RADIATION PROTECTION STRATEGIES IN MEDICAL DIAGNOSTIC CENTERS IN LAGOS STATE, NIGERIA.

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Abstract. In recent years, Medical imaging has recorded a canonized level of advancement in the medical chronicles of achievement feats. This has made the diagnosis of ailments easy in reducing the death rate of patients. Imaging machines have different functions and some of them use radiation that is dangerous to the human body. Although radiation is important and it is needed for the patients in need of treatment but not needed by the machine operators, staff and visitors of the building where the imaging machines are been housed. The aim is to investigate different design and construction strategies employed to reduce transfer of radiation in various diagnostic imaging centres in Lagos State Nigeria; in order to reduce health risk associated during radiation emission in medical facilities. Qualitative method of research was adopted and data were collected via review of pertinent literature and field work of three diagnostic centres in the study area. The data were analysed using content analysis and presented with sketch and pictures. The finding reveals that lead lining was the most common material used to shield the different diagnostic rooms in the study area. This shielding was not only done for walls but also embedded in the doors. In addition, Lead glass was also used to protect the machine operators from radiation. Finally, this study recommended that other less harmful materials need to be explored for radiation shielding other than the use of Lead. For competency in Educational, professional, curricular practices and even hygienic exigencies; further research may advance investigations to find out other protective materials and strategies that are relevant to medical exploits as well as Architects design specification knowledge for the design of medical facilities.

Keywords: Diagnostic-Centers, Medical-Imaging, Protection, Radiation, shielding.

1. Introduction

The use of radiation in medicine is one of the longest applications of radiation. In 2008, the statistics of annual number of diagnostic and radiology procedures throughout the world was put at about of 3000 million and more than 5 million radiation therapy treatments [1]. This is an indication that medical use of radiation brings considerable public health benefits. In the medical world it is used for radiation therapy, and radiology imaging techniques such as dental radiography computer tomography, fluoroscopy, mammography, x-ray radiography. Some other uses are the industrial application such as sterilization of fabric equipment or food and electrical energy production, development of nuclear weapons in the military application.

In spite of the versatility in the usage of radiation in medical sciences, its consequential effects could really be dangerous if not carefully handled. A safe and healthy system needs to strike a good balance between the dangers enfaced and benefits derivable by radiation exposure to radiographers, patients, general public. In a way to safeguard radiation emission against human health, diagnosis and interventional strategies may be put in place because, it has the ability of damaging healthy cells and tissues after ionization with organic tissues through a number of ways. Improper protection towards excessive exposure of human body to radiation can cause radiation infertility, cataract, skin burn, cancer and death. To proffer adequate solutions, shielding method could be employed as a safeguarding mechanism to protect people from the radiation hazards and serve to discharge the excessive radiation to the surrounding environment. This method is engaged to protect people and the surrounding from the dangerous effect of excessive exposure of radiation. Johnson [2] also describes the reduction of radiation exposure to patient and medical staffs as being hazardous and worrisome. The study aimed at investigating different design and construction strategies employed to reduce emission of radiation in selected diagnostic imaging centres in Lagos State Nigeria in order to reduce health risk associated during radiation emission. In the same vein, this study asked the following questions in the course of investigations. They are: what are the various techniques and strategies used for reduction of radiation transfer in medical diagnostic facilities? (ii)To what extent are the identified radiation reduction strategies adopted in medical diagnostic facilities in the study area? While the Objectives of the Study are to: (i) reduce health, risk associated during radiation emission identify various techniques adopted for reducing radiation transfer, (ii) investigate the extent to which radiation protection strategies were adopted in selected medical diagnostic facilities in the study area.

2. Literature

Before and in the nineteenth century, physicians and medical practitioners were hindered to acquire details of illness and injuries of patients. The discovery of Diagnostic medicine has enhanced significantly, and treatments have advanced for cure or support of people with various kinds of ailments [3]. In November 1895 a physicist at the University of Wurzburg named Wilhelm Rontgen, was conducting an experiment with cathode rays. He found out that the new radiation could move through different materials and could be recorded on photographic plates and called the Radiation x-ray. In the early 1970s a major innovation was introduced into diagnostic imaging. This innovation, x-ray computed tomography (CT), is recognized today as the most significant single event in medical imaging since the discovery of x rays.

2.1 General Requirements on Radiation Shielding

Most radiographic procedures are always carried out in a dedicated room and to protect the people in the room and immediate environment from ionizing radiation then there is need to set aside radiation protection methods. The source of this ionizing radiation can either be from the x-ray tube, or primary beam, or even scattered off the patient. All x-ray rooms according to World Health Organization [4] only be accessible to patients that needs to be diagnosed and the others such as the operator of the radiographic machine who also needs to be in the room during the procedure should be protected by means of radiation shielding.

