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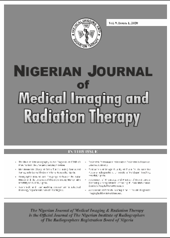

COMPLIANCE TO SHIELDING STANDARDS OF SOME SELECTED RADIO- DIAGNOSTIC CENTERS IN GOMBE STATE, NIGERIA.

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ABSTRACT

Background: Shielding design goals are reference values, used in the design or evaluation of barriers constructed for the protection of patients, staff and the general public

Objectives: To assess the compliance to shielding design goals (P) of some selected radio diagnostic centres in Gombe State as recommended by the NCRP.

Materials and Method: The survey was conducted in six radio diagnostic centers in Gombe State Nigeria, labeled A to F for anonymity. A measuring tape was used to measure distances from the X-ray source to the nearest barrier. A Radiation survey meter RDS 200 was used for radiation survey of controlled and uncontrolled areas. Simple statistical tools such as mean and standard deviation were used for analysis with the aid of Microsoft Excel version 2010.

Results: The Measured exit dose (MED) at a distance of 1.9 m from the source in the controlled area of facility A is 0.21000±0.0000mSv/wk. The measured exit dose behind wall1 in facility B is 0.20832±0.0001 mSv/wk, at a distance of 2m from the source Facility C and D recorded doses at all locations were within the recommended design dose limits. MED in uncontrolled area, that is behind wall 2 at a distance of 2m from the source in facility E is 0.03192±0.0005 mSv/wk. In facility F, MED for uncontrolled areas; behind the door 0.22344±0.0000, behind wall 1 0.21670±0.0161 and behind wall 2 0.04536±0.0012 at a distance of 3.7m, 2.1m and 3.4m respectively from the source.

Conclusion: Measured exit dose were found to be above the recommended dose in some certain locations in facility A, B, E and F.

INTRODUCTION

Shielding design goals (P) are levels of air kerma used in the design calculations and evaluation of barriers constructed for the protection of employees and members of the public [1]. Shielding is the third radiation protection action. There are many types of radiations which may be injurious to health; the primary ones of concern being x-rays, gamma rays and neutron particles. It is widely accepted that if adequate shielding is provided for these forms of radiation, then the effects from the others can be considered negligible [2]. Theoretically, all materials could be used to attenuate the radiation to safe limits, however, due to certain characteristics, lead, copper and concrete are among the most commonly used materials. Shielding implies that certain materials (concrete, lead) will attenuate radiation (reduce its intensity and energy) when they are placed between the source of radiation and the exposed individual [3].

Hence, shielding strength or "thickness" is conventionally measured in units of g/cm^2. The radiation that manages to get through falls exponentially with the thickness of the shield. In x-ray facilities, walls surrounding the room with the x-ray generator may contain lead sheets, or the plaster may contain barium sulfate. Almost any material can act as a shield from gamma or x-rays if used in sufficient amounts [4]. There are two types of protective barriers; The Primary Barrier: is one which is directly struck by the primary or the useful beam and the secondary Barrier: which is the one which is exposed to secondary radiation either by leakage from x-ray tube or by scattered radiation from the patient. The shielding of x-ray room is influenced by the nature of occupancy of the adjoining area. In this respect, two types of areas have been identified.

The control Area is the area routinely occupied by radiation workers who are exposed to an occupational dose [5]. Controlled areas are limited access areas in which the occupational exposure of personnel to radiation and the radiation environment is subject to monitoring. Examples of controlled area include the x-ray rooms or x-ray control booth.

National Council on Radiation Protection and Measurements (NCRP), (2005) recommends 5mSv/year and a weekly shielding design dose limit of 0.1mSv/week for controlled areas [6]. This P value adopted for controlled areas will allow pregnant radiation workers continued access to their working areas.

Recommendation for controlled areas shielding design goal (P) (in air kerma): 0.1 mGy week–1 (5 mGy y–1) [1].

Uncontrolled areas are those areas which are not occupied by occupational workers [5]. Uncontrolled areas are those occupied by individuals such as patients, visitors to the facility, and employees who do not work routinely with or around radiation sources.

