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Efficacy of Shielding Structure in Computed Tomography Suite in selected Radiodiagnostic centres in Uyo metropolis Akwa Ibom state Nigeria

by

Chiaghanam N.O.[1], Esien-umo E.O[1], Egbe N.O[1], Asuquo C.F[1] and Akpanama, D.P.[1]

1- Department of Radiography and Radiological Science, University of Calabar, Calabar Nigeria.

Corresponding Author- nochiaghanamm@gmail.com

ABSTRACT

This study was aimed at radio-diagnostic facilities in Uyo Metropolis as some were converted from building not specified for radio- diagnostic purposes, hence questioning its efficacy. To assess this, a Radex 1212 survey meter was used to take readings of radiation inside Computed tomography room during exposure, and another meter used to take reading at the console and waiting areas simultaneously. Minimum of 15 exposures was made in each facility studied. The dimensions of the facilities were taken in the five facilities studied (represented alphabetically as A - E), they includes - the length, width, wall thickness, distance from Gantry to console and waiting areas and results recorded. The transmitted and attenuated radiation for waiting areas in the five facilities are 5.6% and 94.4%, 5.3% 94.7%, 3.9% and 96.1%, 3.0% and 97%, 7.4% and 92.6%, respectively, with mean dose of 0.18 $\pm$ 0.03mSv for centres A,B,C,D and E respectively. The operating console gave 5. $\pm$3% and 94.7%, 4.7% and 95.3%, 7.5% and 92.3%, 2.2% and 98%, 5.5% and 95% respectively with a mean dose value of 0.17$\pm$0.02mSv. The estimated dose at console for a year gave a mean dose of 0.36mSv and waiting area gave 0.41mSv per year. The dimension for facility A,B,C,D and E, wall thickness are 28cm, 30.2cm, 35cm, 32cm, 30.3cm: Door thickness - 2cm, 17cm, 5cm, 8cm, 17cm: Distance from Gantry to console 4.62m, 3.28m, 4.20m, 6.50m and 3.30m: Distance from Gantry to waiting area – 7.28m, 4.60m, 6.10m, 10.4m and 4.60m respectively. The estimated dose is below the stipulated dose of 20mSv/year for workers and 1mSv/year for public members hence, the facilities are safe.

Key words- Uyo, Metropolis, Radiodiagnostic, Gantry, Attenuation, Dimension

Introduction

Radiological studies are primarily operated by the use of ionizing radiation to diagnose and treat infirmities or predict the advent of disease later in life. Advancement in this aspect of medicine has led to the evolution of Computed Tomography (CT) for production of cross-sectional images and for simulation (Bushberg, 2001).

The evolution of computed tomography became imperative to enhancing diagnosis since conventional images could be classified as 2D images. Therefore, obtaining images in different planes was the idea in view. But, this principle did not rule out the use of X-radiation (Carlton and Adler, 1996). In this context, X-radiation is most beneficial, but controlling and making it completely harmless has recorded challenges especially in the exposure of subjects to radiation (Chiaghanam and Nwoyi, 2020)

According to the ICRP() 0.01% mSv predisposes to cancer, the regulatory bodies on the use of radiation have stipulated 0.02mSv for public (members of the public) and 0.7mSv/week for radiation workers. Therefore, shielding is identified as a measure to controlling or accounting for the other effect or aftermath of radiation. Shielding became the gateway to tackling this century challenge, and on many assembly stipulations have been enacted on effective dose, absorbed dose and percentage of transmission of x-radiation (NCRP, 1993).

In view of complaint made of various forms of radiation, hazard were suffered as a result of uncontrolled use of radiation by scientist after discoveries, inadequate shielding in Radiology facilities in hospital and inherent shielding deficiency in X-ray facilities (NCRP, 1993).

