ESTABLISHMENT AND UTILISATION OF LOCAL DIAGNOSTIC REFERENCE LEVELS FOR COMMON SCAN PROCEDURES IN NUCLEAR MEDICINE

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Abstract– **The concept of Diagnostic Reference levels (DRLs) is an important tool use for optimization process in nuclear medicine procedures. Nuclear Medicine facilities are encouraged to set up their own institutional or local DRLs (LDRLs). This potentially could have a tendency of undermining radiation protection of patients undergoing nuclear medicine procedures. This study establishes LDRLs for bone, renal and thyroid scans, the three most common adult scan procedures performed in the facility. Quality control tests were first undertaken to assess the performance of the radionuclide dose calibrator and the SPECT Scanner. The International Commission for Radiological Protection (ICRP) recommended methodology was used to established the institutional LDRLs for the facility. The study established that there were 1,540 adult patients who were scanned with the SPECT system between the period January 2021 to December 2023 of which 1,240 (80.5%) were male and 300 (19.5%) were female. The study also found that the most commonly performed procedures were bone scan (1,250; 81.2%), renal scan (150; 9.7%) and thyroid scan (140; 9.1%), with mean radionuclide doses of 661±3.03 MBq, 175±1.17 MBq and 155±1.32 MBq respectively. The institutional preliminary LDRLs are proposed as follows: 483 MBq for bone scan, 133 MBq for renal scan and 86 MBq for thyroid scan. These data will guide the application of radionuclide dose levels in medical procedures at the hospital, thereby ensuring optimized procedures and improved patient protection. The Nuclear Regulatory Authority of Ghana is recommended to collaborate with relevant national professional bodies and policy makers to establish national DRLs based on the proposed LDRLs.**

Keywords— **Optimization, DRL, ICRP, LDRL, SPECT, Radionuclide, Dose, Calibrator**

I. INTRODUCTION

Nuclear medicine includes procedures for diagnosis, staging of disease, therapy, and/or tracking the progress of a disease process [1-4]. For either diagnostic or therapeutic purposes, the radiopharmaceutical given to the patient orally, intravenously, or by inhalation localizes in the target cells. One of the efficient strategies for improving nuclear medicine examinations while lowering patient exposure is the use of diagnostic reference levels (DRLs) [5]. In medical imaging, DRLs are used to show if a patient's dose or the amounts of radiopharmaceuticals utilized in a specific radiological technique are typically high or abnormally low for that radiological procedure under normal circumstances [6,7]. One of the processes in the overall optimization process is DRL setup.

DRLs are regular dose estimates for a "standard-sized patient" during a certain examination. Image-guided interventional radiology, diagnostic nuclear medicine, or treatments must abide by examination-specific criteria that are adapted to the size or age of the patient, the location of the imaging, and the therapeutic purpose in order to improve patient safety [7,8]. This guarantees that patient doses are kept as low as feasible in order to fulfil the study's clinical goal. DRLs should be defined for representative tests or processes carried out in the locality, nation, or area where they are employed

In nuclear medicine, DRLs are determined by the activity delivered per kilogram of body mass to the patient or other factors [5,9]. Therefore, the DRLs in nuclear medicine represent the degree of activity deemed appropriate for use during a typical patient assessment. DRLs are usually determined based on customary practice of administered activity at the practical levels. Hence DRL values have historically reflected the normal optimum values in this regard rather than expressing inquiry levels.

The ICRP [10] and the European Directive (2013/59/Euratom) [11] both support the establishment of DRLs to aid in the optimization of radiological investigation. Several studies have been done to establish preliminary local DRLs including a retrospective, cross-sectional investigation of various nuclear medicine procedures in southwest Nigeria which significantly improved dose optimisation in the facility as the established DRL were within the range of international best practices [12, 13]. A review of various studies on the establishment of DRL reported varied DRL values, for instance, data obtained from Gabon shows that the DRL values were greater than those from the UK but lower than those from Sudan, Kuwait, Nigeria, and Australia. However, these values were within accepted values as recommended by EU [11].

Regular monitoring, optimization and adherence to DRLs contribute to safer and more standardized approach to

medical imaging. Hence, the objective of the study is to establish local DRLs (LDRL) for common nuclear medicine imaging procedures (bone, renal and thyroid scans) at the Korle-Bu Teaching Hospital..

II. MATERIALS AND METHOD

Equipment

The study was performed at the Nuclear Medicine Unit of the Korle Bu Teaching Hospital. The equipment and materials used include dose calibrator, flood field uniformity phantom, quadrant bar phantom, Jasczcak phantom, planar sensitivity phantom and dual-head SPECT scanner. The phantoms were used to perform basic quality control to assess the performance of the equipment.

