THE NEED TO ESTABLISH NATIONAL DOSE REFERENCE LEVELS FOR RADIOLOGICAL EXAMINATIONS IN NIGERIA: RADIOGRAPHER'S ROLE

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ABSTRACT

INTRODUCTION: The imperativeness of establishing National Diagnostic Reference Levels (NDRLs) is important in Nigeria because it forms a comprehensive, concise and a powerful tool for optimizing radiation protection of patients. National diagnostic reference levels can be established by collaboration with radiographers across the country, the regulators, and professional bodies involved. The first step begins when each facility begins to set local, regional then national diagnostic reference levels.

OBJECTIVE: The objective of the study is to review literatures on existing Diagnostic Reference Levels (DRLs) for radiological examination, the methodologies of establishing them and then justify the need and reasons for establishing NDRLs in Nigeria.

METHODOLOGY: A systematic search through the internet, medline, web of science, Scopus, google scholar and manual search was conducted using search terms extracted from three terms DRLs, doses in radiological examination, DRLs in different countries. The search resulted in 90 articles in which 30 were included after a screening process.

RESULT: The combined search strategy identified 90 articles 6 identified from medline, 4 from Scopus, 5 from web of science and 15 from google scholar and manual search. The result showed that no comprehensive DRLs for radiological examination have been set for Nigeria.

CONCLUSION: There is need to establish local, regional and national DRLs in Nigeria as a tool for optimizing radiation protection.

KEY WORDS: Diagnostic Reference Levels, Dose, Radiological Examination, Establish

BACKGROUND

Diagnostic reference level is defined as an investigation level used to identify unusually high radiation doses for Radiological examinations[1,2]. They are suggested action levels above which a facility should review its methods and determine if acceptable image quality can be achieved at lower doses [3]. Diagnostic reference levels should be used by regional, national and local authorized bodies [4,21]. The numerical values of diagnostic reference levels are advisory however; implementation of the DRLs concept may be required by regulatory and professional bodies. [6,36].

Diagnostic Reference Levels are values which are usually easy to measure and have a direct link with patient doses. They are therefore established to aid efficient dose management and to optimize patient doses. If such doses are found to exceed the corresponding reference dose, possible causes should be investigated and corrective action taken accordingly, unless the unusually high doses could be clinically justified[7,8,9].

The ICRP publications recommended that values should be determined by professional medical bodies, reviewed at intervals that represent a compromise between the necessary stability and the long-term changes in observed dose distributions and be specific to a country or region. The concept of Diagnostic Reference Level is beginning to be a well-defined tool in many countries and is used to reduce patient dose during medical interventions and examinations[17].The use of diagnostic reference levels has been supported by national and international advisory bodies [6]. These and other organizations have provided guidelines on measuring radiation dose and setting diagnostic reference levels [17].

It is known that of all man made sources of radiation, diagnostic x-rays contribute the largest part to the collective population dose and are the most encountered radiation in diagnostic radiology leading to injurious somatic and genetic effects on human beings[34]. The assessment of dose includes the contributions from primary beams, scattered and leakage radiation. Shield used for primary beam are primary shield while secondary shields are used for scattered and leakage radiation[23].

The concept of investigation levels for diagnostic medical exposures was first proposed by the International Commission for Radiological Protection (ICRP) in its 1990 recommendations and further developed Diagnostic Reference Levels (DRL) its 1996 ICRP publication[73,12,13]. The Australian Radiation Protection and Nuclear Safety Agency, 2014 suggested that the DRLs is the 75th percentile (third quartile) of the spread of median doses of common protocols as recorded from data submitted to the National Diagnostic Reference Service[2]. Facility Reference Levels (FRLs) is defined as the median value of the spread of doses for common protocols surveyed at a Radiology facility[2]. The major objective of DRLs is to help avoid excessive radiation dose to the patient that does not contribute additional clinical information to diagnostic radiology task[2,3]. DRL should be selected by professional medical bodies often in conjunction with health and radiation protection authorities and their values would be specific to a country or a region. DRL are a guide to encourage good clinical practice.(Donald et al., 2010). Diagnostic reference levels are a quality assurance and quality improvement tool for controlling radiation dose[7]. They are intended to be a reasonable indication of dose for average size patients and to provide guidance on what is achievable with current good practice rather than optimum performance[7]. The aim of this article is to present the status of the different concepts of Diagnostic Reference Levels in different countries and discuss on the rationale for establishing National DRLs in Nigeria with Radiographers actively involved in the process.