During the planning of radiology rooms, it is important to weigh if expanding the space have economic benefit or providing more structural radiation shielding. The size of an x-ray room has an influence on radiation shielding [4]. This was mathematically explained using the inverse square law which is increase in the distance by two meters reduces the dose by a factor of its square as seen in figure 1 below. Radiation shielding requirements can relatively be reduced according to Radiation Protection Institute of Ireland [5] if it is possible to assign a relatively large space for an x-ray room thereby increasing the distance to occupant of nearby spaces.

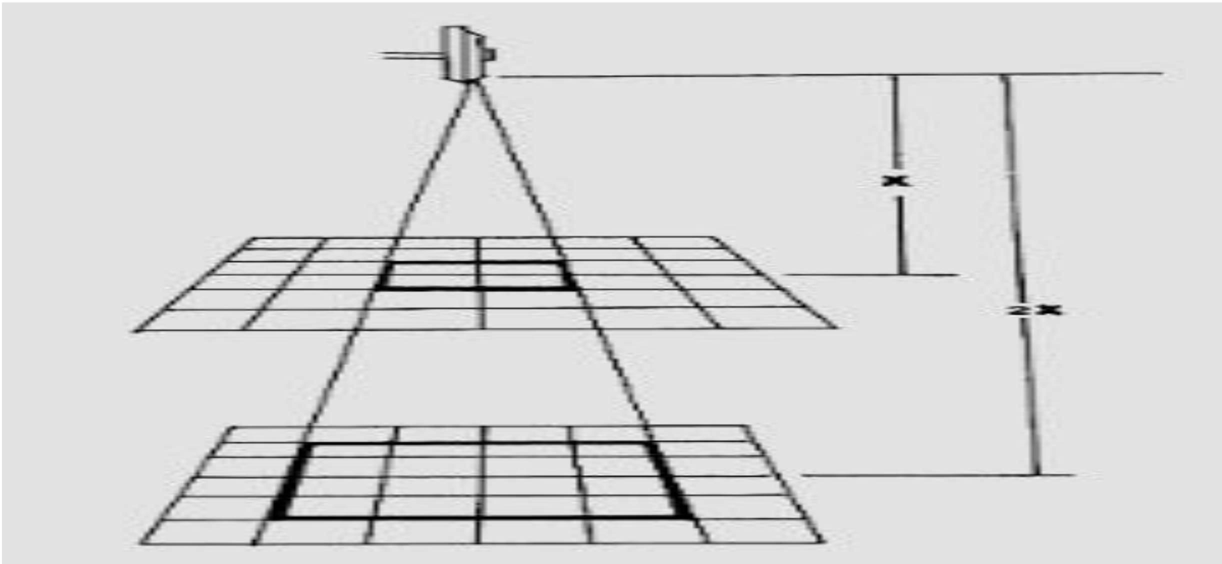

Figure 1: Diagram showing the principal of the inverse square law
Source: World Health Organization (2004)

The personnel that must work within the supervised and controlled area in the radiology rooms must be protected from being exposed to ionizing radiation. This protection can be done using three approaches which impact on room design and equipment specification [5]. Fixed screen or cubicle is used to shield the operator from the exposure of radiation when the radiology machine is in use with a minimum height of 2.2 meters and long length so as to give full body protection of the operator from exposure to scattered radiation. At the back of this screen is where the necessary control systems such as emergency stop switch are located [6], [7]. A lead sheet of 15 kgm^{-2} (1.3mm) or its lead equivalent is used for the screen or cubicle and the lead thickness can be higher if the distance of the cubical to the x-ray tube or patient is less than 2 meters. The protective cubical or screen also have a lead glass so as to allow the operator see clearly the patient during procedure and this glass is generally either lead glass with a thickness of 6mm and 1.5 lead equivalent or H-22 lead acrylic with 1mm lead equivalent with 100 kVp [8]. The lead thickness might also increase depending on the distance to the patient and the man source of radiation [9]. Partial frame protecting used to protect staffs which are required to be close to the patient for the duration of x-ray exposures. The protection of the body can be broadly divided into two types which are protection of the upper body and protection of the lower body. The protecting of the upper part of the body is regular in interventional rooms and emphasis is given to the head and neck, and especially on eye protecting. The protection is typically composed of lead glass or lead acrylic and mounted at the ceiling on the end of an arm that is mobile.

2.2 Shielding of X-Ray Rooms.

The bounds all occupied regions such as walls, doorways, door frames, ground, ceiling, home windows, window frames and the protective viewing display screen should be shielded as it should. Usually this requirement can be met with the aid of 2 mm of lead, or its equivalent with the use of other materials [5], [7]. Notwithstanding, a strategy of protecting to in excess of 2 mm thick lead level may lessen issues that may emerge with future difference in use and inhabitant in the regions that are opposite to the room. Despite this it is critical to evaluate each room on an individual premise with a discussion with the National radiation protection regulatory body. The lead equivalent used for the x-ray room should be noted on the wall for future references.