A planned layout with specifications was adopted by the World Health Organization, via the assembly of regulatory bodies overseeing the activities of radiations of various kinds in the world. The planning of CT layout became imperative due to the level of radiation. This takes into consideration shielding structures and materials (lead, wood, gypsum board etc.), space (distance apart, that is length and width of the layout) and Architectural siting of layout, siting of offices, rooms and waiting areas (Sutton et al,2012; NCRP, 1991)

Professionals, members of the public (patient relatives and other staff outside radiology facility) are susceptible to accumulation of radiation dose. This may take place at strategic areas like patient waiting areas and operator console. Therefore, structural design for radiation sources should satisfy the required minimum radiation protection specifications (NCRP, 2004).

Observations holds tenaciously that in many areas (Nigerian Towns/Communities) example Uyo metropolis, many radio-diagnostics centers now in operation were converted from purposes not related to diagnostic units. Also, in some radiology units, layouts are not in line with the standard as set by radiation monitoring bodies. These radio-diagnostic centres include X-ray conventional modality, Computed Tomography, Fluoroscopy units and so on. Computed Tomography was chosen because of its high radiation dose and increasing availability in most Nigerian cities. It is therefore imperative to assess the efficacy of these center's shielding structures in Uyo, Akwa Ibom State, Nigeria.

Materials and Method

The study employed a prospective design (Measurements) to assess the integrity of shielding in selected Computed Tomography suite in the study area and its comparison with standards by international regulatory bodies. The design entail taking measurements of dimensions of the CT Suites and Readings of the radiation dose at the console and assessing the dose rate at the waiting areas using a Radex 1212 survey meter.

Method of Data Collection

A measuring tape calibrated in meters/centimeters was used to measure Firstly, the length and width (Dimension of the room) by fixing the edge of the tape to the wall, extended the tape by rolling to the end of the walls. Measurement of the thickness of the leaded doors and walls were also done. The tape was equally used to measure distance from the isocentre of the Gantry to the operating console and isocentre of the gantry to the patient waiting areas.

Background radiation was measured by nulling the Radex 1212 radiation survey meter, placed at strategic positions in the unit/suite (i.e. 30cm outside the radiology unit). This involved taking the readings when the machines were not switches on or tube warm (x-ray machines around and computed tomography machines). It took 60 seconds for a reading. But, the measurement was done for about 5 (five) times in each position and average taken. A total of five diagnostic centers were used for this study.

During exposure, constant values of 110kv and 120kv were adopted for cranial and chest CT scans respectively. In each study center, five examinations were adopted also as a constant for the study, both pre-contrast and contrast examination was adopted too.

On exposure, a radiation survey meter (Radex 1212) was placed at 30cm away from the wall separating the CT room from the operating console while another Radex 1212 was placed at the console. So, these meters worked simultaneously and the readings are recorded after sixty seconds of each examination. The same procedure was repeated for the waiting area and CT room. These measurements were done across the five CT facilities studied.

RESULT

Table 1: Values of background radiation obtained in the five studied facilities.

FACILITY ENCODED IN LETTERS	**A**	**B**	**C**	**D**	**E**
BACKGROUND RADIATION	0.11 (µS/hr)	0.10 (µS/hr)	0.09 (µS/hr)	0.10 (µS/hr)	0.10 (µS/hr)

Table 2- Dose rate at waiting area estimated for a year

Facility	Dose rate at waiting area +SD (μSv)	Estimated dose rate 40hrs/week (μSv)	Dose rate estimate for 52 weeks (mSv)
A	0.15 ± 0.01	6.0	0.31
B	0.18 ± 0.04	7.2	0.44
C	0.12 ± 0.02	7.0	0.30
D	0.22 ± 0.07	9.0	0.50
E	0.24 ± 0.01	10.0	0.52
	0.18 ± 0.03	7.84	0.41

SD - Standard deviation

Table 3- Estimated dose rate/year for Dose rate at the operating console

Facility coded lettered	Dose rate at console +SD (μS/hr)	Estimated dose rate in 40hrs/week (μSv/hr)	Estimate dose rate in 52 weeks (mSv)
A	0.14 ± 0.01	6.0	0.31
B	0.16 ± 0.03	6.4	0.33
C	0.23 ± 0.02	9.2	0.54
D	0.16 ± 0.05	6.4	0.33
E	0.16 ± 0.03	6.4	0.33
	0.17 ± 0.02	6.88	0.36

