Compliance level assessment of the recommended standards in the design of privately owned radio diagnostic centers in Anambra State.

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DOI: https://doi.org/10.56293/IJASR.2022.5497

IJASR 2023
VOLUME 6
ISSUE 1 JANUARY - FEBRUARY **ISSN: 2581-7876**

Abstract: Background: Buildings used for radio-diagnostic purposes are expected to satisfy a certain radiation safety measures, however, the privately owned radio-diagnostic facilities in Anambra State are not purpose built.

Objective: To evaluate the building design and layout of diagnostic x-ray rooms of privately owned radio-diagnostic facilities in Anambra State against the internationally recommended standards.

Methodology: The building designs of all privately owned radio-diagnostic facilities registered with the ministry of health, Anambra State were assessed by measuring the x-ray room sizes, distances between the x-ray tubes and the control consoles, and the wall thicknesses using a well calibrated meter rule. Presence of lead lining on the walls and doors of the diagnostic rooms were noted and their thickness measured.

Results: The studied centers showed 14 (70%) compliance to NNRA recommended x-ray room size ($16m^2$). A total of 12 (60%) of the studied centers were in compliant with x-ray tube to console distance (≥ 1 meter) whereas 14(70 %) of the centers complied on the use of minimum of 2mm thickness of lead for wall lining.

Conclusion: The designs and outlay of privately owned radio-diagnostic facilities in Anambra State are in compliance with recommended standards.There was however no significant difference in the level of compliance among the studied parameters ($p<0.05$).

Keywords: Design parameters, Tube- to -console distance, Radio diagnostic facilities, Recommended Standard.

INTRODUCTION

Ionizing radiation has been noted to pose grave health hazard to all living things, especially humans. Medical use especially x-ray, is the major cause of man- made source of radiation exposure to the global population [1]. Because of this, national and international regulatory bodies were set up to generate safety guideline and regulate standards for setting up diagnostic and therapeutic outfits that uses ionizing radiation. They also have the responsibility of ensuring compliance to the set standards and proper installation of x-ray facilities and proper working condition of these facilities before they are put to public use.

Compliant to this radiation safety standard begins with location, structural design, procurement, and equipment layout of the x-ray facility [2]. The aim of having a standard structural design of the x-ray rooms is to protect not only the patients but also the x-ray departmental staff, patient's relatives and the general public [3]. A standard x-ray room must have the luxury of space to allow free movement of persons, trolley and machines and also for effective application of the inverse square law which promote the ALARA principle. Inadequate x-ray room sized diagnostic room results in increased radiation dose to the personnel and reduces the focus to film distance which results in image unsharpness (Jirijesh et al., 2008).

Effective shielding of the walls of a diagnostic x-ray room ensures proper attenuation of the x-ray energy and thereby protecting persons outside the x-ray room from radiation exposure. Lead has proven to be most effective in attenuation of x-ray radiation [4], which explains why most x-ray protective devices such as apron, goggles, screens, glasses are impregnated with lead. Many national and international ionization regulatory bodies have recommended specifications on maintaining good radiation safety. The Nigerian Nuclear regulatory Agency (NNRA) recommended a minimum radiographic room area of 16m² [5]. A study co-sponsored by the international labor organization (ILO) , the World Health Organization (WHO) and International Atomic Energy Agency(IAEA) recommended a radiographic room area of 24m²[6].The Atomic energy Regulatory Board , recommended a minimum x-ray room sizes ranging from 16 m² to 20m² [7,8]. International Atomic Energy Agency [2] recommended that the distance between the x-ray tube and the operator's console must not be less than 1 meter. According to the Atomic Energy Authority of Sri Lanka [8] and Atomic Energy Regulatory Board [9] the distance between the x-ray tube and the control console should not be less than 2 and 3 meters, respectively. Radiological Protection Institute of Irland [10] and NNRA recommended that x-ray room wall be lined with 2mm thickness of lead or its equivalent.