Secondary or scattered radiation can be dealt with by using a 4mm thick lead equivalent for shielding and assuming the boundaries are not exposed to the primary beam. But when the boundaries are to be exposed to this primary beam then and additional lead shielding is to be used with an example of having an additional lead beam blocker behind a vertical Bucky or chest stand. For situation where tube movement is directed towards the wall, additional shielding is required to extend to the possible areas the tube will extend to. The protective barrier or operator console cubicle as seen in Fig 2 is made or composes of lead lining with lead glass on at the upper part of the barrier. This glass gives the operator a good panoramic view of the patient having the diagnosis with the glass protecting him or her from radiation exposure. The use of a lead glass with a length of 2m to 4m and height of 0.6-1m is adequate [5]. Consideration should also be given to how this fit into the general room design of the x-ray room

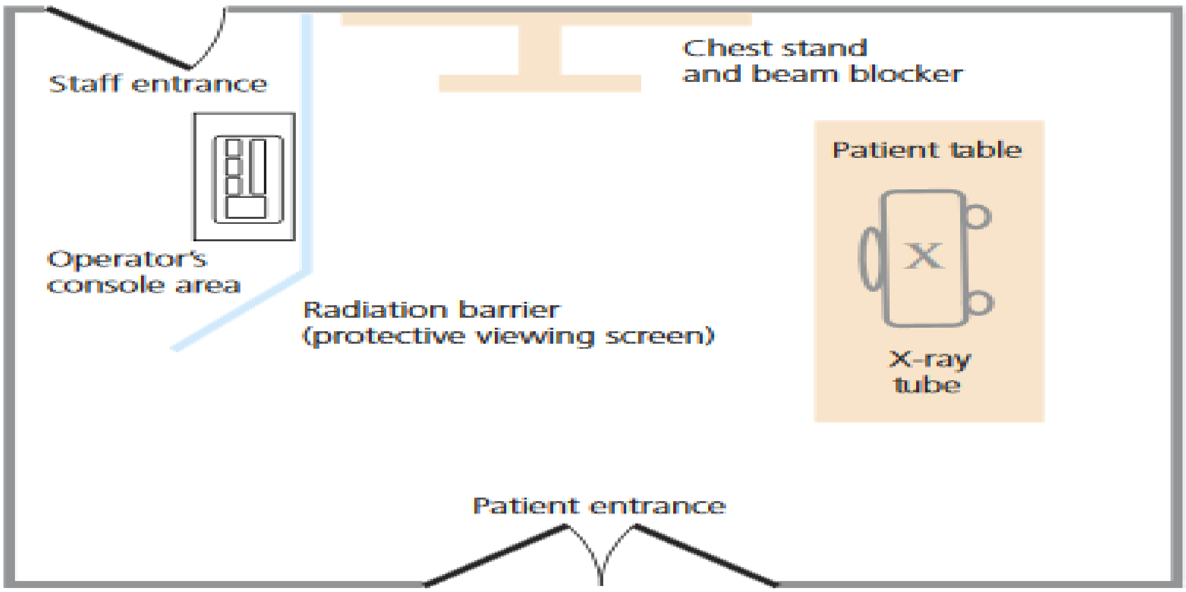

Figure 2: Floor Plan of X-ray room with chest stand
Source: Radiation Protection Institute of Ireland (2009)

2.3 Shielding of Computed Tomography (CT) Rooms

Large numbers of staff are mostly involved during computed tomography procedures and will need to access the control room, the patient in the room. The operators or control room as seen in Fig 3 serves a lot of purposes in a computed tomography room. The purposes are image processing, reporting of the image processing, reporting of the image, teaching or training of personnel and also consulting and this must be taken into consideration when choosing the radiation shielding and thickness to be used. According to Ahmed [6] lead glass that covers the whole length of the wall that faces the equipment room prodding a panoramic view can be used to shield the operators control room from radiation.

There are different variations when it comes to shielding computed tomography rooms. For the modern computed tomography system that emits very high level of scattered radiation in the equipment room, then greater level of radiation shielding needs to be done. The distribution of scattered radiation in computed tomography rooms are differed from other imaging rooms. The manufacturers of the machines make isodose curve for each of the scanner available which can be used to determine the radiation shielding requirement and also taking into account local techniques available. The radiation shielding requirement for newly introduced multi-slice computer tomography machines are between 3 mm to 4 mm lead [10].

