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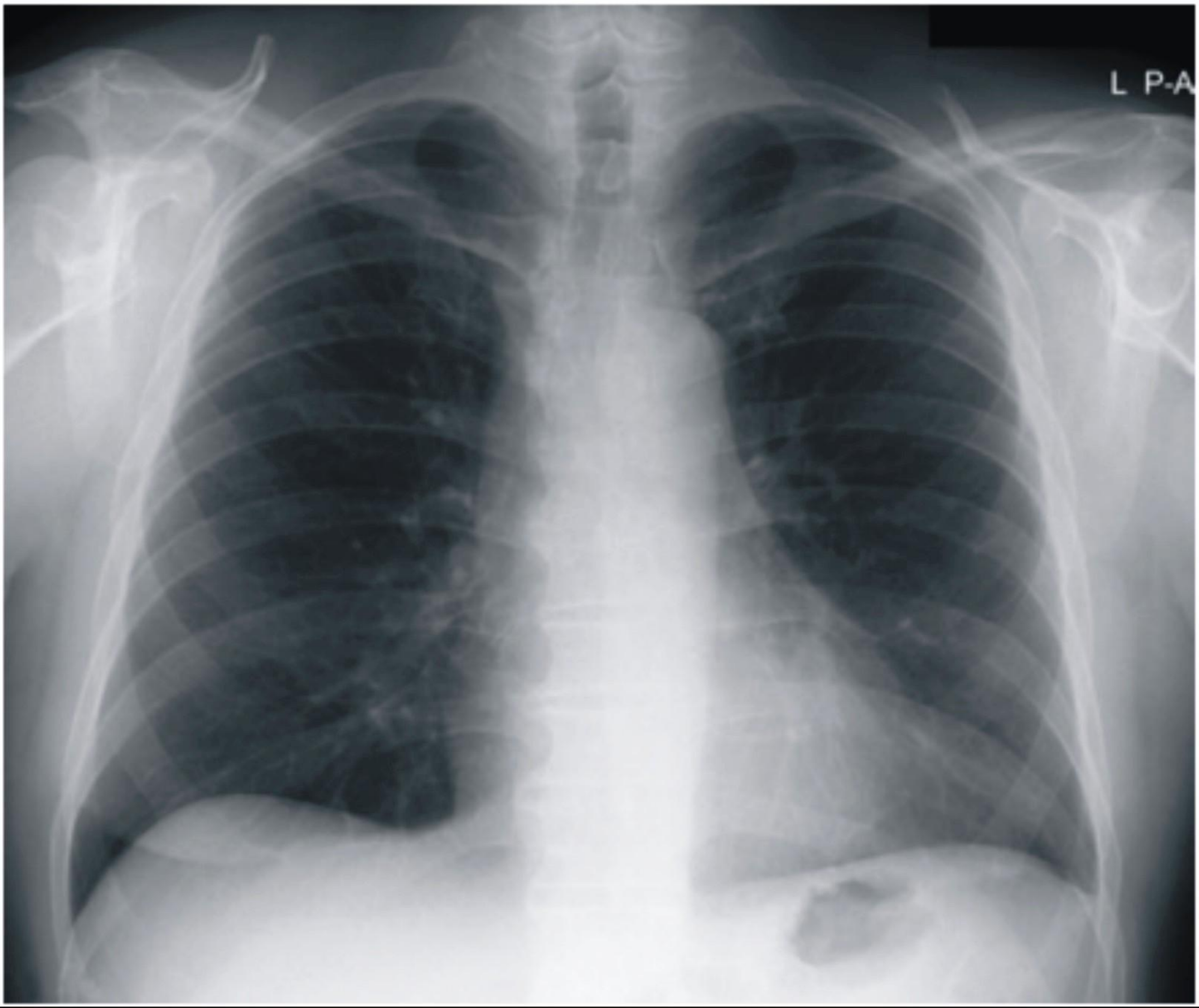

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Radiographic Room Design and Layout for Radiation Protection in Some Radio-Diagnostic Facilities in Katsina State, Nigeria

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ABSTRACT

Background: The radiographic room design and layout of the radio-diagnostic facilities involved in this study were converted from existing structures without the input the various professionals who use these facilities.

