American Journal of Biodiversity
https://biojournals.us/index.php/AJB
ISSN: 2997-3600

A Practical Assessment of the X-Ray Rooms Efficiency in Iraqi Hospitals Using a Detector and Radioactivity Level Sensor

Shahad Ibrahim Nawaf Hamadi, Ahmed Majeed Saleh Fayhan,
Noor Al-Huda Ahmed Ayed Fayyad, Noor Subhi Abd al-Ghafour Nassar,
Duha Rahim Falih Hassan, Abdul Ghafour Mohammed Abdul Ghafoor Askar
University of Fallujah College of Applied Science Department of Medical Physics/medical optics

Received: 2024, 15, Dec
Accepted: 2025, 21, Jan
Published: 2025, 22, Feb

Copyright © 2025 by author(s) and Bio Science Academic Publishing. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/ by/4.0/

Open Access

Annotation: The primary goal is to evaluate the efficiency of X-ray rooms, protect patients and examiners from leaking X-rays, and detect whether there is a leak of radiation and the extent of this leakage, if any. During our field visit to the hospitals in the city of Fallujah (F.T.H, A.G.H), all the dimensions of the X-ray rooms were measured, and it was found that all of them were designed according to the international standards for the dimensions of the rooms, as stipulated by the American National Standards Institute (ANSI), except for Al-Amriya General Hospital (Consultative), where it was found that the control room is located inside the examination room. The thickness of the lead was measured using a caliper (Vernier), and the shielding thickness of all radiology rooms was 2mm, which complies with ANSI international standards. The radiation leakage rate in X-ray rooms for all hospitals mentioned above was measured using a detector to sense the level of radioactivity. Low leakage rates were recorded at Fallujah Teaching Hospital (CR, DR), except for the door area of the CR room, where an average percentage of leakage was recorded. Therefore, there is a need to put warning signs of radiation in all leaked areas to alert auditors not to stand or sit in places of leakage. Everyone must be sufficiently aware to avoid exposure, so we urge the Ministry of Health and all concerned authorities to take action to find solutions to reduce the leakage rates that could lead, over time, to serious exposure for examiners.

Keywords: X-ray room efficiency, radiation leakage, radiation safety, hospital compliance, shielding, nuclear radiation detector.

