

# A Preliminary Radiation Dose Audit in some Nigerian Hospitals: Need for Determination of National Diagnostic Reference Levels (NDRLs).

C.J. Olowookere<sup>1\*</sup>; I.A. Babalola<sup>2</sup>; N.N. Jibiri<sup>3</sup>; R.I. Obed<sup>3</sup>; L. Bamidele<sup>4</sup>; and E.O. Ajetumobi<sup>5</sup>

<sup>1</sup>Department of Physical Sciences, Ajayi Crowther University, Oyo, Nigeria.

<sup>2</sup>Department of Physics with Electronics, Bells University of Technology, Ota, Nigeria.

<sup>3</sup>Department of Physics, University of Ibadan, Ibadan, Nigeria.

<sup>4</sup>Department of Physics, Osun State College of Technology, Esa Oke, Osun State, Nigeria.

<sup>5</sup>Department of Physics, Tai Solarin University of Education, Ijebu-Ode, Ogun State, Nigeria.

E-mail: [olowkerec@yahoo.com](mailto:olowkerec@yahoo.com)\*

Telephone: +234 805 533 6092

## ABSTRACT

The European Commission introduced the use of diagnostic reference levels (DRLs) as an efficient standard for optimizing the radiation protection of patients in diagnostic radiology. These dosimetric parameters were introduced to verify that the dose descriptors used during imaging process are below the defined European values established after many trials. In Nigeria both LDRLs and NDRLs are not available; the diagnostic reference levels available for comparison are of European origin and have not been determined in line with equipment, training and patient found in Nigeria.

In this paper we have shown that NDRLs is not universal but specific to a country, equipment and training of the personnel. Therefore, a national diagnostic reference levels and local diagnostic reference levels are required for dose optimization in Nigeria. We also showed methods of estimating DRLs using exposure factors. The paper further presented the result of local dose audit in three diagnostic centers. Comparison of the dose audits with the NDRLs established in the UK show that corrective measures are required in two of the three hospitals audited.

(Keywords: reference levels, X-rays, dose optimization, entrance surface dose.)

## INTRODUCTION

X-ray is the most frequently used ionizing radiation for diagnostic imaging and it plays a significant role in the health care both in developed and developing countries. However,

X-ray is said to be the major contributor to the collective effective dose of the general public (personnel and patient). The need for radiation dose assessment of the patient during diagnostic X-ray examinations has been highlighted by increasing knowledge of hazard of ionizing radiation (Johnston and Brennan, 2000). Moreover, wide variations in patient dose for the same type of X-ray examination have been evident from various International dose surveys (NRPB, 1986, Gray, 1999). These variations indicated that a good imaging technique was necessary to reduce patient doses to the lowest practicable levels consistent with the clinical purpose of medical examination.

The patient dose surveys provide important information on the levels of patient exposure and provided an insight into causes of their variation; radiographic procedure, patient attributes technical and equipment factors, exposure parameter and the level of quality assurance in place. Considerable evidence shows that significant reductions in radiation dose deliver to patient are possible without detriment to patient care (NRPB, 1992).

As a result of wide variations in patient dose levels for the same X-ray examination up to a factor of 100 (Shrimpton et al, 1986 and Faulkner & Corbelt, 1998) both the International Commission on Radiological Protection (ICRP) and International Atomic Energy Agency (IAEA) recommended the use diagnostic reference levels (DRLs) in radiology (ICRP, 1990, IAEA, 1990). These reference levels were intended to act as thresholds to trigger investigations or corrective action in ensuring optimized protection of patients

and maintaining appropriate levels of good practice. This according to EC is to encourage department to investigate their patient radiation levels (CEC, 1996; Tung et al, 2001). Diagnostic reference levels have been defined in European legislation (EC, 1997) as “dose levels in medical radiodiagnostic practices or , in the case of radiopharmaceuticals levels of activity for typical examination for group of standard-sized patients or standard phantoms for broadly defined type of equipment”. The reference levels should result from a broad spectrum of defined type of equipment to be widely applicable because of the performance of X-ray procedures, equipment and thus resulting patient doses can vary considerably within an X-ray department and among hospitals (ICRP, 1996, Hart et al, 1994).