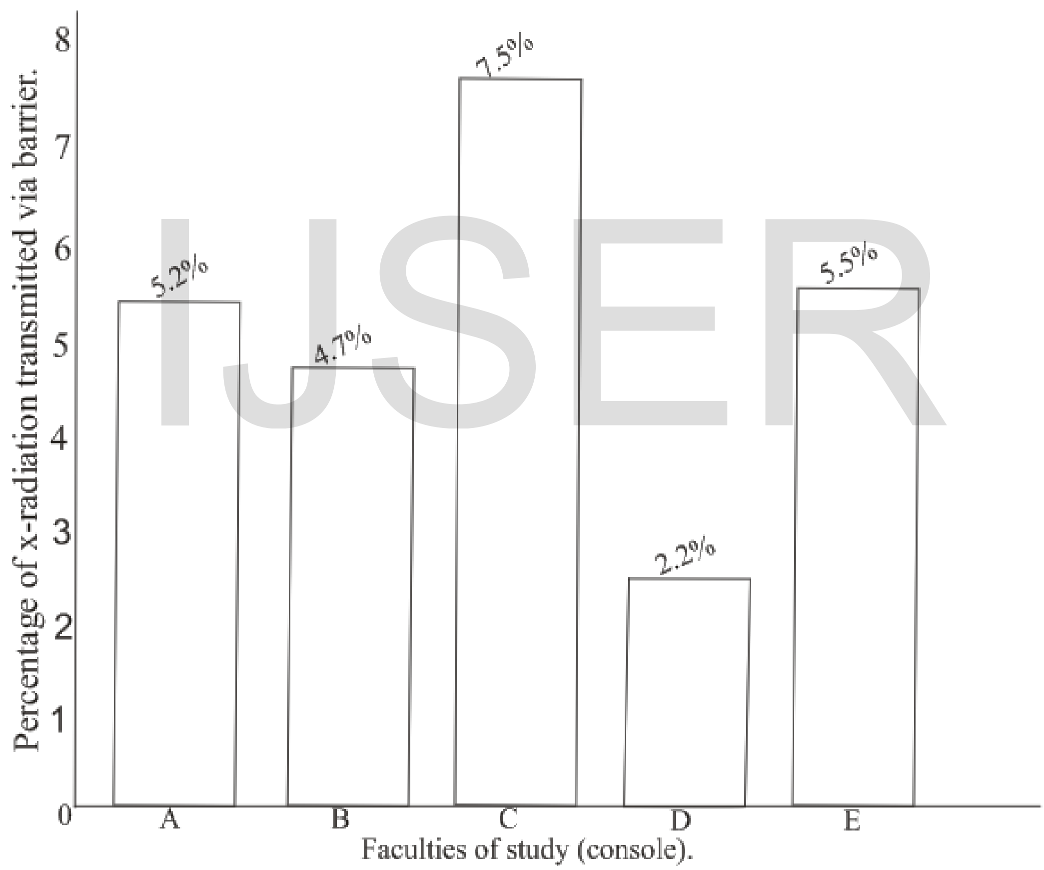

Fig. 1: The percentage of x-radiation transmitted through the barrier to the operating console, with facility C having the highest percentage and facility D showing the lowest percentage.

