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Full Length Research Paper

Scatter radiation dose assessment in selected areas at a radiology department in a teaching hospital in South Western, Nigeria.

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This study assessed the scattered radiation exposure level in a few selected locations, in the Radiology Department of the Ondo State University of Medical Sciences Teaching Hospital, Nigeria. The radiation leakages from the x-ray device and interaction of the patient's body with the beam of radiation formed the radiation exposure level which has tendency to produce stochastic and deterministic effect on patients under the clinical procedures. The x-ray operating potential (KVp) and current time product (mAs) parameters utilized at the X-ray control room during the clinical diagnosis were 65 KVp, 75 KVp, 80 KVp, 90 KVp and 6.30 mAs,10 mAs, 14 mAs, 45 mAs, respectively and examinations carried out during the experimental measurement covered chest, abdominal, lumbosacral, pelvis and wrist in the three projections (anterior-posterior, posterior-anterior and lateral). The smallest average exposure rate obtained at the Dark Room Location was 0.118 μSv/h and highest average exposure value recorded at the cubicle area as shown in the graphs with the value of 0.126 μSv/h. Moreover, the result obtained in this studied indicated that the values recorded were very close to the background exposure rate of 0.10 μSv/h measured before the conventional X-ray began its operations. Therefore, there were no danger of high radiation exposure to patients, health professionals and visitors at Radiology Department of the Teaching Hospital under the study. However, effort should be made to reduce the exposure rate through the enforcement of personal protective devices for staffs who directly conducted the X-ray procedure.

Key words: Radiation, anterior, posterior, lateral, deterministic, threshold

INTRODUCTION

The significance of X-rays in medicine cannot be overemphasized because they are crucial components for clinical, diagnostic, and therapeutic purposes (Donya et al., 2014; Martins et al., 2020). During clinical X-ray examinations, the interaction of X-ray beam energy with patients can result in scattered radiation, which has the potential to propagate into space (Vlachos et al., 2015). The patient also serves as a transient source of scatter

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radiation during X-ray examinations (Eyisi-Enuka et al., 2021 Several studies on radiation dose distribution in pediatric patients have highlighted that scattered radiation is the primary contributor to occupational exposure for personnel (Malimban et al., 2018).

Conventional X-ray and computed tomography (CT) scanners have been widely employed for years in diagnostic imaging of internal organs and tissues, including the chest, brain, abdomen, and more (Hussain et al., 2022). The CT scanner is especially valued in medical radiology due to its ability to provide high-quality three-dimensional images of internal tissues and organs like the skull, brain, chest, pelvis, and abdomen (Christos et al., 2022).

However, these radiation-based imaging technologies come with associated risks due to their deterministic effects (Frane and Bitterman, 2023). The potential danger of scattered radiation exposure is significant for both patients undergoing clinical examinations and the medical personnel directly involved in these procedures (Aborisade and Balogun, 2012). Moreover, there is substantial evidence from previous studies regarding the health effects of ionizing radiation, particularly when the exposure levels are high enough to cause disease or even death (Chaturvedi and Jain, 2019).

While cancer is a well-known side effect of ionizing radiation, researchers have also reported that infants exposed to radiation during pregnancy due to their mothers' exposure may potentially experience mental retardation as a result of high doses of ionizing radiation (Marazziti et al., 2012).

Furthermore, the biological and medical dangers associated with the constant rise in diagnostic radiological examinations and radiation exposure to patients, radiologists, radiographers, and other health practitioners have been a major concern for international regulatory organizations (Tsapaki et al., 2018). Similarly, efforts have been directed toward developing a suitable comparable dose threshold for expert exposure limits (Frane and Bitterman, 2023).

Recently, Owusu-Banahene *et al. (2018)* investigated the radiation dose in selected controlled and uncontrolled areas at the Cape Coast Teaching Hospital Ghana Radiology Department and reported that the distance from an X-ray machine and the efficacy of barriers had a significant impact on the radiation dose measured at various locations (wall and door). Furthermore, the observed radiation dose variation relative to background radiation levels at various locations was influenced by the distance between the locations and posed no danger to health personnel at the concerned hospital's Radiological Department (Owusu-BanaheneJ et al., 2018).