Areas adjacent to but not part of the x-ray facility are also uncontrolled area. Examples of uncontrolled area include the corridors and public toilets [7].

NCRP, (2005) recommends that a suitable source control for shielding individuals in uncontrolled areas is an effective dose of 1mSv/yr with a design dose limit of 0.02mSv/week.

Recommendation for uncontrolled areas shielding design goal (P) (in air kerma): 0.02 mGy week^{-1} (1 mGy y^{-1}) [1].

National Council on Radiation Protection and Measurements (NCRP) recommendations. NCRP, (2005) provides the widely accepted methodology for radiation shielding design. However this study is aimed to determine shielding design goal values (P) of the studied area and compare to the recommended values set by the NCRP

MATERIALS AND METHOD

The study was a cross sectional survey, conducted on x-ray equipment of six radio-diagnostic centers in Gombe state, Nigeria between the period of 2 months (from August to September, 2018). These centers were labelled A B, C, D, E and F for anonymity. Center B and C are private radio-diagnostic centers while center A, D, E and F are government-owned hospitals. They are selected because their x-ray machines were functional at the time of this study and they consented to participate in the study. Ethical clearance was obtained from research and ethical committee of Federal Teaching Hospital Gombe. A Survey meter (RDS 200 with serial number 300091. Manufactured by RADOS TECHNOLOGY and calibrated on June 12th, 2018 with uncertainty in calibration factor which correspond to a coverage factor k=2.

The survey meter was used to measure the exit dose through controlled radiation exposures to strategic areas within the x-ray room and the surroundings. Background radiation was measured in each center to establish baseline before other exposures were taken. For each location, three exposures were taken and the average was recorded. After each reading, the survey meter was zeroed to avoid accumulation of readings from previous exposure measurements. Background radiation was measured in each center before exposures were taken.

All exit radiation measurements through barriers were taken at a distance of 0.3m (30 cm) from the nearest barrier as recommended by NCRP report No. 147. These measurements were grouped based on controlled areas and uncontrolled areas.

The measurements were in micro Seviert per hour (μSv/h) and then converted to milli Seviert per week (mSv/wk)

RESULTS

The radiation survey carried out in radio-diagnostic centers at six selected hospitals to measure the exit dose at different locations in the radio-diagnostic department.

Table 1.0a: Measured exit dose for control and uncontrolled areas from facilities A-C

Facility	Place of measurement	Distance from the source (m)	Measured exit dose (mSv/wk)	Recommended dose (mSv/wk)
A	Background radiation		0.00840±0.0000	
	Behind door	3.1	0.09408±0.0000	0.02
	Control panel	1.9	0.14616±0.0000	0.1
	Behind wall 1 (W1)	3.3	0.02856±0.0000	0.02
	Behind wall 2 (W2)	2.6	0.01008±0.0000	0.02
	Darkroom	2.8	0.01176±0.0000	0.1
	Changing cubicle	1.9	0.21000±00000	0.1
B	Background radiation		0.01008±0.0000	
	Behind door	2.6	0.01848±0.0000	0.02
	Control Panel	1.6	0.05544±0.0000	0.1
	Behind wall 1 (W1)	2	0.20832±0.0001	0.02
	Behind wall 2 (W2)	2.4	0.01848±0.0004	0.02
	Day light processing room	2.8	0.01848±0.0000	0.1
C	Background radiation		0.01176±0.0000	
	Behind door	4	0.02268±0.0000	0.02
	Control panel	2.6	0.01680±0.0000	0.1
	Behind wall 1 (W1)	3.7	0.02688±0.0000	0.02
	Behind wall 2 (W2)	2.9	0.02016±0.0000	0.02
	Darkroom	4.2	0.01512±0.0000	0.1
	Changing Cubicle	2.9	0.19992±0.0002	0.1

Table 1.0b: Measured exit dose for control and uncontrolled areas from facilities D-F