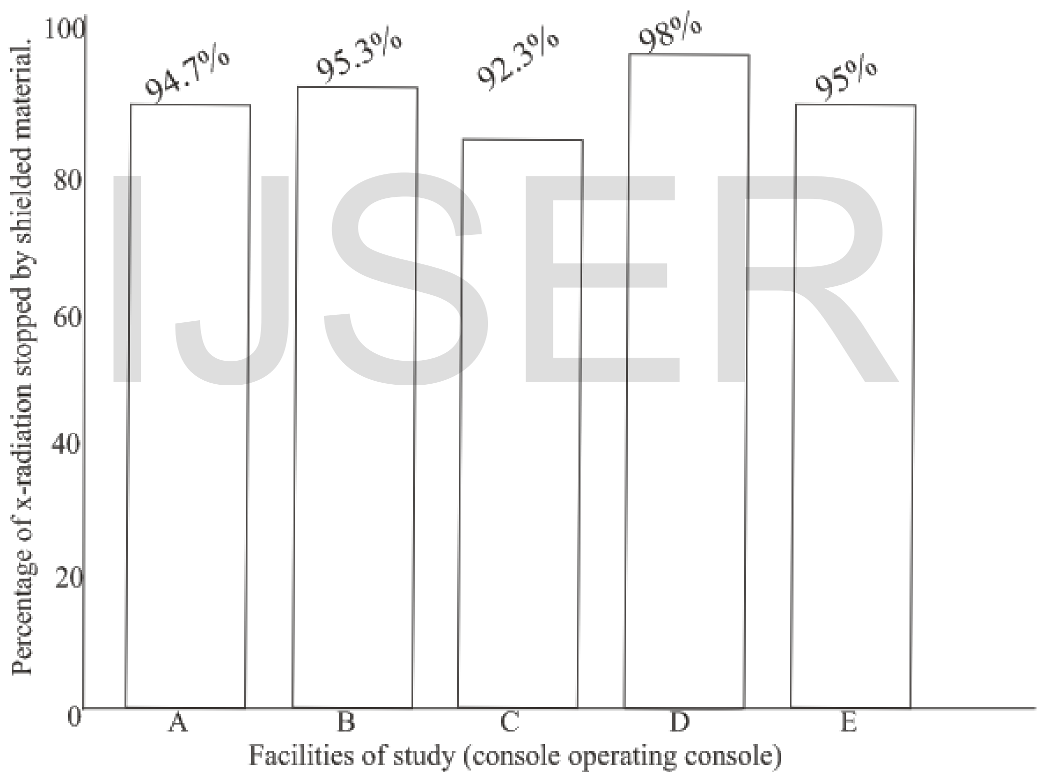

Fig 2: Percentage of x-radiation attenuated by the barrier separating the CT Room from the console, facility D has the highest percentage and C the lowest of the facilities studied.