Objective: The aim of the study was to assess the measures for radiation protection installed in the building design and the layout of some radio-diagnostic facilities in Katsina state.

Methodology: The room dimensions, distances between the operator booth and the radiation source and between the operator booth and the cheststand were measured. Lead lining on doors and room walls, warning signs, warning lights and the use of personnel monitoring devices were also carefully checked.

Result: X-ray room dimensions were 20m^2, 38.5m^2 and 12.8m^2 for x-ray unit A, B and C, respectively. The distance from the operator to tube was 3.4m, 3.8m and 3.1m while that of operator to chest stand was 3.2m, 4.5m and 3.1m for x-ray unit A,B and C respectively. There were warning signs and lights in all the units.

Conclusion: The use of radiation accessories and warning lights were satisfactory. Meanwhile, in order to ensure optimization of radiation protection, the various professionals such as radiographers, radiologists and medical physicists should, alongside the architect and engineers, play their role in the building design and the room layout of radio-diagnostic facilities.

Keywords: Room design, layout, optimization, radio-diagnostic facilities

Introduction

The use of radiation in medicine is on a continuous increase and studies have revealed that the medical use of x-ray is the major contributor of man-made source of radiation to the world's population [1, 2, 3]. Furthermore, because of the hazards associated with the use of radiation, it is important that the fundamental radiation protection principles of justification of practice, optimization of protection and dose limit are implemented appropriately [1, 4].

Radiation protection can be achieved by maximizing the distance from the radiation source, minimizing the time of radiation exposure, making use of shielding against the radiation source and also containing the radiation source [5]. This is even more necessary in view of complaints of various forms of radiation hazards which were suffered as a result of the uncontrolled use of the x-radiation by scientists after the discovery of x-rays [6].

Structural design for radiation sources should satisfy the required minimum radiation protection specifications [7, 8]. From experience and observation in our locality, some general radiographic rooms were converted from other buildings not primarily meant for radio-diagnostic purpose.

It is therefore, important to assess the building design and layout of these facilities. The radiographer/radiologist, the patient and the members of the public should be protected from radiation exposure by applying the "As Low as Reasonably Achievable" (ALARA) principle. In addition, the fundamental principles of consideration are distance, time and shielding [9].

It is also important that the building design and layout (whether the building was originally designed as a radiographic room or it is converted from an existing building to a radiographic room) meet the recommended radiographic room dimension and structural shielding. The x-ray facilities should also be carefully planned as part of an integrated radiology/imaging department with inputs from a team including architects, engineers, hospital management, radiographers, radiologists and medical staff such as cardiologists or vascular surgeons [8]. It is also critical to check whether radiation protection accessories such as warning signs, warning light, lead aprons and so on, are in place.

This study was necessitated after a pilot survey of some radio-diagnostic facilities in the locality revealed that many of the radio-diagnostic facilities were converted from buildings designed for other purposes.

Material and Methods

A factory calibrated ionizing radiation meter (RADOS RDS 120) obtained from the Centre for Energy Research and Training, Zaria, Nigeria was used for area monitoring of various strategic places around the radiographic room when the x-ray machines were exposing at working capacity per centre studied. Recorded radiation information for each location within the rooms and for the respective diagnostic ray rooms were collated and studied. From the information obtained, deductions were made about the radiation protection implication of the room designs.

Results

The building layout of the radiographic rooms was sketched to show the dimensions and adjoining structures (such as offices, reception area, x-ray archive etc). The cheststand, x-ray machine and the control console were also shown in the sketch and the distances between them were also measured. Radiographic rooms A and B are located in a government-owned hospital while radiographic room C is located in a private radio-diagnostic centre. All the three general radiographic rooms involved in this study were not purpose-built. Figures 1 to 3 are the sketched layouts of the facilities studied. Tables 1 shows the x-ray room design and layout parameters for the various x-ray units A, B and C while **t**he measurements obtained for the background, and the respective selected measurement points are presented in Table 2.

