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Full Length Research Article

Evaluation of Radiation Safety Levels in the Monitor Rooms of Selected Diagnostic Centres in Lagos State Using Thermoluminescent Dosimeter

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ABSTRACT
The hazard of exposure to ionizing radiation at low doses has been scientifically proven to be possible for cancer and non-cancer diseases. International and national regulatory bodies have recommended dose limits for occupationally exposed workers to ionizing radiation and the general public. The objective of this study was to assess the radiation safety levels in monitor rooms of x-ray diagnostic radiology facilities. Sixty monitored rooms in twenty radio diagnostic centers were visited. Three tissue-equivalent thermoluminescent dosemeters (TLD-100 (LiF: Mg. Ti)) chips were placed in strategic places a few centimeters from the viewing glass in the monitored rooms for two weeks. The TLDs were analyzed using the RADOS RE 2000 TLD reader. Questionnaires were also distributed to ascertain compliance with the basic principles of radiation protection. The average personnel dose equivalents in the monitored rooms of conventional x-rays, mammography, computed tomography, and fluoroscopy were 0.33, 0.32, 0.28, and 0.34 mSv/year, respectively. The status of the radiation safety levels in the selected monitored rooms is satisfactory because the values obtained were below the international recommended dose limit of 50 mSv in a single year for occupationally exposed radiation workers.
Keywords: Radiation Dose, Radiation monitor, Radiation protection, Thermoluminiscent, Dose equivalent

INTRODUCTION
After discovering x-ray and its quantum leap applications in medicine and industry, the likelihood of its biological effects had been extensively reported to be either stochastic or non-stochastic (BEIR, 2006; UNSCEAR, 2022). Cancers and genetic damage are, for example, consequences of stochastic effects. If the probability of effects and the extent of damage depend on the applied dose and its spatial and temporal distribution, the effect is said to be a non-stochastic or deterministic effect (Shannoun *et al*. 2008). Once the threshold value is exceeded, cells, tissues, and organs become exposed to likely radiation damage (Cox, 1994; Muirhead *et al*, 1999; Smith *et al*, 2003; Cardis *et al*, 2006; Wrixon, 2008; Mothersill and Seymour, 2013). International organizations and national authorities responsible for radiological protection have taken the recommendations and principles issued by the International Commission on Radiological Protection (ICRP) as a key basis for their protective actions (ICRP, 1991; IAEA, 2014). The system of dose limitation recommended by the ICRP is founded on three basic principles: justification, optimization and dose limitation (ICRP, 1991; IAEA, 2014).

Scattered radiations are the major source of worker exposure to radiation in controlled rooms. Improper design of the treatment or investigation rooms might permit radiation leakage to the controlled and supervised areas (Hendee and Ritenour, 2002). The use of poor and inadequate shielding materials usually affects the attenuation coefficient thereby increasing radiation intensity to the environment. Materials such as lead sheets and concrete have been suggested to be efficient in attenuating ionizing radiation to a safety level. Compliance of the registrants and licensees to the provision provided by regulatory bodies will protect the public and radiation workers from undue radiation exposure (IAEA, 2014).

A well-calibrated radiation survey meter is required for workplace monitoring while a thermoluminescence dosimeter for individual monitoring is essential. Since the stochastic effect is based on the probability of occurrence, there is a need for constant monitoring of radiation workers in controlled and supervised areas. The objective of this study therefore, was to assess the effective dose equivalent levels in the controlled rooms of selected diagnostic radiology facilities in Lagos metropolis, Nigeria.

MATERIALS AND METHODS
X-Ray Units
A total of 60 controlled rooms in 20 radiodiagnostic centres in Lagos metropolis were evaluated for radiation dose levels consisting of 29 (48.3%) conventional x-ray machines, 11 (18.3%) computed tomography machines, 16 (26.7%) mammography x-ray machines and 4(6.7%) fluoroscopy suites.

TLD Processing and Readings
One hundred and eighty annealed and calibrated thermoluminescent dosemeters (TLD-100 (LiF: Mg. Ti)) of dimensions 4.5 mm x 0.9 mm (Radiation Monitoring and Service Center, Lagos State University, Ojo, Lagos State) were used. Three TLDs were placed at different locations in each controlled room with the protective screen as a reference point for two weeks. Before each measurement, background radiation was recorded. Post-processing of the TLDs took place at the dosimetry provider centre. Before exposure, the TLDs were annealed at 400 °C to restore them to their original state. However, after exposure, each TLD was preheated at 100 °C for 10 minutes (the useful dosimetric peak of the

