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Annual Effective Dose Status among the Radiation Staff of Lagos University Teaching Hospital, Lagos, Nigeria

[1]*Z. Ibitoye,* [1]*M. Aweda and* [2]*N. Irurhe*

[1]Department of Radiotherapy, Lagos University Teaching Hospital, Idi-Araba.Lagos, Nigeria
[2]Department of Radiodiagnosis, Department of Radiotherapy,
Lagos University Teaching Hospital, Idi-Araba. Lagos, Nigeria

Abstract: The purpose of individual radiation monitoring of occupationally exposed workers is to determine the status of annual effective dose. The status of the annual effective doses of occupationally exposed radiation workers in Lagos University Teaching Hospital (LUTH), Idi-Araba, Lagos, Nigeria was hereby reviewed. 75 medical radiation workers dose records were studied for a period of one year. Two study groups were identified; Radiodiagnosis and Radiotherapy and workers were divided into subgroups according to profession. Average Quarterly Effective Dose (AQED) and Average Annual Effective Dose (AAED) distribution were calculated and results presented in terms of Deep Dose Equivalent (DDE) and Shallow Dose Equivalent (SDE). Diagnostic radiographers received average of DDE 0.580 mSv which is the highest in the Department. Medical physicists have the highest value of DDE of 1.20 mSv in the Radiotherapy Department. The average annual effective dose was highest with Medical Physicists with DDE and SDE values as 0.844mSv and 0.857 mSv respectively. Generally, most of SDE values among all the categories of workers were greater than DDE except in few cases. The results showed that occupationally exposed staff in Radiotherapy and Radiodiagnosis Departments received doses lower than the recommended annual limit of 20 mSv.

Key word: Effective dose · Dose limits · Shallow dose · Deep dose

INTRODUCTION

The purpose of radiation monitoring and exposure assessment is to provide information on the health risk of radiation workers and to ensure good practice. Absorbed radiation dose is measured to determine the "safe level" and to make necessary adjustments to correct unsuitable situations where necessary. It also serves to establish records for legal purposes.

The Basic Safety Standard (BSS) [1, 2] prescribed individual monitoring employed to work in the controlled areas and who may receive significant exposure. Professionals that are mainly concerned are radiation oncologists, diagnostic radiologists, medical physicists, radiographers, technicians and other supportive staff [3, 4]. Several regulatory bodies at international and national levels have provided guidelines for radiation safety and protection of both radiation staff and the public. These include International Commission for Radiation Protection (ICRP) [5], International Atomic Energy Agency (IAEA) [6] and at national level, Nigerian Nuclear Regulatory Agency (NNRA) [7]. In Nigeria, NNRA is charged with the responsibility to establish framework for ensuring that occupational exposures to ionizing radiation is kept as low as reasonably achievable according to the ALARA principle and ensure that exposures do not exceed dose limits recommended for individuals [5-8].

Evidences obtained from the experimental, epidemiological and other studies on both animal and human populations showed that ionizing radiations induce cancers. The current radiation protection standards are therefore based on justification of practice, optimization in relation to the magnitude of doses and dose limitation for the occupationally exposed, the public, the embryo and the fetus [9-12].

Dose monitoring of professionally exposed workers is an essential regulatory measure in radiation protection. There was established a radiation protection committee in LUTH to monitor the use of ionizing radiation in the hospital according to the requirements of the nuclear

Corresponding Author: Z. bitoye, Department of Radiotherapy, Lagos University Teaching Hospital,
Idi-Araba. P.M.B. 12003 Lagos, Nigeria. E.Mail: azibitoye@cmul.edu.ng

regulatory body in Nigeria [7]. The duties of the committee include to inform and advise and the hospital management on radiation safety and protection issues. It also oversees the monitoring of occupationally exposed staff organizes environmental radiation safety program, educate and facilitate the awareness on radiation safety in the hospital community. LUTH was the first institution in West Africa to practice Radiotherapy and Nuclear Medicine. The hospital recently upgraded a number of the radiation facilities to enhance services. Available are one Siemens and one high speed spiral CT, static x-ray machines, mobile x-ray machines, bucky and C-Arm fluoroscopy, mammography and portable x-ray machines in the Radiodiagnosis Department. Also in Radiotherapy Department are one ELEKTA LINAC facility with Photons of 6 MeV and 15 MeV and range of electron energies of 4, 6, 8, 10, 12 and 15 MeV as well as a spiral CT simulator for treatment planning. There are two Curietron machines for low dose rate intracavitary brachytherapy. The aim of this study was to determine the radiation safety and protection status of occupationally exposed staff in both Departments within the past one year of activities. In this paper, we present the results of doses to workers in both Departments. The professional workers reviewed were radiologists, radiotherapists, medical physicists, radiographers, technicians and ancillary staff. The results obtained were compared with the international recommended dose limits [4-7].