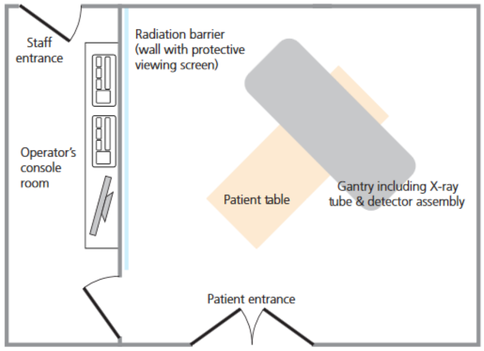

Figure 3: Floor Plan of Computed tomography (CT) room
Source: Radiation Protection Institute of Ireland (2009)

3. Methodology

In achieving the objectives of this study, two types of investigations namely; literature review and field work were carried out. Several literatures from books, journals and reliable internet sources relevant to the subject matter were reviewed. The study area which is Lagos State consist of high number of diagnostic which houses various radiology machines and purposive sampling was used to select the diagnostic centres that was visited. This was also based on selecting one government and two privately owned centres as shown in table 1 below. The radiation protection strategy employed in the different diagnostic centres were observed and investigated. The data was then analysed using content analysis and then presented using sketches and pictures.

Table 1: *List of selected diagnostic centres selected for field work.*

S/N	List of Diagnostic Centres Visited	Public or Privately owned
1	Clinix Diagnostic Centre, Gbagada-Oshodi Expressway Anthony, Lagos State.	Private
2	Bola Tinubu Health and Diagnostic Center, Lagos State University Teaching Hospital, Ikeja, Lagos.	Public
3	Arrive Alive Diagnostic and Imaging Service, Ojuelegba, Lagos State	Private

4. Data Analysis and Presentation

The radiation protection strategist in the three (3) various medical diagnostic centres visited are analysed and presented below:

4.1 Radiation Protection Appraisal for Clinix Diagnostic Centre, off Gbagada-Oshodi Expressway Anthony, Lagos State.

The centre has its radiology unit on the ground floor making it easy for patients on stretchers to access the radiology rooms. The machines on the ground floor include x-ray room, computed tomography room and the magnetic resonance imaging room. Three of the machines used in this centre emit radiation when in use and they are the mammography machine, x-ray machine and the computer tomography machine. Lead material was used to protect radiation from escaping through the walls and doors of the computer tomography, x-ray and mammography room. This centre used 2mm thick lead lining on the walls and the doors of computer tomography, x-ray and mammography rooms to prevent the escape of radiation. Plaster of paris was used to finish this lead lining and also steel was used to cover the lead lining inside the door. The computer tomography and magnetic resonance room share the same control room as seen in figure 4 and lead glass as seen in plate 1 below was employed to protect the different operators from radiation exposure coming from the computer tomography room.

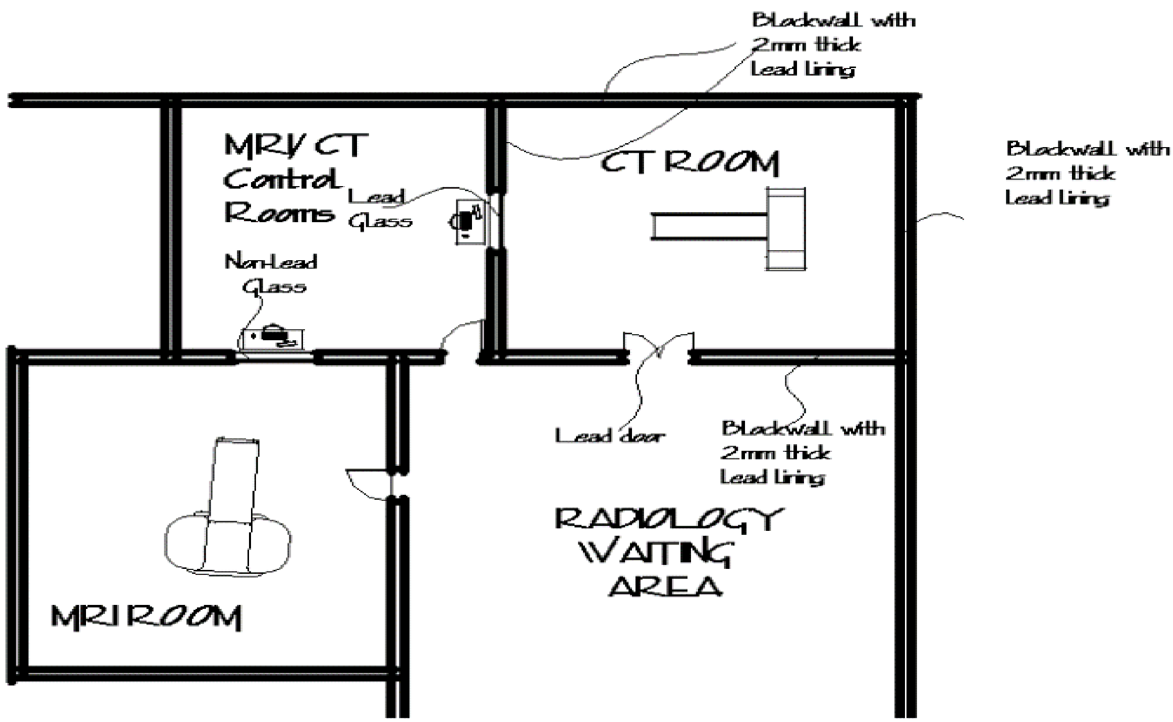

Figure 4: Sketch showing Floor plan of CT and MRI room sharing one control room.
Source: Author's field Study (2019)