1.1 Justification for establishing DRLs in Nigeria

I. There are no established Diagnostic Reference Levels for radiological examinations in Nigeria[22,26]. Absence of DRLs could result to unsafe practice which poses detrimental effects on patients and personnel.

ii. There is no comprehensive and holistic radiation dose assessment for radiological examinations in Nigeria. Identifying situations where the level of patient dose is unusually high cannot be determined without dose assessment. Hence the need for National Patient Dose Database (NPDD).

iii. The burden of knowing whether the protection of patients has been adequately optimized is a major problem that necessitated this review because organ doses from various radiation doses administered to the patients are not known.

1.2 Objectives of establishing Diagnostic Reference Level in Nigeria

The General objective of this study is to educate Radiographers and the academic community on the rationale and imperativeness of establishing diagnostic reference levels for radiological examinations in Nigeria.

1.3 Significance of Establishing DRLs in Nigeria

i. Establishing DRLs in Nigeria will permit individuals and institutions performing radiological procedures to compare the radiation doses used in their center with other established work used as standard.

ii. This seminar is intended to serve as reference document to competent authorities like International Atomic Energy Agency, Nigerian Nuclear Regulatory Authority, professional and academic groups involved in the practical implementation of medical radiological procedures.

iii. This seminar will give indications in a national scale of unusually high typical doses, against which hospitals, clinics and diagnostic centers can check their own performance.

iv. The study will show the imperativeness of collecting dosimetric data that will be used to educate and alert regulatory bodies, professional bodies and other professionals such as radiographers, radiologists and medical physicists on the radiation doses delivered during various radiological examinations.

v. This review on DRLs in this region is intended to serve as a simple test for identifying situations where the level of patient dose is unusually high and to know whether the protection of patients has been adequately optimized.

vi. This review will highlight the need to establish local, regional and national DRLs which will be used as a guidance level for optimization and will also help to reduce unnecessary doses and the consequent radiation risks.

vii. This article also gives information on the periodicity and the methods used to update the DRLs as well as on the future outlook.

2.0 Conceptual Review

2.1 Diagnostic Reference Levels

Diagnostic reference levels were first mentioned by the International Commission for Radiological Protection (ICRP) in 1990 and subsequently recommended in greater detail in 1996 from the 1996 report[14]. 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[20]. 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. 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[20].

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[33]. Patient dose measurement is an integral part of optimization process [30]. Quality management of any use of medical x-ray imaging should include monitoring of radiation dose[33]. A major goal of the quality program for all forms of x-ray imaging is to minimize radiation risk without degrading clinical performance [33].

2.2 Objective of Diagnostic Reference Level

The objective of Diagnostic Reference Level (DRL) is to avoid excessive radiation to the patient that does not contribute additional clinical information and value to the medical imaging task[17].

2.3 Uses of a Diagnostic Reference Level

Diagnostic Reference Level is used; [17]

a) To improve a local regional or national distribution of observed results for a general medical imaging task, by reducing the frequency of unjustified high or low dose values;

b) To promote attainment of a narrower range of values that represent good practice for a more specific medical imaging task; or

c) Typically, diagnostic reference levels are used as investigation levels (as a quality assurance tool), they are advisory and not a dose limit therefore, should not be applied to individual patients.

d) The application of Facility Reference Levels (FRLs) is for the local imaging facility to establish a reference dose for their common imaging protocols that can be used for internal and external comparison.

e) DRLs can also be used for international comparative dosimetry.

