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Research Paper

Shielding Evaluation of Computed Tomography (CT) Centres in Lagos

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ABSTRACT

The health implications of human exposures to ionizing radiation may be deleterious on the immunity mechanism, particularly when high but sub-lethal doses are received over a period of time. Quality control tests and environmental monitoring of eight different CT diagnostic centers in Lagos state was carried out using Redeye B20-ER α β γ Survey Meter. Measurements were taken at two different locations (supervised and control area). The background radiation of each center was also measured. Three measurements were taken at four different points at both the supervised and control areas. The mean dose rate ranges from 0.18 to 211.30 μSv/h at the supervised areas and from 0.12 to 223.60 μSv/h at the control areas. The results recorded shows high radiation leakages in some of the CT centers, indicating higher risk to both the health personnel and the public. It was observed that most of the diagnostic centers were not properly shielded, lack qualified Radiation Safety Officer and Medical Physicists Experts and do not carry out an environmental monitoring assessment. The diagnostic centers should ensure periodic and regular inspection and radiation monitoring using redeye survey meter, thermo luminescent detectors, pocket dosimeters, and Geiger-Muller detector.

Index terms: *Radiation Protection, Computed Tomography, Geiger Muller Detector, Quality Assurance.*

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I. INTRODUCTION

Ionizing radiation can be harmful to people who are exposed to it.(1) In fact, ionizing radiation is the second most common cause of cancer in humans, after tobacco use. Ionizing radiation is also a concern for those who handle radioactive material and come into contact with low-level radioactive waste on a regular basis.

CT shielding is one solution for preventing ionizing radiation exposure(2) (4).The purpose of radiation shielding is to limit radiation exposures to employees and members of the public to an acceptable Level. General shielding requirement for Computed Tomography centers

1.1.1 **PROTECTIVE SCREENS :**Typically, 15 kgm^{-2} (1.3 mm) sheet lead or its shielding equivalent is specified.This may need to be higher if the protective screen is less than 2 m from either x-ray tube or patient. Other requirements include:(17)

- Sheet lead must be supported on both sides such as a ply-lead-ply sandwich or similar to prevent creeping under gravity. Sheets must be overlapped to ensure continuous shielding or butt jointed with an overlapping lead strip. A permanent label must indicate the thickness of lead in the protective screen.(8) (9)
- The screen must extend from the floor to a height of not less than 2 m and be wide enough (> 90 cms) to protect the operator from leakage radiation from the tube housing and scattered radiation from the patient. Side protective shields may be required.(18)
- The protective window needs to contain the same lead equivalence and have dimensions > 30 cm x 30 cm so that the radiographer can observe the patient during an x-ray exposure. Generally the protective window is either lead glass (nominal thickness 6 mm, 1.5 mm lead equivalence) or H-22 lead acrylic (1.0 mm lead equivalence at 100 kVp). All shielding must overlap by a minimum5 mm. A permanent label indicating the lead equivalence of the window at a nominal kVp is required.(20)
- The screen is to be secured to either the floor or wall so that the location of the protective screen is fixed. Although fixed in position for everyday use, the screen may be hinged for service access to controls. A small gap (< 5 cm) between the floor and screen for castors is permitted.(5)

1.1.2 WALLS

For installations other than CT, shielding equivalent to at least 1 mm lead at 100 kVp is required. A choice of building materials is available to achieve this degree of shielding; including a single layer of solid clay brick with fully mortared joints, two thicknesses of ordinary cored brick, 15 kg m^{-2} sheet lead (suitably supported and overlapped) or two layers (2 x 16 mm) of barium plaster x-ray panels. For CT installations, shielding equivalent to 1.5 mm lead or more may be required. Protection needs to extend from the floor to a height of not less than 2 m and be continuous. Where recessed wall boxes such as GPOs and medical gas panels are installed, sufficient shielding must be added to maintain the level of shielding provided by the rest of the wall.(14) (15).

1.1.3 DOORS

Shielding may only be required for major medical installations. 10 kgm^{-2}sheet lead is generally satisfactory unless the area outside the door is likely to have reasonably continuous occupancy, e.g. if the area is an office, film sorting / processing area. The doors to CT rooms should generally not have less than 15 kg m^{-2} lead.Where radiation protection is requested for doors; the frames are excluded from this requirement. It is sufficient that the steel door frame be detailed to overlap the wall structure for the necessary protection to be achieved. Warning lights at room entrances may be required for fixed general purpose, fluoroscopic or CT equipment where entry is not directly under the equipment user's control. Where required, warning lights ("Caution x-rays") should be mounted alongside the entrance and connected into the x- ray generator circuit so that they illuminate at 'prep' and for the duration of the exposure. (6)

1.1.4 FLOORS/CEILINGS

Generally, 150 mm solid concrete provides sufficient shielding between floors of multiple storey buildings.(11)

1.1.5 VERTICAL BUCKY/CASSETTE HOLDERS

Except for walls equivalent to at least 1.4 mm lead, an additional protective panel may be specified for use behind the vertical bucky, depending on the occupancy of the adjoining area. This is generally 15 kg m^{-2} sheet lead, suitably supported and overlapped. If required, the panel needs to extend from the floor (although up to 30 cm from the floor will be permitted) to a height of around 200 cm and extend 30 cm either side of the vertical bucky. The protective panel may be attached to the wall with the vertical bucky supports provided its presence is obvious and there is no risk of physical injury to anyone dismantling the vertical bucky.(13)

1.1.6 DARKROOM PASS HATCHES

Film pass hatch between the x-ray room and dark room must be lined with 15 kg m^{-2} sheet lead, suitably supported and overlapped. The shielding must be on the x-ray room side of the pass hatch.io(7)

1.1.7 BONDING METHODS FOR SHEET LEAD

Sheet lead is incapable of supporting itself and will tear and fall under gravity if not bonded to a suitable substrate. Rigid glue (such as araldite or wall bond adhesive) that does not permit creep under gravity is required. Rubber based contact cements are generally unsuitable.(10) The best method of attaching sheet lead to a supportive substrate is to glue it under pressure in a press similar to a door press. Sheet lead may be glued to chipboard, custom board, plywood, plastic laminate sheeting, galvanized steel sheet or aluminum sheet. Sheet lead can be incorporated into a metal stud wall clad with gyprock wall board by gluing it to thin galvanised steel sheet, fastening to the metal studs and then covering with gyprock sheet. Sheet lead glued to chipboard or similar substrate may be covered with a glued layer of a laminate or similar which becomes the final wall finish or the lead side can be placed against the wall studs with laminate on the outside.(16) (19).

1.1.8 GENERAL

Each x-ray installation must be assessed for shielding requirements based on the:

- Dimensions of the room
- Positions of the x-ray control, vertical bucky and operator
  - Proposed construction materials (protective screens, walls, floors, doors)
  - Areas adjacent to x-ray room (occupancy, future use)
  - X-ray workload

TABLE 1.1: SHIELDING PROPERTIES OF COMMON BUILDING MATERIALS

Material	Thickness (mm)	Pb equivalence (mm)	Transmission (%)
Concrete (solid)	100	1.5	0.20
Concrete (aerated)	150	0.05	3.0
Brick (solid)	110	1.5	0.02
Brick (cored)	90	0.41	5.3
Lead sheet (15 kg m-2)	1.3	1.3	0.30
Lead sheet (10 kg m-2)	0.88	0.88	1.1
Plasterboard (2 sheets of 13 mm gyprock)	26	0.15	20
Plasterboard (2 sheets of R40 barium board)	32	1.1	0.50

1.2 AIMS AND OBJECTIVE

The following are the objectives of this study:

1. To determine radiation leakage from a CT-scanner.
2. To determine the background radiation at various CT centers
3. To compare the background radiation to the radiation from CT centers.