Plate 1: Computed tomography room through the lead glass used to protect the operator's area.
Source: Author's field Study (2019)

Also the use of warning and danger signs were also employed to protect people from the danger of the machines as seen in plate 2. The danger signs are easily seen by people trying to enter this rooms when the radiology machines are in use to give warning. Warning lighting in red colour was employed to alert people of danger and this light immediately comes up immediately the machines are on to be used.

Plate 2: View of warning light above the door with danger signs on the surface of the door.
Source: Author's field Study (2019)

4.2 Radiation Protection Appraisal for Bola Tinubu Health and Diagnostic Centre, Lagos State University Teaching Hospital, Ikeja, Lagos.

The centre has its radiology unit on the ground floor making it easy for patients on stretchers to access the radiology rooms. The machines on the ground floor include x-ray room, computed tomography, fluoroscopy room and mammography. At the x-ray, fluoroscopy and 16-slice computed tomography rooms; 2mm thick of lead was used to shield radiation from escaping as seen in figure 5, 6 and 7 below. Also these rooms only have one entrance leading to them respectively. These rooms also have their console area that is been shielded with lead and made of wooden structure. The console has a glass screen that contains lead which allows the operator to be able to see the patient when undergoing diagnosis as seen in plate 4 below. The rooms also have doors with lead so as to protect people on the wall way from radiation exposure. There was no radiation protection for the ceiling since the height of the room was more than 2.5 meters and the concrete slab at the upper floor was 150mm thick.

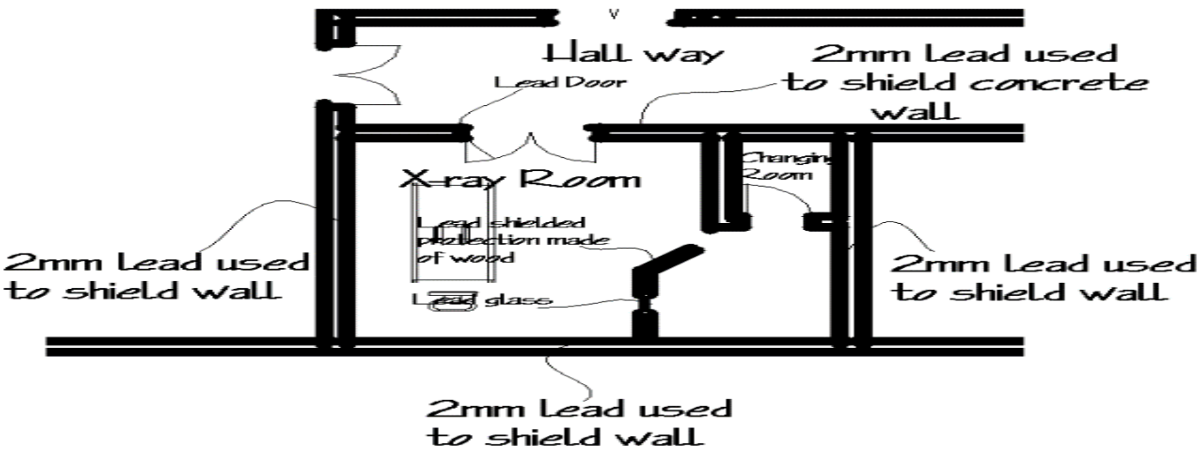

Figure 5: Sketch showing the Floor Plan x-ray room.
Source: Author's field Study (2019)

Plate 3: View of the protective cubicle in the x-ray room.
Source: Author's field Study (2019)