2.4 Applications of DRLs

DRLs, together with an optimization process, help reduce unnecessary patient doses and the consequent radiation risks [17].

A diagnostic reference level can be used to:

- improve local, regional, or national distributions of observed doses for a general medical imaging task, by reducing the frequency of unjustified high or low dose values
- promote a narrower range of doses that represent good practice for a more specific medical imaging task
- promote an optimum range of doses for a specified medical imaging protocol
- provide a common dose metric for the comparison of FRLs between facilities, protocols and modalities
- assess the dose impact of the introduction of new protocols
- provide compliance with the relevant state and territory regulatory requirements

Appropriate local review and action is required when the doses observed are consistently outside the selected diagnostic reference level, unless clinically justified.

However this elevated dose with clinical justification should be an exception rather than the norm across multiple DRLs.

2.5 Dosimetric Quantities commonly used to estimate DRLs

From a practical perspective, the DRL should be expressed as an easily measured patient dose-related quantity for the specified imaging platform, for example, Multi-Detector Computed Tomography (MDCT);

I. MDCT examinations - volume Computed Tomography Dose index (CTDI mGy) and the Dose-Length Product (DLP, mGy.cm) New CT scanners in accordance with Australian Standards, AS'NZS32002.449, should display the CTDI and/or the DLP on the operator's console after the selection of technique factors and prior to the initiation of x-rays. Average CTDI and total DLP should be available at the end of the scan procedure.

ii. Fluoroscopic examinations - Dose Area Product (DAP, mGy.cm2), screening time (sec).

iii. General Radiographic Examinations - either Entrance Skin Dose (ESD, mGy) or the Dose Area Product (DAP, mGy.cm2)

iv. Mammography – the Mean Glandular Dose (MGD, Gy).

v. Nuclear Medicine - Adult Reference Activity (mBq)

2.6 Effective Dose (mSv) from DRL Assessment

Different imaging modalities have different basic dose metrics. To compare these dose metrics and gain some information on the radiation dose delivered and the consequent population statistical risk it is useful to convert the individual DRL dose metrics into approximate effective dose (ED, mSv)[3].

It should be noted that these effective dose conversions are to be used with caution. They should not be applied to an individual but rather are statistical estimates of a dose and risk to a population who may receive that dose[3].

2.7 Australian National DRLS

ARPANSA, in collaboration with other stakeholders have developed the National DRL Service which facilities can use to compare their doses with the National DRLs and from which dose data will be used to develop and update National DRLs.

Due to its significantly higher population dose contribution, the National DRL service will initially be applied to MDCT. This will be followed by interventional fluoroscopic procedures, nuclear medicine, mammography and general radiography & fluoroscopy.

The ARPANSA NDRL project will initially give emphasis to the higher dose modalities. ARPANSA will provide an easy to use tool for all modalities but until these are developed and distributed each facility is encouraged to undertake paper based local surveys to establish their own FRLs as soon as possible.

Australian national DRLs for adult and pediatric MDCT are now available [2]. One of the key issues in the regulations that govern the use of ionizing radiation in medicine is the establishment and use of diagnostic reference levels[11]. Regulations, 2000, require employers to establish and to undertake appropriate reviews if these are consistently exceeded. The regular review of these diagnostic reference level (DRL) at National, Regional and Local levels provides a feedback loop that ensures good practice [18].

