifo and al 2017)*

synthesis of approaches

The methodological approach proposed by our team results from observations made in the methods used by the authors of our literature reviews. This approach takes into account the common points that exist between these papers and corrects the shortcomings mentioned during the carrying out of the work on the data collection sites.

To do this, we have summarized the existing similarities between these documents in the tables

below:

	Type of study	Target population	Sample size	Duration of the study	Study variables	Materials needed	Number of facilities	Statistical analyses
Kenya	Prospective	Person who came to do CT scan exam	20 person per type of exam per hospital	1 year	Age , height and weight, Type of exam, Kv, mA, mAs per rotation, Effective mAs, rotation on time (s), total mAs, Dose modulation used, scan length, acquisition slice setting, Pitch, total DLP, mean CTDI. scanogram informations: Namely, scanner manufacturer and model, scan length, slice thickness/ beam collimation , operating	-CT scan device -Head and body phantom and accessories questionnaire	15	

					conditions, displayed patient doses, Projection, kV, mA, typical scan length, slice width, total mAs and number of scanograms.			
Ghana	Retrospective study	Adult person - (weight between 80kg-120kg) who came to do CT scan exam	20 typical adult patients		patient data (Age and weight), protocol use, CTDIW, reference Phantom, DLP, image accepted or rejected, AEC used, scanning mode, kV, exposure time, pitch, Beam width, Scanning range, AP diameter and lateral width. Dose descriptors (CTDIVOL and DLP)	-Multi-detector (MDCT) scanners -Head and body phantom and accessories - MeVisLab workstation (Application Software)	26 CT facilities	The median values of the CTDIVOL and DLP - The upper quartile (Q3/4) values of the estimated median values were calculated as the estimated DRL value for a specific procedure of the facility.

Tanzania	Prospective	CT examinations of head, chest, abdomen, lumbar spine and pelvis	10 person per exams per device		exposure related parameters (e.g. kilovoltage (kV), tube current (mA), exposure time, slice thickness, table increment and number of slices) on patient doses, typical exposure parameters		8 hospitals	the mean values of CTDIw and DLP, Mean values of effective dose, 3rd quartile of DLP (mGy cm), for CTDIw (mGy) and for Effective dose (mSv)
Uganda	retrospective cross-sectional study	adult CT examinations	minimum number of 20 patients.		kVp, mAs, reference mAs, examination mAs, total mAs, slice thickness, scan length, scan time, DLP, CTDIvol Effective dose for head, chest, abdomen and lumbar spine exams per study site		7 hopsitals	DRLs using the 75th centile of the median values.

Nigeria	retrospective study	adult CT examinations	20 cases but somes hospitals provided 13 patients and have been included because their median dose values were not significantly different from those with 20	20 months	patient age, height weight, and gender, scan mode, tube potential (kVp), tube current and time (mAs), gantry rotation time, pitch, slice thickness, type and reconstruction algorithm.		36	The Median, 75th and 25th percentile CTDIvol and DLP

			or more patients					
Egypt	prospective	Adult ct examinations	20 patients per examination in each facility	18 months	Patient weight, type of the equipment, number of detector rows and detector width of the CT scanner, tube voltage (kVp), average tube current when modulation was switched on, rotation time (s), helical/axi		50	

					al scanning, helical pitch, number of phases, use of tube current modulation, CTDIvol (mGy) and DLP (mGy.cm)			
Cameroon	Prospective and retrospective	Peadiatric head ct exam	Participants were asked to extract from the scanner archive, data for at least 10 patients of		gender, age, height and weight; place, examination data: date, number of phases and scanning mode (axial or		15 CT scanners	minimum, maximum, median of CTDIvol and DLP values were calculated -mean values of

			each examination and each age group (retrospective part), and for at least 10 patients of each group in the prospective data collection.		helical); exposure parameters: tube voltage, tube current/current–time product (average values if tube current modulation utilised), rotation time and beam width; dose indexes recorded from the scanner console: weighted CTDIw or volume			each data ser-minimum, maximum, median of 75th percentile values

					CTDIvol for each sequence/ phase, and DLP for the whole exam			

The proposed methodology is as follows:

- **Type of study:** prospective and transversal study
- **Target population:** adult persons (over 18 years old) who come to have a scanner exam with an exam report
- **Sample size:** 20 people per protocol
- **Duration of the study:**
- **Study variables:**

- Age and sex of the patient
- Patient weight
- CT examination
- Device characteristic
- kV
- mAs
- Current intensity
- Pitch
- Axial or helical mode
- rotation time (s),
- Number of detectors
- Number of phases
- CTDIvol
-PDL

-

- **Materials:** weighing machine, software Excel, data collected paper form
- **Statistical analysis: software** SPSS, mean and mode of quantitative values, median (50th percentile), first quartile (25th percentile), third quartile (75th percentile that will be consider as diagnostic reference value).

Conclusion and Future Work

The multi-factorial nature of optimisation in CTscanning requires relevant training in patient dosimetry among medical imaging professionals, automated display of patient parameters such as weight and radiation exposure and establishment of equipment efficiency performance standards. LDRLs could help facilities to address the optimisation of patient radiation dose during the rapid expansion and increasing kinds of CT examinations that are being performed.

There is a need to establish customised CT facility optimization strategies, justification and LDRLs specific to the facility performing the procedures. The large patient radiation exposure in CT procedures at 30 % of all the CT facilities revealed an inconsistent pattern for optimisation of CT imaging protocols to adequately match the prevailing clinical

conditions. The authors which consider in this review have carried out data collection either by carrying out a retrospective study or a prospective study.

The role of medical physicists in the optimisation, quality assurance and quality control of radiological equipment, especially CT scanners, is vital and needs to be adequately supported. *(Geoffrey K. Korir and al 2015)*.

It is for this reason that some authors propose to carry out firstly a project to characterize CT device technologies in the geographic area of interest, then carry out other work on the quality control of devices eligible for the project*(Korir GK and al 2015, 2010)*. Some others suggest starting the project by researching effective doses by examinations in order to choose the most irradiating protocols which will require NRDL *(Korir GK and al 2015, 2012)*

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