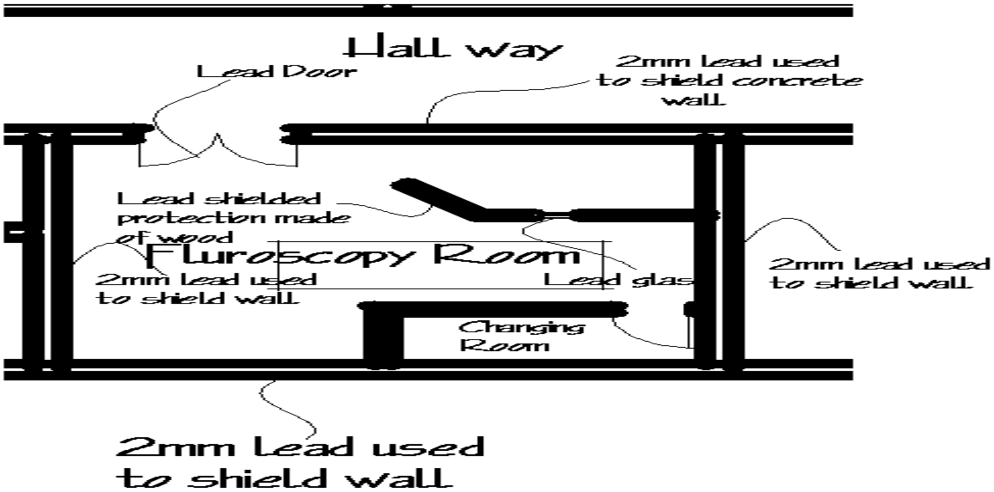

Figure 6: Sketch showing the floor plan of fluoroscopy room.
Source: Author's field Study (2019)

Plate 4: View of the protective cubicle in the fluoroscopy room.
Source: Author's field Study (2019)

Also, in order to protect people on a hall way from emission of radiation, the inner wall that links the hall way with the respective diagnostic rooms was constructed with concrete instead or the normal block work and then lined with lead in the rooms. For the 64-slice computed tomography room, 5mm thick lead lining was used. The reason for doing it was that the 64-slice CT machine emits higher radiation than the 16-slice with a better imaging output.

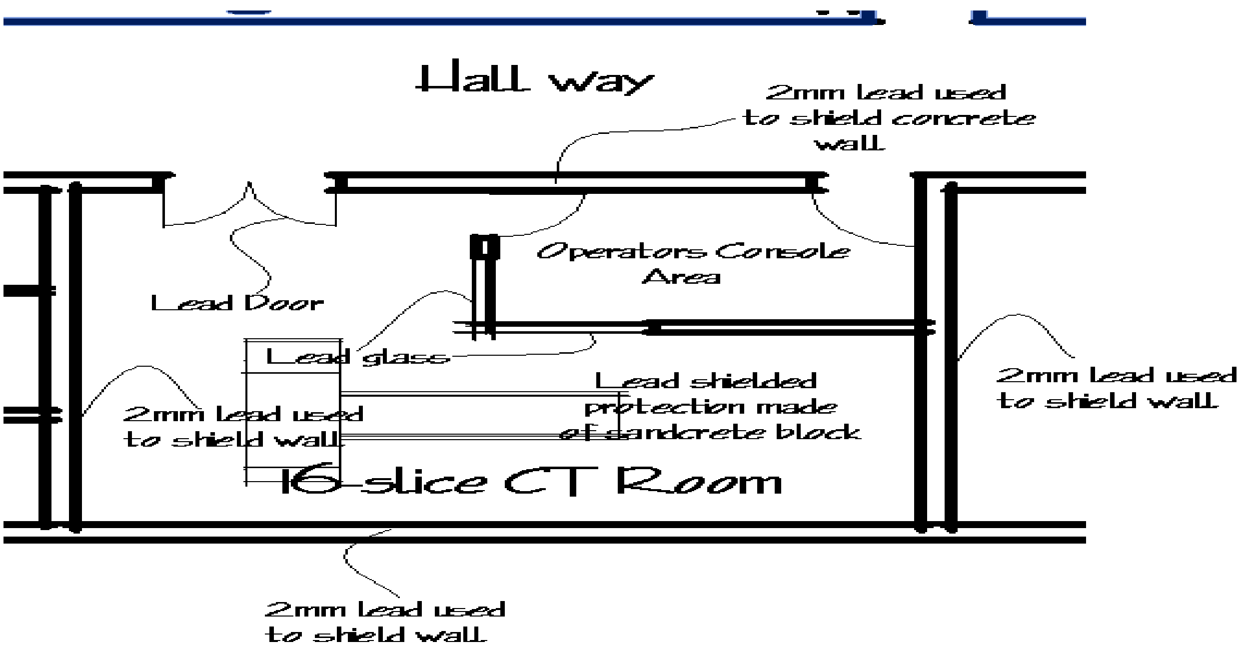

Figure 7: Sketch showing the 16-slice computed tomography room.

There were also two lead doors leading to the 16-slice computed tomography room which are the one from the hallway and the other one from the operator console area as seen in figure 7 above.

Plate 8: The operator control room with lead glass in the 16 slice CT room.

For the 64-slice computed tomography machine there is only one lead door leading into the room which is also close to the operator console area as seen in figure 8 below. Lead glass was also used to protect the operator from radiation exposure as the operator have to see the patient as the diagnosis is been done as seen in plate 10 below.

Plate 9: View of an uncovered lead lining in the 16-slice computed tomography room.