INTRODUCTION

The importance of our research is to measure the rate of X-ray leakage in order to protect examiners and patients to ensure their protection and design X-ray rooms according to international standards and to detect any defect in the rooms, which leads to a large leakage of rays. X-ray leak measurement devices are essential for ensuring safety in environments where X-ray radiation is utilized. These devices monitor radiation levels to comply with safety standards, such as the ALARA principle. Various technologies have been developed to enhance the accuracy and efficiency of these measurements. Geiger Muller Sensor-Based Devices Devices utilizing Geiger Muller sensors can effectively monitor X-ray leakage. A study demonstrated that a custom-designed module using this sensor achieved measurements of 0.00097 mGy/hour and 0.00092 mGy/hour, both below the safety threshold of 1 mGy/hour [1]. The integration of Adriano programming allows for real-time data processing and display, enhancing usability in monitoring environments. X-ray Reflection Measurement Devices Another innovative approach involves X-ray reflection measurement devices, which utilize a rotating X-ray tube and detector system. This design simplifies the measurement setup and improves accuracy by comparing reflected X-ray signals from both the measurement object and a calibration plate [2]. Advanced Detection Technologies Advanced X-ray detectors, such as those employing multiple SDD chips, enhance detection efficiency and resolution, allowing for more precise measurements of X-ray signals [3]. This technology can be crucial in identifying leaks and ensuring compliance with safety standards. While these devices significantly improve safety monitoring, challenges remain in standardizing measurement protocols across different technologies and ensuring consistent accuracy in diverse operational environments. Occupational exposure in the medical field. X-ray exposure is not limited to patients, but extends to practitioners [4-5]. The number of people professionally exposed to radiation in medicine is much greater than in any other practice, because of the wide spread and the number of medical procedures in which radiation sources are used. The average collective dose as estimated by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCAER) is higher in the medical field than in any other field dealing with radioactive sources [6-7]. Individual occupational exposure varies greatly among radiology related medical care providers depending on the number of procedures performed, and the skill and experience of the specialist [8-9]. General recommendations for the design of the X-ray room can be explained, the equipment must be positioned so that the primary radiation beam is not directed at the controller, windows or doors of the operator. The floor of the radiology room must be protected from primary beam radiation if there is occupancy in the room below and beam 2 is not, otherwise diluted The protective screen must be at least 2 meters high and be sufficient in width to allow at least two people to stand behind the screen during exposure Personal protective equipment (lead aprons, thyroid shields, gonads shields must be available and reinforced hangers must be used to store lead aprons. Radiation warning signs should be placed appropriately written up on arrival at the doors of the room. Room layout and shielding design should be reviewed by RPA every time equipment or technology changes. The radiology room may not be used for more than one radiologic session at a time, unless it is specially designed for this purpose. The radiology room should not be a crossing for another room [10]. In our research we used a nuclear radiation detector to measure the rates of X-ray leakage. Nuclear radiation detectors are essential tools for measuring and monitoring radiation levels, utilizing various technologies to enhance detection efficiency and user convenience. These detectors incorporate advanced materials and systems to ensure accurate readings and user safety. The following sections outline key features and advancements in nuclear radiation detectors. Key Features of Nuclear Radiation Detectors Shielding and Protection: Many detectors, such as those described by Wang et al., utilize special materials for radiation shielding, reducing damage and enhancing durability[11].Data Acquisition and Display: Detectors often include CCD sensors for radiation data collection, which is processed and displayed on screens, allowing for real-time monitoring[12].Power Supply and Portability: Modern designs feature rechargeable batteries and USB charging interfaces, making them convenient for field use and extending operational lifetimes[13].

MATERIALS AND METHODS

Nuclear Radiation Detector This product uses the Geiger Müller counter, which is a meter to detect the intensity of ionizing radiation (beta particles, gamma rays, X-rays) and uses a gas pipe or small chamber as a sensor. The number of rays per unit of time is measured. Alarm threshold rate can be optionally selected. Main features:1. X-ray detection, gamma ray sand beta rays2. High sensitivity, and can be used in differentenvironments.3. The data is saved duringshutdown.4. High-definition LCD screen.5. Light/vibration/sound built in alarm modes for choice.6. Real-time clock display.7. The product can set the dosage rate and cumulative dose alarm threshold in advance, Work Steps: Several hospitals were elected in the city of Fallujah, and these hospitals were elected based on their location suitable for the conditions of the rese arch students, including:1- Fallujah Teaching Hospital (F.T.H)2- Al-Amiriya General Hospital (A.G.H).Several visits were allocated to each hospital, the first visit included reviewing the examination rooms, the nature of the examiners' work, asking a set of questions to the workers in the X-ray rooms, photographing the entire rooms and knowing the tools that must be used during the work, which included (metric tape, caliper, a device to measure the percentage of radiation leakage (detection and sensing the level of radio activity), a mobile phone for imaging, a stand to install the mobile phone, while the second visit included measuring the engineering dimensions of the X-ray rooms, including walls, doors, Windows, after the devices from the walls and doors, were done using metric tape, and measuring the thickness of the lead using the caliper) Vernier(And photographing the examination devices used and knowing the specifications of each device, while the third visit included identifying the places of gaps and glitches and measuring the leakage rate using a detector and sensing the level of radioactivity, this was done by installing the mobile phone using the stand in the place to be examined and filming a video clip of the detection device that is placed under the camera and placing the right side of the device towards the radiation, because it contains the Geiger X-ray detector counter, while the last visit included confirming all of the above and returning Measuring leakage rates in the specified places. It took 4 days for each hospital and finally two and three-dimensional plans were drawn using the (Palette Home) program for all X-ray rooms in the elected hospitals and compared to the international standards for the design of X-ray.

