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ESTABLISHMENT OF LOCAL DIAGNOSTIC REFERENCE LEVELS (DRLS) FOR RADIOGRAPHY EXAMINATIONS IN NORTH EASTERN NIGERIA

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ABSTRACT
Diagnostic reference levels (DRLs) is an essential optimization tool in radiography and radiological sciences. The objective of the study is to establish DRL for radiography examinations in north eastern Nigeria. A Prospective cross- sectional study conducted in two university teaching hospitals in north eastern Nigeria. Seven hundred and fifty (750) patients were considered for the study. Thermoluminiscent dosimeter (TLD) chips were exposed for each examination. Pearson's correlation was used to determine the relationship between the dose and anthropotechnical parameters. Statistical significance was set at P<0.05. The DRL for PA chest x-ray and lateral were 0.59 mGy and 1.02 mGy, PA skull x-ray and lateral skull x-ray were 1.02 mGy and 1.01 mGy. The DRL for PA elbow and lateral elbow are 0.57 mGy and 1.77mGy. AP shoulder x-ray and lateral were 0.71 mGy and 0.83 mGy The DRL for dorsi-plantar foot and dorsi-plantar oblique foot were 0.58 mGy and 0.61 mGy .AP dorsal spine x-ray and lateral dorsal spine are 1.03 mGy and 1.09 mGy. AP cervical spine and lateral were 0.62 mGy and0.79 mGy. Lumbosacral spine AP and lateral was 1.22 mGy and 1.59 mGy. AP wrist, lateral wrist, AP knee, lateral knee, Abdominal x-ray, pelvic x-ray, hand dorsi-palmar ,hand dorsi-palmar oblique and dental x-ray were 0.52mGy,0.87mGy, 0.50mGy, 0.50 mGy, 0.91 mGy, 1.01 mGy, 0.82 mGy,0.28 mGy, 0.83 mGy and 0.46 mGy respectively. DRLs in this work recorded lower values compared to international established work. Regular dose optimization etiquette's are required to ensure good practice.

Keywords: Diagnostic reference levels, Radiography, Thermoluminiscent dosimeter, Dental, x-rays, Entrance skin dose

INTRODUCTION

Diagnostic reference levels were first mentioned by the International Commission on Radiological Protection (ICRP) in 1990 and subsequently recommended in greater detail in 1996 from the 1996 report (ICRP 73, 1996).The Commission now recommends the use of diagnostic reference levels for patients. These levels which are a form of investigation level, apply to an easily measured quantity, usually the absorbed dose in air, or in a tissue equivalent material at the surface of a simple standard phantom or representative patient. The diagnostic reference level is intended for use as a simple test for identifying situations where the level of patient dose or administered activity is unusually high. If it is found that procedures are consistently causing the relevant diagnostic reference level to be exceeded, there should be a local review of procedures and the equipment in order to determine whether the protection has been adequately optimized. If not, measures aimed at reduction of dose should be taken. (Jenia and Madan, 2015)

Diagnostic reference levels are subject to professional judgment and do not provide a dividing line between good and bad practice. It is inappropriate to use them for regulatory or commercial purposes (Jenia and Madan, 2015). Diagnostic reference levels apply to medical exposure, not to occupational and public exposure. Thus, they have no link to dose limits or constraints. Ideally, they should be the result of a general optimization of protection. In practice, this is unrealistically difficult and it is simpler to choose the initial values as a percentile point on the observed distribution of doses to patients. The values should be selected by professional medical bodies and reviewed at intervals that represent a compromise between the necessary stability and the long-term changes in the observed dose distributions. The selected values will be specific to a country and or region (Jenia and Madan, 2015). Diagnostic reference levels are not the suggested or ideal dose for a particular procedure or an absolute upper limit for dose. Rather, they represent the dose level at which an investigation of the appropriateness of the dose should be initiated (Hart *et al.,* 2011). In conjunction with an image quality assessment, a qualified medical physicist should work with the radiographer to determine whether or not the required level of image quality could be attained at lower dose levels. Thus, reference levels act as "trigger levels" to initiate quality

improvement. Their primary value is to identify dose levels that may be unnecessarily high - that is, to identify those situations where it may be possible to reduce dose without compromising the required level of image quality. In keeping radiation dose to patients to a minimum in hospitals, it is needful to be able to estimate prior to medical examination the dose to patients as a function of radiographic exposure parameters (Edmonds, 2014). Monitoring of patients during the examination has been a major way of assessing radiation dose received in diagnostic and therapeutic radiology (Egbe *et al*., 2010). For the purpose of optimization in radiation protection, dose delivered to patients during diagnosis is studied with assessment of image quality (Johnson and Brenan 2012). This is a common practice in many parts of the world who present with clinical cases requiring x-ray examination which are often times not properly done and this is largely due to lack of facilities and suitable qualified personnel. As a result, there is no sufficient information about patient's radiation dose (Ragulla *et al*., 2014).