1.3 SIGNIFICANCE OF THE STUDY

CT is an important and sometimes life-saving tool for diagnostic medical examinations and guidance of interventional and therapeutic procedures. It allows rapid acquisition of high-resolution 3-D images, providing radiologists and other physicians with cross-sectional views of the patient's anatomy. Since the radiation dose from CT machine is high compare to other medical imaging equipment, there is a need to investigate the shielding of the machine operation to avoid radiation leakage to members of the public and the radiation workers.(3) (12).

2.0 MATERIALS AND METHODS

The radiation leakage level of eight different diagnostic centers in Lagos state, Nigeria where carried out using Radeye B20-ER α β γ Survey Meter as shown in Fig. 1.1 below. The survey meter is manufacture in Germany and has a thin end window in which the amount of radiations detected is recorded. The γ efficiency of these detectors is only a few per cent (as determined by the wall absorption), the β response is near 100% for β particles entering the detector and α particles can easily be detected by their ionizing interactions.

Fig. 1.1: Radeye B20-ER αβγ Survey Meter.

The same method was used to determine both the radiation leakage and the background radiation in the eight different centers. In view of protecting the real identities of the

CT centers, the name and addresses of the CT centers will be designated with alphabets. At center A, measurements were taken at three different locations, the supervised area, control area, background measurement. At the supervised area, three measurements were taken at four different points denoted as (A1, A2, A3 and A4). At point A1 the measurement was taken at the top of the entrance door to the CT room .At point A3, measurement was taken at the point where the receptionist stays. At point A4, measurement was taken 2 m away from the entrance door to the CT room. At the control area of center A, three measurements were taken at four different points denoted as (A5, A6, A7 and A8). At point A5, measurement was taken at the top of the entrance door to the CT room.At point A7, measurement was taken at the point where the radiographer controls the CT machine. At point A8, measurement was taken 2 m away m the entrance door to the CT room. Three measurements of the background iation at a point were also taken when the machine was off.

RESULTS

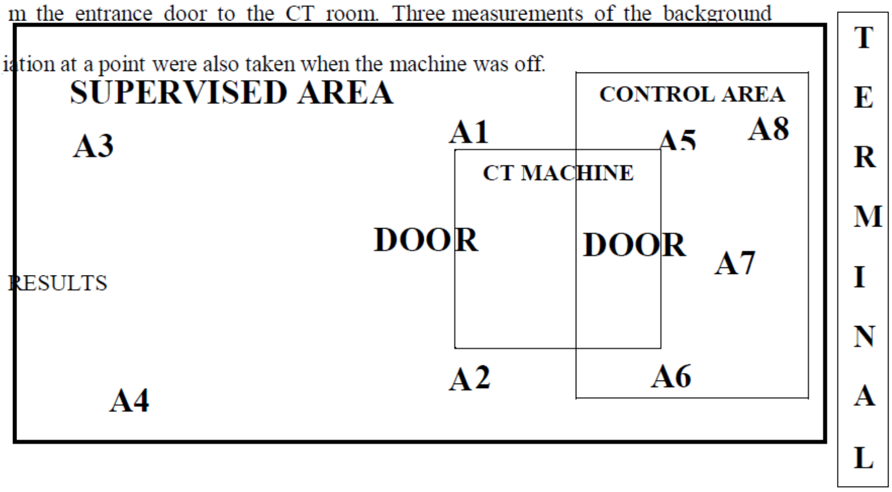

Fig. 2.1 CT center A showing the points at which measurements were taken

TABLE 2.1: Measurement of radiation leakage at CT center A

	SUPERVISED AREA (µSv/h)					CONTROL AREA (µSv/h)			
	Point A1	Point A2	Point A3	Point A4	Background (µSv/h)	Point A5	Point A6	Point A7	Point A8
	211.30	40.50	0.98	0.51	0.1O	14.73	19.50	1.35	0.48
	187.10	22.70	1.64	0.63	0.07	5.94	12.91	0.93	1.41
	192.80	17.90	0.57	0.29	0.12	11.76	7.27	0.26	0.73
S.D	17.89	16.84	0.77	0.24	0.04	6.32	8.66	0.62	0.68
MEAN	197.07	27.03	1.06	0.48	0.09	10.81	13.23	0.85	0.87
% DEV.	99.95	99.66	91.51	81.25		99.17	99.32	89.41	89.66

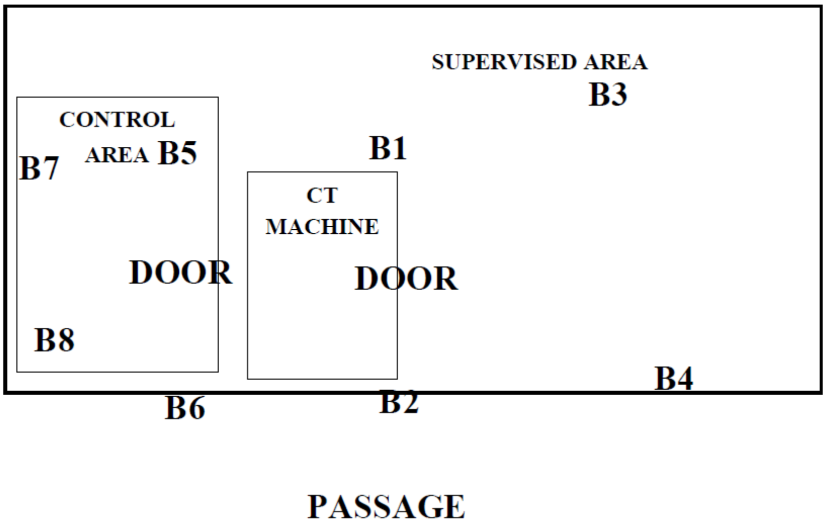

Fig. 2.2 CT center B showing the points at which measurements were taken

TABLE 2.2: Measurement of radiation leakage at CT center B.

	SUPERVISED AREA (µSv/h)				Background (µSv/h)	CONTROL AREA (µSv/h)			
	Point B1	Point B2	Point B3	Point B4		Point B5	Point B6	Point B7	Point B8
	50.70	43.91	3.17	0.24	0.13	30.16	16.38	1.19	0.96
	37.16	70.08	7.60	0.43	0.08	22.18	8.12	3.20	0.31
	32.41	61.53	2.19	0.19	0.10	15.72	12.90	1.85	1.23
S.D	13.42	18.87	4.08	0.18	0.04	10.23	5.86	1.45	0.67
MEAN	40.09	58.51	4.32	0.29	0.10	22.69	12.47	2.08	0.83
% DEV.	99.75	99.83	97.69	65.52		99.56	99.20	94.29	87.95

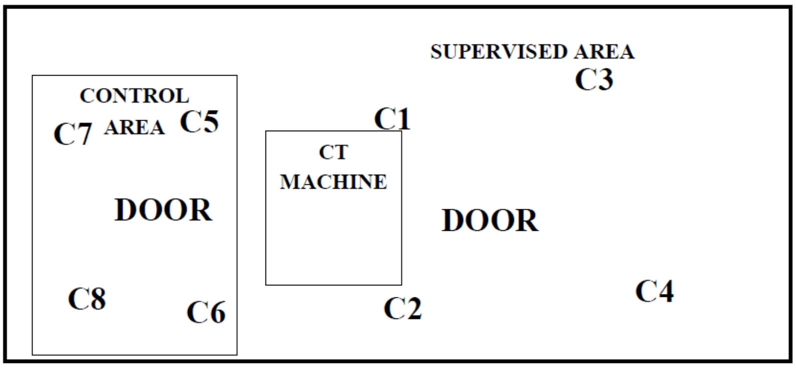

Fig. 2.3 CT center C showing the points at which measurements were taken

TABLE 2.3: Measurement of radiation leakage at CT center C.

