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TECHNICAL NOTE

Thermoluminescence Dosimetry Measurement of Ionizing Radiation at the Radio Diagnostic Center, National Orthopaedic Hospital Igbobi, Lagos, Nigeria

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Abstract: Ionizing radiation measurement and monitoring are very important and pose an increasing international concern. In this study, the level of exposure to ionizing radiation among radiation health workers and outdoor patients at the Radio Diagnostic Center of the National Orthopedic Hospital Igbobi, Lagos State, Nigeria was determined. Thermoluminescence dosimeters (TLDs) made from Lithium Fluoride were deployed at ten strategic locations within and around the X-ray facilities over a 41-day period to measure effective radiation doses received by health workers and the general public. In the X-ray rooms, mean annual effective doses (mSv) of 39.52, 2.05, 1.25 and 1.16 were detected at the Trauma X-ray unit, main X-ray unit and modular theatres 1 and 2, respectively. Outside the X-ray rooms, the mean effective doses were significantly lower, indicating good containment of radiation emitted from the X-ray machines. The study confirms that while some occupational zones exceed recommended limits under continuous exposure, standard operational protocols (e.g., avoiding presence in the room during exposure) and proper shielding effectively protect both workers and the public from harmful radiation levels.

Keywords: Radio-diagnosis, Thermoluminescence, Dosimeter, Effective dose, Ionizing Radiation.

1. Introduction

Radiation levels associated with radiological procedures have come under increasing scrutiny, requiring quantitative monitoring and accurate measurement due to the widespread applications of ionizing radiation worldwide [1]. The latest United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report estimates that there are about 4 billion X-ray examinations per year worldwide [2]. Hospitals use X-ray machines and other radiation-emitting sources for radiographic examinations (computerized tomography, fluoroscopic procedures, dental diagnosis, and routine X-ray exposure), radioisotope procedures, and radiation therapy. Some hospital employees who work in radiology, nuclear medicine, radiation oncology, and some laboratories are specifically trained to operate radiation machines and handle radioactive materials and sources, to which they are exposed in one way or another.

Radiographic examination, radioisotope procedures, and radiation therapy have contributed to increased background radiation and radiation levels in hospitals [3]. Radiation health workers who administer these treatments, along with the patients receiving them, get exposed to ionizing radiation; the amount depends on the type of radiation and the frequency or duration of exposure [4, 5].

In addition, radiation leakage to the immediate environment outside the facilities where these sources are kept/used can occur if containment (shielding) or disposal is improper. This could result in public exposure to ionizing radiation without their awareness, which over time could become detrimental. Therefore, it is

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necessary to know environmental radiation levels inside and outside radiation facility rooms, as well as the effective doses received by radiation workers and the public in the immediate environment of radio-diagnostic centers, where radiation facilities are in use.

One of the recognized methods of assessing the radiation dose individuals can be exposed to is thermoluminescence dosimetry. Thermoluminescence dosimetry (TLD) measures ionizing radiation exposure by detecting the amount of light emitted from a special crystalline material, typically lithium fluoride (LiF), when heated. The crystal absorbs energy from radiation over time, and when heated, this stored energy is released in the form of visible light. The intensity of the emitted light is directly proportional to the radiation dose received, making this method highly effective for both personal and environmental radiation monitoring [6, 7]. TLD is widely used because of its high sensitivity, broad dose measurement range, reusability, and relatively low cost, making it suitable for routine monitoring in clinical and research settings [8, 9].

In this study, the radiation effective doses to health workers and the general public upon the emission of ionizing radiation from X-ray facilities utilized in the radiology department and the modular theatres of the National Orthopaedic Hospital, Igbobi, Lagos are determined using thermoluminescence dosimeters (TLD).

2. Materials and Method

This study was carried out at the radiology department of the National Orthopaedic Hospital Igbobi, Lagos. Particular attention was paid to the Trauma X-ray unit because of the high demand for radiologic investigations by the public.

Ten pairs of TLD chips made of lithium fluoride (LiF) were mounted at 7 different locations: the X-ray room, the control room, the dressing room, the corridor, the break room, the sleeping room, and the reception. In addition, TLDs were placed in the X-ray rooms at the main X-ray unit and the two modular theatres (Table 1).

TABLE 1. Distribution of TLD chips at Sampling Locations.

	TLD Chip No.	Position of Placement	Building
1.	3069	X-ray room	Trauma X-ray Unit
2	3068	Control room	
3.	3109	Dressing room	
4.	3079	Break room	
5.	3092	Reception	
6.	3078	Sleeping room	
7.	3070	Corridor	
8.	3073	X-ray room	Main X-ray unit
9.	3088	Suite1	Modular Theatres
10.	3091	Suite 3	

The samples were left in these locations for a period of 41 days.