Sampling

Data of injected radionuclide activities for patients undergoing varied nuclear medicine procedures were retrieved from database of the hospital. Data on bone, renal and thyroid scans, were randomly selected for this study.

Retrieval of Research Data and Estimation of DRLs

Data on patients who had undergone the three scan procedures (bone, renal and thyroid examinations) between the period January 2021 to December 2023 were retrieved. The data covered patients' age, weight, height, scan procedure, administered radionuclide activity and gender. The study found that 1,540 patients underwent nuclear medicine procedures, of which 1,240 (80.5%) were male and 300 (19.5%) were female. Overall, data on 1,250 bone scan patients, 150 renal scan patients and 140 thyroid scan patients were retrieved.

The minimum, maximum, mean, median and upper quartile values from the collected radionuclide activity were estimated, tabulated and analyzed to determine the DRLs for the Nuclear Medicine department for the three scan procedures.

Inclusion criteria

Patients with complete data, both in the PACs and daily records were included. Both paediatric and adult patients' data were included in the study.

III. RESULTS AND DISCUSSION

Demographics of study

Figure 1 shows the percentage distribution of the Gender variation of the data collected. While Figure 2 shows that the most common protocol undertaken in the facility was bone scan (n =1250, 81.2%), followed by renal scan (n =150, 9.7%) and then thyroid scan (n =140, 9.1%).

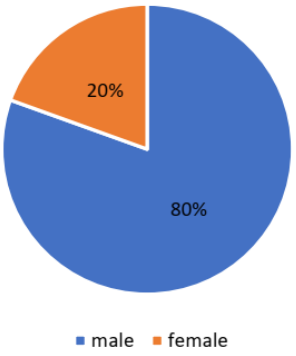

Figure 1: Percentage distribution based on Gender

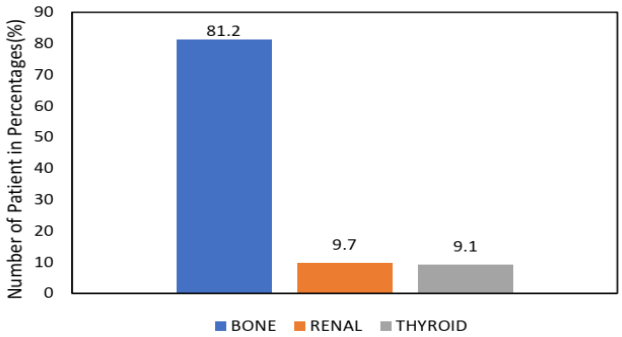

Figure 2: Percentages of Patient based on scan procedures

Figure 3 shows the attended rate of various age categories based on Adults (n =1540, 88.5%) and Paediatrics (n =200, 11.5%) distribution.

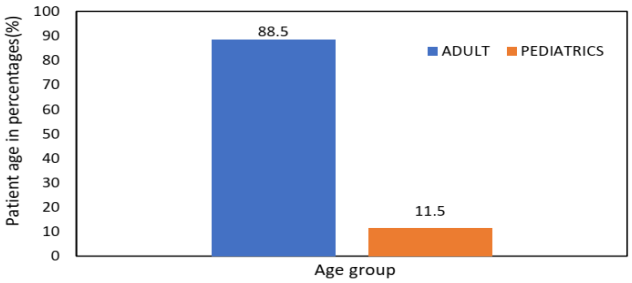

Figure 3: Percentages of Patients based on Adult (17-97 yrs) and Paediatrics (0-16 yrs)

Established DRLs

This section presents the results on age (adults and paediatrics) and administered activity for each of the protocols based on the median values.

Table 4: Radionuclide activity for common procedures

Protocol	Radionuclide Activity (mCi)							
	Adult				Paediatric			
	Min	Max	Mean	Median	Min	Max	Mean	Median
Bone scan	17.00	28.00	17.84±3.03	17.40	2.97	24.80	13.35±8.01	13.10
Renal scan	2.10	5.46	4.72±1.17	4.8	0.59	5.60	2.23±1.05	1.90
Thyroid scan	0.37	6.20	3.13±1.32	3.10	1.30	3.00	2.15±1.20	2.15

Table 4 shows the overall mean and corresponding deviation of the injected activity for both adult and paediatric patients based on the established protocols in the department. The mean adults and paediatric activity for bone were found to be 17.84 ±3.03 and 13.35 ±8.01, Renal were 4.72 ±1.17 and 2.23 ±1.05. while the Thyroid were 3.13 ±1.17 and 2.15 ±1.20 respectively. These results are comparable to a reference mean age of 17.0 ± 7.6 years for adult as published by ICRP 135, 2017 [5].