LiF:Mg,Ti glow curve is between 180° and 260 °C) to remove low-temperature peaks as well as stabilizing it before transferring it to the RADOS RE 2000 TLD reader. This TLD reader system is made up of two major components which are the TLD Reader with the Win TLD light software which was installed on a personal computer and connected to the reader via serial communications ports. All dosimetric data storage, instrument control, and operator inputs were done in the user interface software while transport subsystem control, gas, and vacuum controls, signal acquisition, and conditioning were performed in the reader system. The reader consists mainly of rear data processing electronic system, a sample drawer assembly, a precision light measurement system, a detector heating system, a light voltage power supply, data storage facilities, and photomultiplier tubes. The photon counts read from the TLD reader was subtracted from the background radiation and multiplied by the TLD calibration factor to obtain the true dose for the exposure period. The obtained values minus the background radiation were presented in mSv/year for comparison with international recommended dose limits for occupationally exposed radiation workers. The effective equivalent dose per year was calculated by assuming that radiation workers work continuously for 8 hours a day, 5 days a week, and 52 weeks a year. Since the TLDs were placed in the controlled rooms for two weeks, the dose recorded by the TLD was extrapolated for one year by multiplying the readings by 2080 hr/year and then dividing by 336 hours (two weeks). The obtained results were compared with the recommended annual dose limit of 50 mSv in a single year according to BSS Schedule II and ICRP Report 60.

Data Analysis

The data were analyzed with Statistical Packages for Social Sciences (SPSS) version 20 (IBM, Armonk, NY). Mean differences of values obtained from different radiodiagnostic controlled rooms visited were compared using tukey post hoc test. A p-value of less than 0.05 was considered to be significant.

RESULTS

The results of the annual radiation safety levels of 60 monitored rooms at 20 different radiodiagnostic centres in the metropolis are presented in this section. The conventional x-ray units as presented in Figure 1 are 29 (48.3%) and 4(6.7%) fluoroscopy suites in Lagos metropolis. From the obtained data as in Figures 2-5, the average effective dose equivalent levels in the conventional x-ray, mammography, computed tomography, and fluoroscopy-controlled rooms are 99.3%, 99.4%, 99.3% and 99.3% respectively lower than the 50 mSv/year recommended limit for occupationally exposed radiation workers. No statistically significant difference was also observed in the effective dose equivalent levels measured at different radiodiagnostic controlled rooms visited (p = 0.13)

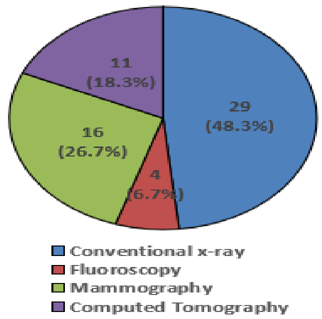

Figure 1: Distribution of radiation-emitting machines in the visited radiodiagnostic centres.

Figure 2 shows the radiation safety levels at different conventional x-ray monitored rooms with mean values of 0.33±0.11 mSv/yr. Similarly, the radiation safety levels at different mammography rooms indicate maximum and minimum values of 0.49 mSv/yr and 0.16 mSv/yr, respectively with the mean values of 0.28±0.08 mSv/yr (Figure 3)

Radiation safety levels in the monitored tomography rooms as presented in Figure 4 reveal maximum and minimum values of 0.51 mSv/yr and 0.16 mSv/yr respectively and mean value 0.33±0.09 mSv/yr.

Figure 5 shows the radiation safety levels as observed in the fluoroscopy-monitored rooms. The maximum and minimum values obtained were 0.44 mSv/yr and 0.25 mSv/yr while calculated mean value is 0.33±0.08 mSv/yr.

DISCUSSION

The effective dose equivalent levels in the conventional x-ray, mammography, computed tomography, and fluoroscopy-controlled rooms in the Lagos metropolis were investigated. There is a variation in the measured personal dose equivalents across the centres visited. Findings in this study observed that the maximum value of 0.51 mSv/year radiations level is 99.0% lower than the ICRP 50 mSv/year recommendation limit for occupationally exposed radiation workers. The average effective dose level for conventional x-ray, computed tomography, and fluoroscopy-controlled rooms was 0.33 mSv/year while in mammographic units the average value was 0.28 mSv/year. The values obtained in this study suggest safety levels of radiation doses which were below safe recommended dose limit of 50 mSv/per year. Findings in this study agree with previous reports on hospital related work place exposure to radiation (Kharita *et al.*, 2021; Aung and Khaing, 2021; Bouchareb *et al.*, 2021; Fan *et al.*, 2021; Choi *et al.*, 2018; Chinangwa *et al.*, 2017). Moreover, the low values observed may be attributed to adherence to radiation protection practices in the centres studied including the optimization applied in the construction shielding. Nevertheless, cancer risks from low-dose exposures have been reported to increase linearly with dose regardless of dose rate (Brenner and Sachs, 2006; Heyes *et al*. 2009; Martin *et al*, 2014; Desouky *et al.*, 2015; Burtt *et al.*,2016; Harbron, 2016).