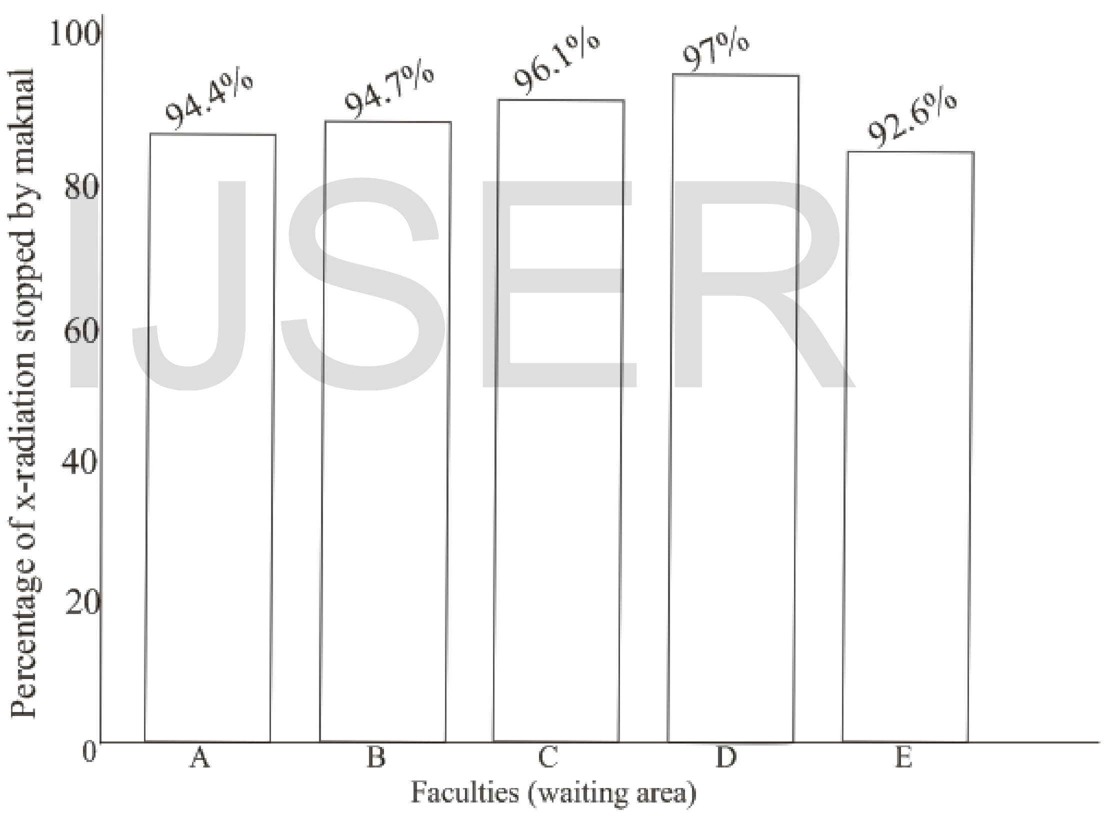

Fig. 3: Percentage of x-radiation attenuated by the shielding structure separating CT Room from waiting area. With facility D h aving the highest shielding percentage and E showing the lowest.

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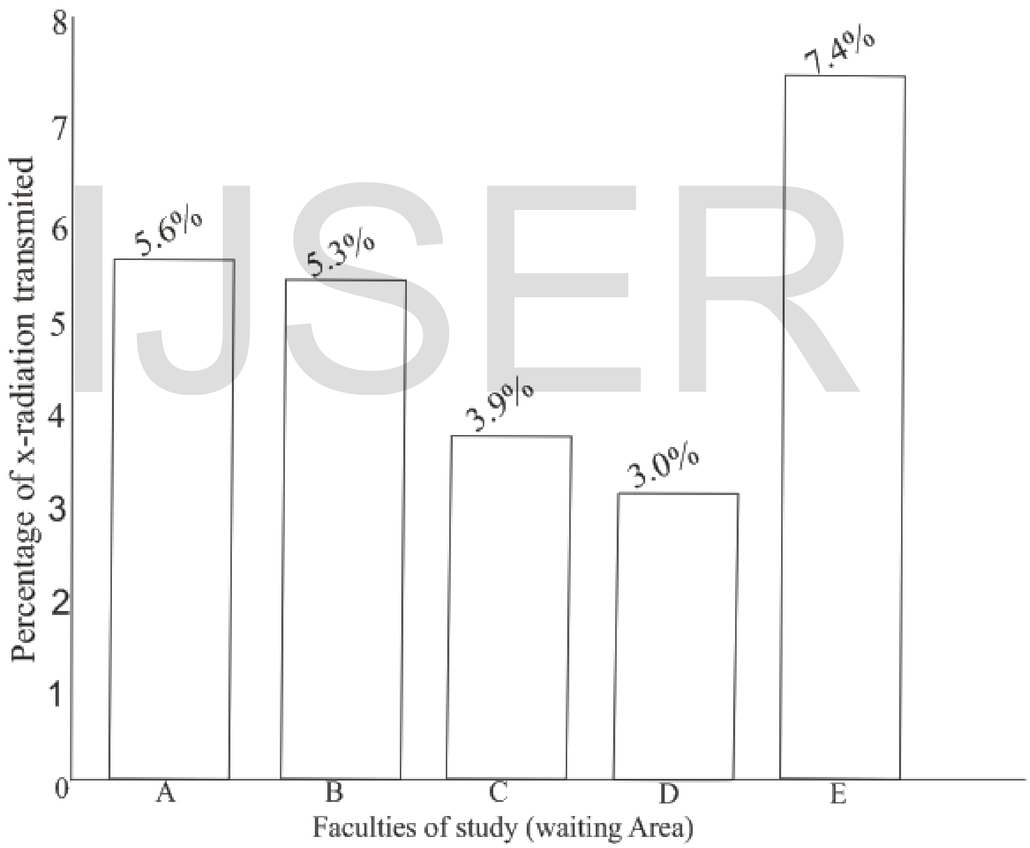

Fig. 4: Percentage of x-radiation transmitted via the shielding structure separating the CT room from waiting area. With facility E having the highest percentage and D having the lowest.