The choice of TLD for absorbed-dose estimation is based on its broad detection range, reusability, linearity, and cost-effectiveness [10–12].

The round pellet TL crystals were first pre-annealed to remove any previously trapped radiation or energy. After pre-annealing, the TLD crystals were carefully placed in holders. Two TLD detectors were placed at each sampling location, so that a mean radiation dose can be obtained. Necessary precautions were taken to ensure that the TLD chips were not exposed to sunlight, directly hand-held, or allowed to fall to the ground, to prevent extraneous radiation prior to measurement or contamination from dirt and impurities. The chips were afterwards transported to the Radio Diagnostic Center of the National Orthopaedic Hospital, Igbobi and placed in the positions listed in Table 1. Particular attention was given to the Trauma X-ray unit building because of its high patient volume, which requires daily operation of the X-ray machine—unlike the less frequent use in the other buildings.

After the TLD exposure period ended, they were carefully removed, placed in a non-transparent bag to avoid direct sunlight, and taken back to the radiation laboratory at Lagos State University Ojo for analysis.

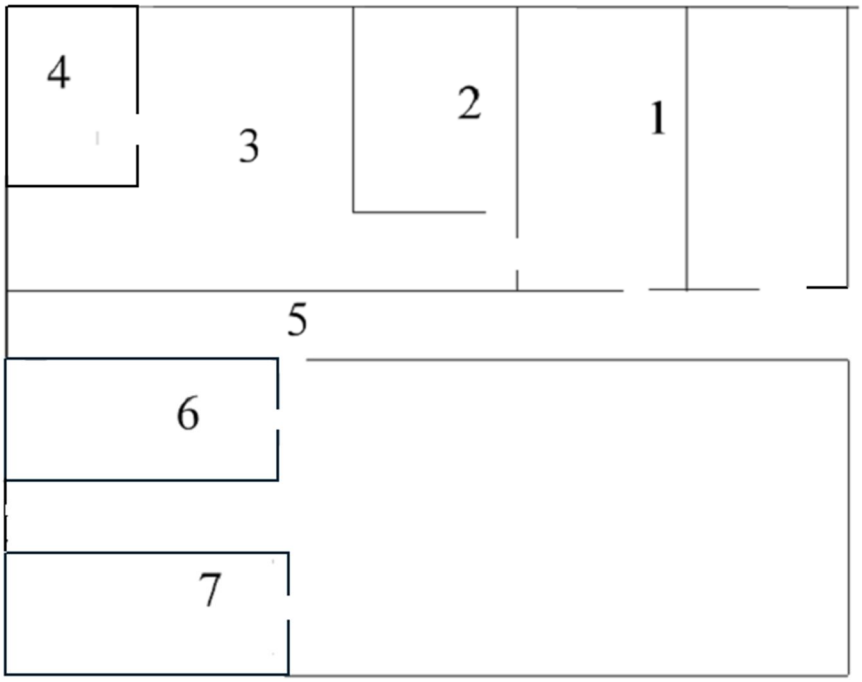

FIG. 1. Schematic diagram (not to scale) of the layout of the Trauma-X-ray unit building. Key: 1- Reception, 2- Control room, 3- X-ray room, 4- Dressing room, 5- Corridor, 6- Break room, 7- Sleeping room.

2.1. Sample Analysis

The irradiated TLDs were removed from their holders and placed in TL cards labeled for easy identification. The cards were loaded into a TLD reader (model 2000A), and it was ensured that the round crystal TL pellets were placed correctly to avoid damage or result anomalies [13, 14]. The calibration of the TLD chips and the TLD reader was carried out at the Secondary Standard Dosimetry Laboratory (SSDL) of the Nigerian Institute of Radiation Protection and Research, University of Ibadan, Nigeria. A Cs-137 gamma radiation source was used for this calibration, in accordance with the recommendations of the International Atomic Energy Agency [15]. The personal dose-equivalent calibration factors, specifically Hp(10) for deep dose (representing whole-body exposure) and Hp(0.07) for shallow dose (representing skin or surface exposure), were applied to convert the raw thermoluminescent light output into absorbed dose values, using Equation 1 [16]:

$$Dose\ (mSv) = Light\ Output\ (nC) \times Calibration\ Factor\ (mSv/nC) \quad (1)$$

Before reading the TLDs, the TLD reader was allowed to warm up for 20 minutes, with gas flowing into the TLD card case. As the TLDs were read, the glow curve was displayed and examined for any abnormalities. The light output of each TLD was recorded and saved. The light output was multiplied by the appropriate calibration factors to obtain the dose values.