Discussion

The Nigerian Nuclear Regulatory Agency (NNRA) recommends a minimum radiographic room area of at least $16m^2$ [10]. A study jointly sponsored by the International Labour Organisation (ILO), International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) recommend a radiographic room dimension of not less than 6 x 4 x 3 in length, breath and height [11]. Therefore, this gives a room area of at least 24 m^2.

The Atomic Energy Regulatory Board AERB [12] and a work by Nilantha *et al.* [13] recommended a minimum room dimension ranging from 16 m^2 to 20 m^2. Table 1 shows the room area of the three radiographic rooms with A (20 m^2), B (38.5 m^2) and C (12.8 m^2), respectively. Room 'B' met all recommended standards. Room A did not meet the WHO standard but met NNRA recommendation [10] AERB [12] and Nilantha *et al.* [13]. Room C however, did not meet any of the standards.

The implication of the above measurements notwithstanding, the rooms designated as X-ray rooms in the studied centres largely suggest poor radiation protection to the operator and perhaps, other people within the controlled area during operation. The inverse square law states that the radiation intensity is inversely proportional to the square of the distance from the radiation source.

From radiation protection perspective, the larger the room dimension; the more distance would be between the x-ray tube and the control room (operator's booth), therefore the lesser the radiation that will reach the operator and the wall of the radiographic room. It is recommended that the x-ray tube is not closer than 1 m to the operator's booth [9]. Thus, doubling the distance reduces the dose by a factor of four [14].