Table 2.1: UK and EU MDCT DRLs

Comparison of Head, Chest and Abdominal CT Dose Values with DRLs[3]

Examination	Mean Value	3rd Quartile Value	United Kingdom Study (3rd Quartile Value)	European DRL
Head CT				
CTDlw (mGy)	39	47	66	60
DLP (mGy - cm)	544	527	787	1050
Chest CT				
CTDlw (mGy)	9.3	9.5	17	30
DLP (mGy - cm)	348	447	448	650
Abdominal CT				
CTDlw (mGy)	10.4	10.9	19.0	35
DLP (mGy - cm)	549	696	472	780

Table 2.2: Recommended Diagnostic Reference Doses for General Radiography for Individual Radiographs on Adult Patients [12]

Radiograph	ESD per Radiograph (mGy)	DAP per Radiograph (Gy cm^2)
Skull AP/PA	3	-
Skull LAT	1.5	-
Chest PA	0.2	0.12
Chest LAP	1	-
Thoracic Spine AP	3.5	-
Thoracic Spine LAP	10	-
Lumbar Spine AP	6	1.6
Lumbar Spine LAP	14	3
Lumber Spine LSJ	26	3
Abdomen AP	6	3
Pelvis AP	4	3

Note: Adult is defined as a personal average size (40 to 80kg)

Table 2.3: Recommended Diagnostic Reference Doses for Fluoroscopic/Interventional Examination on Adult Patients [12]

Examination	DAP Per Exam (Gy.cm^2)	Fluoroscopy time per exam (mins)
Barium (or water soluble) swallow	11	2.3
Barium meal	13	2.3
Barium follow through	14	2.2
Barium (or water soluble) enema	31	2.7
Small bowel enema	50	10.7
Biliary drainage/intervention	54	17
Fermoral angiogram	33	5
Hickman line	4	2.2
Hysterosalpingogram	4	1
IVU	16	-
MCU	17	2.7
Nephrostogram	13	4.6
Nephrostomy	19	8.8
Retrograde pyelogram	13	3
Sialogram	1.6	1.6
T-tube cholangiogram	10	2
Venogram (leg)	5	2.3
Coronary angiogram	36	5.6
Oesophageal dilation	16	5.5
Pacemaker implant	27	10.7

Table 2.4: Recommended Diagnostic Reference Doses for CT Examinations (CTDlvol and DLP) [12]

Patient group	Scan Region	CTDlvol (mGy) Single Slice/multi Slice	DLP (mGy.cm) Single Slice/Multi Slice
Adult	Brain	55/65	760/930
18-80 years old	Abdomen (liver metastases)	13/14	460/470
	Abdomen & Pelvis	13/14	510/560
	(Lymphoma staging or follow up)	22/26	760/940
	Chest (lung cancer)	10/13	430/580
	Chest Hi-res	3/7	80/170
Children	Head	30	270
0-1 years old	Thorax	12	200
5 year old	Head	45	470
	Thorax	13	230
10 year old	Head	50	620
	Thorax	20	370

Table 2.5: Recommended Diagnostic Reference Level for Mammography for a Typical Adult Patient

For film screen examinations using a grid, the mean glandular dose (MGD) is 2 mGy based on the 4.2 cm acrylic American College of Radiologists phantom[12]. Additionally for Digital Mammography, the MGD shall be≤ 1 mGy and ≥ 4.5mGy

2.8 CT Diagnostic Reference Levels from other Countries

Diagnostic reference levels must be defined in terms of an easily and reproducibly measured dose metric using technique parameters that reflect those used in a site's clinical practice. In radiographic and fluoroscopic imaging, typically measured quantities are entrance skin dose for radiography and dose area product for fluoroscopy. Dose can be measured directly with TLD or derived from exposure measurements. Some authors survey typical technique, factors and model for dose metric of interest[4,5].

In CT, published diagnostic reference levels use CTDI-based metrics such as CTDIw, CTDIvol, and DLP. Normalized CTDI values (CTDI per mAs) can be used by multiplying them by typical technique factors, or CTDI values can be measured at the typical clinical technique factors. Tables 2.4, provide a summary of CT reference levels from a variety of national dose surveys[12].