The DRLs should include all the procedures frequently undertaken during radiodiagnosis in radiology department of the hospitals for example chest, skull, thoracic spine, abdomen, pelvic etc. Aside, fluoroscopic examinations, dental radiography, Computer Tomography (CT) and angiography, Computer Tomography is gaining more recognition in Nigeria and it delivers higher radiation doses to patients of up to 20 mSv and radiation induced cancer risks of up to 1 in 1000 per examination Wall ( 2001), hence the urgent need for reference doses for routine CT examination is a necessity in Nigeria and all other developing countries in Sub- Sahara Africa.

The diagnostic reference dose is a useful tool to indicate where optimization studies may be useful, however, it has its attendant problems. This is the complex issue of striking a balance between image quality and low doses. Without careful consideration of the necessary image quality to make the required diagnosis, an overzealous drive to lower doses could be at the expense of clinical outcome.

In the United Kingdom, reference doses are based on 75 percentile, which are values of the distribution of the mean dose observed in many hospitals (Faulkner and Corbelt, 1998; Wall, 2001). Meanwhile, in the US the DRLs are based on 80 percentile of the survey distributions Gray et al (2005) of doses without backscatter. Consequently, in the UK and the US equipment using higher radiation doses than 75% and 80%, respectively, requires corrective measure. Because the reference level dose corresponds to the 75<sup>th</sup> percentile, 75% of individual receive doses less than this value. This implies that dose

reduction should be possible for the 25% of individual whose dose exceed the guidance value (IAEA, 1996). DRLs for diagnostic radiology should be based on doses measured at various types of hospitals (government owned, private, Teaching Hospitals, Federal Medical Centers, well equipped and sparsely equipped hospitals).

The DRLs provide a practical system that allows hospitals (X-ray departments) to compare their radiation doses delivered to patients. In order to do this, the dose must be expressed in terms of dose quantities that are clearly defined and can be easily measured directly or calculated from readily available exposure parameters (Wall, 2004). The dosimetric parameter should bear a close to linear relationship to the radiation risks associated with the examinations. To achieve these objectives the following dosimetric parameters have been widely adopted for DRLs:

- i. entrance surface dose (ESD) –conventional radiography (could be obtained with TLD or by calculations),
- ii. Dose-area product (DAP) –conventional radiography (obtainable with DAP meter),
- iii. Dose-area product (DAP)- fluoroscopy,
- iv. Weighted computed tomography dose index (CTDI<sub>w</sub>) per slice in serial CT scanning or per rotation in helical CT scanning,
- v. Dose-length product (DLP) per complete CT examination.

The ESD (mGy) is defined as absorbed dose to air at the point of intersection of X-ray beam axis with the entrance surface of the patient, including backscattered (BSF) radiation from the patient (NRPB, 1992). This quantity can be measured directly with suitably calibrated thermoluminescent dosimeters (TLDs) attached to the patient's skin or with ionization chamber supported in free air on the X-ray beam axis and corrected to the focus-skin-distance (FSD) and by a suitable backscatter factor. On the other hand, the X-ray tube output measured during routine quality control (QC) test at a distance of 100 cm at 80 kVp and 10 mAs are frequently used to calculate ESD values from exposure parameter (kVp, mAs, FSD) used for radiographs on particular patient (Mohammadain, et al., 2004, Davies et al., 1997 and Suliman et al., 2006). This

is possible using Equation 1 (Suliman and Elshiek, 2008).

$$ESD = O/P_{mAs, kVp, 100} \times \left(\frac{kV}{80}\right)^2 \times mAs \times \left(\frac{100}{FSD}\right)^2 \times BSF \quad (1)$$

Where O/P (mGy/mAs) is the output measured at 80 kVp normalized to 10 mAs at a distance of 100 cm from the focal spot, FSD is the focus-skin distance, KV is the tube voltage in kilovoltage, mAs is the product of tube current and exposure time and BSF is the backscatter factor; 1.30 for paediatric patient and 1.35 for adult (CEC, 1996).

Another method for ESD determination is given in Equation 2 (George et al, 2004).

$$ESD = O/P_{50} \times \left(\frac{50}{FFD-t_q}\right)^2 \times mAs \times BSF_q \quad (2)$$

Where O/P is the radiation output (mGy/mAs) measured at 50 cm from the tube focus at the tube potential used for the examination. The term  $t_q$  is the sum of patient thickness and the patient film distance for the examination q.