	SUPERVISED AREA (µSv/h)				Background (µSv/h)	CONTROL AREA (µSv/h)			
	Point C1	Point C2	Point C3	Point C4		Point C5	Point C6	Point C7	Point C8

	10.30	23.40	1.43	0.53	0.1O	3.90	6.63	2.16	0.41
	18.93	12.16	3.64	1.13	0.10	3.86	4.15	1.14	0.32
	15.41	19.87	1.79	1.00	0.11	2.16	5.72	2.07	0.62
S.D	6.14	8.13	1.68	0.85	0.01	1.40	1.77	0.80	0.15
MEAN	14.88	18.48	2.29	0.89	0.10	3.31	5.50	1.79	0.45
% DEV.	99.33	99.46	94.87	81.82		96.98	98.18	96.02	77.78

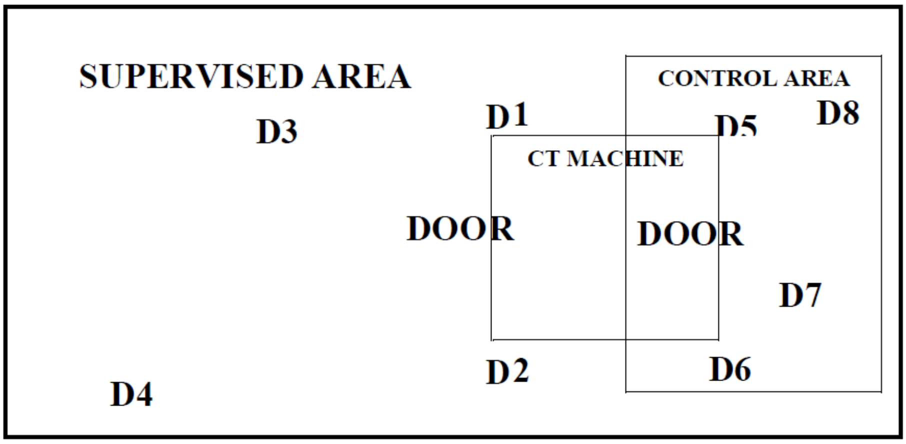

Fig. 2.4 CT center D showing the points at which measurements were taken

TABLE 2.4: Measurement of radiation leakage at CT center D.

	SUPERVISED AREA (μSv/h)				Background (μSv/h)	CONTROL AREA (μSv/h)			
	Point D1	Point D2	Point D3	Point D4		Point D5	Point D6	Point D7	Point D8
	132.07	73.17	20.48	0.68	0.11	13.80	17.72	12.30	0.98
	163.91	87.36	12.63	1.32	0.09	11.90	13.93	7.03	1.14
	116.75	75.04	9.91	2.64	0.13	8.13	15.40	10.17	1.02
S.D	34.02	10.90	7.76	1.41	0.03	4.08	2.72	3.75	0.12
MEAN	137.58	78.52	14.34	1.55	0.11	11.28	15.53	9.83	1.05
% DEV.	99.92	99.86	99.23	92.90		99.02	99.29	98.89	89.52

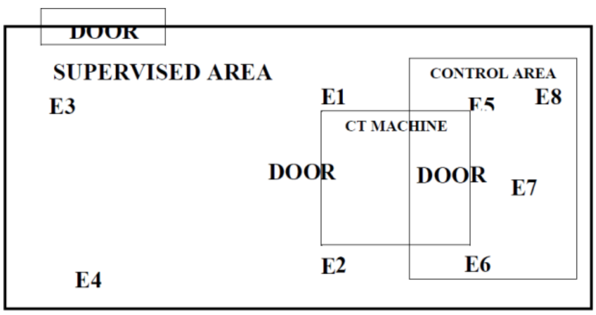

Fig. 2.5 CT center E showing the points at which measurements were taken

TABLE 2.5: Measurement of radiation leakage at CT center E.

	SUPERVISED AREA (μSv/h)					CONTROL AREA (μSv/h)			
	Point E1	Point E2	Point E3	Point E4	Background (μSv/h)	Point E5	Point E6	Point E7	Point E8
	10.13	27.90	1.46	1.23	0.07	30.18	26.83	13.16	2.51
	16.19	17.08	6.33	1.47	0.09	30.04	24.90	16.93	1.96
	21.45	23.14	4.07	3.96	0.12	27.46	24.15	10.07	2.97
S.D	8.01	7.67	3.45	2.14	0.04	2.17	1.95	4.86	0.72
MEAN	15.92	22.71	3.95	2.22	0.09	29.23	25.29	13.39	2.48
% DEV.	99.43	99.60	97.72	95.95		99.69	99.64	99.33	96.37

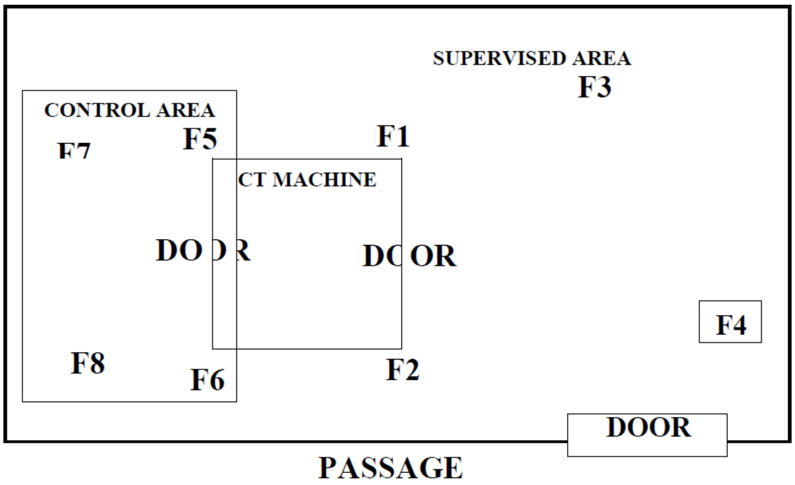

Fig. 2.6 CT center F showing the points at which measurements were taken

TABLE 2.6: Measurement of radiation leakage at CT center F.

	SUPERVISED AREA (μSv/h)					CONTROL AREA (μSv/h)			
	Point F1	Point F2	Point F3	Point F4	Background (μSv/h)	Point F5	Point F6	Point F7	Point F8
	123.46	112.90	7.81	1.60	0.12	223.60	198.73	35.60	6.30
	100.72	94.82	5.16	2.23	0.14	200.98	167.17	24.99	9.12
	149.00	107.51	9.12	3.90	0.11	211.61	169.34	27.13	4.44
S.D	34.16	13.13	2.85	1.68	0.02	16.00	24.93	7.93	3.33
MEAN	124.39	105.08	7.36	2.58	0.12	212.06	178.41	29.24	6.62
% DEV.	99.90	99.89	98.37	95.35		99.94	99.93	99.59	98.19

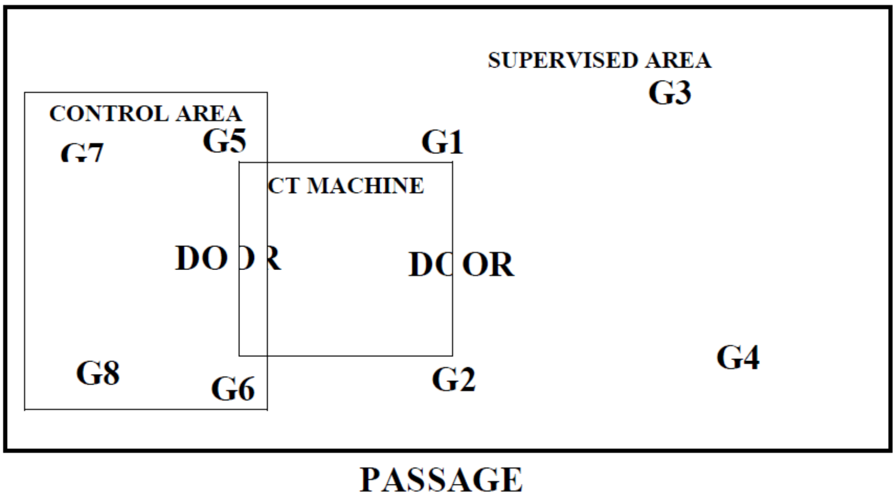

Fig. 2.7 CT center G showing the points at which measurements were taken

TABLE 2.7: Measurement of radiation leakage at CT center G.