More recently, Lopez et al. (2021) assessed the radiation exposure of medical practitioners who participated in clinical neuro-endovascular diagnostic and therapeutic diagnosis at the hospital facility. Lopez et al. (2021) reported that patients were exposed to radiation levels below the average World threshold during clinical examinations. This study measured the quantity of scatter radiation exposure in the selected areas to assess the dose exposure for the patients and various health professionals who were either directly or indirectly involved in the clinical diagnostic process. The assessment of scattered exposure level was measured at specific locations concurrently with the conventional clinical examination X-ray machine operations in the control room at the Radiology Department of Ondo State University of Medical Sciences, Teaching Hospital, South Western Nigeria. The locations covered include the cubicle area (CA), radiographer’s office (RO), patient waiting area (PWA), receptionist desk (RD), and dark room (DR).

MATERIALS AND METHODS

Study location

The Ondo State University of Medical Sciences (UNIMED) research study center was established on December 8th, 2015. The university has proven medical technology facilities. It was established with the purpose of reducing the rate of maternal and infant fatalities among the inhabitants of Ondo State, Nigeria, in particular, and the entire country. The institution is located in Ondo City along the Laje Road at latitude 32.32 and longitude 90.17. The radiographers and other medical professionals who worked in the hospital displayed a high level of professionalism and were experts in their fields, as was observed during the experimental part of this paper. The facility was recognized as a referral hospital for X-ray diagnosis in Nigeria’s Western Region. Figure 1 shows the schematic diagram of the Radiology Department at the Ondo State University of Medical Sciences (UNIMED), Teaching Hospital, Nigeria.

Procedures

The procedure employed for the research was divided into two main groups: Installation of gamma scout device used and collection of data through the Machine.

Installation of gamma scout

The installation of the Gamma Scout device began with attaching the Gamma Scout window to the research computer system and verifying its compatibility before connecting the Gamma Scout machine using the supply cable. This sequence of steps enables convenient data reading and accurate documentation of measurements via the personal computer system, all while avoiding exposure to scattered radiation in the vicinity of X-rays. This is particularly beneficial when assessing radiation exposure levels in controlled areas. The installation of Gamma Scout software on the personal computer system strictly followed the manufacturer's manual instructions. The Gamma Scout was employed for detecting and measuring various research parameters, including counting rate, pulse rate, and dose rate, as required for the research work.

Collection of data through the machine

The installed gamma scout machine was linked to the computer

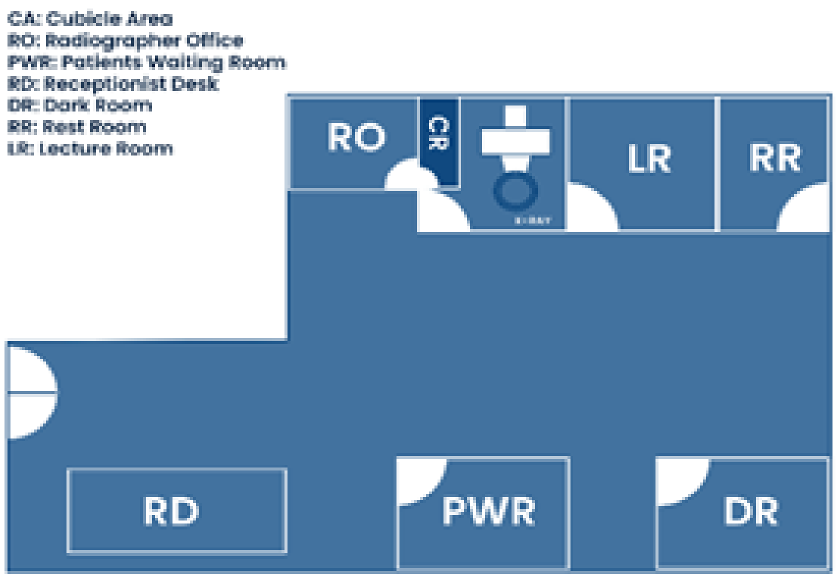

Figure 1. Schematic diagram of Radiology Department of Ondo State University of Medical Sciences (UNIMED), Teaching Hospital, Nigeria.

Table 1. Data measured at different location with X-ray operating parameters 65 Kev and 6.30 mAs .