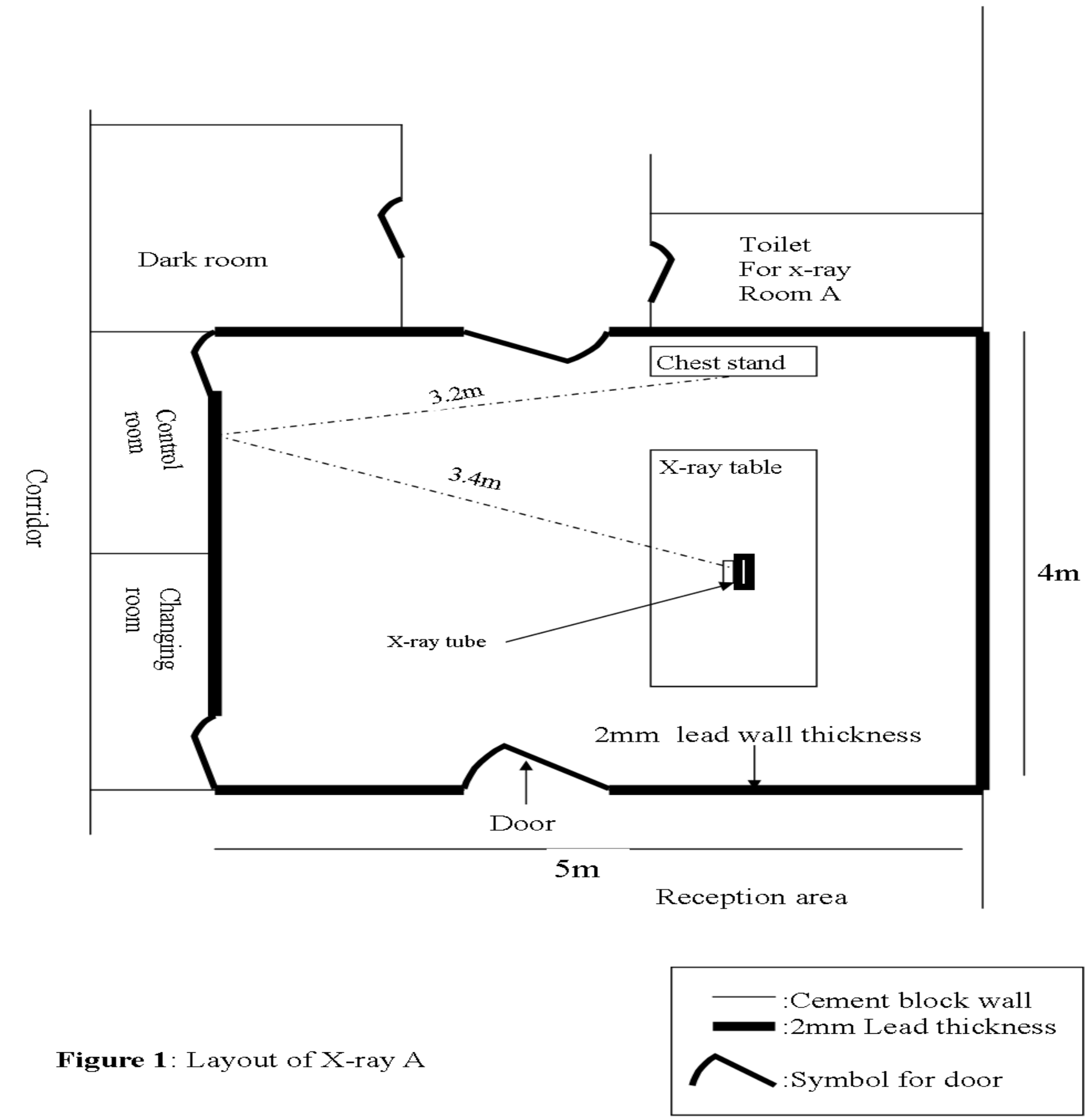

Figure 1: Layout of X-ray room A

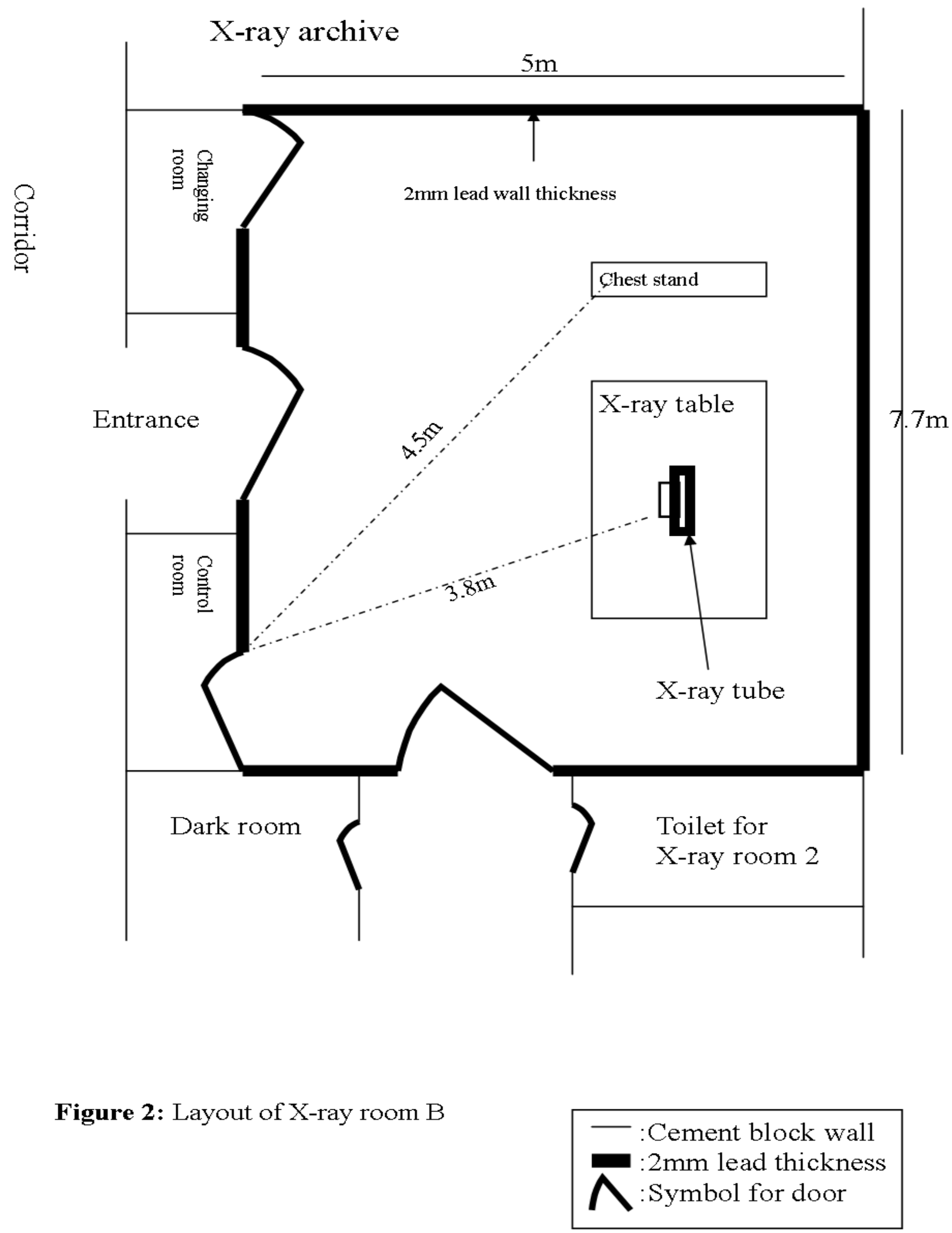

Figure 2: Layout of X-ray room B

Figure 2: Layout of x-ray room B

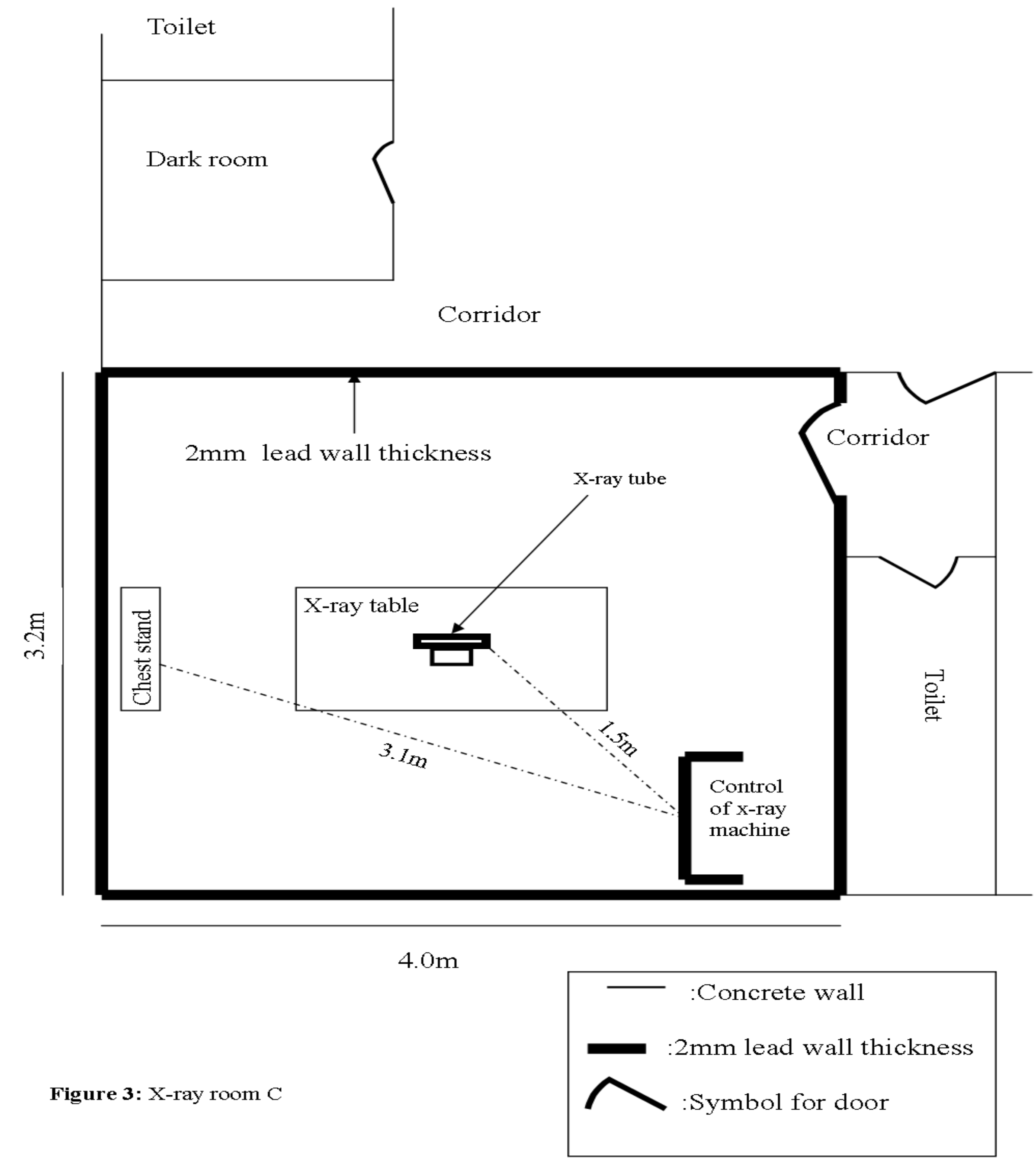

Figure 3: Layout of x-ray room C

Table 1: The x-ray room design and layout parameters for the various x-ray units A, B and C

Parameters	X-ray Units		
	A	B	C
X-ray room type	Bungalow	Bungalow	Bungalow
Dimension (m^2)	20.0	38.5	12.8
Wall type	Cement block	Cement block	Cement block
Thickness (m)	0.27	0.27	0.27
Lead thickness (mm)	2.0	2.0	2.0
Lead lining height (m)	3.3	3.3	2.8
Door			
Number	2.0	2.0	1.0
Type of material	Wooden board	Wooden board	Wooden board
Dimension (m^2)	1.2 x 2.1	0.8 x 2.1	0.8 x 2.1
Lead lining	Yes	Yes	Yes
Lead thickness (mm)	2.0	2.0	2.0
Ceiling			
Type of material	Wooden board	Wooden board	Concrete
Height from floor (m)	3.3	3.3	2.8
Window			
Number	None	None	None
Distances			
Operator – tube (m)	3.4	3.8	1.5
Operator – chest stand (m)	3.2	4.5	3.1
Control Cubicle			
Type of material	Concrete	Concrete	Leaded screen
Warning Signs	Yes	Yes	Yes
Warning Lights	Yes	Yes	Yes