3. Results and Discussion

The TLD detection results are displayed in Table 2. As expected, the highest effective dose was recorded in the X-ray room of the Trauma unit, since the primary source of the artificial ionizing radiation is situated there. The dose value in the Trauma unit is also higher than the values obtained in the X-ray rooms of the radiology unit and those in the modular theatres. Unlike the Trauma unit, where the X-ray facility is operated frequently every day, the ones at the modular theatre are operated four times a week, whereas the one in the radiology unit is operated only one day a week.

TABLE 2. Dose measurements at the Radio Diagnostic Centre, Igbobi.

	TLD no.	Building	Description	*Monthly Effective dose (mSv)		Monthly Mean Effective dose (mSv)
1	3069	Trauma X-ray Unit	X-ray room	4.32	4.56	4.44
2	3068		Control room	0.08	0.13	0.10
3	3109		Dressing Room	0.46	0.43	0.44
4	3079		Break room	0.09	0.14	0.11
5	3092		Reception	0.08	0.12	0.10
6	3070		Corridor	0.10	0.18	0.14
7	3078		Sleeping room	0.07	0.10	0.08
8	3073	Main X-ray unit	X-ray room	0.24	0.23	0.23
9	3088	Modular	suite1	0.11	0.17	0.14
10	3091	Theatres	suite3	0.14	0.13	0.13

* Month = 41 days.

The effective dose inside the X-ray room at the radiology unit was higher than that recorded in the modular suites, even though it operated only one day a week. This is likely due to the higher energy and greater penetrating power of the X-ray machine in the radiology unit, or the proximity of the TLD placement to the radiation source in the modular theatres (the researchers were not privileged to place the TLD directly inside the X-ray room). The effective doses obtained in the control room, dressing room, corridor and reception area in this work are within the range of 0.89– 3.92 mSv. The result obtained in this work in the control room is higher than what was reported in the control (monitor) rooms of selected diagnostic centers in Lagos State [17].

The effective dose inside the X-ray rooms of the two modular suites compares favorably; the difference is 0.01 mSv.

Outside the X-ray room of the Trauma unit, the effective dose was observed to drop significantly to between 18% and 2% of the initial dose. This shows good containment of the radiation emissions from the X-ray room, whose walls and entrance door are lined with lead. The control room, which is a compartment within the X-ray room but demarcated from the X-ray facility, recorded a value that was within the range of the values obtained outside the X-ray room, which again shows that proper shielding is in place in the control room that effectively attenuates the radiation coming from the X-ray tube when it is in use. The control room wall had a lead-glass viewing window.

The annual mean effective dose computed from the monthly mean dose is depicted for the various locations in Figs. 2a and 2b. Its value in the X-ray room of the Trauma X-ray unit was computed to be 39.52 mSv. This exceeds the International Commission on Radiological Protection (ICRP) annual limit of 20 mSv for radiation health workers [18]. While it is not expected that any personnel would remain in the X-ray room during exposures, the elevated dose recorded in this area highlights the critical importance of enforcing rigorous radiation safety protocols such as establishing operational procedures that actively prevent occupational exposure, incorporating engineering controls to restrict access during equipment use, and maintaining a system of continuous monitoring to ensure compliance with radiation safety standards. Moreover, routine evaluations of shielding performance and regular assessment of worker dose levels are essential to sustaining a safe working environment in high-use diagnostic settings.