Product name	Nuclear radiation detector
Types of detection rays	Gamma rays, beta rays, x-rays
Detector	Geiger counter
Equivalent dose	(0.00-10000 μSv/h) (10 mSv/h)
Language	Chinese/English
Capacity	Lithium battery with capacity of 1100mA/h
Warning Method	Light, vibration, sound

(a) (b)

FIGURE 1. (a) Radioactivity Level Detection and Sensor, (b) Table showing the technical specifications of the GC-01.

Fallujah Teaching Hospital (F.T.H) We have visited this hospital four times and, in each visit, we accomplish a new step in the business. In the first visit, the two radiology rooms (Digital Radiography (DR) and Computed Radiology (CR)) and their contents were reviewed, and the details of the rooms were identified and the tools required in the measurements were prepared. In the second visit, the engineering dimensions of these two rooms, including the walls, doors, windows, and the distance of the devices from the walls were measured using metric tape measurement and lead thickness measurement using calipers, while the third visit included identifying gaps and measuring leakage rates. In the last visit, all of the above was confirmed and the leakage rates were re-measured Dimensions of the first room DR: 1-Length = 6.60 m 2-Width = 6.30 m Door dimensions from the corridor side: 1-Length = 2.13 m 2-Width= 1.23 m First room window DR: 1-Length = 54 cm 2-Width=50 cm DR Control Room: 1-Length = 1.90 m 2-Width = 1,90 m Dimensions of the second room CR: 1-Length = 6,60 m 2-Width = 6,30 m Second Control Room CR: 1-Length = 2,28 m 2-Width 1,90 mSecond Room Window CR: 1-Length = 44 cm 2-Width=44 cm Amreya General Hospital (A.G.H) We have visited this hospital four times and in each visit we accomplish a new step in the business. On the first visit, the rooms and their contents were reviewed, the details of the rooms were identified, and the tools required in the measurements were prepared. In the second visit, the engineering dimensions (consulting room) was measured, including walls, doors, windows, and the distance of devices from the walls using metric tape measurement and lead thickness measurement using calipers, while the third visit included identifying gaps and measuring leakage rates. In the last visit, all of the above was confirmed and the leakage rates were re-measured Dimensions of the consulting room: 1-Length = 5.90 m 2-Width = 3.87 m Xray room door: 1-Length = 1.87 m 2 -Width = 89 cm Control room: 1- Length = 1.93 m 2- Width= 1.95 m Control Room Window: 1-Length = 74 cm 2-Width = 49 cm Control Room Door: 1-Length = 1.95 m 2-Width = 74 cm Examiners room: 1- Length = 3.93 m 2-Width = 2.95 m

RESULT & DISCUSSION

The data we obtained were not all within the permissible exposure levels. The most, medium and least radioactive areas were identified. The readings recorded in each hospital were as follows: Al-Amiriya Hospital (Consulting) has an X-ray machine. We measured the radiation leakage rates before from all sides of the room. The highest leakage rate was at the door of the X-ray room (18.33 μSv/h) and the lowest leakage rate was at the door of the X-ray room (0.13 μSv/h). The room was designed according to international standards, but it was old and disorganized. The patient registry data contained many age groups, most of whom were between 16 and 60 years old. The number of employees is good and they work in shifts to avoid exposure to radiation. As for Fallujah Teaching Hospital, it contains two rooms for examining patients, a CR room and a DR room, and each room contains 3 fixed and mobile X-ray examination devices. We conducted several measurements and from several places we found the highest leakage rate at the door of the

CR room (0.80 µSv/h) and the lowest leakage rate at the window of the control room of the DR room (0.16 µSv/h). The design of the two rooms matched the international designs of X-ray rooms, and they were covered with lead and spacious, and the number of workers rotated well. We drew charts for the patients' data. The numbers were large during the day, but they did not mention their ages, just the names of the patients, and thus we did not know the age groups being examined.