Exposures to low-dose radiation could result in mutational changes (Heyes *et al.*, 2009), genomic instability (Panera *et al*, 2021), multiple stressors (Mothersill and Seymour, 2013), carcinogenesis (Cardis *et al,* 2006; Burtt *et al.,* 2016) and dynamic change in blood cell levels (Xu *et al*, 2021). Studies have shown that exposure to low radiation doses does not guarantee lower risks levels for cancer is (Guo *et al,* 2022; ICRP, 2004; Jacob *et al*, 2009; Cardis *et al,* 2006). Despite low dose radiation observed in the radiodaignostic rooms as observed in this study, efforts however should be made to periodically conduct radiation surveys of the controlled room in radiodiagnostic facilities to ensure the ALARA principle is maintained.

CONCLUSION

In conclusion, the effective doses in the radiodiagnostic controlled rooms assessed in this study were lower than the recommended dose limit of 50 mSv/year for occupationally exposed radiation workers. Although the measured doses may appear to be small, there is still a need to adhere to guidelines provided by the international and national regulatory bodies to avoid stochastic effects and other non-cancer-related diseases associated with exposure to low radiation doses. Regular workplace surveillance and individual monitoring should also be part of the principle of radiation protection in the controlled rooms to keep dose limits exposure of radiation workers as low as reasonably achievable.

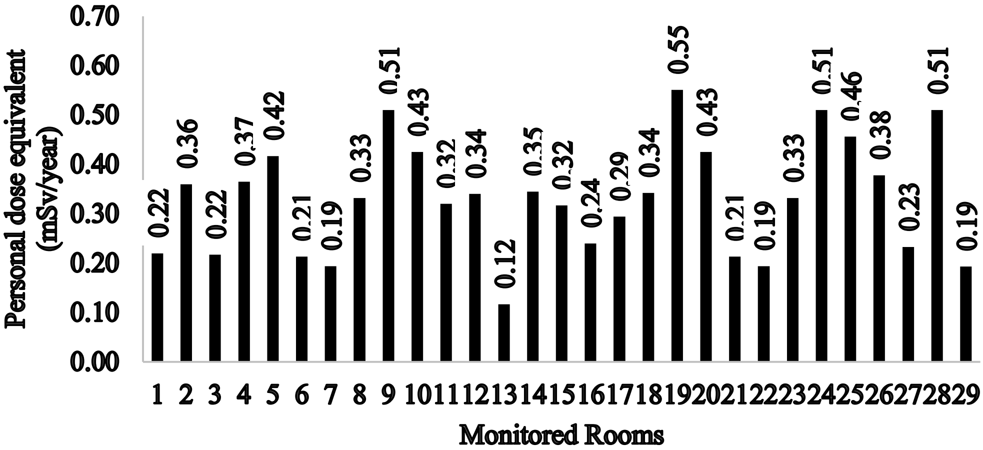

Figure 2: Radiation safety levels distributions in mSv/year at different conventional x-ray monitored rooms.

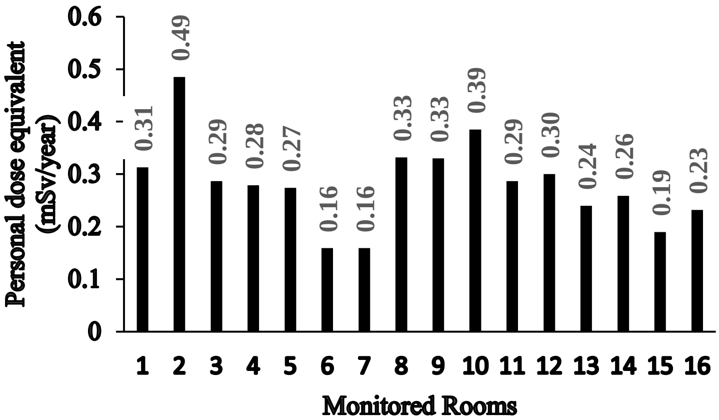

Figure 3: Radiation safety levels distributions at different mammography-monitored rooms.

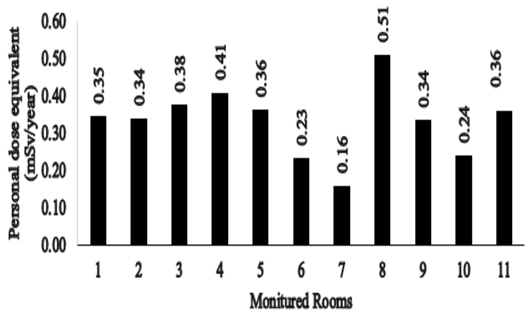

Figure 4: Radiation safety levels distribution at different computed tomography monitored rooms.

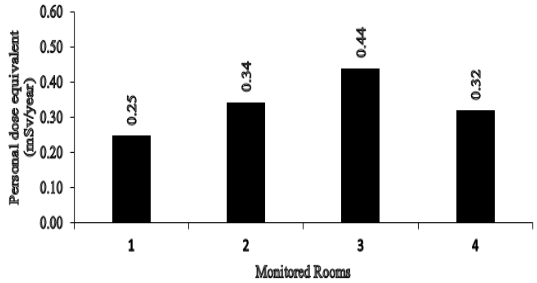

Figure 5: Radiation safety levels distributions at different fluoroscopy-monitored rooms.

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