Standards are only effective if they are properly applied in practice. Ethics of every profession demand standard level of practice at all time. Periodic monitoring on professionals and institutions on level of practice is a major way of holding them to their responsibilities. Paucity of information on the level of compliance to recommended diagnostic facility design standard among privately owned radiodiagnostic centers in Anambra State was what motivated this work.

Materials and Methods

This was a prospective study that targeted all the privately owned radiodiagnostic centers in Anambra State. In accordance with Helsinki declaration, the research design and protocol were approved by the Research and Ethical committee, Nnamdi Azikiwe University College of Health Sciences, Nnewi. A total of twenty privately owned diagnostic centers were enlisted. The centers were represented with letters A to T, for anonymity. Nine of the studied centers are located at Onitsha, 4 at Awka, 3 at Nnewi, and 1 and 2 at Ekwulobia and Ihiala, respectively.

Informed consent was sought and permission to carry out the research was obtained from the management of each participating center prior to enrolment in the study. The lengths and the widths of each X-ray room, the distances between the operator console and the X-ray table and the thickness of the room walls were measured using a well straightened e meter rule. The type of shielding material used for the doors, walls, control panel and its glass window were documented.

Data analysis

Descriptive statistic such as mean and standard deviations were calculated for the x-ray room sizes, wall thicknesses and the source to console distances. Frequency tables and percentages were used to show the distribution of data. Measurement of level of dispersion was done using range. Data analysis was done using SPSS version 20. Statistical significance was considered at $p<0.05$.

Results

A total of 20 diagnostic centers who met the inclusion criteria were selected for the study. The minimum room size was 8m2, and the maximum was 65 m², with a mean and standard deviation of 25.70 m² ± 13.01. The minimum wall thickness was 20 cm, and the maximum was 45 cm, with mean and standard deviation of 27.60 cm ± 05.18. The minimum focus-to-console distance was 1.2 m, and the maximum was 4.3 m, with a mean and standard deviation of 2.7 m ± 0.85. (Table 1).

Table 1. Metric characteristics of the studied variables

Characteristics	Minimum	Maximum	Mean ± SD
Room size(m^2),	8	65	25.70 ± 13.01
Wall thickness (cm)	20	45	27.60 ± 05. 18
Focus- to-console Distance(m)	1.2	4.3	2.7 ± 0.85

Table 2 shows that 8 (40.0 %) of the studied centers had room sizes ≤ 21m²; 6 (30%) had room size of 21-30 m²; 4 (20%) had room sizes of 31-40m² ; 1 (5%) had room size of 41-50 m²; and1 (5%) had room size of 61-70 m².

Table 2: Frequency distribution of the studied centers according to their room sizes

Room size(m²)	frequency	percentage
≤ 20	8	40
21 -30	6	30
31-40	4	20
41-50	1	5
51-60	0	0
61-70	1	5
Total	20	100

Table 3 shows the frequency distribution of the studied centers according to their wall thicknesses. Centers whose wall thickness were ≤ 25 cm, had 7 (35 %) frequency ; those with wall thicknesses of 26-30cm,were 11 (55 %) ; and those with wall thicknesses 31-35, were 1 (5 %) ; Centers with wall thicknesses between 41 – 46 had 1 (5 %) occurrence.

Table 3. Percentage distribution of the studied centers according to their wall thicknesses

Wall thickness	frequency	Percent
≤ 25	7	35
26-30	11	55
31-35	1	5
36-40	0	0
41-46	1	5
	20	100

Table 4 shows the frequency distribution of the focus to console distance of the studied centers. It shows that 5 (25%) of the studied centers had focus to console distance ≤ 2.0 m; 6 (30%), has focus to consul distance ≤2.5 m;4 (20%) had distance ≤ 3.0 m; centers with focus to console distances of 31.1-3.5 m and 3.6-40 m had 2 (10%) occurrence each; whereas centers with distances of 4.1 – 4.5 m had 1 (5%) presentation.