2.9 Fluoroscopically-Guided Interventional Procedures

For fluoroscopically-guided interventional procedures, diagnostic reference levels, in principle, could be used to promote the management of patient doses with regard to avoiding unnecessary stochastic radiation risks. However, the observed distribution of patient doses is very wide, even for a specified protocol, because the duration and complexity of the fluoroscopic exposure for each conduct of a procedure is strongly dependent on the individual clinical circumstances. A potential approach is to take into consideration not only the usual clinical and technical factors, but also the relative "complexity" of the procedure. More than one quantity (multiple diagnostic reference levels) may be needed to evaluate patient dose and stochastic risk adequately[21].

2.10 European Reference Levels

European diagnostic reference levels should be used as guideline for keeping doses as low as reasonably achievable. The currently available European DRLs for diagnostic radiology is given in Table 2.6 however, other acceptable levels used in different member states, expressed in Gycm2, are given. The levels relate to frequent and relatively low-dose exposures. The exposures requiring the most attention, however, are those in pediatrics and high-dose examinations such as CT -scans and interventional radiography[8,9].

Table 2.6 Examples of Diagnostic Doses, expressed in entrance surface does per images, single view, EU 1996 Criteria Reference Doses[8]

Radiograph	1996 Quality Criteria Reference Dose Entrance Surface Does per single View (mGy)[2]
Chest Posterior Anterior (PA)	0.3
Chest Lateral (LAP)	1.5
Lumber Spine Anterior of v v (AP)	10
Lumber Spine Lateral (LAP)	30
Lumber Spine Lumbo-Sacral (LSJ)	40
Breast Cranio-Caudal (CC) with grid	10
Breast Medio-Lateral Oblique (MLO) with grid	10
Breast Lateral (LAP) with grid	10
Pelvis Anterior Posterior (AP)	10
Skull Posterior Anterior (PA)	5
Skull Lateral (LAP)	3
Urinary Tract either as firm or before administration of contrast medium	10
Urinary Tract after administration of contrast medium	10

3.0 Medical Applications for which DRLs are defined

3.1 France

In France, Diagnostic Reference Levels are established for 21 X-ray examinations and for 10 nuclear medicine examinations. The levels apply to radiography examinations (fluoroscopy is excluded) of standard-sized adult patients[9]. Examinations for which DRLs have been proposed include:

- 9 types conventional X-ray including mammography on adult patients
- 2 types of conventional X-ray (thorax and pelvis) for children – 0 to 1 5 years old
- 7 types of conventional X-ray for children – 5 years old
- 4 types of CT examination on adult patients
- 10 nuclear medicine examinations including 18F-PET

3.2 Germany

In Germany, Diagnostic Reference Levels are established for x-ray and nuclear medicine examinations[9]. In particular DRLs are established for:

- 12 types of radiograph for adult patient
- 5 types of radiography/fluoroscopy examinations for adult patients
- 7 types of CT examination for adult patients
- 2 types of fluoroscopically-guided interventional procedure for adult patients
- 6 types of radiograph for paediatric patients (2-5 years old)
- 1 type of radiography/fluoroscopy examination for paediatric patients (4 years old)
- 17 types of diagnostic nuclear medicine procedures for adult patients and conversion factors for children

3.3 Greece

The requirement for the establishment and application of Diagnostic Reference Levels is imposed by the Greek Radiation Protection Regulations. The Greek Atomic Energy Commission (GAEC) as the national authority for radiation protection, is responsible for the establishment and enforcement of the national DRLs. DRL values for mammography and 12 types of nuclear medicine examinations have already been approved by GAEC's board. DRL values for 7 types of Computed Tomography examinations are in the process of approval, while DRLs for 10 conventional radiography and for fluoroscopy examinations are expected to be determined in the near future[8].