Location	DR 1	DR 2	DR 3	DR 4	Mean DR μSv/h
CA	0.130	0.120	0.120	0.130	0.125
RO	0.130	0.110	0.132	0.130	0.126
PWR	0.120	0.130	0.120	0.120	0.123
RD	0.125	0.121	0.121	0.130	0.124
DR	0.130	0.085	0.130	0.130	0.119

CA -Cubicle Area ; RO-Radiographers Office; PWR -Patient Waiting Room; RD -Receptionist Desk; DR- Dark Room.

system via a long cable and positioned to measure the scattered exposure level at various selected locations in the cubicle area, radiographer's office, patient waiting room, receptionist desk, and dark room, all while conventional X-ray clinical examinations were being performed in the X-ray control room. During the course of the exposure measurement, a total of 150 patients were subjected to X-ray clinical diagnosis. The X-ray operating potential (*KVp*) and current time product (*mAs*) parameters used were 65 KVp, 75 KVp, 80 KVp, 90 KVp, 6.30mAs, 10 mAs, 14 mAs, and 45 mAs, respectively, and examinations covered the chest, abdominal, lumbosacral, pelvis, and neck in three projections (*anteriorposterior, posteriorposterior)*.

RESULTS AND DISCUSSION

The average background dose level measured at the Radiology Department of the teaching hospital under study before the clinical examinations began was 0.102 Sv/h. Table 1 shows the average exposure dose level at Cubicle Area (CA), Radiographers Office (RO), Patient Waiting Room (PWR), Receptionist Desk (RD), and Dark Room (DR) as 0.125 Sv/h, 0.126 Sv/h, 0.123 Sv/h, 0.124 Sv/h, and 0.119 Sv/h, respectively, when the X-ray operating potential and current time product were 65 Kev and 6.30 mAs.

The highest estimated exposure dose values were reported at the CA and RO locations, ranging from 0.125 Sv/h to 0.126 Sv/h, while the lowest result was obtained at the DR location, with a value of 0.119 Sv/h, as shown in Figures 2 and 3. Similar results were obtained in Table 2, as shown in Figures 4 and 5, when the conventional X-ray machine's operating parameters were 75 KeV and 10 mAs. The measured exposure dose levels at the teaching hospital locations ranged between 0.110 and 0.126 Sv/h. The highest average value recorded was 0.126 Sv/h at the Radiographers Office, and the lowest exposure value was 0.110 Sv/h at the Dark Room (DR), which is close to the background radiation value of 0.102 Sv/h.

The reported radiation dose exposure at the cubicle

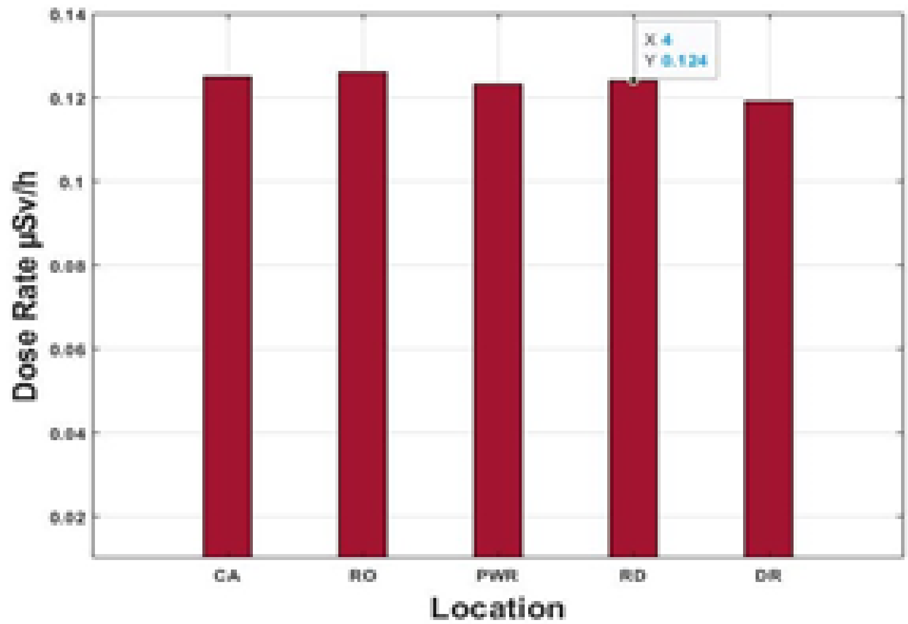

Figure 2. Measured data with 65 Kev and 6.30 mAs operating parameters.

