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Assessment of the effective radiation dose of controlled and uncontrolled area of selected hospitals in Uganda

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Abstract

The effective radiation dose rates were measured in the four hospitals using Gamma scout dosimeter. This research study was conducted at four different major hospitals in Uganda, because these hospitals and medical institutions might have maximum chances of radiation hazards to the personnel and public. From the results obtained, dose values only in controlled and uncontrolled areas of both hospitals A, B and C are below prescribed dose limits due to efficiency of protection as well as design of X-rays rooms in these hospitals. Hospital D (doors and walls) are not appropriate to the standards except hospitals A, B and C. There are risks of high radiation for patients and people visiting X-rays departments of hospital D as well as risks for clinical staff working at those X-rays departments.

The current study reveals that, currently, radiographers' practices are unsatisfactory in regard to reducing radiation exposure for patients and themselves. Thus, a systematic and harmonized approach should be initiated in the form of corrective actions to ensure that radiation protection measures and standards are properly implemented in radiology departments.

1 Introduction

Diagnostic X-ray provides great benefits that their use involves some risks of developing human carcinogen is generally accepted (Damilakis et al., 2010). It cannot be ignored that the diagnostic X-ray procedures contribute maximum population radiation dose as compared to other man made radiation sources. Therefore, X-ray beam must be constricted to outside (both controlled and uncontrolled area) of X-ray departments by protecting them with high shielding materials such as lead. Patients, clinical staffs and public must be carefully protected from un-useful beam of X-ray. Patients are protected by installing good and carefully calibrated X-ray machines, while clinical staffs and public are protected by building high protected X-ray rooms.

Photons penetrating through of X-ray room may be divided into two groups; photons that are generated from primary beam scattering that is used for diagnosis and photons that penetrate the X-ray tube (leakage) (Jadiyappa, 2018). Both groups contribute the dose at the control and uncontrolled areas which depends on the thickness, elemental composition, and density of the concrete walls as well door and window of the room.

Based on International Commission on Radiological Protection (ICRP, 1991; ICRP, 1993; ICRP, 2004) and International Atomic Energy Agency (IAEA, 1997) recommendations for the annual limit of effective dose to members of the general public that are in uncontrolled areas such as patients, visitors to the facility, and employees who do not work routinely with radiation sources, shielding designs should limit exposure to an effective dose that does not exceed 1 mSv per single year (Omojola et al., 2021). Radiologists are occupationally exposed to low level of ionizing radiation during normal working. However, the dose level should not exceed 1 mSv in a single year with the maximum possible limit of 20 mSv per year (IAEA, 1997; Omojola et al., 2021). As the dose level exceed limit the probability of occurring cytogenetic abnormalities and fatal cancer risk for the clinical staffs performing diagnostic procedures would increase (Radiological Protection Institute of Ireland, 2009). The dose received by the clinical staff changes from machine to machine, number of patients and working hours per day and safety precautions followed. The best way to ensure that personnel are following effect safety rules is with personnel monitor and this is recommended by all radiation protection agencies. The dosimeter must be fixed so that it measures good indication of the radiation dose uniformly received on the body.

To prevent scattering radiation, when designing new facilities the design should be to a standard that will keep the doses to clinical staffs and members of the public as low as reasonably achievable (the ALARA principle) taking social and economic factors into account. This means that the facility should be designed to ensure that the radiation exposure of clinical staffs and members of the public are much lower than those of the legal dose limits (Sanchez et al., 2020). It is advisable to check periodically the X-ray installations for proper filtration, kVp calibration, mAs linearity, leakage radiation etc. (Omojola et al., 2021).

2 Method

2.1 Research design

The study adopted a descriptive experimental design as the variables cannot be controlled.

2.2 Scope

This research study was conducted at four different major hospitals in Uganda, because these hospitals and medical institutions might have maximum chances of radiation hazards to the personnel and public.

2.3 Data Collection Instrument

This study used Gamma scout dosimeter as the data collection instruments.

2.3.1 Gamma Scout

The device is equipped with an end- window Geiger-Muller counter cylindrical tube enabling to detect different kinds of ionizing radiation such as gamma and X-rays. Therefore, it was suitable for the current survey to detect and measure effective dose from X-ray. The dosimeter was used to measures the effective dose at the control area, exact position of working radiologists and uncontrolled area such as patient waiting area or corridors near main door of diagnostic X-ray units.

Measurements were performed during the daytime, normal working hours of the selected hospitals which were eight hours per day from 9 AM to 5 PM and 6 days per week. Measurements were carried out at one meter above the ground surface by fixing the dosimeter on a stand of one meter height which was approximately parallel to the X-ray tube with the same height. Before the machines were switched on, the background radiation was measured in all selected hospitals. Subsequently after the exposure to the radiation, the fall out radiation was measured in control panel and patient waiting area. Machines were operated for a range of energies (60, 81 and 105 KeV) and X-ray intensities (1.4, 28 and 45 mAs) which represents the exposures for diagnostic imaging of body parts such as hands and legs, nasal sinus and vertebrae respectively. For each exposure three measurements were recorded to reduce the statistical error and calculating standard deviation. Above exposure ranges and types of imaging were selected because are most popularly applied in the selected hospitals. Data collected by the utilized dosimeter were measured in unit μSv/hr and are converted into mSv/yr by multiplying measurements by 8 hours per day and six days per weeks and 52 weeks per year in order to make comparison between background and X-rays radiation, time of working in the selected hospitals.