MATERIALS AND METHODS

The detector used for this study was lithium fluoride (LiF-100) doped with magnesium and titanium and the Reader was Harshaw 4500 TLD Reader. The TLD materials were annealed under an increasing temperature of between 100 to 300 °C to remove residual doses. An irradiator which has an annealing plate that can hold 5 cards contain Sr-90/Yt-90 source used to dose the TLD chips between 390 and 490 ìSv to prepare the cards for calibration. The cards are then calibrated with the TLD 4500 under the same conditions of annealing. Medical radiation workers were categorized into two namely, radiology and radiotherapy and the quarterly and annual doses received were determined. Radiodiagnosis staff comprised of radiologists, diagnostic radiographers and x-ray technicians. Radiotherapy staff comprised of radiotherapists, medical physicists, nurses, technicians and engineers. Occupationally exposed radiation workers are being monitored. The current report covered the period from February 2010 to January 2011. The use of TLD [14] is an acceptable method by the regulatory body and as stipulated in the NNRA act [7]. It is highly sensitive with excellent energy response and is tissue equivalent. The personal dose equivalent H_p (d) is defined for both strongly and weakly penetrating radiations as the equivalent dose in soft tissue below a specified point on the body at appropriate depth d. The quantification of the absorbed dose distributions is based on Deep Dose Equivalent (DDE) for photon energies above 15 keV and Shallow Dose Equivalent (SDE) for weakly penetrating radiations of photon energies below 15 keV and â radiations [15,16]. DDE (H_{10}) is the external whole body exposure dose equivalent at a tissue depth of 10 mm (1000 mg/cm^2) while SDE ($H_{0.07}$) quantifies the external exposure of skin or the extremity at a tissue depth of 0.07 mm (7 mg/cm^2) averaged over an area 1 cm^2.

RESULTS

Table 1 presents the calculated average Quarterly Effective Dose (AQED) in mSv for the radiation staff in the Radiology Department. The results were presented with their standard deviations (SD). Table 2 represents AQED for the radiation workers in radiotherapy department. Table 3 is the comparison of Average Annual Effective Dose (AAED) distribution among occupationally exposed workers in LUTH within the period of this review.

Table 1: Average Quarterly Effective Dose (AQED) in mSv, Distribution in Radiology Unit

Batch	A				B				C				D			
Profession	DDE	SD	SDE	SD	DDE	SD	SDE	SD	DDE	SD	SDE	SD	DDE	SD	SDE	SD
Radiologists	0.49	0.15	0.62	0.56	0.41	0.11	0.41	0.17	0.51	0.45	0.50	0.18	0.56	0.06	0.66	0.42
Diagnostic Radiographers	0.48	0.01	0.48	0.14	0.39	0.04	0.54	0.33	0.52	0.32	0.58	0.10	0.58	0.04	0.53	0.09
Technicians	0.44	0.00	0.41	0.01	0.35	0.01	0.49	0.34	0.54	0.01	0.53	0.25	0.55	0.08	0.74	0.49

DDE = Deep Dose Equivalent, SDE =Shallow Dose Equivalent, SD = Standard Deviation

Table 2: Average Quarterly Effective Dose (AQED) in mSv, Distribution in Radiotherapy Unit

Batch	A				B				C				D			
Profession	DDE	SD	SDE	SD	DDE	SD	SDE	SD	DDE	SD	SDE	SD	DDE	SD	SDE	SD
Radiotherapists	0.37	0.05	0.38	0.07	0.51	0.06	0.54	0.20	0.57	0.72	0.52	0.55	0.28	0.38	0.30	0.95
Therapy Radiographers	0.50	0.18	0.50	0.19	0.63	0.12	0.54	0.06	0.55	0.28	0.52	0.18	0.30	0.32	0.40	0.08
Medical Physicists	0.61	0.56	0.65	0.50	0.55	0.03	0.49	0.05	1.20	1.57	0.92	0.78	0.77	0.60	1.34	0.58
Others	0.35	0.10	0.50	0.22	0.67	0.37	1.56	1.85	0.51	0.27	0.51	0.33	0.26	0.04	0.28	0.06