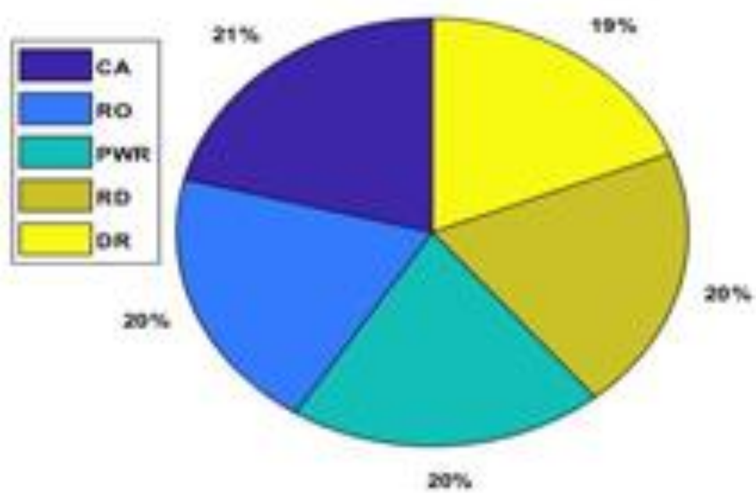

Figure 3. Average radiation exposure level in percentage at various spots with 65 Kev potential and 6.30 mAs current-time product.

Table 2. Data measured at different location with X-ray operating parameters 75 Kev and 10 mAs.

Location	DR 1	DR 2	DR 3	DR 4	Mean DR µSv/h
CA	0.120	0.131	0.123	0.130	0.126
RO	0.110	0.120	0.130	0.100	0.115
PWR	0.130	0.132	0.130	0.120	0.128
RD	0.120	0.112	0.130	0.100	0.116
DR	0.100	0.110	0.120	0.110	0.110

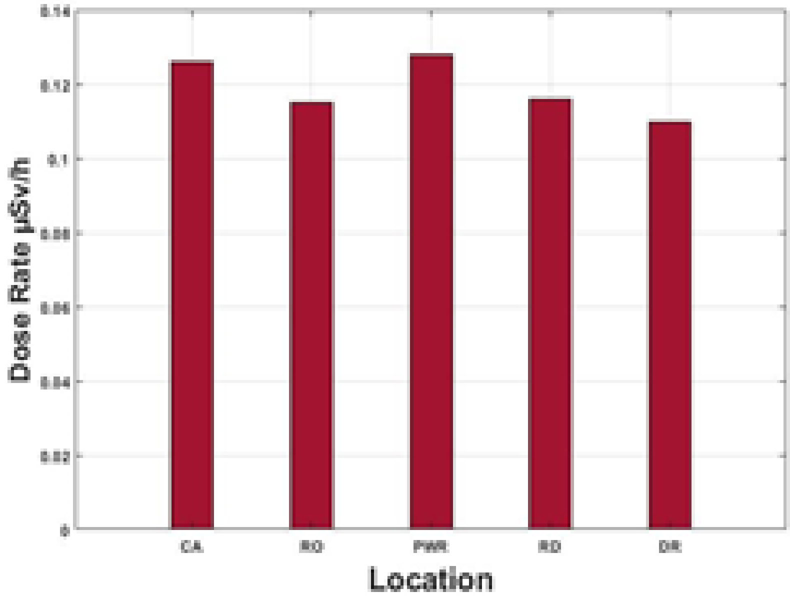

Figure 4. Measured data with 75 Kev and 10 mAs operating parameters.