The DAP ( $Gycm^2$ ) is defined as the air kerma averaged over the area of the X-ray beam in a plane perpendicular to the beam axis, multiplied by the area of the X-ray beam in the same plane. It is usually measured with DAP meter attached to the diaphragm housing of the X-ray tube which intercept the entire cross section of the beam.

Moreover, the major dosimetric quantity used in CT is the computed tomography dose index (CTDI). This quantity is defined as the integral along a line parallel to the axis of rotation (z) of the dose profile [D(z)] for a single rotation and a fixed table position divided by nominal thickness of the X-ray beam (Wall, 2004). CTDI can be measured using a pencil ionization chamber with an active length of 100 mm so as to provide a measurement of  $CTDI_{100}$  expressed in terms of absorbed dose to air (EC, 1999).

$$CTDI_{100} = \frac{1}{nT} \int_{-50}^{+50} D(z) dz \quad (mGy) \quad (3)$$

Where n is the number of tomographic slices, each of nominal thickness T, imaged during a single rotation. Detail measurement of weighted

$CTDI_w$  and Dose length product DLP are described in the reference Wall, (2004).

The aims of this paper was to sensitize the professionals and the public on the need to establish the National Diagnostic Reference Levels (NDRLs) in Nigeria, highlights the role of Nigerian Nuclear Regulatory Authority (NNRA) and National Institute for Radiation Protection and Research (NIRPR) in determining NDRLs. A preliminary result of local dose audit is also presented.

### **NDRLs for Nigeria**

The DRLs is not universal but specific to a country, region, equipment and procedure. The document of European Commission EC (1999), guidance on diagnostic reference levels for medical exposure indicates that DRLs should be set by member states taking in to account individual national or regional circumstances such as the availability of equipment and training. The document further states that the values of DRLs should be selected by professional bodies (including Medical Physicist) and reviewed at intervals that represent a compromise between the necessary stability and the long term changes observed in dose distributions. They should be adequately adapted to new techniques or methods. Additionally, if the measured doses on a sample of standard-sized patients or on a standard phantom for a standard procedure consistently exceed the relevant DRL, a local review of procedure and equipment is required.

Following the incorporation of EU Directives 97/43 EURATOM into member states law in may, 2000 all the radiology department were given legal obligation to promote the use of DRLs (Johnston and Brennan, 2000). Ever since, these directives have been followed by the member states. The United Kingdom carried out its dose survey in mid 1980s and determined the NDRLs. In 1996 the NRPB reviewed the entire dose data received from the radiology department throughout the country that have been following the national protocol (Hart et al, 1996). Analysis of the data received in 1996 from 375 UK hospitals showed an average of 30% reduction in mean doses for common type X-ray examination since the survey in 1980s and less than 10% of hospitals was exceeding the original reference doses. Four reviews of NDRLs have been carried out in UK; 1995, 2000, 2005 and 2007 (Hart et al,

2002; Hart et al 2007). Other member states such as France, Germany, Italy, Spain, Sweden, Switzerland and Irish republic have established their NDRLs at various times IRSN (2004), Bundesamt (2003), Compagnone et al (2005), Royal Decree (1995), Holm and Leitz (2002), Aroua et al (2007), Johnston and Brennan (2000) and the US (Gray et al, 2005).

It is important to note that most of the reference dose used in published dosimetry reports of Nigeria origin and researches based on dose comparison were established fifteen years ago in the UK and have undergone several reviews. It is therefore uncertain whether the UK NDRLs recommended by NRPB are applicable to Nigeria radiographic practice since according to Oritz et al. (1995), universal NDRLs may not be suitable for all countries because of different procedures, varied equipment and training. Nigeria NDRLs have never been established, therefore, there is an urgent need to determine it for the common radiographic views in line with equipment, practice patient characteristics and training of the personnel responsible for exposure. This will enhance dose reduction and optimization during radiographic examinations.