Figure 4 shows the comparison between the estimated mean administered activity of the Bone, Renal and the thyroid of adults and paediatrics patients. The results show adherence to the varied protocol of the paediatric and adult patients. In all the cases the adults mean activity were higher than those of the paediatrics patients.

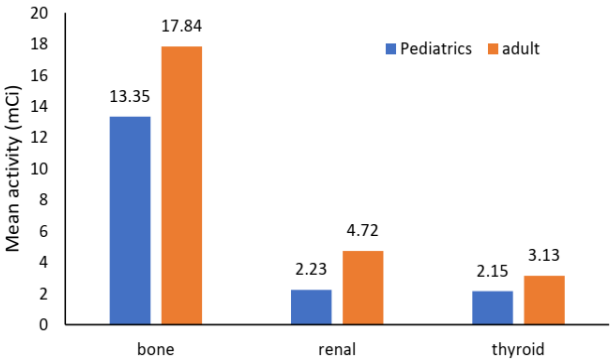

Figure 4: Comparison of mean administered activity of Adult and Pediatrics

Table 5: DRL(MBq) for most common nuclear medicine procedures in Ghana.

Procedure Name	Activity (MBq)				
	25th Percentile	75th Percentile	Max Value	Min Value	LDRLs
Bone scan	160.95	482.85	1036.00	629.00	482.85
Renal scan	44.40	133.20	555.00	77.70	133.20
Thyroid scan	28.67	86.02	229.40	113.69	86.02

From Table 5, the maximum and minimum values were found to be 1036.00 and 629.00 for bone scan; 555.00 and 77.70 for renal scan and 229.40 and 113.69 for the thyroid scan. Also, the 75th and 25th percentile values were calculated to be 482.85 and 160.95 for bone scan; 133.20 and 44.40 for renal scan and 86.02 and 28.67 for thyroid scan. Finally, LDRL values for each of the common procedures (bone, renal and thyroid scan) were found to be 482.85, 133.20 and 86.02 respectively.

The established DRL are comparable to other countries as the estimated values were within the recommended estimates. For instance, the mean activity for Bone was estimated to be 660 mCi, which is similar to published value in France 668 mCi. The estimated values were however lower than those published in Sudan, Brazil, Korea, and UNSCEAR, but was slightly higher than those published by IAEA Basic Safety Standard (BSS). Details of these are presented in Figure 5.

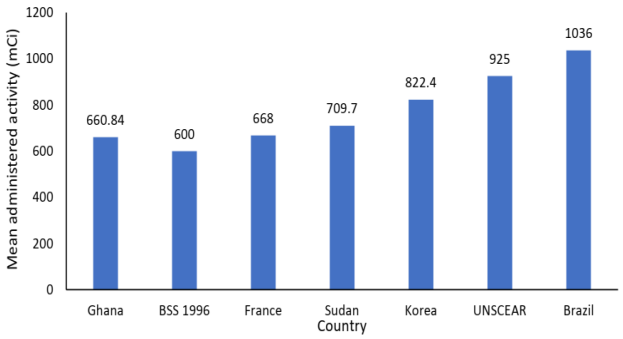

Figure 5: Mean administered activity (mCi) of 99mTc-MDP for bone scintigraphy in different countries.

Figure 5 shows that, the injected activity were within accepted range compared to other countries

The distribution in terms of 25th Percentile, 75th Percentile, Maximum, Minimum value associated with the DRL of administered activity are presented in Table 5.

Table 6: Proposed local DRL in comparison to DRLs from other countries

Protocol	DRL (MBq)								
	Ghana	Korea	Australia	Qatar	Kuwait	Japan	UK	USA	EU
Bone	483	945	920	740	944	950	600	848-1185	500-1110
Renal	133	185	200	101	200	210	80	189-289	70-183
Thyroid	86	217	215	195	185	300	80	-	75-222

Table 6 shows the 75th Percentile of administered radionuclide activity for scan procedures in Ghana as compared to other countries with administered activity for Bone, Renal Thyroid examination as 483, 133 and 86 MBq respectively. By comparison the values from Ghana were comparable to other international recommendations, for instance a recommendation from the US, proposed an administered to be within a range of 370 to 740 MBq (14) (ACR - SPR, 2014). These values are comparable to other countries including Korea, Australia, Qatar, Kuwait and Japan.

IV. CONCLUSION

The study is the first LDRL proposed for any nuclear medicine procedure in a medical facility in Ghana. The proposed DRL are Bone (483 MBq), Renal (133 MBq) and Thyroid (86 MBq). The proposed DRL values should be periodically reviewed and updated as recommended by the ICRP.

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