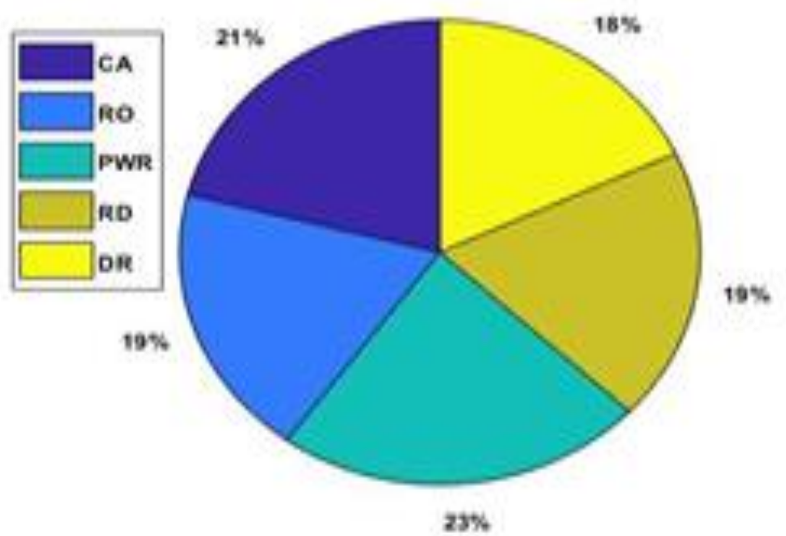

Figure 5. Average radiation exposure level in percentage at various spots with 75 Kev potential and 10 mAs current-time product.

area location was exceptionally high, measuring 0.129 µSv/h, particularly when the X-ray operating parameters were set at 80 Kev and 14 mAs, as illustrated in Table 3 and Figures 6 and 7. The Desk (RD) location had the lowest average value of 0.118 µ Sv/h and the highest average exposure level reported at the Cubicle Area (CA) with a value of 0.129 µ Sv/h. In the same vein, Table 4 and Figures 8 and 9 recorded and showed an exposure dose rate of 0.120 µ Sv/h at the radiographers office and a 0.121 µ Sv/h value at the patient waiting room when the 90 Kev and 45 mA were utilized by the machine during the experimental measurement. 0.123 µSv/h was reported at the cubicle area location, and the Dark Room area had the lowest value of 0.118 µSv/h. Finally, the overall average values of exposure dose rate measured at all selected locations, as mentioned before, are summarized in Table 5 and presented in Figures 10 and 11.

Table 3. Data measured at different location with X-ray operating parameters 80 Kev and 14 mAs.

Location	DR 1	DR 2	DR 3	DR 4	Mean DR μSv/h
CA	0.121	0.130	0.134	0.130	0.129
RO	0.130	0.110	0.121	0.123	0.121
PWR	0.130	0.130	0.121	0.120	0.125
RD	0.120	0.110	0.120	0.120	0.118
DR	0.130	0.130	0.112	0.130	0.126

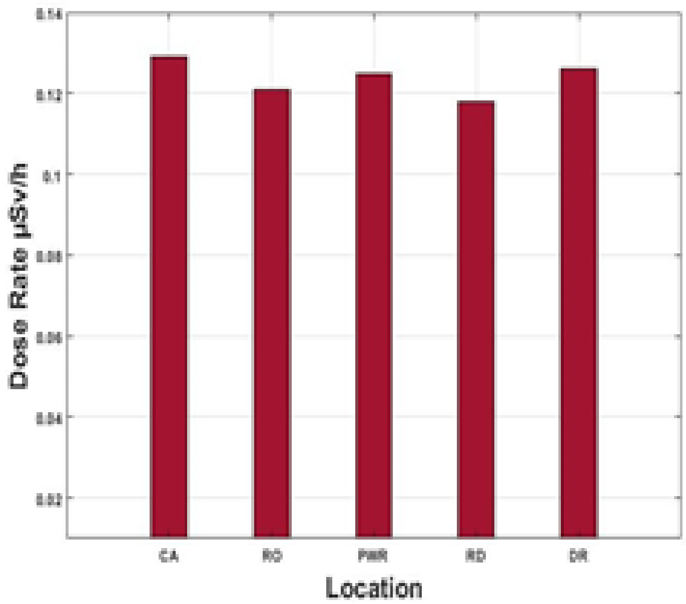

Figure 6. Measured data with 80 Kev and 14 mAs operating parameters.