Table 4 .Percentage Distribution of the studied centers according to the focus-to-console distance

Distance from focal spot,	Frequency	Percentage
≤ 2.0	5	25
2.1-2.5	6	30
2.6-3.0	4	20
3.1- 3.5	2	10
3.6- 4.0	2	10
4.1-4.5	1	5
Total	20	100

Table 5 shows the frequency distribution of the studied centers according to the shielding materials used. A total of 14 (70 %) of the studied centers used lead as shielding material for the walls, whereas 6 (30 %) used no lead; Only 6 (30 %), of the centers used lead as the shielding material for the doors; 9(45 %) used no shielding material while 5 (25 %)) used steel as shielding materials for the doors.

Table 5: Percentage distribution of the studied centers according to the shielding materials used

Shielding material	shielded area	frequency	percentage
Lead	wall	14	70
	Door	6	30
Concrete	wall	9	45
	Door	0	0
Steel	wall	6	30
	Door	5	25

Table 6 shows that 70% of the studied centers complied with the recommended minimum x-ray room size of 16m². It also shows that 60% and 70% of the studied centers complied with the recommended focus-to-consol distance and minimum lead thickness of ≥ 1m and ≥2mm, respectively.

Table 6 Distribution showing the percentage compliance of the studied centers to NNRA/IAEA recommendations

Recommended Parameter standards	No that complied	No that did not comply	Total N0	Percentage compliance
X-ray room size ≥ 16m²	14	6	20	70
Focus-to-consol-distance ≥ 1 m	12	8	20	60
Lead thickness ≥ 2mm	14	6	20	70

Table 7 is a Chi-square table showing the studied parameters on their level of compliance. No significant difference is noted among the studied parameters p<0.05.

Table 6: A Test statistic table showing the level of significance of the studied variables

	Room size M2	**Wall thickness cm**	**Source-to console distance m**	**Shielding**
Chi-Square	**0.667[a]**	**2.000[b]**	**0.667[a]**	**0.667[a]**
df	4	3	4	4

Asymp. Significance	0.955	0.572	0.955	0.955

Discussion

The results of this work show that the design of a greater part of the studied centers was in compliance with the recommended standards. Seventy percent (70%) of the studied centers complied with the recommended room size of ≥16m² by the NNRA and AERA [2, 9, 8]. This corresponds to 60% compliance to room size (≥24m²) by the studied centers as recommended by International Labor Organization (ILO) and World Health Organization [6]. Large x-ray room size provide twin benefit of distance and space which enable the x-ray worker on the use of appropriate focal film distance(FFD) which is necessary for adequate image sharpness and accurate anatomical representation. It also encourages radiation protection as it can cause x-ray dose reduction according to the inverse square law [11]. Severe decrease in the distance between the patients and the x-ray source could lead to increased skin dose which could result in skin damages such as dermatitis and erythema etc [4, 12]. Sixty percent (60%) of the studied centers complied with the International Atomic Energy agency's recommended focus-to-console distance of ≥ 1 meter [2]. This corresponds to 55% compliant to the ≥2m focus- to -console distance among the studied centers ,as recommended by the Ionization regulation Agency of Sri Lanka, [8]. According to the inverse square law, the greater the distance between the x-ray tube and the operator console, the lower the x-ray intensity getting to the x-ray booth and consequently the better protected the operator would be. So, use of small x-ray room sizes exposes the operator to greater danger of occupation hazard.

This study also recorded that 70% of the studied centers complied with the use of 2mm thickness of lead in lining of the walls of the x-ray rooms as recommended by NNRA, Radiological Protective Institute of Sri Lanka and Irland. Lead has proven to be most effective in attenuation of x-ray radiation [13]. This is why most x-ray protective devices such as apron, goggles, screens, glasses are impregnated with lead.

Conclusion

Although purpose renovated, the design and outlay of the studied privately owned radio-diagnostic facilities in Anambra State are in compliant to recommended standards. This implies that workers and persons accessing the studied facilities are adequately protected against radiation exposure that could be due to the studied parameters.

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