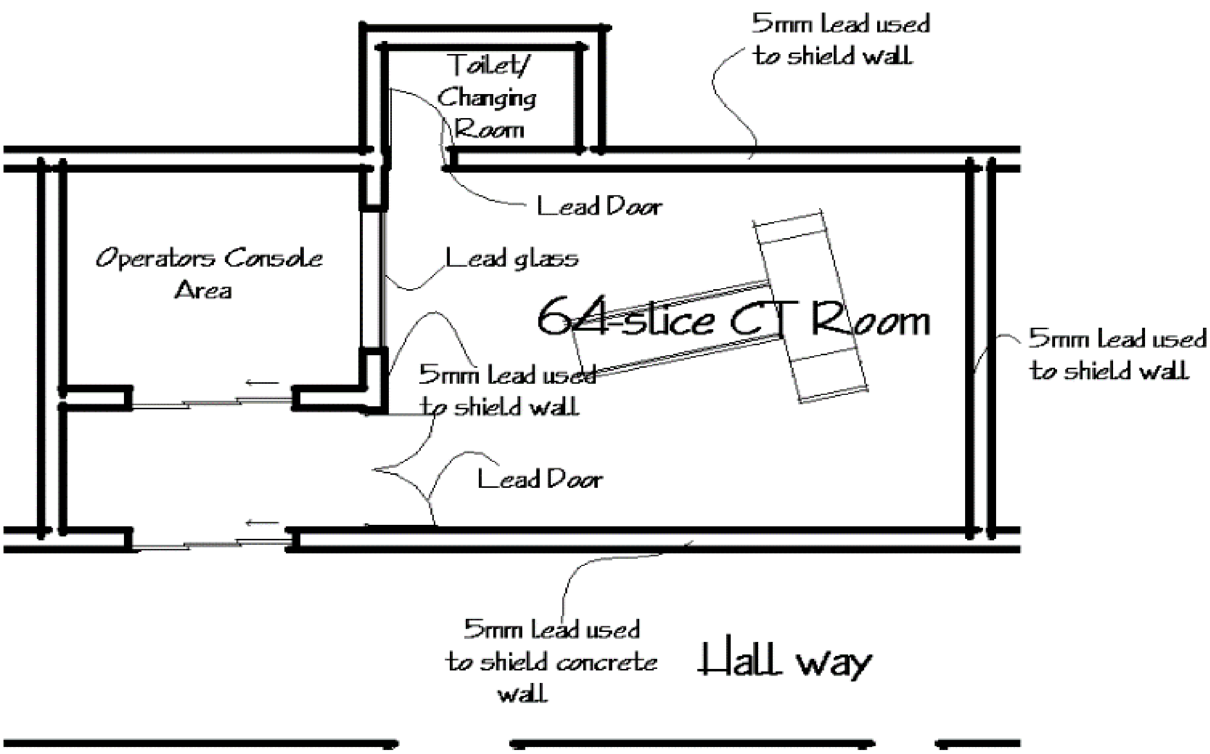

Figure 8: Sketch showing the 64-slice computed tomography room.

Plate 10: The 64-slice CT through the lead glass from the operator's area.

Also, the use of warning and danger signs were also employed to protect people from the danger of the machines as seen in plate 11. The danger signs are easily seen by people trying to enter this rooms when the machines are in use to warn them. Warning light in red colour as seen in plate 12 was also employed to alert people of danger and this light immediately comes up when the machine is powered to be used.

Plate 11: Lead door leading to the x-ray room with danger signs on the surface of the door.

Plate 12: View showing danger signs on the entrance door leading into the radiology room.

4.3 Radiation Protection Appraisal for Arrive Alive Diagnostic and Imaging Service, Ojuelegba, Lagos State.

The walls of the computer tomography and x-ray rooms are shielded with 2mm thick lead lining to prevent the transfer of radiation to other spaces. The operator of the computer tomography machine is also shielded in the control room with the use of a lead glass so also lead partition is been used to shield the operator of the x-ray.