### **Role of NNRA and NIRPR in NDRLs Determination in Nigeria**

Radioactive materials and other ionizing radiations including X-rays are increasingly in use in Nigeria today for the improvement of public health and for research. The use of X-ray for radiodiagnosis has been on for more than four decades in the University College Hospital (UCH), Ibadan. As a result of the necessity of controlling the use of both ionizing and non ionizing radiation and because of the need to monitor the radioactive fallout following the French Atomic Test (FAT) in Sahara Desert, the Federal Radiation Protection Service (FRPS) was established in 1964 by Act of parliament (Babalola, 2004). This body was placed under the supervision of Federal Ministry of Health.

As the responsibilities of FRPS increases and the need to have a proper legislative base for performing its responsibility, draft legislation for nuclear safety and radiation protection was prepared by FRPS staff in 1971 under the supervision of Federal Ministry of Health. The draft legislation was promulgated as Decree No. 19 in 1995. Meanwhile, because of the necessity

of meeting the requirement of International Atomic Energy Agency (IAEA), in 1996 FRPS metamorphosed into Interim Regulatory Competent Authority pending the establishment of Nigerian Nuclear Regulatory Authority (NNRA) as stipulated in the law. This was followed by establishment of National Institute for Radiation Protection and Research (NIRPR) in 2005 by Act 19 of 1995. These two bodies in cooperation with the department of Physics University of Ibadan are responsible for research, regulating and training of Radiation Protection Personnel (RPP) in Nigeria.

In view of the need to establish the NDRLs in Nigeria and the significant roles played by parallel bodies in the UK (National Radiological Protection Board and Royal College of Radiologist), and in the US (American Association of Physicist in Medicine and American College of Radiologist) in establishing NDRLS. The parallel bodies responsible for this in Nigeria are; NNRA and NIRPR. They are expected to be responsible for the periodical review to ensure dose optimization. This is possible by carrying out dose auditing regularly, and incorporation of NDRLs programs into the accreditation of the health institutions using ionizing radiation. A legal framework is also required to make dose auditing and quality control tests mandatory in all the X-ray units all over Nigeria for both private and Government hospitals.

Moreover, registration of the existing X-ray units using conventional radiography, CT, fluoroscopy etc is currently being undertaken throughout Nigeria. Besides, a National Radiation Dose Database (NRDD) is required to access dose information and easy processing of the same for future optimization programs. Meanwhile, comprehensive and extensive dose data could be collected by funding researches at masters and Ph.D. level in that regard.

### **NIGERIAN EXPERIENCE (PRELIMINARY DOSE AUDIT)**

#### **MATERIALS AND METHODS**

The present data were collected on patients undergoing routine X-ray examinations in conventional radiology. Exposure factors such as kVp, mAs, FSD and detail of patient age weight, height and thickness of the irradiated region were obtained for 195 adult patients. The data were



collected in three different hospitals located in South-Western Nigeria [Osogbo (LTHOS), Ibadan (ADHOS) and Ijebu-Ode (STHOS)]. The average weight of the patients investigated during the routine X-ray examinations ranges between 61 and 71 kg, a little below the standard weight of 65-75 kg with average of 70 kg (Hart et al, 2009).

The film investigated were representative of the diagnostic image. The radiation output (mGy/mAs) of the X-ray tube was measured at 80 kVp at a distance of 100 cm normalized to 10 mAs using factory calibrated kV meter. The entrance surface dose of the patient was assessed by an indirect method using Equation 1.

## RESULTS AND DISCUSSION

In the study a total of 195 patients from three different hospitals were included in the study. Data for certain projections were excluded due to the inadequacy of at least ten patients for a particular projection (IPSM/NRPB, 1992, CEC, 1992). Four radiographic views were included in the study: chest PA, abdomen AP, head PA and LAT.

Table 1 is the specific data of the machines and personnel of the X-ray units investigated. Columns 2, 3 and 4 show the set kV, the measured kV and percentage deviation. The percentage deviation of the kVs are greater than the acceptable limit of 5% in all the hospitals. Moreover, the magnitude of deviation varies from one hospital to another. The deviations experienced here is an indication that higher kVp than that set on the machine are being delivered to patients during the production of radiographic images.

In addition, the filtration used in ADHOS and STHOS are lower than the recommended filtration of 2.5 mm Al (CEC, 1990) for voltage above 75 kV. This is an indication that less

attention is paid to patient dose. Low filtration leads to higher doses since energy level below 40 keV is not used for diagnostic imaging but it rather contributes to patient dose.