DDE = Deep Dose Equivalent, SDE =Shallow Dose Equivalent, SD = Standard Deviation

Table 3: Average Annual Effective Dose (AAED), mSv Distribution among Radiation Workers in LUTH

	DDE		SDE	
Profession	AAED, mSv	SD	AAED, mSv	SD
Radiologists	0.486	0.13	0.562	0.43
Radiotherapists	0.406	0.373	0.423	0.298
Diagnostic Radiographers	0.508	0.093	0.511	0.17
Therapist Radiographers	0.486	0.211	0.486	0.137
Physicists	0.844	0.883	0.857	0.572
Technicians	0.445	0.102	0.535	0.333
Others	0.433	0.259	0.722	0.996

DDE = Deep Dose Equivalent, SDE =Shallow Dose Equivalent, SD = Standard Deviation

DISCUSSION

Radiographers in the Radiodiagnosis Department received an average annual effective dose of 0.580 mSv which was the highest DDE in the Department. The radiologists received 0.56 mSv, 0.54 mSv was the mean value for the other supportive staff while 0.744, 0.58 and 0.66 mSv were the SDE for supportive staff, radiologists and diagnostic radiographers respectively (Table 1). The medical physicists had the highest value of DDE of 1.20 mSv. Radiotherapists, Therapy Radiographers and supportive staff have values of 0.57, 0.63 and 0.67 mSv respectively. Supportive staff received highest value of DDE of 1.56 mSv while the values for physicists, radiotherapists and therapy radiographers were 1.57, 0.54 and 0.54 mSv respectively as seen in table 2. The comparison of the annual effective dose distribution among personnel showed medical physicists had AAED of 0.844 mSv and 0.857 mSv as the highest values of DDE and SDE respectively. Radiotherapists received the least values of 0.406 and 0.423 for DDE and SDE respectively. Generally, most of SDE values are greater than DDE in all the presentations except in few cases. The absorbed doses were low compared to the internationally recommended limits. Valuckas *et al.*, evaluated 1331 occupationally exposed workers in Lithuania during 1991-2003period. They observed that 97.4% of the doses received were below 5 mSv. They also found out that average annual effective doses decreased among all the occupational categories of medical radiation workers during this period of review. They compared their results with the international dose limits and found that it was 20 % of the annual dose limits [18]. In Saudi Arabia, Al-Haji *et al.*, studied the variation in occupational doses among sub-specialties in diagnostic radiology. The mean annual dose for the 5-year period was found to be in the range of 0.48-0.94 mSv for all the monitored workers [16]. Milatovic *et al.* [19] reported the dose estimation for persons occupationally exposed to ionizing radiation in Montenegro. They observed that the highest average monthly value recorded was 1.1 mSv among about 600 radiation exposed workers. The average annual effective doses from all these data are far below the international absorbed dose limits.

The International Atomic Energy Agency (IAEA) serves as the world's central inter-governmental body for scientific and technical co-operation in the nuclear field and as the international inspectorate for the application of nuclear safeguards and verification measures covering civilian nuclear programs. IAEA (a specialized agency within the United Nations (UN)) recommendations for radiation protection are contained in the Basic Safety Standards [5-6, 21-23]. The BSS represents an internationally agreed standard that has, in principle, been accepted by all member states and is based on the recommendations of the ICRP. The BSS sets out the requirements for a framework to regulate radiation safety in each country.

The overriding principle of staff radiation protection is to ensure that dose is kept 'as low as reasonably achievable'. This principle is known as the ALARA principle and is the backbone of all radiation protection practice. Essentially, ALARA requires that any measure that can reasonably be implemented should be to ensure that radiation protection is optimized. In deciding reasonableness, economic and social factors can be taken into account [24].

In conclusion, the results from this study revealed that the personnel occupationally exposed to ionizing radiation have values of annual effective doses within the recommended limits. The quarterly and annual average dose variations were small within the period of the investigation. The low annual staff dose in radiotherapy and radiodiagnosis departments indicate that no radiation workers received dose higher than the stipulated limits of 50 mSv within the year as recommended by international and national regulatory bodies. The low radiation exposures can be attributed to establishment and strict compliance with local rules, restriction of traffic and working procedures of radiation workers. Also environmental radiation survey of the facilities is done periodically as well as monthly calibration and quality assurance of each radiation facility.

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