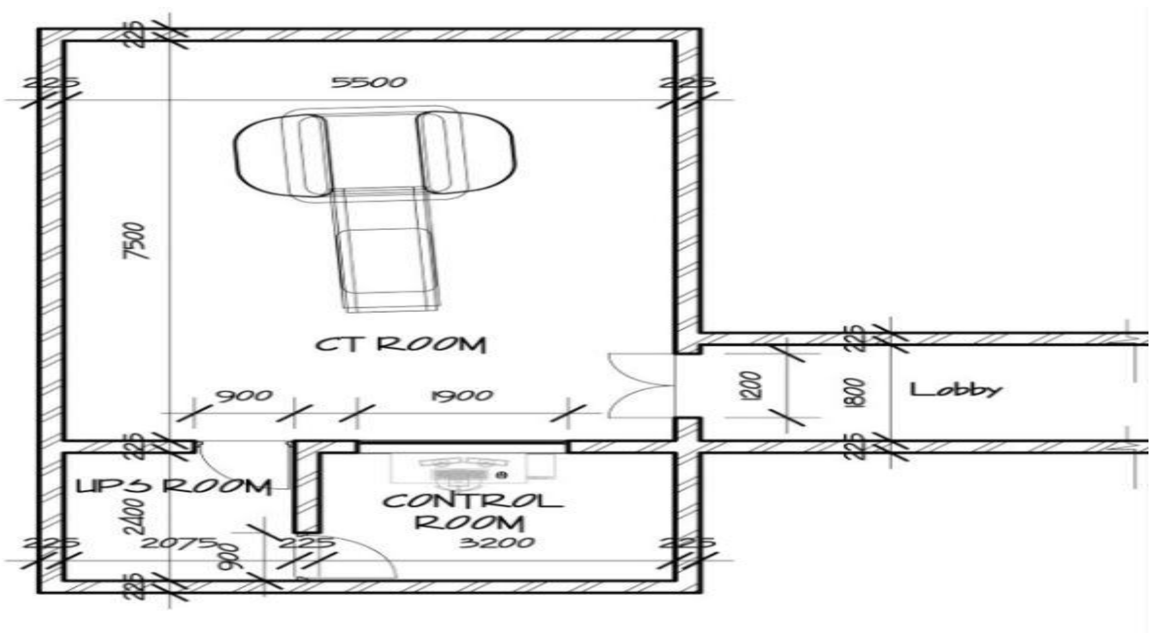

Figure 9: Sketch showing the 16-slice computed tomography room.

Also, the doors leading into the different diagnostic rooms are all shielded using 2mm thick lead lining to shield radiation.

Plate 13: The 16-slice CT through the lead glass from the operator's area.

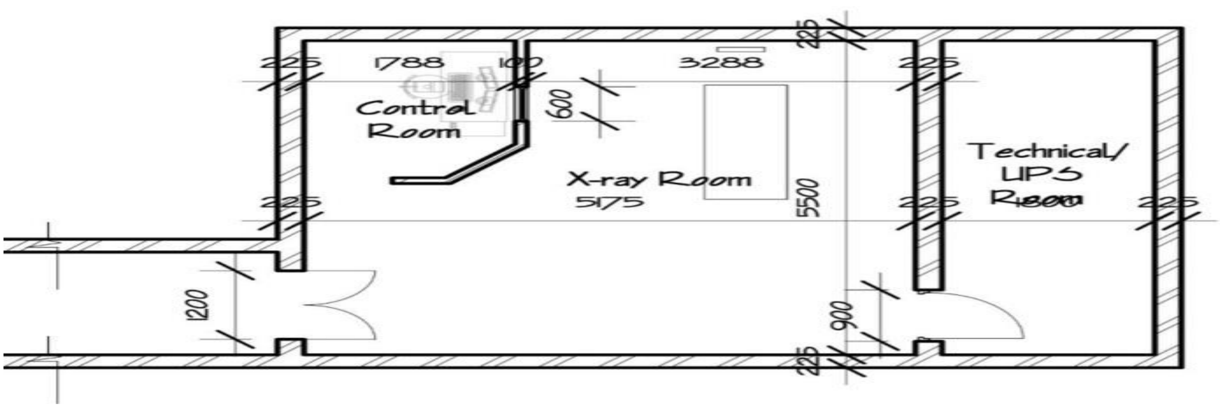

Figure 10: Sketch showing the x-ray room; Source: Author's field Study (2019)

Plate 14: View of the protective cubicle in the x-ray room.
Source: Author's field Study (2019)

5. Conclusion and Recommendation

This study premised its recommendation and conclusion from the analysis and findings of the field works. And, it was observed that all the diagnostic centres visited in the study area engaged the use of lead lining for radiation shielding. The shielding for the openings such as doors was also done using lead. The application of lead for shielding purpose is directly proportional to the intensity of radiation that is been emitted from the various diagnostic machines; as the specification for shielding in computed tomography that has 16-slice and 64-slice, whereas, the shielding of the rooms differ as the thickness of lead used for 64-slice is higher than that of 16-slice CT. Also lead glass and other irradiation diagnostic apparatus were used in all the diagnostic rooms and as utilities in medicinal chemistry (12) to protect the machine operators from radiation. Wooden barriers with lead lining embedded in them were also used in the x-ray rooms of the various imaging centres. The machines in the centres were also positioned in a way that the radiation source does not face the operator's area directly.

Lead over the years has been regarded as a poisonous material which is not also environmentally friendly. So it is recommended that other flexible materials need to be explored in the context of radiation protection and construction protection. By doing this the construction workers can also be safe from lead poisoning while installing radiation shielding. Finally, this study recommended that other less harmful materials from radiation hazards (11) need to be explored for radiation shielding other than the use of Lead. For competency in Educational, professional, curricular practices and even hygienic exigencies; further research may advance investigations to find out other protective materials and strategies that are relevant to medical exploits as well as Architects design specification knowledge for the design of medical facilities.

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