Table 2 is the patient characteristics for different X-ray projections. The patients in LTHOS (Head PA and LAT) are of standard weight of 71 kg while the mean weight of the patients examined during the dose audit range between 61 and 71 kg.

Table 3 summarizes the mean and range of radiographic data (kVp, mAs and FSD) used to obtain the ESD of the patients. High values of mAs were used in Abdomen AP, Head PA and Head LAT, while constant values were used in chest PA (in ADHOS and STHOS) for patient of different sizes. This trend found in ADHOS and STHOS could lead to abnormally high doses being delivered to patients and poor image contrast; that results in repeat radiographs, which might consequently lead to excessively high doses. The use of constant value of 15 and 9 mAs in ADHOS and STHOS show that patient of different weight are delivered the same radiation dose. Patient of smaller weight receive more radiation dose, and hence may be at higher health risk.

Table 4 shows the mean, third quartile and maximum value of the entrance surface dose of the dose audit carried out in the three hospitals. The standard deviations of the mean show that there is a little spread in ADHOS (chest PA), while a higher spread is found in LTHOS (Abdomen PA) with the highest mean dose of 23.35 mGy. This high dose could probably be as a result of high mAs used in LTHOS (Abdomen PA) by the Radiographer during examinations. Moreover, the large spread found in LTHOS (Abdomen AP, Head PA and LAT) is also attributable to the non-standardization of procedures (Gonzales et al, 1999).

**Table 1:** Specific Data of the X-ray Machines and Personnel Data in Each hospital

Hospital	set kV	kV measured	Magnitude of Deviation (%)	Filtration used mm Al	No. of Radiologist (Radiographer)
LTHOS	80	89.83	12.3	3.0	4 (4)
ADHOS	80	97.07	21.4	1.0	(1)
STHOS	80	94.45	18.1	2.0	3 (1)

**Table 2:** Patient Information for Different X-ray Examinations.

Radiograph (Hospital)	Patient thickness (cm)	Patient weight (kg)	Patient Height (cm)
Chest PA (LTHOS)	20(12-30)	62 (35-91)	168 (133-192)
Chest PA (ADHOS)	21 (17-25)	61 (46-77)	167 (148-180)
Chest PA (STHOS)	23 (20-26)	68 (48-170)	164 (116-181)
Chest LAT (LTHOS)	26 (15-33)	61 (37-91)	165 (149-176)
Abdomen AP(LTHOS)	23 (16-34)	68(55-97)	169 (157-176)
Head PA (LTHOS)	21 (16-27)	71 (48-109)	165 (152-182)
Head LAT (LTHOS)	16 (11-23)	71 (48-100)	162 (152-182)

**Table 3:** Mean and Range of Radiographic Data used in the Hospital Investigated.

Radiograph (Hospital)	Tube potential (kVp)	Mean mAs (range)	FSD (cm)
Chest PA (LTHOS)	66 (16-80)	20 (8-100)	105 (55-100)
Chest PA (ADHOS)	80 constant value used	15 constant value used	129 (125-135)
Chest PA (STHOS)	85 (75-90)	9 constant value used	125 (66-157)
Chest LAT (LTHOS)	71 (63-90)	23 (15--40)	96 (63-114)
Abdomen AP(LTHOS)	76 (70-90)	131 (100-250)	85 (60-110)
Head PA (LTHOS)	76 (60-85)	106 (82-160)	95 (67-132)
Head LAT (LTHOS)	74 (60-100)	69 (10-100)	98 (66-118)

**Table 4:** Distribution of Individual Entrance Surface Dose (ESD).

Radiograph (Hospital)	Sample size (N)	ESD (mGy)		
		Mean (S.D)	3 <sup>rd</sup> quartile	Max value
Chest PA (LTHOS)	80	1.37± 0.85	1.47	6.32
Chest PA (ADHOS)	43	0.32± 0.01	0.33	1.88
Chest PA (STHOS)	12	0.61 ± 0.41	0.62	1.56
Chest LAT (LTHOS)	11	2.04 ± 0.66	2.49	3.17
Abdomen AP(LTHOS)	10	23.35±23.30	29.99	82.39
Head PA (LTHOS)	28	12.11± 5.35	12.67	26.43
Head LAT (LTHOS)	11	8.35 ± 7.49	9.17	24.13

Similar trend is found in both LTHOS (Head PA and LAT). It is necessary to note that the third quartile recorded here is not the established reference dose levels for Nigeria but rather the value of local dose audit. The reason for this is that dose data for common X-ray projection for minimum of 20 different hospitals are required to determine the reference dose levels. The third quartile of ESD obtained in this work if compared with the NDRLs established could trigger the necessity for corrective and dose reduction measures to be instituted in the hospitals

investigated in order to enhance dose optimization.