	SUPERVISED AREA (µSv/h)				Background (µSv/h)	CONTROL AREA (µSv/h)			
	Point G1	Point G2	Point G3	Point G4		Point G5	Point G6	Point G7	Point G8
	30.64	12.51	3.91	1.60	0.10	25.59	18.17	9.91	1.40
	23.70	15.79	2.88	1.03	0.12	18.58	13.66	7.29	3.97
	29.35	15.40	1.15	1.71	0.11	23.83	15.89	7.38	3.63
S.D	5.22	2.53	1.97	0.52	0.01	5.09	3.19	2.10	1.97
MEAN	27.90	14.57	2.65	1.45	0.11	22.67	15.91	8.19	3.00
% DEV.	99.61	99.25	95.85	92.41		99.51	99.31	98.66	96.33

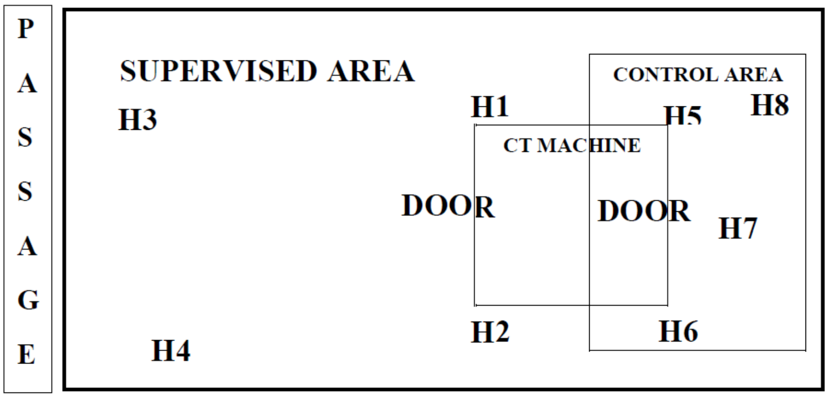

Fig. 2.8 CT center H showing the points at which measurements were taken

TABLE 2.8: Measurement of radiation leakage at CT center H.

	SUPERVISED AREA (μSv/h)				Background (μSv/h)	CONTROL AREA (μSv/h)			
	Point H1	Point H2	Point H3	Point H4		Point H5	Point H6	Point H7	Point H8
	15.70	12.40	3.75	1.00	0.09	12.53	7.79	2.88	1.78
	15.10	10.98	3.93	1.93	0.10	9.33	8.10	2.09	1.67
	13.60	12.67	4.22	2.13	0.11	11.17	7.66	2.13	0.99
S.D	1.53	1.28	0.33	0.85	0.01	2.15	0.32	0.63	0.61
MEAN	14.80	12.02	3.97	1.69	0.10	11.01	7.85	2.37	1.48
% DEV.	99.32	99.17	97.48	94.08		99.09	98.73	95.78	93.24

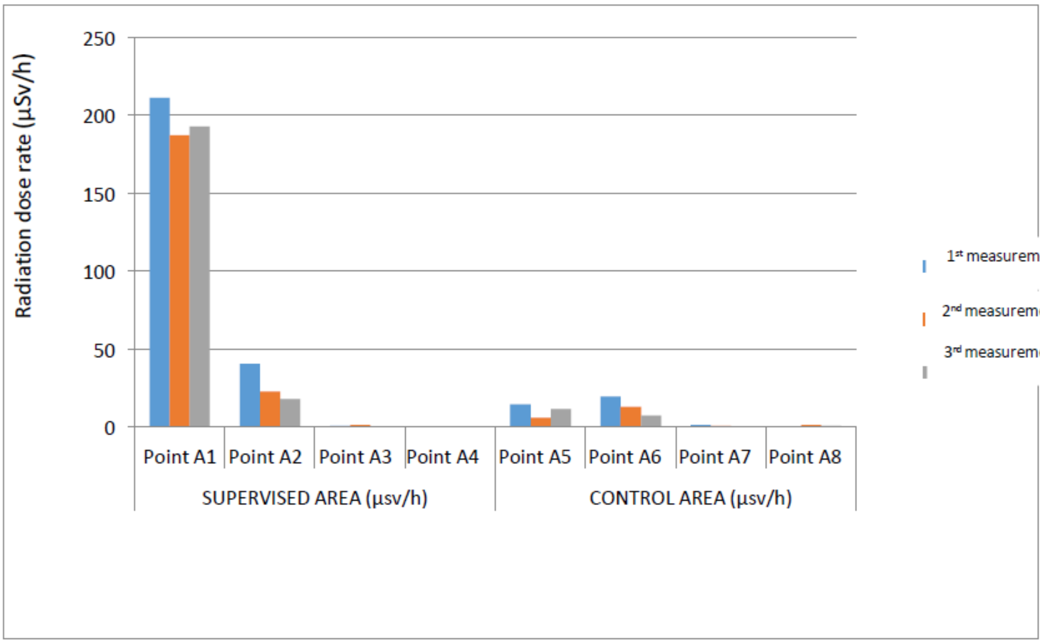

Fig. 2.9: Graph of radiation leakage at both supervised and control area with background of 0.09 µSv/h at center A.

The graph above shows higher radiation leakage at the supervised area, therefore indicating a higher radiation risk to the public than the health worker. The absorbed dose by the public depends on the time spent (the longer the time spent, the higher the absorbed dose by the public).

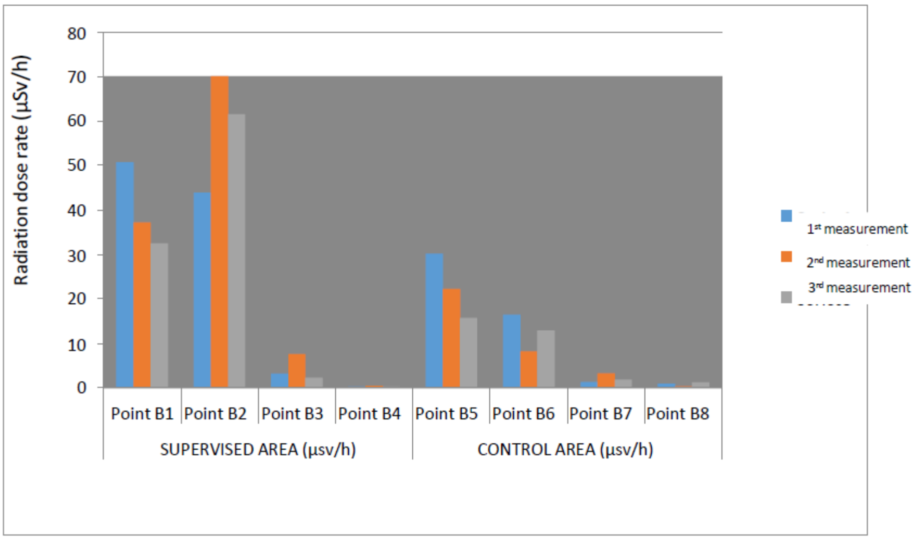

Fig. 2.10: Graph of radiation leakage at both supervised and control area with background of 0.10 µSv/h at center B.