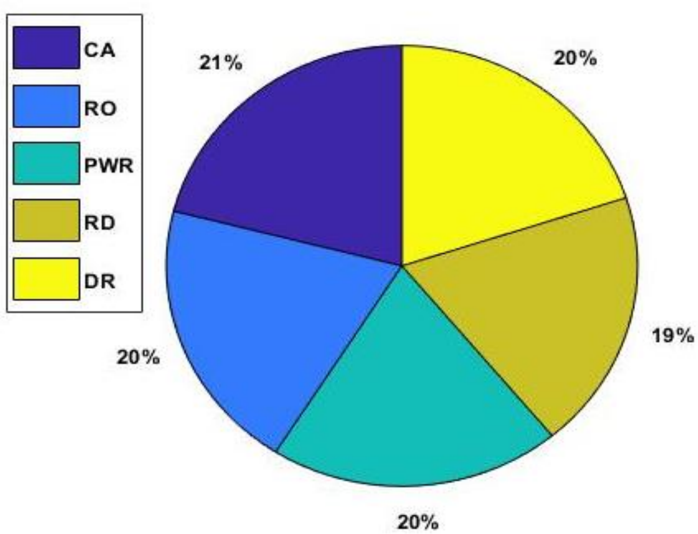

Figure 7. Average radiation exposure level in percentage at various spots with 80 Kev potential and 14 mAs current-time product.

Table 4. Data measured at different location with x-ray operating parameters 90 kev and 45 mAs.

Locations	DR 1	DR 2	DR 3	DR 4	Mean DR µSv/h
CA	0.120	0.121	0.120	0.130	0.123
RO	0.120	0.120	0.120	0.120	0.120
PWR	0.123	0.130	0.111	0.120	0.121
RD	0.120	0.121	0.120	0.114	0.119
DR	0.122	0.120	0.120	0.110	0.118

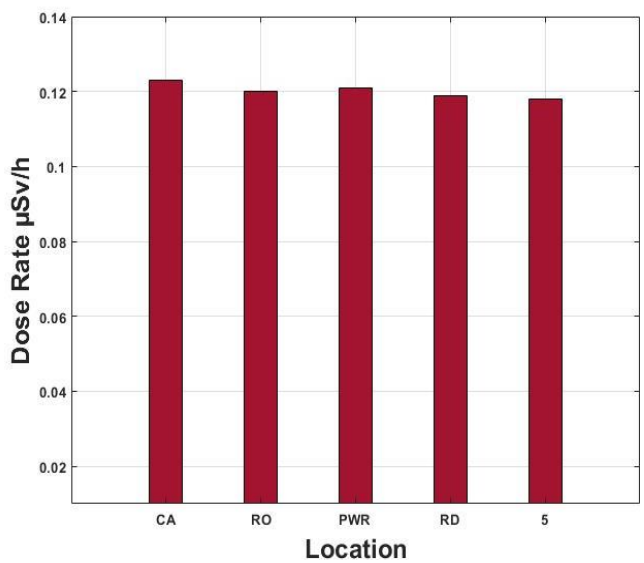

Figure 8. Measured data with 90 Kev and 45 mAs operating parameters.

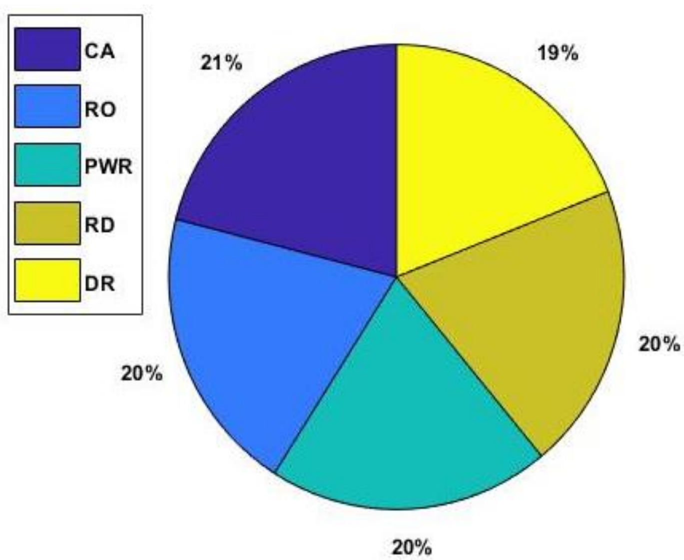

Figure 9. Average radiation exposure level in percentage at various spots with 90 Kev Potential and 45 mAs current-time product.

Table 5. Overall mean of data measured at different locations.