Table 5 is a comparison of a local dose audit (this work) in Nigeria with UK and other developed nations. It is evident from the results that the local audit carried out in the present study ( in Nigeria) in LTHOS (chest PA) is greater than the reference values determined in UK in 1980s, 2000, 2005 2007 by a factor of 4.9, 7.5, 10.5 and 9.8, respectively.

**Table 5:** Comparison of Third Quartile of Dose Audit (ESD) in This Study with UK and Developed Countries

Radiograph (Hospital)	This Work	*UK mid 80s	*UK 1995	*UK 2000	**UK 2005	*UK 2007	+France 2004	++Italy 2000	+* USA 2005	*+ Irish 2000	+++ Estonia 2002-03
Chest PA (LTHOS)	1.47	0.30	0.20	0.20	0.14	0.15	0.30	0.40	0.25	0.30	0.36
Chest PA (ADHOS)	0.33	0.30	0.20	0.20	0.14	0.15	0.30	0.40	0.25	0.30	0.36
Chest PA (STHOS)	0.62	0.30	0.20	0.20	0.14	0.15	0.30	0.40	0.20	0.30	0.36
Chest LAT (LTHOS)	2.49	1.50	0.70	1.00	0.55	0.60	1.50	1.50	-	-	1.00
Abdomen AP(LTHOS)	29.99	10.00	7.00	6.00	4.20	4.00	10.00	10.00	4.50	10.00	7.00(LS)
Head PA (LTHOS)	12.67	5.00	4.00	3.00	2.00	2.00	5.00	5.00	-	-	-
Head LAT (LTHOS)	9.17	3.00	2.00	1.60	1.30	1.30	3.00	3.00	-	-	-

The value of chest PA in ADHOS is comparable with the value determined in 1980s but higher than the reviewed values in UK (2000, 2005 and 2007) by a factor of 1.7, 2.7 and 2.2 each. As regard comparison of dose audit in LTHOS (Abdomen AP), the ESD (third quartile) is greater than the 2007 review of UK NDRLs by a factor of 7.5. Although dose disparity is expected among the hospitals, however, a comparison of the result of this study with the mid 1980s UK NDRLs shows that the ESD in this study is higher by a factor of 3 indicating that there are still rooms for improvement in radiographic practice without losing diagnostic image quality.

The data in Table 5 show that series of reviews have been undertaken in UK and considerable

dose reductions achieved over the years. This shows that NDRLs is not universal but specific, therefore Nigeria needs to determine her own NDRLs in accordance with her local practice, training and facilities.

The practice of determining NDRLs helps to review the technical parameters used at different hospitals, consequently appropriate measures are put in place where dose reduction is necessary in any of the hospitals delivering excessively high doses without losing the diagnostic information.

Figure 1 shows a comparison of the local dose audit determined in this study with developed countries.