The graph above shows higher radiation leakage at the supervised area, therefore indicating a higher radiation risk to the public than the health worker. The absorbed dose by the public depends on the time spent (the longer the time spent, the higher the absorbed dose by the public).

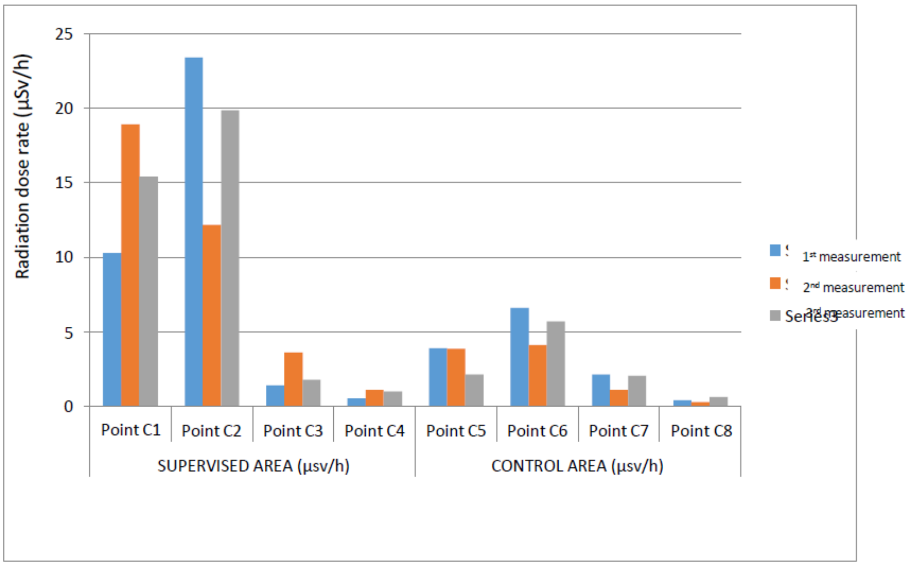

Fig. 2.11: Graph of radiation leakage at both supervised and control area with background of 0.10 µSv/h at CT center C.

The graph above shows higher radiation leakage at the supervised area, therefore indicating a higher radiation risk to the public than the health worker. The absorbed dose by the public depends on the time spent (the longer the time spent, the higher the absorbed dose by the public).

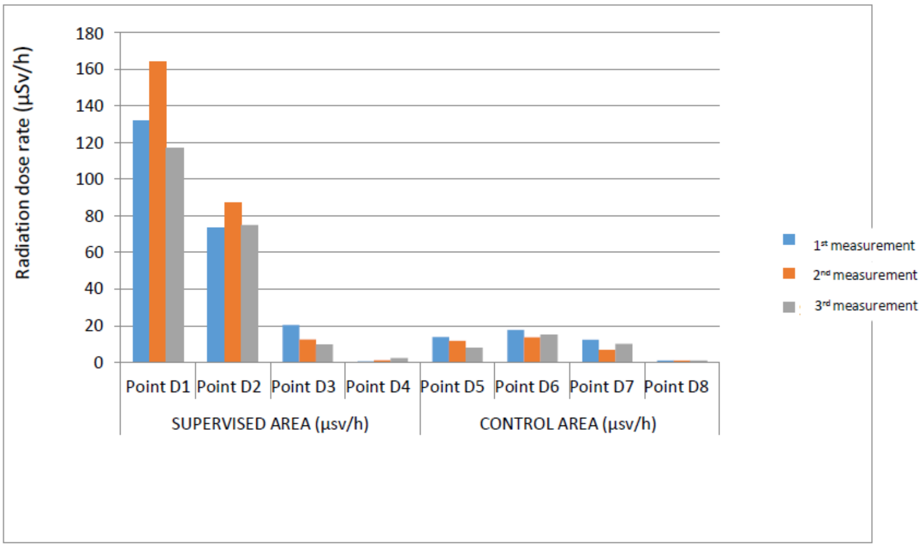

Fig. 2.12: Graph of radiation leakage at both supervised and control area with background of 0.11 µSv/h at CT center D.

The graph above shows higher radiation leakage at the supervised area, therefore indicating a higher radiation risk to the public than the health worker. The absorbed dose by the public depends on the time spent (the longer the time spent, the higher the absorbed dose by the public).

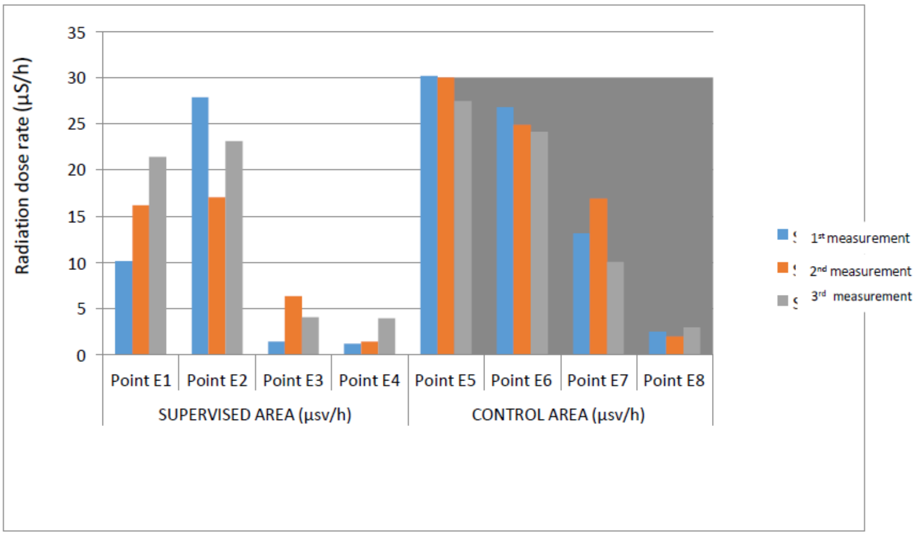

Fig. 2.13: Graph of radiation leakage at both supervised and control area with background of 0.09 µSv/h at CT center E.

The graph above shows lower radiation leakage at both the supervised and control areas. This diagnostic center is safe for both the public and the health worker

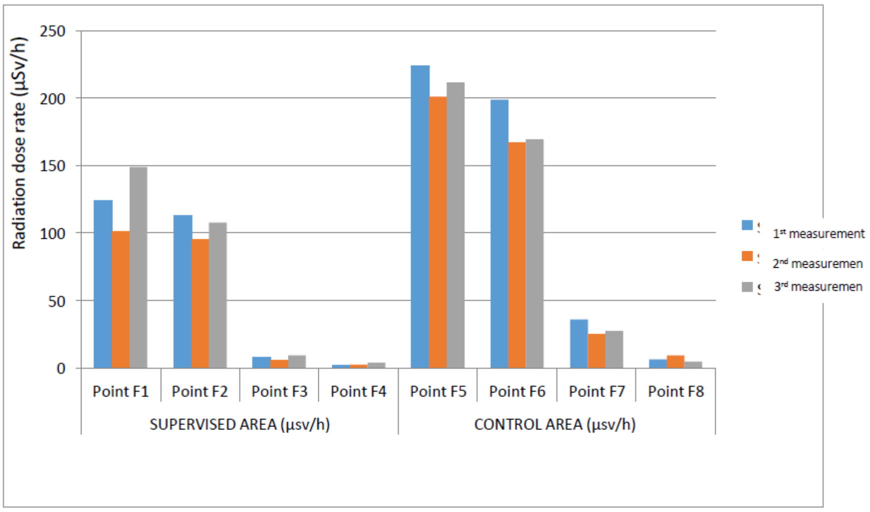

Fig. 2.14: Graph of radiation leakage at both supervised and control area with background of 0.12 Sv/h at CT center F.

