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Evaluation of X-Ray Radiation Levels in Radiology Departments of Two Educational Hospitals in Ahvaz, Iran

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ABSTRACT

Introduction: The ionizing radiation is increasingly applied in various fields for industrial and medical purposes due to its benefits. The aim of this study was to measure the radiation levels in six radiology departments of two educational hospitals in Ahvaz, Iran.

Materials and Methods: The radiation levels were measured at six locations of six radiology departments, including behind the patient observation window, staff rest room, office, patient waiting room, behind the door of the X-ray room, and outdoor. These measurements were carried out while the X-ray equipment was in on and off status, using the halogen-quenched Geiger-Mueller counter.

Results: According to the results, the range of radiation levels inside the radiology departments at X-ray units with on/off status were 0.36±0.12 to 0.09±0.02 μSv/h and 0.13±0.02 to 0.09±0.03 μSv/h, respectively. Furthermore, significant differences were observed between the indoor and outdoor radiation levels in all locations.

Conclusion: As the findings indicated, the surveyed X-ray equipment in the radiology departments of two educational hospitals was safe. The radiation dose levels were within the safe recommended limits in all locations except two points due to some structural problems, which were recognized and would be corrected as soon as possible.

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Introduction

Today, the application of ionizing radiation plays a significant role in the medical and industrial procedures. Despite the diagnostic and therapeutic benefits of this type of radiation, the impact of the environmental and occupational exposure to these radiations on human health is still a public concern. The two main sources of ionizing radiation exposure are natural and anthropogenic origins. As estimated, the natural sources (i.e., terrestrial and cosmogony origins) account for 80% of the annual total radiation dose for general population, and the remaining belongs to exposure to the man-made radiation sources [1-3].

The ionizing radiation is mainly applied in the hospitals, clinics, and radiology imaging centers in urban environments for medical purposes. In these places, the radiation is originated from the diagnostic and background radiation. One of the most well-known sources of ionizing radiation for general population is the diagnostic X-ray imaging, which accounts for almost 14% of the total exposure to anthropogenic and natural sources [4].

The relationship between the ionizing radiation and increased cancer risk after exposure to high doses is well documented [5, 6]. Nevertheless, there are doubts on how to extrapolate this knowledge to low-dose radiation since the majority of the people undergo such experience many times during their lives [7, 8]. The ionizing radiation can affect the chemical state of an exposed material, and consequently initiate some biologically important changes. These adverse effects can include a chromosomal transformation, cancer induction, free radical formation, bone necrosis, and radiation cataractogenesis [9-11].

It is documented that both chronic and acute exposure to ionizing radiation can cause clinical symptoms in the exposed body [3, 10]. Regarding these adverse effects, it is crucial to monitor and assess the respective exposure levels of ionizing radiation to keep it as low as reasonably achievable (ALARA). The X-ray with radiation power of 140-180 kV is the effective dose for the patients and personnel in the radiography centers and hospitals [12-14]. Therefore, obtaining the knowledge in terms of the background radiation in such centers is crucial for understanding the high risk of unwanted adverse effects of ionizing radiation exposure [14].

James et al. measured the indoor and outdoor background ionizing radiation levels of Kwali General Hospital in Abuja, Nigeria. They reported the dose

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equivalent range to be 0.107±0.003 and 0.108±0.003 μSv/h for indoor and outdoor, respectively [15].

In a study carried out by Basirjafari et al. (2014), the mean outdoor gamma dose rate was 0.094±0.024 μSv/h [16]. In another study conducted by Okoye et al. (2013) in a medical center, the results showed that the average range for indoor measurement within X-ray department, locations within the hospital, and the departments within this center were 0.14±0.02 μSv/h, 0.14±0.02 μSv/h, and 0.13±0.02 μSv/h, respectively [2].

With this background in mind, this study aimed to measure the indoor and outdoor X-ray radiation level in six radiology departments of two educational hospitals in Ahvaz, Iran.