3 Finding

The effective dose rates were measured in the four hospitals using Gamma scout dosimeter. The results of effective dose rate (mSv/yr) measurements for controlled and uncontrolled area are shown in Table 1. Doses are different from one hospital to another depending on the building design and structure of X-ray rooms. Mean is the average of three measurements for each kVp and mAs values. All measurements are with background radiation.

It can be seen that as the X-rays parameters (kVp & mAs) were increased more X-ray is penetrated through X-rays rooms and detected by the dosimeter at the both controlled and uncontrolled areas. Also it can be seen that in Table 1, the recorded dose values in both hospitals A, B and C are in normal ranges. However, in hospitals D, dose values are more than normal ranges especially in uncontrolled area (public area) in compare to the reference limit 1 mSv per year for public exposure (IAEA, 1997; ICRP, 2004). This means that photons of X-rays are penetrated through diagnostic rooms of these hospitals due to inefficiency of walls or doors of the rooms.

Table 1: Effective dose measured from background radiation and from diagnostic X-ray with background together in controlled and uncontrolled areas

Hospitals	kV_p	mAs	Mean ± SD (mSv/yr)		Background radiation
			Controlled A	Uncontrolled A	
A	60	1.4	0.23 ± 0.01	0.21 ± 0.01	0.21 ± 0.01
	81	28	0.24 ± 0.02	0.21 ± 0.02	
	105	45	0.25 ± 0.01	0.22 ± 0.02	
B	60	1.4	0.22 ± 0.01	0.22 ± 0.01	0.22 ± 0.01
	81	28	0.22 ± 0.03	0.22 ± 0.01	
	105	45	0.22 ± 0.02	0.22 ± 0.02	
C	60	1.4	0.21 ± 0.01	0.22 ± 0.01	0.21 ± 0.01
	81	28	------------	-----------	
	105	45	1.85 ± 0.03	0.56 ± 0.07	
D	60	1.4	0.26 ± 0.01	0.25 ± 0.01	0.21 ± 0.01
	81	28	2.28 ± 0.11	1.80 ± 0.08	
	105	45	12.98 ± 0.16	12.93 ± 0.25	

4 Discussion

From the measurement of effective radiation dose in the controlled areas, it can be noted that the highest values (2.28, 12.98 $mSv \cdot yr^{-1}$) are measured in hospital D for X-ray parameters (81, 105 kVp and 28, 45 mAs). The measured values are below reference limits (20 $mSv \cdot yr^{-1}$) of the NCRP organization for radiation workers; however, these values are not normal and can be reduced by fixing the room and installing shielding materials. Also radiation dose in hospital C somewhat is high (1.85 $mSv \cdot yr^{-1}$) and are above normal ranges. This suggests the risks associated to employees and clinical staff involved in these facilities. Therefore, immediate radiation protection measures to be initiated to the employees (radiologists, radiographers, technicians and attendants).

Also mean amount of radiation found in the uncontrolled area of hospital D surpassed the prescribed dose limit. There is an obvious health risk of radiation exposure for all the exposed population visiting radiography department of this hospitals. So, there is a necessity of adequate and appropriate radiation protection at these X-ray departments. The radiations measured at other hospitals were below the reference dose limit 1 mSv/yr for public and there were no risks for public.

It can be seen that from the results obtained, dose values only in controlled and uncontrolled areas of both hospitals A, B and C are below prescribed dose limits due to efficiency of protection as well as design of X-rays rooms in these hospitals. Hospital D (doors and walls) are not appropriate to the standards except hospitals A, B and C. There are risks of high radiation for patients and people visiting X-rays departments of hospital D as well as risks for clinical staff working at those X-rays departments. The highest effective doses were measured in uncontrolled area of hospital D.

5 Conclusion

The current study reveals that, currently, radiographers' practices are unsatisfactory in regard to reducing radiation exposure for patients and themselves. Thus, a systematic and harmonized approach should be initiated in the form of corrective actions to ensure that radiation protection measures and standards are properly implemented in radiology departments.

The large variation in doses observed in operators and public areas in the selected hospitals suggests that optimising procedure protocols and implementing general use of the most effective types of protective shields may reduce occupational radiation doses to operators as well as patients or visitors.

The ALARA concept is an essential theme in radiation protection in medicine, as its main purpose is to prevent unnecessary radiation exposure and optimize radiation doses. The three major principles of applying ALARA are: time, distance and shielding. Radiographers can effectively improve radiation protection through compliance with the established international guidelines and standards of practice and by utilizing proper tools and equipment.

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