Radiation dosimetry is required to assess the risk associated with x-ray exposure and to inform medical radiation professionals of the levels of exposure received (Shrimpton *et al.,* 2011). Patient dose measurement is an integral part of optimization process (Sharifat *et al.,* 2010). Quality management of any use of medical x-ray imaging should include monitoring of radiation dose (Shrimpton *et al.,* 2011). A major goal of the quality program for all forms of x-ray imaging is to minimize radiation risk without degrading clinical performance (Shrimpton *et al.,* 2011).

The imperativeness of establishing national DRLs is important in Nigeria and other countries in Africa with low resource setting and current technologies because it forms a comprehensive, concise and a powerful tool optimizing radiation protection of patients (Joseph and Nzotta, 2016). National DRLs can be established by collaborating with radiographers, medical physicist across the country, the regulators and professional bodies involved (Joseph and Nzotta, 2016). The first step begins when each facility begins to set local, regional and then national DRLs.

The objective of the study is to establish DRLs for radiography examination in north eastern Nigeria.

MATERIALS AND METHODS

Method

The study is prospective cross sectional study carried out in Radiology departments of two University Teaching Hospitals located in north eastern part of Nigeria. Seven hundred and fifty patients were recruited for the study. The data in this study were collected from October 2015 to January 2016. The centers were chosen because they met the eligibility criteria for the study; having all the imaging modalities for the study and Nigerian Nuclear Regulatory Authority's Requirement for Authorization and Practice (Licensing) involving ionizing radiation. The exposed TLDs were labeled for proper identification and kept in black nylon away from radiation. A dose data capture was drafted, the template sort for information such as patients age, gender, sex, weight, height, Body mass index, focus to film distance and technical parameters. Data were entered by the researcher assisted by two senior Radiographers in each facility and then checked by a medical physicist. The information obtained for the study includes: Age, to make sure that only adult patients are recruited in the study, gender of the patients, patients body region examined**,** technical parameters such as tube potential (kVp), tube current (mAs), scan length, field of view, angle of rotation, focus to film distance, anterior posterior thickness and fluoroscopy time for each examination and procedure where applicable, Weight(kg), height(m^2) and body mass index BMI (kg/m^2) (Jenia and Madan, 2015).

Materials

a. Conventional x-ray machine: The machine used were products of Variant medical system manufactured in China and United states for hospital A and B respectively both manufactured 2009. Maximum and minimum kVp and mAs for the machines are 40-150 and 0.5-630 for hospital A and 40-200 and 0.5-400 for hospital B respectively and inherent filtration of 1.5mmAL and 0.8mmAL for hospital A and B respectively.
b. Thermoluminescent dosimeters (TLD): TLD–chips 100 Dosimeters (calibrated) annealed. They are round, small, white in colour and very sensitive. They are enclosed in a black leather and labeled. The Thermoluminiscent dosimeter chips were obtained from the Radiation Safety Adviser (RSA), Nigerian Nuclear Regulatory Authority (NNRA), Abuja, Nigeria.

Procedure for Dosimetric Measurements

Thermoluminiscent dosimeters (TLDs) were used for dose measurement for conventional x-ray, dental x-ray, and mammography. The TLDs were annealed and read at Center for Energy Research and Training Zaria, Kaduna State, Nigeria after each reading and measurement. The annealing was done at a high temperature of 98 degree centigrade; this process essentially zeroed the thermoluminescent material by releasing all trapped electrons before the TLD is used. Thermoluminescent Dosimeters (TLD) chips were placed on each patient at the region of interest depending on the projection. The TLDs were placed at the central axis where the x-ray beam strikes the patient skin to obtain the entrance surface dose. The TLDs placed on the patients was optimized for each procedure. Patient details and exposure factors were documented. About ten percent (10%) of the TLD chips used were set aside as controls in the various centers to help record background radiation. The control TLD chips are kept in a black nylon away from exposure to irradiation (both primary and secondary beam). After collection of the TLD readings, the collective values were recorded for each examination. The mean and third quartile (75^{th} percentile) values were obtained from the mean dose received.

Thermoluminescent Dosimeter Dose Algorithms

a. Glow curve analyzer which determines the quality of the glow curve. See appendix K for dose curve profile of TLD-100 (LiF-TLD).
b. Glow curve deconvulation which segregates the glow curve into their individual glow peaks
c. Chain of custody and health physics record system, which updates and maintains dose data
d. The peak value of the glow curves produced (plate 1) were automatically converted to dose using the formula:

$$\text{Dose} = \frac{Q \times ECC}{RSF} \quad (1)$$

Where
Q = Charge (the glow peak value, in nano-columb).
ECC = Element correction coefficient = 3749
RCF = Reader calibration factor = 0.0171

Processing of the TLD

The TLD reader in Center for Energy Research and Training, Zaria is the Harshaw Model 4500. It has a hardware comprising the following system.

1. The model 4500 Harshaw TLD reader which contains data processing electronic, a sample drawer assembly, a precision light measurement system, a detector heating system, a light voltage power supply, data storage facilities and photo multiplier tubes.
2. A video display unit (VDU) for the display of data graphics, operating instruction and messages.
3. Keyboard that provides the interactive central interface with the TLD reader Harshaw model 4500.
4. A set of floppy disk for backup.

The model 4500 Reader is capable of reading a number of forms of thermo luminescence dosimeters, such as the whole body and the environmental dosimeter.