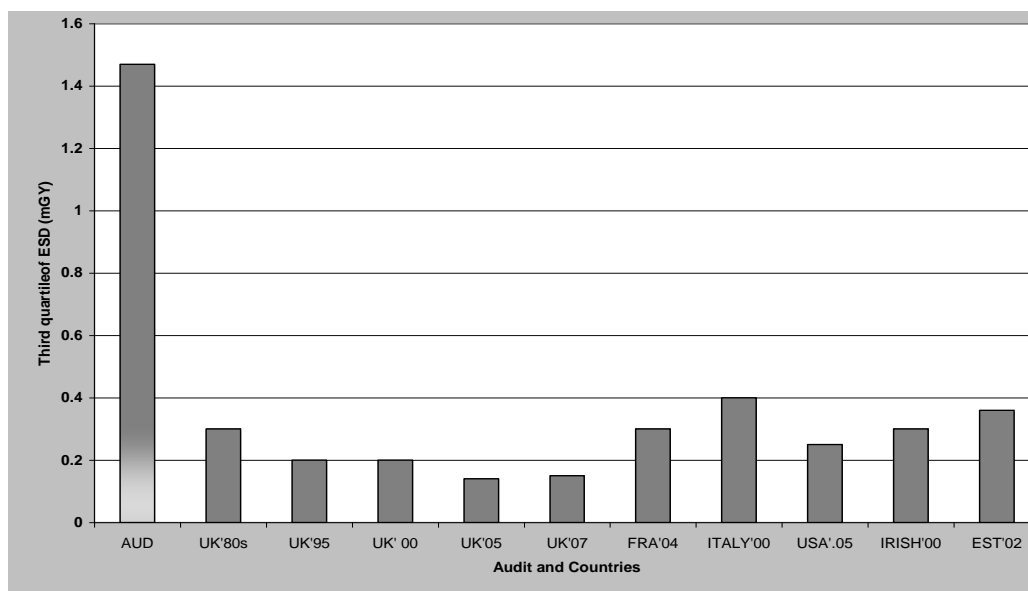


Figure 1: Comparison of Local Dose Audit with UK and other Developed Countries in Chest PA.

The inter-comparison shows that the value found in ADHOS is comparable with UK (mid 1980s), France (2004), Irish Republic (2005), but greater than the value established in Italy (2000) and Estonia (2000-2003). This is an indication that reasonably low doses could be obtained in Nigeria without losing the diagnostic information. This implies that dose optimization is possible in Nigeria, if appropriate.

Corrective measures are put in place through education of the Radiologist and Radiographers about the specific factor that affect radiation doses to patient as well as the steps that could be taken to minimize such doses. Education could also help to ensure that the justified dose is optimized. The local dose audit reported in this study reveals the practice in few X-ray units, although it is not representative of what happens in every hospital but it is an indication that dose optimization is possible in Nigeria.

It is not possible to attribute the causes of high doses as indicated in LTHOS and STHOS to only one factor, it is rather multifactorial; technical parameter, patient size, film screen speed, filtration, radiographic technique and perhaps the condition of the X-ray machine. One of the main reasons often quoted as the reason dose reduction measures are not implemented is cost. Nonetheless, low cost measures such as increasing the level of filtration or changing to faster film-screen combination are effective methods of reducing radiation dose delivered to patient.

## CONCLUSION

In this study we have shown that NDRLs is not universal and we have proposed that Nigeria, and other developing nations, establish their NDRLs against which local hospitals could compare their dose results. If the comparison indicated excessively high doses, corrective measures are necessary. The results of the dose audit carried out indicate necessity of corrective measures in two hospitals (LTHOS and STHOS) for dose optimization.

## REFERENCES

1. Babalola, I.A. 2004. "In Quest of Light Quanta". University of Ibadan Inaugural Lecture Series.

2. CEC, Commission of European Communities. 1990. "Quality Criteria for Diagnostic Radiographic Images". Working document CEC XII/173/90, 2nd edition. Commission of the European Communities: Brussels, Belgium.
3. CEC. 1996. "European Guidelines and Quality Criteria for Diagnostic Radiography Images". Eur 16260 EN. The European Commission: Brussels, Belgium.
4. CEC. 1997. "Council Directive on Health Protection of Individual against Danger of Ionizing Radiation in Relation to Medical Exposure and Replacing Directive 84/466/Euroatom". The European Commission: Brussel, Belgium.
5. Compagnone, G., Pagan, L., and Bergamini, C. 2005. "Effective Dose Calculation in Conventional Diagnostic X-Ray Examinations for Adult and Pediatric Patients in a Large Italian Hospital". *Radiation Protection Dosimetry*. 114(1.3):164 - 167.
6. Davies, M., McCallum, H., White, G., Brown, J., and Hlem, M. 1997. "Patient Dose Audit in Diagnostic Radiography using Custom Designed Software". *Radiography*. 3:17-25.
7. Faulkner and Corbelt. 1998. "Reference Dose and Quality in Medical Imaging". *Br. J. Radiol*. 71:4001-2.
8. George, J., Eatough, J.P., Mountford, P.J., Koller, C.J., Oxtoby, J., and Frain, G. 2004. "Patient Dose Optimization in Plain Radiography based on Standard Exposure Factors". *Br. J. Radiol*. 77:858-863.
9. Hart, D., Jones, D.G., and Wall, B.F. 1994. "Estimation of Effective Dose in Diagnostic Radiology from Entrance Surface Dose and Dose-Area Product Measurement". ICPB - R 262. National Radiological Protection Board.
10. Hart, D.G. and Wall, B.F. 1996. "Coefficient for Estimating Effective Doses from Pediatric X-ray Examinations. NRB Report 279 (National Radiological Protection Board, Didcot, Oxon).
11. Hart, D., Hillier, M.C., and Wall, B.F. 2009. "National Reference Doses for Common Radiographic, Fluoroscopic and Dental X-ray Examinations in UK (commentary)". *British Journal of Radiology*; 82:1-12.
12. IAEA, International Atomic Energy Agency. 1996. "International Basic Safety Standard for Protection against Ionizing Radiation and for the Safety of Radiation Sources". Safety Series No 115. IAEA: Vienna, Austria.