Table 2: Area monitoring results of the strategic areas from the x-ray tube at maximum operation

Area	Dose Rate (μSv/h)		
	X-ray Room A	X-ray Room B	X-ray Room C
Background	0.12±00	0.12±00	0.13±00
Control stand	0.14±01	0.12±04	2.20±00
X-ray room door	0.11±00	0.13±01	1.30±06
Darkroom	0.10±00	0.10±00	0.10±00
Reception	0.10±00	Not sighted	Not sighted
Archive	Not sighted	0.10±00	Not sighted
Toilet	0.10±00	0.10±00	0.17±00
Behind x-ray room	0.10±00	0.10±00	No access

Furthermore, the distance between the operator to the radiation source and the operator's booth to the chest stand should be at least 3m [12] whereas, according to Atomic Energy Authority of Sri Lanka, the minimum distance between the operator and source should be 2 m [13]. The findings from this work showed a distance less than recommended value in room C. This implies that more radiation would be reaching the operator of the x-ray machine in facility C. This is undesirable in the face of the likelihood of the operator exceeding the maximum permissible occupational dose. Some corrective measures are recommended.

All the walls of radiographic rooms involved in this study were lined with 2 mm lead equivalent which satisfied the recommendations of NNRA [10] and the Radiological Protection Institute of Ireland, RPII [8]. Structural shielding should be calculated by a medical physicist in order to ensure adequate radiation protection [15].

There was adequate use of lead aprons in all the x-ray rooms. The use of radiation monitoring devices (thermo-luminescent dosimeter) by the staff in first radiation facility was impressive while there was no personnel monitoring devices of the staff in the second radiation facility. More so, warning lights and warning signs were used at the entrances of all the x-ray rooms (see Table 1). And written warnings translated in local languages were also boldly displayed on all the x-ray room doors.

CONCLUSION

The foregoing reveals that while facilities developed from existing buildings may be adequate in room size, shielding of the radiographic room walls and doors, provision of warning lights and signs, optimization of radiation protection could be achieved through careful consideration of the radiographic room design and layout by adherence to room specifications by regulatory bodies.

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