The Harshaw Model 4500 Manual TLD Reader with WINREMS is a state-of-art; tabletop instrument used for thermo luminescence dosimetry (TLD) measurement of a wide variety of TL materials in many forms and sizes. This model incorporates two Photomultiplier Tubes in a sliding housing, with both planchet and hot gas (nitrogen or air) heating methods. The TL element may be heated by hot gas or by a planchet. Hot gas is used for whole body and Environmental TL cards and extremity Dosimeters (Chipstrates and Ringlets), while the planchet is used for the unmounted TL elements: chips, disks, rods, and powders. The system consists of two major components: the TLD Reader and the Windows Radiation Evaluation and Management System (WinREMS) software resident on a personal computer (PC), which is connected to the Reader via a serial communications port.

a. WinREMS Application software

The data architecture of the system includes both a host computer in the Reader and a Windows based PC connected through an RS-232-C serial communication port. The dosimetric functions divided between the Reader and the Harshaw WinREMS (Windows Radiation Evaluation and Management) software on the PC. All dosimetric data storage, instrument control, and operator inputs are performed on the PC, transport subsystem control, gas and vacuum controls, and signal acquisition and conditioning are performed in the Reader.

Data Analysis

Data was obtained and saved on a computer Microsoft excel spread sheet and categorized for each examination and imaging modality respectively. It was independently checked by a statistician and two senior radiographers. Statistical Package for Social Sciences version 21.0 was used to analyze the mean and standard deviation of the anthropometric variables, technical parameters and radiation dose received. Seventy fifth (75^{th}) percentile or (3^{rd} quartile) value of the total mean of the examinations and or procedures were obtained at 95% confidence interval. Using Kolmogorov- Smirnov to test for normality of data distribution it was verified that, for 95% of confidence level, there was a normal distribution. Therefore, we used a parametric test that was suitable for the set of data and analysis. Pearson's correlation was used to determine the relationship between radiation dose and weight at statistical significance of $p<0.05$.

Deriving Diagnostic Reference Dose Levels

Diagnostic reference levels will be taken from the third quartile (75^{th} percentile) readings of the distribution of mean doses from different radiological examination values obtained.

Step 1

Mean TLD values derived from each examination and procedure is recorded. The mean summarizes all the data; it is calculated by adding all the values and dividing the sum by the number of observations. This was achieved by using Statistical Package for Social Sciences version 21.0.

Step 2

The DRLs was set at approximately the level of 75^{th} percentile (3^{rd} quartile) of the average of dose distribution applied on radiological procedures. The 75^{th}percentile (3rd quartile) is chosen as the appropriate investigation level on the grounds that if 75% of the units can operate satisfactorily below this dose level, the remaining 25% should be made aware of their potentially less than optimal performance. They should then be encouraged to work on their radiographic technique to bring their dose in line with the majority (European Commission, 1999).

Step 3

Comparison of the established DRL values obtained in this study with the data from other countries where DRLs have been established.

Step 4

Test for normality of data was done using Kolmogorov Smirnov to determine whether the data is normally distributed or not. Pearson's correlation was used to determine the relationship between dose and anthropotechnical parameters while students T-test was used to compare the mean radiation dose between the two hospitals.

Ethical Clearance

In line with Helsinki declaration 1964, ethical approval was obtained from the research ethics committee of the Faculty of Health Science and Technology, Nnamdi Azikiwe University Nnewi Campus and from each hospital under study. Informed consent form interpreted in Hausa language was filled by each (volunteer, Patient) participant in compliance with the Human Research Ethics Guidelines for patients who do not understand English Language. The first author/researcher also underwent web based training by National Health Institute on Research Ethics United States involving human subject for adequate knowledge on research procedures and guidelines involving human subjects.

RESULTS AND DISCUSSION

It is recommended that the entrance skin dose measurements be made on statistically significant sample of patients (minimum 10) whose weights are near the standard adult patients of average weight 70±10kg as a major step to establish standardized patients for our population(European commission, 1996; Hart *et al.,* 2012; Saravanakumar, 2014). This study complied with the recommendations and therefore the estimate of ESDs for the various examinations could be considered sufficiently as a representative value for specific protocols and examination. This corroborates with other studies by ARPANSA, UK, EC and IPEM, 2005 (Hart *et al.,* 2012)

Table 1: Shows the mean and standard deviation of anthropometric and technical parameters for Radiographic and dental examination. and it represents the relative alkalinity or acidity of water. The pH scale lies between 0 and 14. On a typical pH scale, the medium is increasingly more acidic from pH of 0 to 7, and more alkaline from pH of 7 to 14. At pH of 7, the medium is neutral.