13. ICRP. 1990. "Recommendation of the International Commission on Radiological Protection". ICRP Publication 64. *Ann ICRP* 1991. 21 (1-3). Pergamon Press: Oxford, UK.
14. IPEM/ NRPB/RCR/BIR. 2000. "The Newsletter of the Institute of Physics and Engineering in Medicine". Publication, No. 67. IPEM: New York, NY.
15. Johnston and Brennan. 2000. "Reference Dose Levels for Patients undergoing Common Diagnostic X-Ray Examination in Irish Hospitals". *Br. J. Radiol.* 73: 396-402.
16. Mohammadain, K.E.M., da Rosa, L.A.R. Azevedo, A.C.P., Guebel, M.R.N., Boechat, M.C.B., and Habani, F.I. 2004. "Dose Evaluation for Pediatric Chest X-ray Examination in Brazil and Sudan: Low Dose and Reliable Examinations can be achieved in Developing Countries". *Physics in Medicine and Biology.* 49:1017-1031.
17. NRPB. 1986. "A National Survey of Doses to Patients Undergoing Selection of Routine X-ray Exposures in English Hospitals". NRPB-2000
18. NRPB Radiological Protection Board Report. 1992. "Software for Evaluating the Detriment Associated with Radiation Exposure". National Radiological Protection Board; NRPB Report 200. NRPB: Chilton, Didcot, UK.
19. Oritz, P., Maccia, C. Padovani, R. et al. 1995. "Result of IAEA-CEC coordinated Research Programme on Radiation Doses in Diagnostic Radiology and Methods for Reduction". *Radiol. Prot Dosim.* 57:95-99.
20. Shrimpton, P.C., Wall, B. F., Jones., D.G., Fisher, E.S., Hillier, M.C., Kendall, G.M., and Harrison, R.J. 1986. "A National Survey of Doses to Patients undergoing a selection of routine X-rays examination in English Hospitals". NRPB- 2000: Chilton, Didcot, Oxon.
21. Suliman, I.I., Abbas, N., and Habbani, F.I. 2006. "Entrance Surface Doses to Patients undergoing selected Diagnostic X- ray Examinations in Sudan". Radiation Protection Dosimetry (Technical paper).
22. Suliman, I.I. and Elshiekh, E.H.A. 2008. "Radiation Doses from some Common Pediatric X-ray Examinations in Sudan". *Radiation Protection Dosimetry.* 132 (1): 64-72.
23. Tung, C.J., Tsai, H.Y., and Lo, S.H. 2001. "Determination of Guidance Levels of Dose for

Diagnostic Radiography in Taiwan". *Medical Physics.* 28 (5):850 - 857.

## SUGGESTED CITATION

Olowookere, C.J., I.A. Babalola, N.N. Jibiri, R.I. Obed, L. Bamidele, and E.O. Ajetumobi. 2012. "A Preliminary Radiation Dose Audit in some Nigerian Hospitals: Need for Determination of National Diagnostic Reference Levels (NDRs)". *Pacific Journal of Science and Technology.* 13(1):487-495.

 [Pacific Journal of Science and Technology](http://www.akamaiuniversity.us/PJST.htm)