3.4 Italy

In Italy, Diagnostic Reference Levels are established and applied to:

- 7 types of conventional X-ray on adult patients
- 4 types conventional X-ray on infant patients ($\leq$ 5 years old)
- 1 type of mammography examination
- 4 types of CT-examinations on adult patients
- 48 types of diagnostic nuclear medicine procedures on adult patients and, based on scaled values taking into account the body mass, on pediatric patients[9].

3.5 Netherlands

The Decree on Radiation Protection of 2001 stipulates that the Minister of Health, Welfare and Sport shall promote the establishment and use of DRLs, but it has not lead to the implementation of DRLs in the Netherlands yet[8,9].

3.6 Sweden

In Sweden, Diagnostic Reference Levels are established for 12 X-ray examinations and for 19 nuclear medicine examinations. The levels apply to complete examinations of standard-sized adult patients[8,9]. Examination for which DRLs have been established include:

- 6 types conventional X-ray on adult patients
- 4 types of CT examination on adult patients
- 2 types of mammography examination
- 19 nuclear medicine examinations

3.7 Switzerland

In Switzerland, Diagnostic Reference Levels are applied to conventional radiology, interventional radiological procedures, Computer Tomography and nuclear medicine, for adult, and in many cases also for infant, patients[8,9]. DRLs are established for:

- 9 types of conventional X-ray on adult patients
- 1 type of mammography examination
- 8 types of interventional procedures in radiology on adult patients
- 4 types of interventional procedures in cardiology on adult patients
- 8 types of CT examination on adult patients
- 4 types of CT examination on infant patients
- 47 types of diagnostic nuclear medicine procedure on adult patients and infant patients

3.8 United Kingdom

A Department of Health DRL Working Party has been set up in the UK to formally adopt national DRLs in compliance with the requirements of the Ionizing Radiation (Medical Exposure) Regulations 2000[8,9.]

The Working Party will consider proposals for DRLs from relevant professional groups and organizations (primarily NRPB/HPA and ARSAC) based on published patient dose data from UK national surveys. Medical applications for which DRLs had been proposed by 2005 include:

- 13 types of individual radiograph on adult patients
- 15 types of radiography/fluoroscopy examination on adult patients
- 12 types of CT examination on adult patients
- 5 types of fluoroscopically-guided interventional procedure on adult patients
- 3 types of radiography/fluoroscopy examination on pediatrics patients (5 years old)
- 2 types of CT examination on pediatrics patients (3 years old)
- 96 types of diagnostic nuclear medicine procedure on adult patients

4.0 Methods and means used to determine the DRLs

4.1 France

The first step consisted of making a list of the most common radiological procedures and in writing down the corresponding standardized protocols with the French Society of Radiology (SFR) , the Institute of Radiation Protection and Nuclear Safety (IRSN) and ASN. On the basis of protocols and data sheets established with the French Society of Medical Physics (SFPM). TLD measurements (entrance dose) and examinations data (parameters or Dose Length Product) were measured, recorded or calculated. The data were collected in 24 volunteer centers and 8 examinations have been selected: 4 in conventional radiology and 4 in computed tomography. Mean dose values and third quartile values were determined for approximately 1300 patients in conventional radiology and 600 in CT. In conventional radiology, it was first concluded that the DRLs proposed by the European Commission can be applied in conventional radiology but for CT the European DRLs can be lowered. For nuclear medicine, the value of activity recommended in the marketing authorization for radiopharmaceuticals was chosen as first value for the reference levels. [8,9]

4.2 Germany

The initial values of the German DRLs in diagnostic radiology were proposed by an expert group of physicians and medical physicists chaired by the Federal Office for Radiation Protection, including representatives of the professional medical societies. For radiographs of adult patients, the European DRLs were adopted accordingly. For fluoroscopy examinations, a restricted survey of current practices in university hospitals, and for CT examinations, a national survey of CT practice performed in 1999 were used to derive the DRLs. For diagnostic nuclear medicine procedures, Federal Office for Radiation Protection had proposed national DRLs based on the results of a national survey on frequencies and administered activities in diagnostic nuclear medicine, on recommendations of national and international societies and on proposals for DRLs in other countries. The Federal Office for Radiation Protection proposal was finally discussed with members of the German Radiation Protection Commission.[8,9]