The graph above shows higher radiation leakage at both the supervised and control areas, therefore indicating a higher radiation risk to both the public and the health worker. The absorbed dose by the public and the health worker depends on the time spent within the environment (the longer the time spent, the higher the absorbed dose by the public and the health worker).

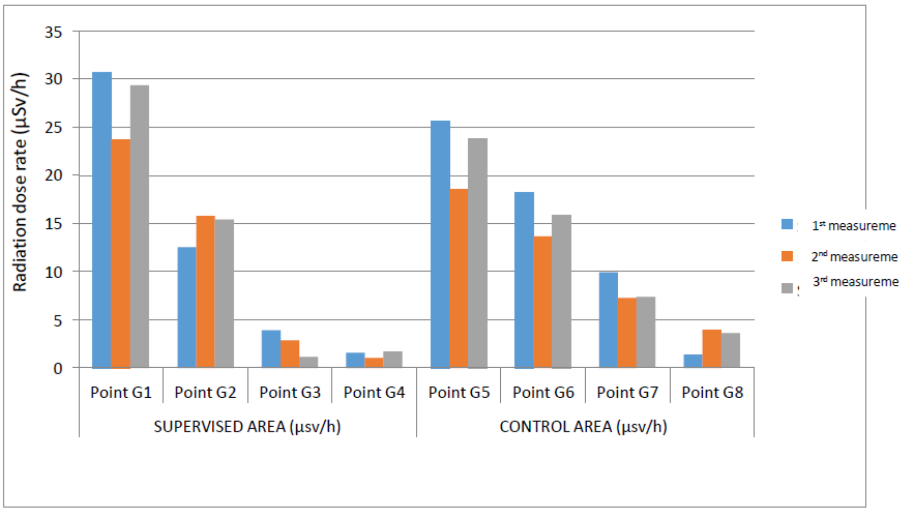

Fig. 2.15: Graph of radiation leakage at both supervised and control area with background of 0.11 µSv/h at CT center G.

The graph above shows lower radiation leakage at both the supervised and control areas. This diagnostic center is safe for both the public and the health worker.

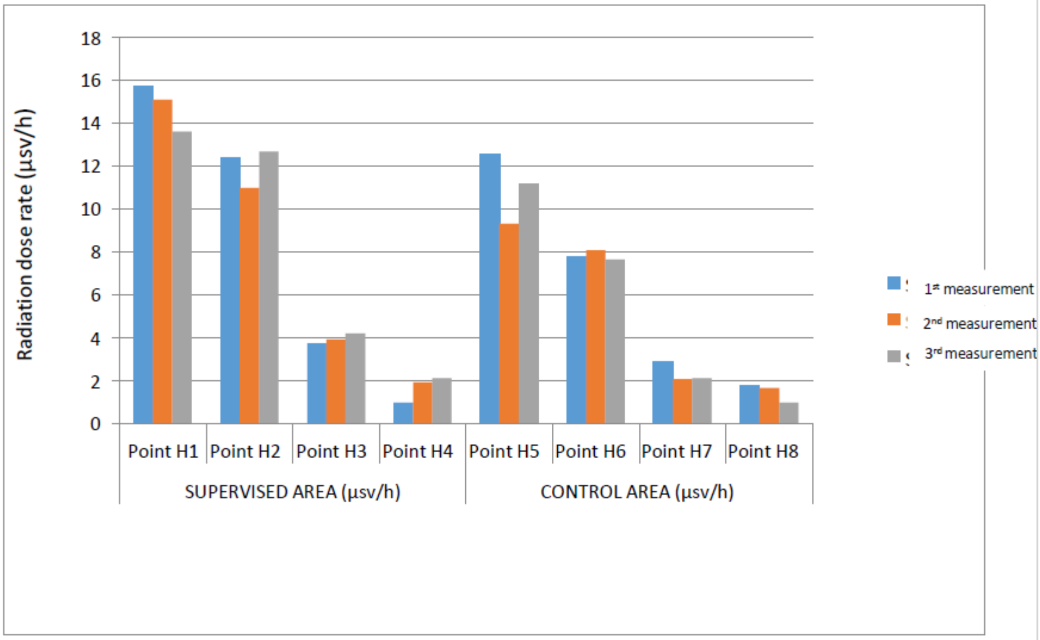

Fig. 2.16: Graph of radiation leakage at both supervised and control area with background of 0.10 µSv/h at CT center H.

The graph above shows lower radiation leakage at both the supervised and control areas. This diagnostic center is safe for both the public and the health worker

SUMMARY AND CONCLUSION

3.1 DISCUSSION

From center A, the mean of radiation leakage at point A1 is 197.07 µSv/h; with standard deviation of 17.89 µSv/h and percentage deviation from the background radiation as 99.95%. From center A, the mean of radiation leakage at point A2 is 27.03 µSv/h; with standard deviation of 16.84 µSv/h and percentage deviation from the background radiation as 99.66%. From center A, the mean of radiation leakage at point A3 is 1.06 µSv/h; with standard deviation of 0.77 µSv/h and percentage deviation from the background radiation as 91.51%. From center A, the mean of radiation leakage at point A4 is 0.48 µSv/h; with standard deviation of 0.24 µSv/h and percentage deviation from the background radiation as 81.25%. From center A, the mean of radiation leakage at point A5 is 10.81 µSv/h; with standard deviation of 6.32 µSv/h and percentage deviation from the background radiation as 99.17%. From center A, the mean of radiation leakage at point A6 is 13.23 µSv/h; with standard deviation of 8.66 µSv/h and percentage deviation from the background radiation as 99.32%. From center A, the mean of radiation leakage at point A7 is 0.85 µSv/h; with standard deviation of 0.62