Materials and Methods

This cross-sectional study was conducted in six radiology departments of two hospitals during May-July 2015. The radiation levels were inspected in six locations of the respective radiology departments in both on and off status of X-ray generating device, using the calibrated digital Geiger-Muller counter (S.E. International Inc., USA). The instrument was calibrated electronically according to the instruction of the manufacturer. The detector is able to measure dose rates from 0.01 μSv/h to 1000 μSv/h with accuracy of 15%. The measurement was repeated at each location for at least five times with 3 min intervals.

The device was placed with the end window facing the area where count rates were taken. We recorded the mean displayed by the detector during the X-ray imaging with high exposure (lumbar spine and abdominal imaging with 0.7 and 1.2 mSv, respectively [17]). The measured locations included behind the patient observation window, staff rest room, office, patient waiting room, behind the door of the X-ray room (entrance door for patients), and outdoor (Figure 1).

The monitor was held one meter above the terrestrial level in all the six locations except for behind the patient observation window, which was 1.5 meter high. The equivalent dose (in μSv/h) was measured in all locations investigated in this study. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report recommended the occupancy factors of 0.2 and 0.8 for outdoor and indoor, respectively [3]. The occupancy factor is the proportion of the total time during which an individual is exposed to a radiation field. In this study, due to major work shifts and overtime, 4600 h/y was used instead of 8760 h/y, which is generally used by the UNSCEAR.

To convert micro Sievert per hour (μSv/h) into mili Sievert per year (mSv/y), the following equations were applied:

1) Annual indoor equivalent dose rate (mSv/y) = indoor equivalent dose rate (μSv/h) × 4600 (h/y) × 0.8 (indoor occupancy factor) × 0.001

2) Annual outdoor equivalent dose rate (mSv/y) = outdoor equivalent dose rate (μSv/h) × 4600 (h/y) × 0.2 (outdoor occupancy factor) × 0.001

The irradiation parameters of X-ray generating lamp included the voltage of 100 or 150 kV, time of 2 s (dead time of survey meter is longer than 0.1 s), and tube current of 50 mA. The data analysis was performed using the descriptive statistics and one-sample t-test through SPSS version 22.0 (IBM SPSS Inc., 1989-2013). P-value less than 0.05 was considered statistically significant.

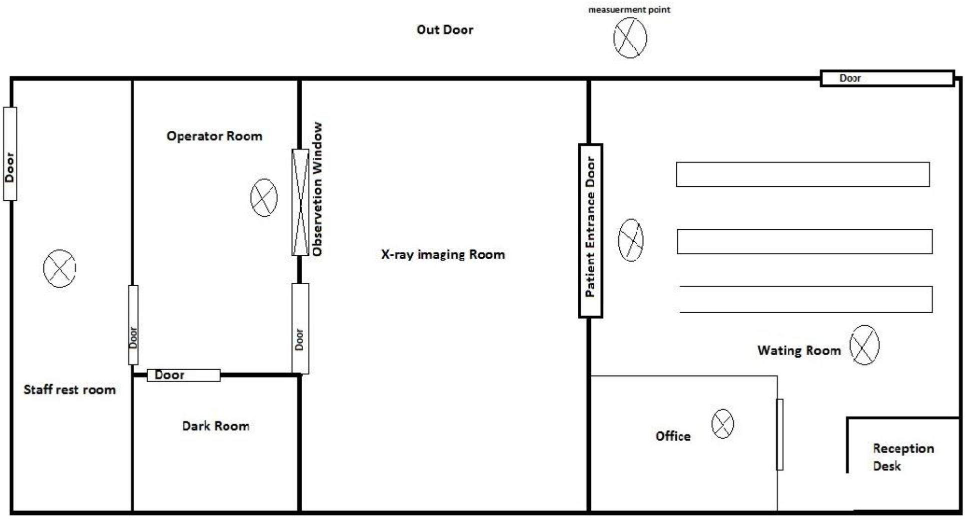

Figure 1. Schematic of a radiology department with six measurement locations

Results

The measured values of different radiation levels in six locations of six radiology departments in two hospitals in both on and off status of X-ray generating device are presented in Table1. The mean dose rate (μSv/h) and annual dose rate (mSv/y) of indoor and outdoor in each of the hospital radiology departments (while the X-ray generating equipment was working) are displayed in Table 2.