Facility	Place of measurement	Distance from the source (m)	Measured exit dose (mSv/wk)	Recommended dose (mSv/wk)
D	Background radiation		0.01008±0.0000	
	Behind door	4	0.02352±0.0000	0.02
	Control panel	2.9	0.04200±0.0000	0.1
	Behind wall 1 (W1)	3.54	0.03192±0.0000	0.02
	Behind wall 2 (W2) (Darkroom)	2.6	0.01680±0.0000	0.1
E	Background radiation		0.01176±0.0000	
	Behind door	3.9	0.02016±0.0001	0.02
	Behind wall 1 (W1)	2.6	0.02352±0.0000	0.02
	Behind wall 2 (W2)	2	0.03192±0.0005	0.02
	Darkroom	4	0.02352±0.0000	0.1
	Waiting Area	6	0.01512±0.0000	0.02
F	Background radiation		0.01176±0.0000	
	Behind door	3.7	0.22344±0.0000	0.02
	Control panel	1.7	0.19488±0.0000	0.1
	Behind wall 1 (W1)	2.1	0.21670±0.0161	0.02
	Behind wall 2 (W2)	3.4	0.04536±0.0012	0.02
	Darkroom	5.3	0.04032±0.0000	0.1

DISCUSSION

Shielding design goals are used in the design or evaluation of barriers constructed for the protection of employees and members of the public.

Based on NCRP Report No 147, Structural Shielding Design for Medical X-Ray Imaging Facilities (2005), the weekly shielding design goal for a controlled area is an air-kerma value of 0.1 mGy week–1. The weekly shielding design goal for an uncontrolled area is an air-kerma value of 0.02 mGy week–1 [1].

In the present study, the measured exit dose at a distance of 1.9 m from the source in the controlled area of facility A, precisely the changing cubicle which is 0.21000±0.0000mSv/wk, exceeded the recommended shielding design goals which is 0.1mSv/wk as recommended by NCRP. This result indicates that patients in the changing cubicle were not efficiently protected.

Furthermore the measured exit dose behind wall1 (primary barrier) in facility B is 0.20832±0.0001 mSv/wk, at a distance of 2m from the source. This is above the recommended shielding design goal value set by NCRP. Facilities C and D recorded doses at all locations were within the recommended design dose limits. Measurement of exit dose in uncontrolled area, that is behind wall 2 (secondary wall) at a distance of 2m from the source in facility E is 0.03192±0.0005 mSv/wk. This is slightly greater than the recommended design dose of 0.02 mSv/wk set by NCRP. High measured value of doses above the recommended shielding design goal were observed at three locations in facility F for uncontrolled areas; behind the door, behind wall 1 and behind wall 2 at a distance of 3.7m, 2.1m and 3.4m respectively from the source. This high dose rate which is as a result of most probably non-lead lining of the facility, could led to unnecessary radiation exposure to the unsuspecting supportive personnel such as nurses, hospital attendants, passers-by and the visitors to or around the facility. These findings were inconsistent to a study conducted by Nkubli *et al.,* 2017[7] on a survey of structural design of diagnostic x-ray imaging facilities and compliance to shielding design goals in a limited resource setting. They found that measured radiation doses transmitted through barriers of two of the three centres studied were in compliance with the recommendations of the shielding design goals [7]. Only Centre Y recorded doses above the recommended design dose limits at some locations. While the measured exit dose for controlled areas in centre Y was below the recommended limit, high measured values above the recommended shielding design goal were observed at two locations for uncontrolled areas; Point C (Primary wall behind the chest stand), and Point F (x-ray room door 2).

Furthermore the result of the evaluation of Alameen *et al*,.[8] on shielding evaluation of diagnostic x-ray Rooms in Khartoum State revealed that 75% of the tested controlled area and 71.4% of the uncontrolled areas passed the test and do comply with the recommended limiting doses. However, only one room was found to be well shielded for both controlled and uncontrolled areas [8].

CONCLUSION

Measured exit dose in this study were found to be above the recommended dose in some certain locations in facility A, B, E and F. In such cases, the patients, personnel and the general public are exposed to unnecessary radiation dose. This highlights the need for optimized design of radiology departments to ensure adequate protection of patient, staff and the public.

Conflict of interest: none

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