μSv/h and percentage deviation from the background radiation as 89.41. From center A, the mean of radiation leakage at point A8 is 0.87 μSv/h; with standard deviation of 0.68 μSv/h and percentage deviation from the background radiation as 89.66%. From center B, the mean of radiation leakage at point B1 is 40.09 μSv/h; with standard deviation of 13.42 μSv/h and percentage deviation from the background radiation as 99.75%. From center B, the mean of radiation leakage at point B2 is 58.51 μSv/h; with standard deviation of 18.87 μSv/h and percentage deviation from the background radiation as 99.83%. From center B, the mean of radiation leakage at point B3 is 4.32 μSv/h; with standard deviation of 4.08 μSv/h and percentage deviation from the background radiation as 97.69. From center B, the mean of radiation leakage at point B4 is 0.29 μSv/h; with standard deviation of 0.18 μSv/h and percentage deviation from the background radiation as 65.52%. From center B, the mean of radiation leakage at point B5 is 22.69 μSv/h; with standard deviation of 10.23 μSv/h and percentage deviation from the background radiation as 99.56%. From center B, the mean of radiation leakage at point B6 is 12.47 μSv/h; with standard deviation of 5.86 μSv/h and percentage deviation from the background radiation as 99.20%. From center B, the mean of radiation leakage at point B7 is 2.08 μSv/h; with standard deviation of 1.45 μSv/h and percentage deviation from the background radiation as 94.29%. From center B, the mean of radiation leakage at point B8 is 0.83 μSv/h; with standard deviation of 0.67 μSv/h and percentage deviation from the background radiation as 87.95%. From center C, the mean of radiation leakage at point C1 is 14.88 μSv/h; with standard deviation of 6.14 μSv/h and percentage deviation from the background radiation as 99.33%. From center C, the mean of radiation leakage at point C2 is 18.48 μSv/h; with standard deviation of 8.13 μSv/h and percentage deviation from the background radiation as 99.46%. From center C3, the mean of radiation leakage at point C is 2.29 μSv/h; with standard deviation of 1.68 μSv/h and percentage deviation from the background radiation as 94.87%. From center C, the mean of radiation leakage at point C4 is 089 μSv/h; with standard deviation of 0.85 μSv/h and percentage deviation from the background radiation as 81.82%. From center C, the mean of radiation leakage at point C5 is 3.31 μSv/h; with standard deviation of 1.40 μSv/h and percentage deviation from the background radiation as 96.98%. From center C, the mean of radiation leakage at point C6 is 5.50 μSv/h; with standard deviation of 1.77 μSv/h and percentage deviation from the background radiation as 98.18%. From center C, the mean of radiation leakage at point C7 is 1.79 μSv/h; with standard deviation of 0.80 μSv/h and percentage deviation from the background radiation as 96.02%. From center C, the mean of radiation leakage at point C8 is 0.45 μSv/h; with standard deviation of 0.15 μSv/h and percentage deviation from the background radiation as 77.78%. From center D, the mean of radiation leakage at point D1 is 137.58 μSv/h; with standard deviation of 34.02 μSv/h and percentage deviation from the background radiation as 99.92%. From center D, the mean of radiation leakage at point D2 is 78.52 μSv/h; with standard deviation of 10.90 μSv/h and percentage deviation from the background radiation as 99.86%. From center D, the mean of radiation leakage at point D3 is 14.34 μSv/h; with standard deviation of 7.76 μSv/h and percentage deviation from the background radiation as 99.23%. From center D, the mean of radiation leakage at point D4 is 1.55 μSv/h; with standard deviation of 1.41 μSv/h and percentage deviation from the background radiation as 92.90%. From center D, the mean of radiation leakage at point D5 is 11.28 μSv/h; with standard deviation of 4.08 μSv/h and percentage deviation from the background radiation as 99.02%. From center D, the mean of radiation leakage at point D6 is 15.53 μSv/h; with standard deviation of 2.72 μSv/h and percentage deviation from the background radiation as 99.29%. From center D, the mean of radiation leakage at point D7 is 9.83 μSv/h; with standard deviation of 3.75 μSv/h and percentage deviation from the background radiation as 98.89%. From center D, the mean of radiation leakage at point D8 is 1.05 μSv/h; with standard deviation of 0.12 μSv/h and percentage deviation from the background radiation as 89.52%. From center E, the mean of radiation leakage at point E1 is 15.92 μSv/h; with standard deviation of 8.01 μSv/h and percentage deviation from the background radiation as 99.43%. From center E, the mean of radiation leakage at point E2 is 22.71 μSv/h; with standard deviation of 7.67 μSv/h and percentage deviation from the background radiation as 99.60%. From center E, the mean of radiation leakage at point E3 is 3.95 μSv/h; with standard deviation of 3.45 μSv/h and percentage deviation from the background radiation as 97.72%. From center E, the mean of radiation leakage at point E4 is 2.22 μSv/h; with standard deviation of 2.14 μSv/h and percentage deviation from the background radiation as 95.95%. From center E, the mean of radiation leakage at point E5 is 29.23 μSv/h; with standard deviation of 2.17 μSv/h and percentage deviation from the background radiation as 99.69%. From center E, the mean of radiation leakage at point E6 is 25.29 μSv/h; with standard deviation of 1.95 μSv/h and percentage deviation from the background radiation as 99.64%. From center E, the mean of radiation leakage at point E7 is 13.39 μSv/h; with standard deviation of 4.86 μSv/h and percentage deviation from the background radiation as 99.33%. From center E, the mean of radiation leakage at point E8 is 2.48 μSv/h; with standard deviation of 0.72 μSv/h and percentage deviation from the background radiation as 96.37%. From center F, the mean of radiation leakage at point F1 is 124.39 μSv/h; with standard deviation of 34.16

μSv/h and percentage deviation from the background radiation as 99.90%. From center F, the mean of radiation leakage at point F2 is 105.08 μSv/h; with standard deviation of 13.13 μSv/h and percentage deviation from the background radiation as 99.89%. From center F, the mean of radiation leakage at point F3 is 7.36 μSv/h; with standard deviation of 2.85 μSv/h and percentage deviation from the background radiation as 98.37%. From center F, the mean of radiation leakage at point F4 is 2.58 μSv/h; with standard deviation of 1.68 μSv/h and percentage deviation from the background radiation as 95.35%. From center F, the mean of radiation leakage at point F5 is 212.06 μSv/h; with standard deviation of 16.00 μSv/h and percentage deviation from the background radiation as 99.94%.From center F, the mean of radiation leakage at point F6 is 178.41 μSv/h; with standard deviation of 24.93 μSv/h and percentage deviation from the background radiation as 99.93%. From center F, the mean of radiation leakage at point F7 is 29.24 μv/h; with standard deviation of 7.93 μSv/h and percentage deviation from the background radiation as 99.59%. From center F, the mean of radiation leakage at point F8 is 6.62 μSv/h; with standard deviation of 3.33 μSv/h and percentage deviation from the background radiation as 98.19%. From center G, the mean of radiation leakage at point G1 is 27.90 μSv/h; with standard deviation of 5.22 μSv/h and percentage deviation from the background radiation as 99.61%. From center G, the mean of radiation leakage at point G2 is 14.57 μSv/h; with standard deviation of 2.53 μSv/h and percentage deviation from the background radiation as 99.25%. From center G, the mean of radiation leakage at point G3 is 2.65 μSv/h; with standard deviation of 1.97 μSv/h and percentage deviation from the background radiation as 95.85%. From center G, the mean of radiation leakage at point G4 is 1.69 μSv/h; with standard deviation of 0.85 μSv/h and percentage deviation from the background radiation as 92.41%. From center G, the mean of radiation leakage at point G5 is 22.67 μSv/h; with standard deviation of 5.09 μSv/h and percentage deviation from the background radiation as 99.51%. From center G, the mean of radiation leakage at point G6 is 15.91 μSv/h; with standard deviation of 3.19 μSv/h and percentage deviation from the background radiation as 99.31%. From center G, the mean of radiation leakage at point G7 is 8.19 μSv/h; with standard deviation of 2.10 μSv/h and percentage deviation from the background radiation as 98.66%. From center G, the mean of radiation leakage at point G8 is 3.00 μSv/h; with standard deviation of 1.97 μSv/h and percentage deviation from the background radiation as 96.33%. From center H, the mean of radiation leakage at point H1 is 14.80 μSv/h; with standard deviation of 1.53 μSv/h and percentage deviation from the background radiation as 99.32%. From center

H, the mean of radiation leakage at point H2 is 12.02 μSv/h; with standard deviation of 1.28 μSv/h and percentage deviation from the background radiation as 99.17%. From center H, the mean of radiation leakage at point H3 is 3.97 μSv/h; with standard deviation of 0.33 μSv/h and percentage deviation from the background radiation as 97.48%. From center H, the mean of radiation leakage at point H4 is 1.69 μSv/h; with standard deviation of 0.85 μSv/h and percentage deviation from the background radiation as 94.08%. From center H, the mean of radiation leakage at point H5 is 11.01 μSv/h; with standard deviation of 2.15 μSv/h and percentage deviation from the background radiation as 99.09%. From center H, the mean of radiation leakage at point H6 is 7.85 μSv/h; with standard deviation of 0.32 μSv/h and percentage deviation from the background radiation as 98.73%. From center H, the mean of radiation leakage at point H7 is 2.37 μSv/h; with standard deviation of 0.63 μSv/h and percentage deviation from the background radiation as 95.78%. From center H, the mean of radiation leakage at point H8 is 1.48 μSv/h; with standard deviation of 0.61 μSv/h and percentage deviation from the background radiation as 93.24%.