The results showed no significant difference between the background radiation and the X-ray radiation levels in the radiology departments while the X-ray generating equipment was off (P>0.365). Nevertheless, there was a significant difference between the background radiation and the X-ray radiation levels during the radiography procedure in two locations of the radiology departments in hospital 2, radiology department 4 (i.e., patient observation window and behind the door of the X-ray room) (P<0.001; Table 1).

Furthermore, there was a significant difference between the indoor and outdoor measured levels in both hospitals (P<0.001; Table 2). The statistical comparison between the two hospitals for indoor and outdoor levels showed no significant relationship. Figure 1 presents the comparison between the recorded dose rates and the standard levels for indoor measured levels.

Table 1. Average levels of radiation levels in six locations of two hospitals (μSv/h)

		Equipment status	Patient observation window	Staff rest room	Office	Patient waiting room	Behind the door of X-ray room	Outdoor
Hospital 1	Radiology department 1	on	0.128±0.014	0.128±0.018	0.132±0.001	0.132±0.001	0.132±0.001	0.085±0.002
		off	0.126±0.01	0.126±0.02	0.130±0.002	0.130±0.002	0.130±0.002	
	Radiology department 2	on	0.131±0.002	0.119±0.024	0.098±0.036	0.131±0.002	0.131±0.002	0.08±0.02
		off	0.130±0.01	0.118±0.01	0.097±0.03	0.129±0.002	0.130±0.002	
	Radiology department 3	on	0.136±0.022	0.131±0.002	0.098±0.036	0.131±0.002	0.131±0.002	0.092±0.001
		off	0.134±0.02	0.129±0.01	0.097±0.03	0.128±0.01	0.130±0.001	
Hospital 2	Radiology department 4	on	0.365±0.11*	0.128±0.018	0.131±0.002	0.132±0.001	0.367±0.12*	0.065±0.03
		off	0.131±0.015	0.127±0.019	0.130±0.002	0.130±0.002	0.124±0.03	
	Radiology department 5	on	0.122±0.023	0.132±0.18	0.131±0.002	0.117±0.022	0.117±0.022	0.085±0.002
		off	0.122±0.01	0.131±0.02	0.130±0.001	0.115±0.02	0.115±0.02	
	Radiology department 6	on	0.128±0.024	0.098±0.036	0.098±0.036	0.132±0.001	0.132±0.001	0.085±0.002
		off	0.125±0.03	0.097±0.03	0.097±0.03	0.130±0.002	0.130±0.002	

*Above the standard level

Table 2. Mean values of indoor and outdoor radiation dose rates while the X-ray generating equipment was working

		Measurement unit	Indoor	Outdoor	P-value
Hospital 1	Radiology department 1	μSv/h	0.130±0.002	0.085±0.002	0.001
		mSv/y	0.48±0.007	0.08±0.0018	
	Radiology department 2	μSv/h	0.122±0.014	0.08±0.02	0.001
		mSv/y	0.45±0.05	0.074±0.0184	
	Radiology department 3	μSv/h	0.125±0.02	0.09±0.001	0.003
		mSv/y	0.46±0.074	0.083±0.001	
Hospital 2	Radiology department 4	μSv/h	0.214±0.09	0.065±0.03	0.000
		mSv/y	0.76±0.017	0.06±0.03	
	Radiology department 5	μSv/h	0.122±0.008	0.085±0.002	0.001
		mSv/y	0.45±0.03	0.08±0.0018	
	Radiology department 6	μSv/h	0.124±0.015	0.085±0.002	0.003
		mSv/y	0.46±0.055	0.08±0.0018	