Examination	Age (years)	Weight (kg)	Height (m^2)	BMI (kg/m^2)	Thickness (cm)	FSD (cm)	kVp	mAs
Chest x-ray PA	37.18±13	66.25±6	1.67±0	26.32±16	14.15±2.6	129.50±16	61.86±4	14.23±2
Chest x-ray Lateral	41.63±12	66.67±6.4	1.64±0.	25.18±7.	18.93±3.0	119.17±20	84.40±5.	34.09±7
Hand Dorsi Palmar	41.17±13	68.56±6.3	1.74±0	23.23±2	1.07±0.25	86.33±7.5	53.70±8	2.33±0.3
Hand DP Oblique	40.82±15	68.60±6.1	1.74±0	23.21±2	1.03±0.14	92.00±9.9	58.00±5.	2.38±0.5
Abdominal x-Ray	43.06±15	68.20±6.1	1.75±0.	22.72±24	20.67±3.8	94.00±4.7	81.02±7.	39.32±7
Pelvic x-Ray	47.70±18	69.12±6.5	1.76±0.	22.23±3.	17.15±3.1	80.00±9.4	77.00±5.	37.22±7.
Skull x-Ray PA	45.07±17	67.87±6.2	1.70±0	24.73±6	13.78±3.3	88.42±12	72.09±9	29.43±9
Skull Lateral	43.43±15.	66.26±2.9	1.75±0	22.86±2	10.57±1.4	87.10±3.8	66.00±7	34.75±3
Knee AP	37.89±13	66.87±5.4	1.75±0	21.59±3	4.66±0.95	89.25±12	54.59±4	4.43±3.6
Knee Lateral	40.67±15	68.70±6.8	1.75±0	22.70±3	22.45±0.8	47.65±5.6	60.08±6	3.60±0.5
Elbow AP	36.23±12	65.23±6.1	1.65±0	23.48±3	4.17±0.89	82.67±11	54.00±7	3.43±0.5
Elbow Lateral	34.58±11	65.24±6.1	1.68±0	23.51±3	4.05±0.67	84.67±9.9	52.43±6	3.23±0.5
Dorsi Plantar Foot	38.42±13	65.60±6.0	1.62±0	24.48±3	3.14±0.7	95.00±6.9	54.17±3	11.37±2
DP Oblique Foot	38.93±13	67.10±6.2	1.64±0	24.89±2	3.14±0.72	98.34±3.7	54.01±3	11.26±2
Shoulder AP	42.27±16	66.19±6.2	1.65±0	24.32±3	5.99±1.01	88.67±9.2	58.82±3	5.57±0.7
Lateral Shoulder	42.49±17	66.18±6.2	1.65±0	24.31±3	5.83±1.07	86.17±11	59.11±3	4.69±0.9
Wrist AP	41.22±13	67.26±6.2	1.71±0	23.06±2	2.35±0.62	73.17±6.4	54.35±4	3.09±0.4
Lateral Wrist	40.23±11	67.27±6.2	1.71±0	23.06±2	12.75±4.0	73.17±6.4	55.67±3	3.70±0.4
AP Dorsal Spine	48.30±9.6	64.30±5.5	1.64±0	22.41±3	19.88±2.9	86.00±4.9	67.08±5	34.42±3
Lat. Dorsal Spine	48.30±9.6	64.12±5.5	1.65±0	22.27±3	26.65±3.4	95.67±5.0	75.00±6	36.42±3
AP C/Spine	42.15±13	65.40±5.8	1.63±0	23.56±3	5.48±0.72	105.00±5	60.34±3	21.87±2
Lateral C/ Spine	42.15±13	65.40±5.8	1.63±0	23.56±3	5.32±0.62	105.00±5.	60.34±3	21.87±2
AP Lumbosacral	46.20±11	68.30±5.5	1.64±0	22.41±3	19.13±1.4	92.00±9.9	61.83±2	31.50±2
Lateral LSS	46.20±11	84.93±5.4	1.65±0	22.13±3	24.83±4.2	91.33±10	68.33±8	33.33±5
Dental x-Ray	42.04±11	65.30±5.8	1.65±0	23.36±3	2.07±0.25	73.50±4.0	47.49±4	11.47±1

Key: DP- Dorsi-plantar, AP-Anterior posterior, PA- Posterior anterior, C/S- Cervical spine, LSS-lumbosacral spine.