Table: 4 - Computed Tomography Suite/Room Dimension, Materials for Barrier and Monitoring Medium

Facility Code (Letter)	CT Room Size (M^2)	Wall Thickness (CM)	Door Thickness (CM)	Patient Monitoring Medium	Materials for Doors and Walls	Distance from Gantry to Console (M)	Distance from Gantry to waiting Area (M)
A	23.6	28	2	Live camera	Wood & concrete + wallboard	4.62	7.28
B	18.13	30.2	17	Live camera	Metal leaf + wood, concrete + wallboard	3.28	4.60
C	35.4	35	5	Leaded glass	Metal leaf + lead concrete + tile	4.20	6.10
D	58.2	32	8	Leaded glass	Metal + lead, concrete +	6.50	10.40

					lead		
E	17.3	30.3	17	Live camera	Metal + wood, concrete + wallboard	3.30	4.60

Discussion

The results obtained show some degree of both transmission and attenuation of x-radiation during each computed tomography examination, which was evident at operating console and waiting area.

At waiting area, percentage of x-radiation transmitted in the five facilities as shown in the fig. 4 are 5.6%, 5.3%, 3.9%, 3.0% and 7.4% respectively with a corresponding mean (dose rate) as shown in table 7 are 0.15 ± 0.01, 0.18 ± 0.04, 0.12 ± 0.02, 0.22 ± 0.07 and 0.24 ± 0.01 respectively all in micro Sievert with a mean value of 0.18 ± 0.03. The percentage of attenuated x-radiation are 94.4%, 94.7%, 96.1%, 97% and 92.6% for facility A, B, C, D and E respectively (Table 2).

At the operating console in facility A, B, C, D and E, the transmitted x-radiation had a percentage of 5.2%, 4.7%, 7.5%, 2.2% and 5.5% respectively as shown in fig. 1 with a corresponding mean (dose rate) of 0.14 ± 0.01, 0.16 ± 0.03, 0.23 ± 0.02, 0.16 ± 0.05 and 0.16 ± 0.03 all in micro Sievert respectively with a mean value of 0.17 ± 0.02 as shown in table 3.

Therefore, the dose rate on estimation at the operating console of the five facilities shown in table 9 is: 0.31mSv, 0.54mSv, 0.33mSv, 0.33mSv and 0.33mSv per year respectively giving a mean dose of 0.36mSv per year as compared to NCRP (2004) standard for radiation workers of 20mSv/year.

Dose rate estimation at waiting area are 0.31mSv, 0.44mSv, 0.30mSv, 0.5mSv and 0.52mSv respectively per annum giving a mean value of 0.41mSv per year as compared to NCRP stipulated dose for members of the public (1msv/year) as shown in table 2.

The shielding specifics in the studied facilities A, B, C, D and E. gave the wall thickness to be 28cm, 30.2cm, 35cm, 32cm and 30.3cm respectively as compared to NNRA (2005, 2006) specifics for computed tomography installation which is 12.18cm of concrete and 0.21 – 0.14cm lead as shown in table 4.

Distance from isocentre to console in A, B, C, D and E are 4.62cm, 3.28m, 4.20m, 6.50m and 3.30m respectively as compared to NNRA (2005) and ICRP (2006) specifics for CT installation 2005, which is 1.5m – 3.0m. Distance from Gantry to waiting area for A, B, C, D and E 7.28m, 4.60m, 6.10m, 10.4m and 4.6m as shown in table 4.

Door thickness A, B, C, D and E are 2cm, 17cm, 5cm, 8cm and 17cm respectively as compared to ICRP (2006), IAEA (2006, 2008, 2009, 2018)specifics of 2.3cm of Door Thickness as shown in table 4.

Conclusion

This study shows that when compared with standards these facilities are safe as specifics for shielding material has proved that the shielding structure is effective.

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