The quantities used to express the DRLs are:

- Dose-area-product (DAP) for conventional X-ray examinations (for radiographs, the entrance surface air Kerma (ESAK) and entrance surface dose (ESD) can be used alternatively)
- Computed Tomography Dose Index (CTDIVol) and Dose-Length-Product (DLP) for Computed Tomography
- Entrance surface dose (ESD) for mammography
- Administered activity for nuclear medicine

4.3 Greece

The determination of DRLs is based on the data collected during the on-site inspections performed by GAEC in radiology and nuclear medicine laboratories. The on-site inspections are carried out as a part of the licensing procedure of the laboratories every 2 years for nuclear medicine and 5 years for radiology laboratories respectively. As it concerns the radiological examinations, adequate dosimetric measurements are performed for the different types of examinations performed, while for nuclear medicine examinations the administered activities for each diagnostic procedure are considered as the appropriate quantity. The DRL for each examination is determined as the rounded 3rd quartile value of the distribution of the corresponding dosimetric or activity values registered.[8,9] More specifically, the quantities used to express DRLs are:

- Entrance Surface Dose (ESD) for conventional X-ray
- Computed Tomography Dose Index (CTDI) for Computed Tomography
- Entrance Surface Dose (ESD) and Average Glandular Dose (AGD) for mammography, and
- Administered activity for nuclear medicine examinations

4.4 Italy

The values of the DRLs were established on the basis of a survey of data reported in the literature, with particular regard to Guidelines published by the EC[8]. The quantities used for the DRLs are:

- Entrance skin dose for conventional X-ray examinations and mammography
- Dose Length Product (DLP) and weighted Computed Tomography Dose Index (CTDIw) for Computed Tomography
- Administered activity for diagnostic nuclear medicine

For all examinations for which a DRL exists, hospitals have to determine the dose or administered activity for a standard sized patient, whose values are compared with the corresponding DRL. If the level is exceeded actions have to be taken in order to reduce the dose.

4.5 Sweden

The present DRLs were determined by studying the radiation dose levels in hospitals. A national survey of doses for X-ray examinations was carried out in 1999. For nuclear medicine examinations the dose situation was roughly known from the nominal administered activities that have been reported each year. The DRLs have been established on the basis of the resulting dose distributions [8,9]. The quantities used for the DRLs are:

- Dose-Area-Product for conventional X-ray examinations
- Dose-Length-Product and the volume Computed Tomography Dose Index for Computed Tomography
- Mean Glandular Dose for mammography and
- Administered activity for nuclear medicine

For all examinations for which a DRL exists hospitals have to determine the radiation dose or administered activity for a standard sized patient. This standard dose or administered activity is compared with the corresponding DRL - if the level is exceeded actions have to be taken in order to reduce the dose, if possible.[8,9]

4.7 United Kingdom

For X-ray imaging procedures, DRLs are based on national surveys of patient doses conducted by NRPB/HPA or the National Health Service Breast Screening Programme (for mammography). National reference doses are set at the rounded 3rd quartile values of the distribution of mean doses seen on representative samples of patients at each hospital in large national surveys. For diagnostic nuclear medicine procedures, national DRLs are based on DRLs recommended by the Department of Health's Administration of Radioactive Substances Advisory Committee (ARSAC)[8,9].