Table 1 shows patients anthropometric and technical parameters. There were variations in the technical parameters. This study has provided some initial baseline data on the size of average adult patient in North Eastern Nigeria and the corresponding dose for radiological examination using different imaging modalities. The mean and standard deviation of the age weight, height, body mass index, anterior posterior thickness, focus to skin distance, tube potential (kVp) and tube current (mAs) for the whole patient population were 38.10±93, 60.00±1.0, 1.65±0.10, 24.32±3.30, 17.12±0.13, 19.88±0.11, 98.34±3.00, 60.11±1.00 and 30.1±0.1. The mean weight recorded in this study was 60.01±9.0kg while the mean patient age was 38.10±9.3 years. This corroborates with a study by International atomic energy agency (IAEA, 1998). In the IAEA study in 2004, on patients undergoing radiographic examination in some European and Asian countries an average weight of 70±10kg was considered appropriate for the European participating countries while 65±10kg was used for the Asian countries. The average age of the only African country that participated in the study, morocco was not stated but a compromise was made to enable a comparison of the measured dose to reference levels. The radiographic technical parameters recorded show that there are variations in technical factor when compared to the recommendations of European commission quality criteria (EC, 1996). Varying radiographic voltages and reduced FFD were noted in this study. All this factors have adverse influence on the outcome of the dose to patients. The above outcome is not isolated to this study, this corroborates with a study in Ghana (Eric, 2013) but it is common in other developing countries (Johnson and Brenan, 2000, Wall et al., 2001, Kings and Pitcher, 2002).This problems could be attributed to inadequate training of imaging staff, variation in patients, body built, different types of equipment and the variety of techniques used in different hospitals. Different methods of documenting data on radiation dose could lead to apparent dose variations (Kings and Picher, 2002 and Minigh, 2005). This study reveals that there are some discrepancies in the use of focus to film distance as recommended by European quality criteria. The European quality criteria recommended an average focus to film distance of 115cm. However, the focus to film distance in our study is 88.34 and the range is 48.00±119. Most diagnostic centers used focus to film distance values below the average values 88.34±3.00 cm. Since the Entrance skin dose is inversely proportional to the of the focus film distance for the same kVp and mAs, the dose reaching the patient is expected to be high. Although the general trend across most centers is the use of lower focus to film distance and this in part might explain higher Entrance skin dose in most of the radiographic examinations. It can be seen that the result did not show this as a universal trend as doses vary with hospitals and technique. It is worth nothing that changing the focus to film distance could be a good change but will not solve all the discrepancies found in the study. It is therefore important and essential that policies on quality control and quality assurance monitoring programs be enforced in the various hospitals to protect the patients from unnecessary exposures through repeat examination (Ikamaise *et al*., 2000).

Table 2: Mean doses and 75 percentile (DRLs) for radiographic examination

Examination	Mean ESD (mGy) Hospital A	Mean ESD (mGy) Hospital B	Mean ESD (mGy) Both	DRL(mGy)
PA chest x-ray	0.34±0.05	0.55±0.43	0.45±0.36	0.59
Chest x-ray lateral	0.78±0.07	0.87±0.49	0.82±0.44	1.02
PA skull x-ray	0.79±0.32	0.74±0.50	0.77±0.41	1.02
Lateral skull	0.77±0.32	0.61±0.45	0.69±0.73	1.01
AP elbow	0.44±0.05	0.36±0.17	0.40±0.25	0.57
Lateral elbow	0.56±0.06	0.36±0.29	0.46±0.34	0.77
AP shoulder	0.29±0.03	0.71±0.27	0.50±0.24	0.71
Lateral shoulder	0.59±0.06	0.66±0.40	0.63±0.37	0.83
Dorsi plantar foot	0.34±0.03	0.56±0.24	0.45±0.21	0.58
Dorsi plantar oblique foot	0.36±0.03	0.45±0.25	0.41±0.23	0.61
AP dorsal spine	0.87±0.33	0.86±0.318	0.86±0.32	1.03
Lateral dorsal spine	0.97±0.50	0.87±0.20	0.92±0.35	1.09
AP cervical spine	0.37±0.18	0.53±0.26		0.62
Lateral cervical spine	0.73±0.25	0.54±0.27	0.64±0.26	0.79
AP lumbo sacral spine	0.99±0.11	0.98±0.45	0.99±0.11	1.22
Lateral lumbo sacral spine	1.43±0.10	1.28±0.33	1.43±0.10	1.59
AP wrist	0.46±0.16	0.42±0.24	0.39±0.25	0.52
Lateral wrist	0.58±0.20	0.42±0.30	0.63±0.44	0.87
AP Knee x-ray	0.36±0.18	0.80±0.42	0.38±0.21	0.50
Lateral knee x-ray	0.58±0.35	0.40±0.24	0.69±0.38	0.91
Abdominal x-ray	0.87±0.46	0.43±0.35	0.83±0.31	1.01
Pelvic x-ray AP	0.62±0.05	0.80±0.34	0.60±0.30	0.82
Hand dorsi palmar oblique	0.21±0.03	0.58±0.28	0.25±0.20	0.59
Hand dorsi palmar	0.49±0.07	0.30±0.21	0.56±0.37	0.58
Dental x-ray (periapical view)	0.41±0.11	0.27±0.24	0.29±0.37	0.46

ESD- Entrance skin dose

Table 2 shows the mean and standard deviation of entrance skin doses in mGy received by patients during radiographic examinations in both hospitals and the established diagnostic reference levels in mGy. The mean dose and standard deviation of the radiological examinations in mGy for hospital A were 0.34±0.05, 0.78±0.07, 0.79±0.32, 0.77±0.32, 0.44±0.05, 0.56±0.06, 0.29±0.03, 0.59±0.06, 0.34±0.03, 0.36±0.03, 0.87±0.33, 0.97±0.50, 0.37±0.18, 0.73±0.25, 0.99±0.11, 1.43±0.10, 0.46±0.16, 0.58±0.20, 0.36±0.18, 0.58±0.35, 0.87±0.46, 0.62±0.05, 0.21±0.03, 0.49±0.07 and 0.41±11 for posterior anterior chest x-ray, lateral chest, posterior anterior skull, lateral skull, anterior posterior shoulder, lateral shoulder, dorsi plantar foot, dorsi plantar oblique foot, anterior posterior dorsal spine, lateral dorsal spine, anterior posterior cervical spine, lateral cervical spine, anterior posterior lumbosacral spine, lateral lumbosacral spine, anterior posterior wrist, lateral wrist, anterior posterior knee, lateral knee, abdominal x-ray, pelvic x-ray, hand