Location	Mean DR µSv/h
CA	0.126
RO	0.121
PWR	0.124
RD	0.119
DR	0.118

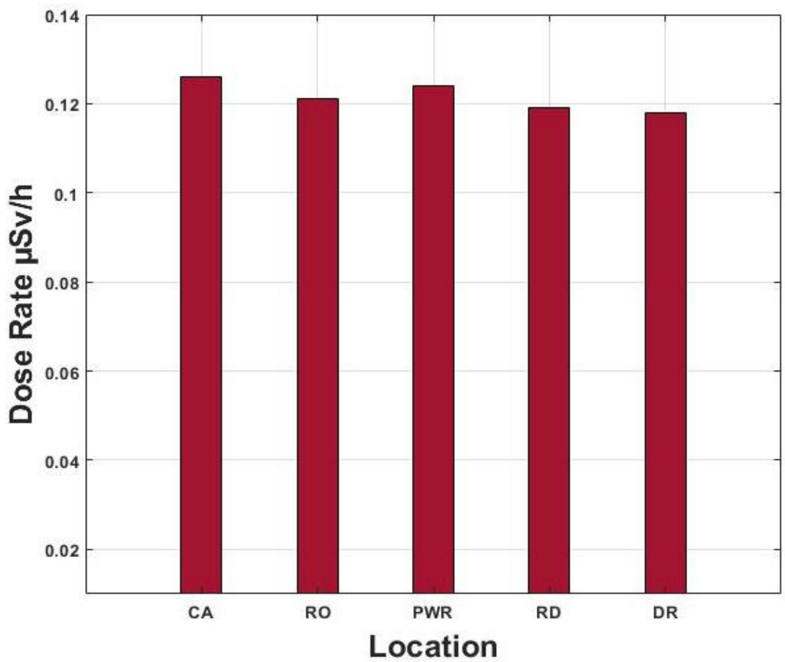

Figure 10. Overall average of data measured at different locations.

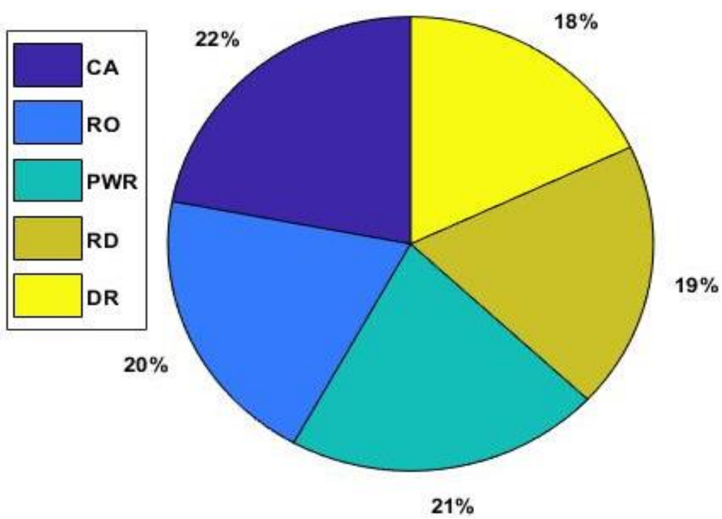

Figure 11. Overall average radiation exposure level in percentage at various spots.

Conclusion

The effective exposure rate results presented in this paper closely align with the average background radiation dose rate measured before the start of conventional clinical X-ray examinations. Any minor variations observed in these areas can be attributed to factors such as the distance between locations, the effectiveness of X-ray room barriers, and the design of walls and doors as radiation obstacles within the teaching hospital. Among the examined locations, the cubicle area exhibited the highest effective dose rate, measuring 0.126 Sv/h, which was 4.1% higher than the exposure rate recorded at the nearest radiographer's office. This difference can be attributed to the distance between these two locations. Additionally, patient waiting rooms showed an average effective dose rate 4.0% and 4.8% higher than that of the receptionist desk and the dark room, respectively. In conclusion, it can be inferred that the distance between locations and the effectiveness of shielding materials within the X-ray control room play significant roles in reducing radiation absorption rates. It is essential to implement measures aimed at reducing radiation exposure from X-ray tubes and ensuring that healthcare personnel consistently use personal protective equipment during clinical examinations, including in the control cubicle area, as even small amounts of radiation can have stochastic effects. Finally, it is advisable to position the receptionist desk, radiographer's office, and patient waiting rooms at a considerable distance from the X-ray control room.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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