The purpose of this quality control test was to ensure the safety of health workers and the general public. From CT centers A, B, C and D the radiation leakage at the supervised areas were higher than that of the control areas, indicating a higher radiation risk to the public than the health worker. CT centers E, G and H, the radiation leakage at both the supervised and the control areas were low, which implies a safe environment for both the health worker and the public. At center F, the radiation leakages are high at both the supervised and the control areas, indicating a higher radiation risk for the public and the health worker. The radiation effect on both the health workers and the public depends on the time spent in the area during CT scan. It was observed that in some centers the doors leading to both the supervised and the control areas were not lead-lined while in some centers there were big openings at both the top and bottom of the CT room entrance door resulting to high radiation leakage. In the eight diagnostic centers, it was also observed that the average radiation leakage at both the supervised and the control areas are very high compared to the study carried out by Mettler et al., (2008) in New Mexico Veterans Administration Healthcare System, department of radiology and nuclear medicine USA, showed the mean ionizing radiation level to be 0.342μSv/h when CT scan was going on. Studies carried out by Jwanbot et al.,(2012) showed that ionizing radiation of Skane Radiodiagnostic Center, Jos, Plateau state was 0.676μSv/h.

4.1 CONCLUSION

The measurements of the radiation leakage at eight different diagnostic centers in Lagos state has been carried out. The study showed radiation levels in most diagnostic centers to be very high due to inadequate shielding and environmental monitoring of the centers. The range of mean dose rates at the supervised and control areas of the centers were from 0.18 to 211.30 μSv/h and 0.12 to 233.60 μSv/h. The gross deviation from acceptable standards may be an indication of exposure of personnel and visitors to radiation risks. Due to the significant values of ionizing radiation recorded in these diagnostic centers, further investigations on the shielding requirements of CT centers in Lagos state should be carried out by IAEA so that precautionary steps can be taken to avert over exposure of the individuals in these centers. Therefore, the diagnostic centers should ensure that periodic and regular inspection and radiation monitoring is carried out by a qualified medical physicists or radiation safety officer using Radeye B20-ER αβγ survey meter, thermoluminescent detectors, pocket dosimeters, and Geiger-Muller detector.

REFERENCES

1. AAPM (1991): Staffing levels and Responsibilities of Physicists in Diagnostic Radiology. Publication of American Association of Physicists in Medicine. Report of Task Group Diagnostic X-Ray Imaging Committee www.aapm.org/pubs/reports/rpt_33.pdf Accessed 13th August 2013.

2. American Institute of Physics. (1995): Radiation information for hospital personnel. Woodbury,NY:AmericanInstituteofPhysics.https://www.aapm.org/pubs/reports/rpt_5 3.pdf

3. Blizard EP (1962): Shield optimization with respect to weight. In: Blizard EP (ed) Reactor handbook, Part B: shielding, 2nd edn, vol III. Interscience, New York..

4.Canadian Nuclear Safety Commission. (2012): Introduction to radiation. Retrieved from https://www.nuclearsafety.gc.ca/eng/resources/publications/books-and-reports/introduction-to-radiation.cfm

5.Frush, D. P., Donnelly, L. F., & Reinhardt, N. S. (2003). Computed tomography and radiation risks: What pediatric health care providers should know? Pediatrics, 112(4), 951-957. doi: 10.1542/peds.112.4.951

6.Verdun, F.R., Aroua, A., Beachler, S., Schmidt, S., Trueb, P.R., & Bochud, F.O. (2010): Criteria for establishing shielding of multi-detector computed tomography (MDCT) rooms. Radiation Protection Dosimetry, 139(1-3), 215-219. doi: 10.1093/rpd/ncq105

7.Godfrey, H., & Allan, C. (1979): The invention of the CT scanner for Medicine. Medical History, 23(2), 169-174. doi: 10.1017/s0025727300040659

8. Heaney, D. E., & Norvill, C. A. J. (2006). A comparison of reduction in CT dose through the use of gantry angulations or bismuth shields. Radiography, 12(4), 291-296.

9Hohl, C., Wildberger, J. E., Suss, C., Thomas, C., Muhlenbruch, G., & Schmidt, T. (2006). Radiation dose reduction to breast and thyroid during MDCT: Effectiveness of an in-plane bismuth shield. Acta Radiologica, 47(6), 562-567.

10. Hungerford, H. E. (1968). Problems in design of fast reactor shields. Transactions of the American Nuclear Society, 11, 702.

11. Hungerford, H. E., Yevick, J. G., & Amorosi, A. (1966). Shielding in fast reactor technology: Plant design. MIT Press, Cambridge, MA.

12. International Commission on Radiological Protection. (2007). The 2007 Recommendations of the International Commission on Radiological Protection (Publication No. 103). Oxford: Elsevier.

13. Bushberg, J. T., Seibert, J. A., Leidholdt Jr, E. M., & Boone, J. M. (2002). The essentials of medical imaging (2nd ed.). Lippincott Williams & Wilkins, Philadelphia, PA. (pp. 4-13).

14Jwanbot, D. I., Izam, M. M., Nyam, G. G., & Agada, I. S. (2012). Evaluation of indoor background ionizing radiation profile in some hospitals in Jos Plateau State, Nigeria. Journal of Natural Sciences Research, 2(4), 35-43.

15.Mathieu, K. B., & Cody, D. D. (n.d.). Partial arc beam filtration: A novel approach to reducing CT breast radiation dose. Journal of the American College of Radiology. Advance online publication. doi: 10.1016/j.jacr.2022.03.014

16Rehani, M. M., Gupta, R., Bartling, S., Sharp, G. C., Pauwels, R., Berris, T., & Boone, J. M. (2010). CT-scanner scatter dose to operator and comparison with measurement. Radiation Protection Dosimetry, 139(1-3), 202-205. doi: 10.1093/rpd/ncq049

17.Mettler Jr, F. A., Walter, H., Yoshizumi, T. T., & Mahadevappa, M. (2008). Effective doses in radiology and diagnostic nuclear medicine: A catalog. Radiology, 248(1), 254-263. doi: 10.1148/radiol.2481071451.

18..MPE, Medical Physics Expert. (2012). Radiation protection: European Commission guidelines on medical physics expert. Directorate-General for Energy, Directorate D – Nuclear Energy, Unit D.4 - Radiation Protection. Retrieved April 30, 2012, from http://lacomplutense.ucm.es/web/medical-physics-expert-project. Accessed July 2013.

19.National Council on Radiation Protection and Measurements. (1988). Quality assurance for diagnostic imaging equipment: NCRP report No. 99. National Council on Radiation Protection and Measurements.

20National Council on Radiation Protection and Measurements. (1976). NCRP report no. 49: Structural shielding design and evaluation for medical use of X-rays and gamma rays of energies up to 10 MeV. Washington, D.C.: National Council on Radiation Protection and Measurements.

21.NIBIRR. (2003). Nigeria basic ionizing radiation regulations. B 166- B247. Nigeria Supplement to Official Gazette No.13 Vol. 92, 3rd March, (2005) – Part B (B45).