dorsi palmar oblique, hand dorsi palmar and dental x-ray (peri-apical view) respectively. The mean dose and standard deviation of the radiographic examinations in mGy for hospital B were 0.55±0.43, 0.87±0.49, 0.74±0.50, 0.61±0.45, 0.36±0.17, 0.36±0.29, 0.71±0.27, 0.66±0.40, 0.56±0.24, 0.45±0.25, 0.86±0.31, 0.87±0.20, 0.53±0.26, 0.54±0.27, 0.98±0.45, 1.28±0.33, 0.42±0.24, 0.42±0.30, 0.80±0.42, 0.40±0.24, 0.43±0.35, 0.80±0.34, 0.58±0.28, 0.30±0.21 and 0.27±0.24 for posterior anterior chest x-ray, lateral chest, posterior anterior skull, lateral skull, anterior posterior shoulder, lateral shoulder, dorsi plantar foot, dorsi plantar oblique foot, anterior posterior dorsal spine, lateral dorsal spine, anterior posterior cervical spine, lateral cervical spine, anterior posterior lumbosacral spine, lateral lumbosacral spine, anterior posterior wrist, lateral wrist, anterior posterior knee, lateral knee, abdominal x-ray, pelvic x-ray, hand dorsi palmar oblique, hand dorsi palmar and dental x-ray (peri-apical view) respectively.

The total mean dose and standard deviation of the radiographic examinations for the hospitals were 0.45±0.36, 0.82±0.44, 0.77±0.41, 0.69±0.73, 0.40±0.25, 0.46±0.34 ,0.50±0 .24,0.63±0.37,0.45±0.21,0.41±0.23,0.86±0.32,0.92±0.35,0.64±0 .26,0.99±0.11,1.43±0.10,0.39±0.25, 0.63±0.44, 0.38±0.21, 0.69±0.38, 0.83±0.31, 0.60±0.30, 0.25±0.20, 0.56±0.37 and 0.29±0.37 all mGy for posterior anterior chest x-ray, lateral chest, posterior anterior skull, lateral skull, anterior posterior shoulder, lateral shoulder, dorsi plantar foot, dorsi plantar oblique foot, anterior posterior dorsal spine, lateral dorsal spine, anterior posterior cervical spine, lateral cervical spine, anterior posterior lumbosacral spine, lateral lumbosacral spine, anterior posterior wrist, lateral wrist, anterior posterior knee, lateral knee, abdominal x-ray, pelvic x-ray, hand dorsi palmar oblique, hand dorsi palmar and dental x-ray (peri-apical view) respectively. While the established diagnostic reference levels for posterior anterior chest x-ray 0.59mGy, lateral chest 1.02mGy, posterior anterior skull 1.02mGy, lateral skull 1.01 mGy, anterior posterior elbow 0.57mGy, lateral elbow 0.77mGy,anterior posterior shoulder 0.71mGy, lateral shoulder 0.83mGy, dorsi plantar foot 0.58mGy, dorsi plantar oblique foot 0.61mGy, anterior posterior dorsal spine 1.03mGy, lateral dorsal spine 1.09mGy, anterior posterior cervical spine 0.62mGy, lateral cervical spine 0.79mGy, anterior posterior lumbosacral spine 1.22mGy, lateral lumbosacral spine 1.59mGy, anterior posterior wrist 0.52mGy, lateral wrist 0.87mGy, anterior posterior knee 0.50mGy, lateral knee 0.91mGy, abdominal x-ray 1.01mGy, pelvic x-ray 0.82mGy, hand dorsi palmar oblique 0.28mGy, hand dorsi palmar 0.53mGy and dental x-ray (peri-apical view) 0.46 respectively. Generally, ESD values for the same type of examination in the hospitals vary possibly due to the differences in patient size and in the radiographic technique used by different radiographers. Variation in ESD values between different x-ray rooms will additionally be due to differences in radiographic equipment, film type, processing and processing conditions. The mean ESD values for the individual examinations varied considerably across all hospitals (Wall*et al.,* 2001). The variation in dose among the study centers is in agreement with the findings of Shrimpton *et al.,* 1991, who found variations in the centers to be up to 10 to 40 in UK and 8 to 20 in Norway. A common position among the hospitals in Nigeria is lack of regular patient dose monitoring and quality control in diagnostic radiology. A major reason for this is the cost of running a standard radiation protection and quality assurance facility. This is in consonance with a study by Egbe *et al.,* (2008) in three Nigerian hospitals.

Table 3: Shows relationship between doses received by patients and anthropometric parameters for radiographic examination.