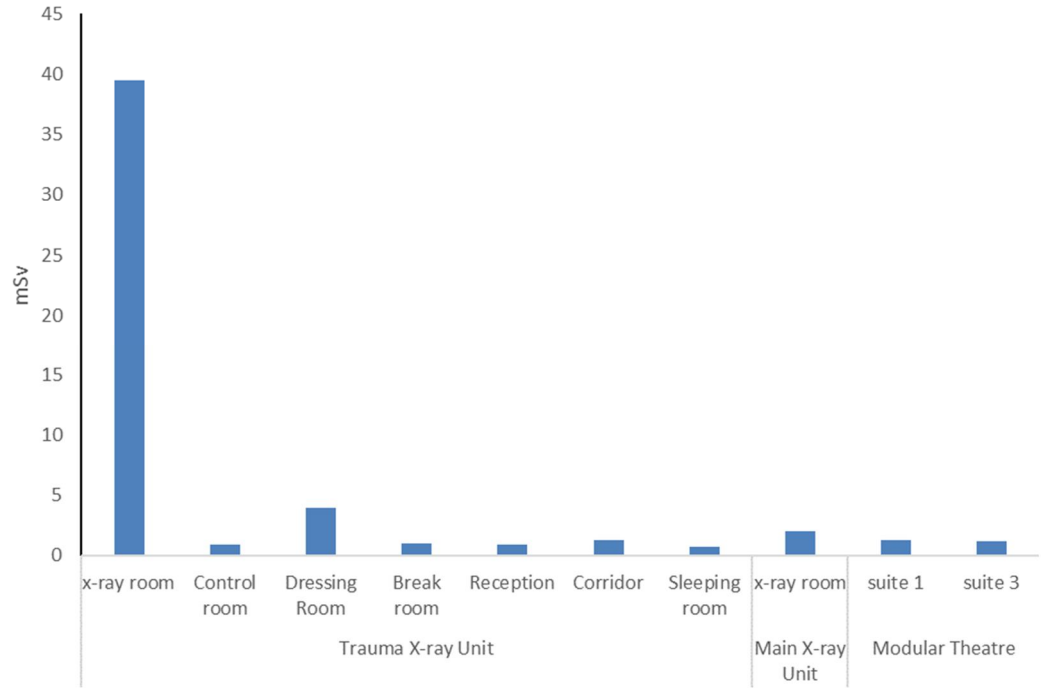

FIG. 2a. Annual Mean Effective Doses at Sampled Locations.

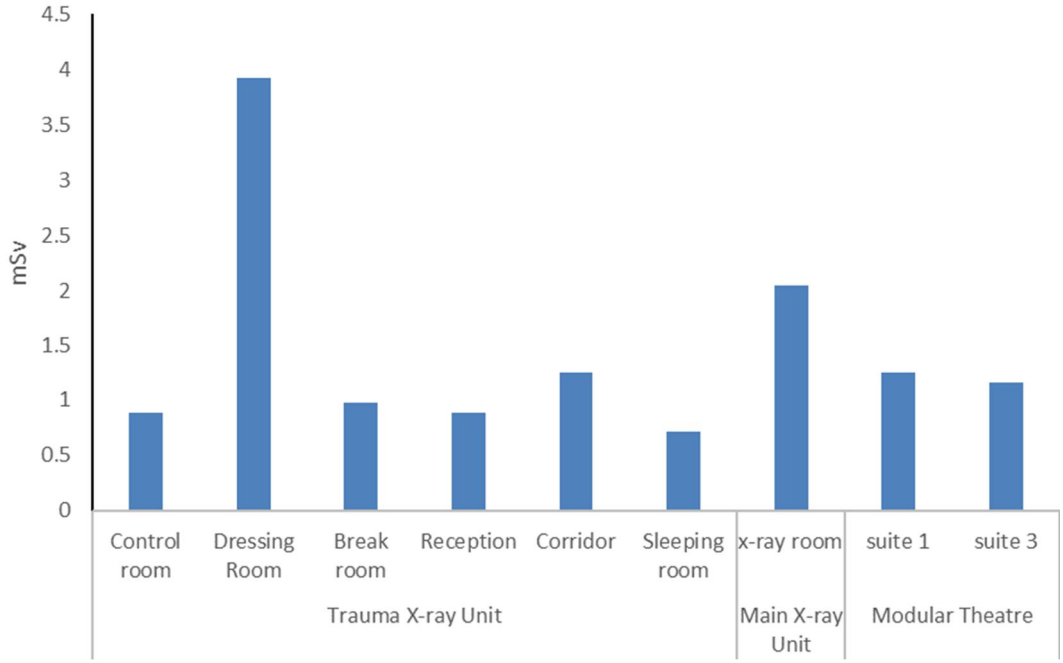

FIG. 2b. Annual Mean Effective Doses at Sampled Locations (excluding the X-ray room in the Trauma unit).

The corresponding values in the X-ray rooms at the main X-ray unit and the modular theatres are 2.05 mSv, 1.25 mSv, and 1.16 mSv, respectively, which makes health workers operating in those environments radiologically safe.

The dressing room recorded an annual mean effective dose of 3.92 mSv. This should not be a cause for alarm, as patients requiring treatment go there briefly to change their clothes. They do not stay there all day. The control unit recorded an annual mean effective dose of 0.89 mSv, which is very safe for the radiation worker who operates the X-ray machine.

Outside the X-ray room, the annual mean effective dose ranged from 0.71 mSv in the night room to 1.25 mSv along the corridor. At the reception, where patients wait before being attended to, the annual mean effective dose was 0.89 mSv. This value does not exceed the ICRP limit of 1 mSv for the general public [18], indicating the area is radiologically safe.

4. Conclusion

The environmental ionizing radiation levels at the Radio-Diagnostic Center of the National Orthopaedic Hospital, Igbobi, owing to the use of X-ray facilities, have been measured using thermoluminescence dosimeters (TLDs) chips placed at various points in and around the X-ray rooms. The largest effective dose was obtained in the X-ray room of the Trauma X-ray unit. Outside the X-ray room, there was a good attenuation of the radiation emissions to levels that were below the recommended permissible limits, thus posing no radiological health risks to humans.

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