The quantities used to express the DRLs are:

- Entrance Surface Dose (ESD) and Dose-Area-Product (DAP) for conventional X-ray examinations
- Computed Tomography Dose Index (CTDI) and Dose-Length Product (DLP) for Computed Tomography
- Mean Glandular Dose for mammography
- Administered activity for nuclear medicine

5.0 Training, Information and Publications on DRLs developed for Medical Staff

5.1 France

Training courses were organized along with the guidance on how to determine the standard doses and administered activity for the medical personal to facilitate the application of the regulation. Dose data recording forms were produced to help collect data [8,9]

5.2.Germany

The DRLs were first published in August 2003. In October 2004, guidelines for the use of DRLs, especially in diagnostic radiology, were issued to the regulatory bodies for further distribution to the various radiological installations in their region. A paper "Establishment and Application of Diagnostic Reference Levels for Nuclear Medicine Procedures in Germany" has been published in the Journal of Nuclear Medicine (2004; 43: 79-84) to inform medical staff. [8,9]

5.3.Greece

GAEC, as the competent authority on radiation protection issues, organizes special courses on the establishment and the implementation of DRLs for personnel in radiology and nuclear medicine departments. Moreover, the RPOs in large hospitals are responsible for providing the required training on the use of DRLs to the medical staff. Also, the importance of the use of DRLs as a radiation protection optimization tool is also underlined during the on-site inspections of GAEC. [8,9]

5.4. Italy

Medical physicists provide local training for radiologists, radiographers and every physician (with particular regard to cardiologists and surgeons) engaged in the different uses of ionising radiation for medical purposes. [8,9]

5.5. Sweden

The regulations are accompanied by guidance on how to determine the standard doses and administered activity. It also gives examples of good radiological practice for the various examinations. In the beginning the authority put a great deal of effort into informing personnel about the concept of DRLs at different national meetings and courses run for the diagnostic community. Personal communications also played an important role in the information process[8,9.]

5.6. Switzerland

Implementation of the DRL concept is promoted by the Swiss Federal Office of Public Health in various ways: users receive training on the concept directly during audits, and information is provided at conferences held by the relevant professional associations; at the same time, training DVDs are made available to users, giving a detailed account of radiological protection for patients and staff. In addition, awareness of the concept is to be raised by the publication of a booklet on this subject[8,9.]

5.7. United Kingdom

Medical physicists in the UK provide local training for health service staff on the use of DRLs. Training is primarily based on guidance on the establishment and use of DRLs for medical X-ray examinations' in IPEM Report 88, 2004. Presentations on the use of DRLs have been given at the UK Radiology Congress and NRPB has published related articles in the British Journal of Radiology and specialist journals and magazines aimed at radiographers. NRPB/HPA also publishes regular reviews of its national patient dose database which include recommended national reference doses for a wide range of diagnostic and interventional X-ray procedures. The Department of Health's Administration of Radioactive Substances Advisory Committee (ARSAC) publishes notes for guidance on nuclear medicine procedures that include DRLs and are updated at regular intervals[8,9.]

Recommendations

i. DRLs should be established for each facility, state, region and at national level, however research is on going in collaboration with NNRA, RRBN and ARN.

ii. DRLs for pediatrics should be established by radiography researchers, hence the need for national awareness.

Conclusion

Many developments and concepts to collect and use DRLs have already been introduced in France, Germany, Greece, Italy, Sweden, Switzerland, Netherlands and the United Kingdom .From that time onwards, the implementation activities started. The methods used to implement diagnostic reference levels, to inform and train the medical staff are quite different for each country. The future outlook and the way DRLs will be developed in these countries are not clearly defined but several projects are well under way. Diagnostic Reference Levels give a direct link to patient doses and are an important tool to perform efficient dose management and to optimize patient doses. Developing countries like Nigeria should therefore take the lead in West Africa to develop concepts in order to implement and use diagnostic reference level to ensure patient doses are reduced as much as possible. The directions shown by these countries for the DRLs are quite promising. Regulatory bodies (Nigerian Nuclear Regulatory Authority), professional bodies (Radiographers Registration Board of Nigeria) and Radiographers Association of Nigeria as well as patient organizations should invest time in this constantly developing concept to optimize dose to patient in the different fields using ionizing radiation.

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