Dose Versus	Thickness (cm)	Weight (kg)	Height (m^2)	BMI (kg/m^2)
Examination	r p	r p	r p	r p
Chest x-ray PA/AP	-0.030, 0.876	0.006, 0.974	0.106, 0.577	-0.152,0.422
Chest x-ray lateral	0.002, 0.991	-0.218,0.248	0.194,0.303	0.325, 0.080
Hand Dorsi palmar	-0.171,0.366	-0.122,0.522	0.005,0.977	-0.222,0.283
Hand Dorsi palmar oblique	0.342,0.065	0.215,0.254	-0.194,0.304	0.344,0.063
Abdominal x-ray AP	0.303,0.104	0.134,0.481	-0.033,0.862	0.058,0.761
Pelvic x-ray AP	-0.006,0.975	-0.074,0.697	-0.474**,0.008	0.961,0.830
Skull x-ray PA/AP	-0.272,0.153	0.288,0.123	0.200,0.290	-0.157,0.408
Lateral skull	0.156,0.409	-0.316,0.089	0.115,0.444	-0.202,0.285
Knee AP	0.131,0.489	-0.008,0.966	-0.163,0.389	0.053,0.783
Knee Lateral	0.511**,0.004	-0.224,0.235	0.312,0.093	-0.421*0.021
Elbow AP	-0.259,0.167	-0.20, 0.917	0.002,0.992	0.011,0.954
Elbow Lateral	0.059,0.756	0.060, 0.755	-0.614**,0.00	0.537**,0.002
Shoulder AP	0.303,0.103	0.016, 0.933	-0.173,0.361	0.201,0.288
Shoulder Lateral	0.100,0.599	-0.109, 0.566	-0.250,0.182	0.244,0.194
Dorsi plantar foot	0.221,0.240	-0.333,0.073	0.373*,0.042	-0.241,0.199
Dorsi plantar oblique foot	-0.501**,0.05	0.122,0.519	0.470**,0.009	-0.428*,0.018
AP Dorsal spine	-0.130,0.493	0.353,0.056	-0.113,0.551	0.026,0.891
Lateral dorsal spine	-0.205,0.277	0.060, 0.753	-0.050,0.793	0.074,0.697
AP Cervical spine	-0.436*,0.016	-0.044,0.818	0.250,0.182	-0.209,0.269
Lateral Cervical spine	0.230,0.222	0.017,0.931	-0.157,0.408	0.153,0.420
AP Lumbosacral	-0.236,0.209	-0.374*,0.042	-0.547**,0.002	0.222,0.239
Lateral Lumbosacral	0.150,0.428	-0.094,0.620	-0.323,0.082	0.187,0.324
AP Wrist	0.037,0.846	0.256,0.172	0.011,0.953	-0.109,0.567
Lateral Wrist	0.153,0.418	0.282,0.130	0.337,0.068	0.635,0.572
Dental x-ray Periapical	0.196,0.299	-0.243,0.196	0.136,0.474	-0.194,0.303

**. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).

Table 3, showed the relationship between doses received by patients during radiographic examination and their anthropometric variables. Detail result from the table shows that, during chest PA x-ray radiological examination, the result indicated that there was a positive no significant relationship ($p>0.05$) between the height and weight of the patients with Entrance skin dose (ESD) received, however, AP thickness showed a negative no significant relationship ($p>0.05$) with Entrance skin dose (ESD) received, while BMI showed a negative significant relationship ($p<0.05$) of the doses received by the patients during radiological examination. The entrance skin dose for lateral chest x-ray showed a positive no significant correlation between AP Thickness, height and BMI and showed a negative no significant correlation.

Similarly, the result showed that there was no significant relationship ($p>0.05$) between the height, weight and focus skin distances (FSD) of the patients, with entrance skin dose (ESD) received, while AP thickness and BMI showed a negative no significant relationship ($p>0.05$). Also, the table result shows that, during Lateral Skull radiological examination, the result indicated that there was a negative no significant relationship ($p>0.05$) between the weight and BMI of the patients with entrance skin dose (ESD) received by the patients, nevertheless, AP thickness and height of the patients showed a positive no significant relationship ($p>0.05$) with the entrance skin dose (ESD) in dose received by the patients during radiological examination. There was no significant relationship ($p>0.05$) between ESD and AP thickness, weight, height and BMI for hand dosi-palmar, dosi-palmar oblique, abdominal x-ray, skull x-ray PA, skull lateral, knee AP, AP elbow, shoulder AP, shoulder lateral, AP dorsal spine, lateral dorsal spine, AP cervical spine, lateral cervical spine, AP lumbosacral, lateral lumbosacral, AP wrist lateral wrist and dental x-rays. However, significant relationship exists between ESD and AP thickness for lateral knee x-ray. There was significant relationship($p<0.05$) between ESD with height and BMI for lateral elbow and dorsi- plantar oblique foot while ESD showed positive significant relationship for AP pelvic x-ray and dorsi-plantar foot.