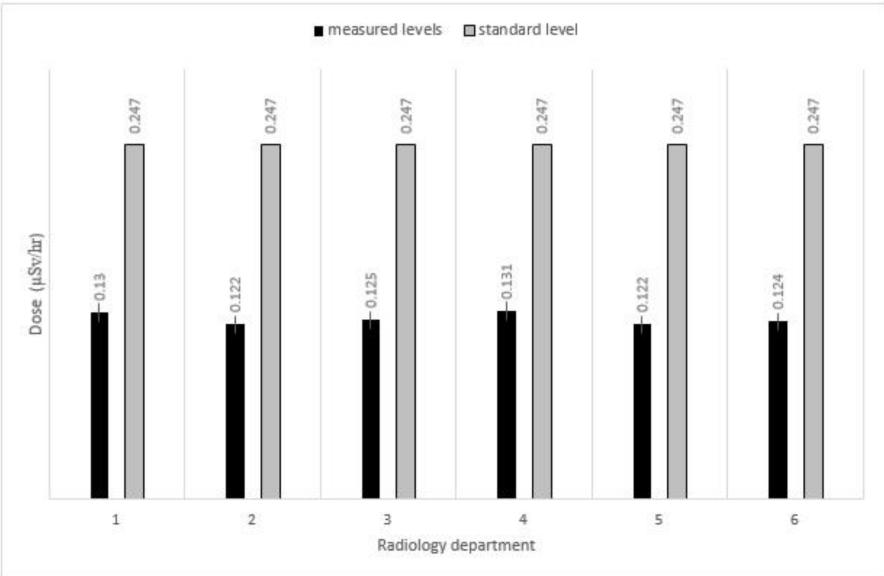

Figure 2. Comparison of the standard level with the measured levels at six radiology departments

Discussion

In this study, we measured the indoor, outdoor, and background radiation levels in six radiology departments of two hospitals. According to the results of the study, the minimum and maximum ionizing radiation levels in indoor spaces of the hospital 1 were 0.097±0.001 μSv/h and 0.136±0.022 μSv/h, respectively. In this regard, in hospital 2, the minimum and maximum values were 0.367±0.122 μSv/h and 0.097 ±0.03 μSv/h, respectively. In terms of the outdoor spaces, these values were 0.092±0.001 μSv/h and 0.065±0.02 μSv/h, respectively, which were much lower than the values reported by Faraj et al. and Oluwafisoye et al. [18, 19].

As the results demonstrated, in one of the radiology departments, the measured values for on/off status of the X-ray generating equipment were significantly different in two locations. This significance can be explained by the fact that the mentioned X-ray imaging room was much smaller than the other radiology departments. Moreover, further inspection revealed that the door of this imaging room could not be completely closed due to some structural problems of the door.

Similarly, in a study conducted by Kanchan et al., similar defects were reported to be responsible for the observed leakage [20]. As noted by Cardis et al., medical doses were much less uniform and very dependent on technical factors that may have not been recorded [21]. The results demonstrated that even the slightest defects in the structural design of the imaging room can lead to higher exposure levels.

The equivalent dose rates (mSv/y) were below the threshold limit of 1 mSv/y in all locations of the radiology departments, which is recommended for the public by the International Commission on Radiological Protection, 1990 [22]. The study showed that the radiation levels were within the permissible limits. This finding was consistent with the results reported by Okoye et al., James et al., and Adhikari et al. [2, 15, and 20].

Conclusion

In order to improve the radiation protection in the hospitals, it is suggested to perform regular maintenance and inspect the accidental defects and leakage of the X-ray generating equipment. As the findings indicated, the X-ray machines working in the radiology departments of the two educational hospitals were safe, and the radiation dose levels in all parts were within the safe limit. The results showed that all the radiology departments were according to the radiation protection criteria except for one ward. The establishment of the basic safety standards is of paramount importance for these centers, which are checked by the national radiation protection agency. Consequently, the enforcement of radiation control and establishments of rules and regulations could be helpful in this regard.

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