Table 4: Comparison of DRLs for radiographic examination in this work with European Commission, United Kingdom and Australian radiation protection and nuclear safety agency DRLs

Examination	ARPANSA DRL(mGy)	EU DRL (mGy)	UK DRL (mGy)	DRL(mGy) This work
PA chest x-ray	0.15	0.3	0.2	0.59
Chest x-ray lateral	0.5	0.4	0.5	1.02
PA skull x-ray	1.8	0.7	1.8	1.02
Lateral skull	1.5	1.0	1.1	1.01
AP elbow	0.4	0.3	0.4	0.57
Lateral elbow	0.5	0.3	0.4	0.77
AP shoulder	0.2	0.7	0.5	0.71
Lateral shoulder	0.5	0.6	0.5	0.83
Dorsi plantar foot	0.3	0.5	0.5	0.58
Dorsi plantar oblique foot	0.3	0.4	0.4	0.61
AP dorsal spine	3.7	2.0	3.5	1.03
Lateral dorsal spine	5.0	3.0	4.0	1.09
AP cervical spine	5.0	4.0	3.0	0.62
Lateral cervical spine	6.0	7.0	5.0	0.79
AP Lumbo sacral spine	10	5.0	5.7	1.22
Lateral Lumbo sacral spine	14	8.0	10	1.59
AP wrist	0.4	0.4	0.3	0.52
Lateral wrist	0.5	0.4	0.6	0.87
AP Knee x-ray	0.4	0.4	0.3	0.50
Lateral knee x-ray	0.5	0.7	0.3	0.91
Abdominal x-ray	6.0	3.0	4.4	1.01
Pelvic x-ray AP	4.0	4.0	4.0	0.82
Hand dorsi palmar oblique	0.2	0.5	0.2	0.28
Hand dorsi palmar	0.4	0.3	0.5	0.83
Dental x-ray (periapical view)	0.4	0.2	0.6	0.46

AP- anterior posterior, PA- Posterior anterior, EC- European commission, UK- United Kingdom, ARPANSA-Australian radiation protection and nuclear safety agency

Table 4, shows comparison of established diagnostic reference levels for radiographic examination with European commission, United Kingdom and Australia. The DRL for PA chest x-ray and lateral in this work were 0.59mGy and 1.02mGy while that of ARPANSA, EC and UK are 0.15mGy and 0.5mGy, 0.3mGy and 0.4mGy, 0.2mGy and 0.5mGy respectively. PA skull x-ray and lateral skull x-ray shows 1.02mGy and 1.01mGy for this work while 1.85mGy and 1.5mGy, 0.7mGy and 1.0 mGy, 1.8mGy and 1.1mGy for ARPANSA, EC and UK respectively. The DRL for PA elbow and lateral elbow in this work were 0.57mGy and 1.77mGy while that of ARPANSA, EU and UK are 0.4mGy and 0.5mGy, 0.3mGy and 0.3mGy, 0.4mGy and 0.4mGy respectively. AP shoulder x-ray and lateral shows 0.71mGy and 0.83mGy for this work while 0.2mGy and 0.5mGy, 0.7mGy and 0.6 mGy, 0.5mGy and 0.5mGy for ARPANSA, EC AND UK respectively. The DRL for dorsi-plantar foot and dorsi-plantar oblique foot in this work were 0.58mGy and 0.61mGy while that of ARPANSA, EC and UK are 0.3mGy and 0.3mGy, 0.5mGy and 0.4mGy, 0.5mGy and 0.4mGy respectively. AP dorsal spine x-ray and lateral dorsal spine shows 1.03mGy and 1.09mGy for this work while 3.7mGy and 5.0mGy, 2.0mGy and 3.0 mGy, 3.5mGy and 4.0mGy were for ARPANSA, EC AND UK respectively. The DRLs values for PA chest, lateral chest, AP elbow, lateral elbow, AP shoulder, lateral shoulder, dorsi-plantar foot, dorsi-plantar oblique foot, AP wrist, lateral wrist, AP knee, lateral knee and hand dorsi-palmar were higher when compared with that of ARPANSA, UK and European commission DRL while that of AP dorsal spine, AP cervical spine, lateral cervical, AP lumbosacral spine and abdominal and pelvic x-ray were below the DRLs of ARPANSA, UK and European commission. The higher DRL in our study may be attributed to the variation in technical parameters, clinical complexity of patients and untimely quality control program in most of our hospitals. This concurs with another study in North central Nigeria by Abdullahi *et al*., (2015). The established DRL for PA skull x-ray (1.02mGy) is higher than that of European commission (0.7mGy) and lower than that of ARPANSA (1.8mGy), and United Kingdom (1.8mGy). Similarly, the DRL for hand dorsi-palmar oblique in this work (0.28mGy) is higher than that of ARPANSA and UK with DRL values of 0.2mGy each but lower than that of European commission with DRL of 0.5mGy. The DRL for dental (peri-apical) x-ray is in this study is 0.46 mGy, this value is higher when compared with the values of ARPANSA (0.4mGy) and EC (0.2mGy) but lower than that of UK (0.6mGy).

Conclusion

This study established DRLs for radiographic examinations and dental examination in two university teaching hospitals in North Eastern Nigeria. The DRLs values for PA chest, lateral chest, AP elbow, lateral elbow, AP shoulder, lateral shoulder, dorsi-plantar foot, dorsi-plantar oblique foot, AP wrist, lateral wrist, AP knee, lateral knee and hand dorsi-palmar were higher when compared with that of ARPANSA, UK and European commission DRL, while that of AP dorsal spine, AP cervical spine, lateral cervical, AP lumbosacral spine, abdominal and pelvic x-ray were below the DRLs of ARPANSA, UK and European commission.

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Conflict of Interest

Nil

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