During our field visit to Fallujah Teaching Hospital, we measured the X-ray leakage rates in several places to ensure that there were no X-ray leakage holes. We found that this hospital did not have high leakage rates, but rather average. We also took measurements of the room to ensure that it was designed according to international standards. We matched the dimensions and the locations of the devices. They were very suitable. We also measured the thickness of the armored lead in the X-ray room, which was 2 mm. We asked the examiners several questions and made sure that they were wearing a protective shield for their safety. Their numbers were large so that they would not be exposed to radiation. We took patient data to find out the number of patients being examined and the examiners being exposed to radiation during the examination. The numbers varied every day; 60 patients examined by 3 over 7 hours a day. There was a simple mistake, which was not mentioning the ages of the patients in the data log, only their names and numbers. We also made sure that there was nothing surrounding it, but we found a laboratory above it, and opposite the room there was a corridor and to it left a room for a mammography device, but there were no high X-ray leakage rates, so the room is safe for examination. After that, we visited Al-Amiriya Hospital (Consultant) and we also measured the leakage rates from several places to ensure that there were no leakage places, but during our work, there were high leakage rates above the door and under the door. There was a clear gap for X-ray leakage. We took measurements and all dimensions of the examination room and control room as well as the corridors to ensure that they were designed according to international standards. They were good. We asked some questions to the examiners. There were two examiners, one in the morning and the other in the evening. They work once a week and wear a badge. They are examined every 6 months. The examiner does not wear a protective vest due to its heavy weight. We also took data for the patients to know their numbers. The number of patients did not exceed 36 patients per day. Most of the patients were between 17-50 years old. We also made sure that there was something surrounding the examination room, but it was isolated from the hospital and nothing surrounded it. Leakage rates in X-ray rooms are critical to ensuring safety standards in medical imaging environments. Various studies have evaluated these rates, revealing that while many facilities comply with safety limits, some areas may exceed permissible exposure levels. The following sections describe key findings regarding leakage radiation in X-ray rooms.Measurement techniques Ion chamber scanning meters are commonly used to measure leakage radiation at various locations around X-ray tubes (14).Studies have shown that distance from the X-ray source significantly affects leakage radiation levels, with increasing distance resulting in decreased exposure (15).The study found that the highest radiation leakage was in the unmonitored areas of X-ray rooms 1 and 2, with average dose rates of 6.33 microsieverts per hour and 26.21 microsieverts per hour, respectively, exceeding the permissible vlimits for general exposure(16). The design of X-ray rooms is critical to ensuring radiation safety and operational efficiency. Key considerations include room dimensions, shielding requirements, and the inte gration of safety features. The following sections outline key aspects of X-ray room design. Based on recent studies Room dimensions and layout The recommended size for X-ray rooms is typically 20 square metres; however, 89% of rooms surveyed exceeded this (17). Size Adequate spacing from the focal point to the operator is critical to minimizing exposure (18). Shielding requirements Shielding design must take into account primary, secondary, andleakage radiation, with wall thickness being an important factor; only 64% of rooms met the criteria for adequate wall thickness (19). A simplified shielding approach based on maximum radiation output rather than workload (20) was effective in Sout Australia. Design and structure: C-arm configuration The X-ray machine features an arm that connects the X-ray tube and the detector allowing for peripheral rotation to improve positioning during imaging(21).Automatic motor Some devices include an automatic motor that adjusts the position of the imaging plate, reducing the need for manual intervention and improving efficiency (22).Mobility features: Mobile X-ray machines are designed with wheels and mounting mechanisms, allowing for easy transportation within medical facilities while maintaining stability during operation (23) Shielding in X-ray rooms is critical to protecting both patients and healthcare workers from exposure to harmful radiation. Various materials and designs have been evaluated to enhance the effectiveness of radiation shielding, with a focus on traditional lead-based and innovative lead-free alternatives. The following sections describe key aspects of shielding in X-ray rooms. Shielding materials. Lead Alternatives: Lead is commonly used, but alternatives such as barium sulfate, tungsten, and bismuth are gaining interest due to environmental and health concerns associated with lead (24) Protection Effectiveness Secondary Radiation: Studies indicate that secondary radiation can significantly impact. Safety levels, necessitating careful design and material selection of protective barriers (25).

1-Fallujah Teaching Hospital (F.T.H)

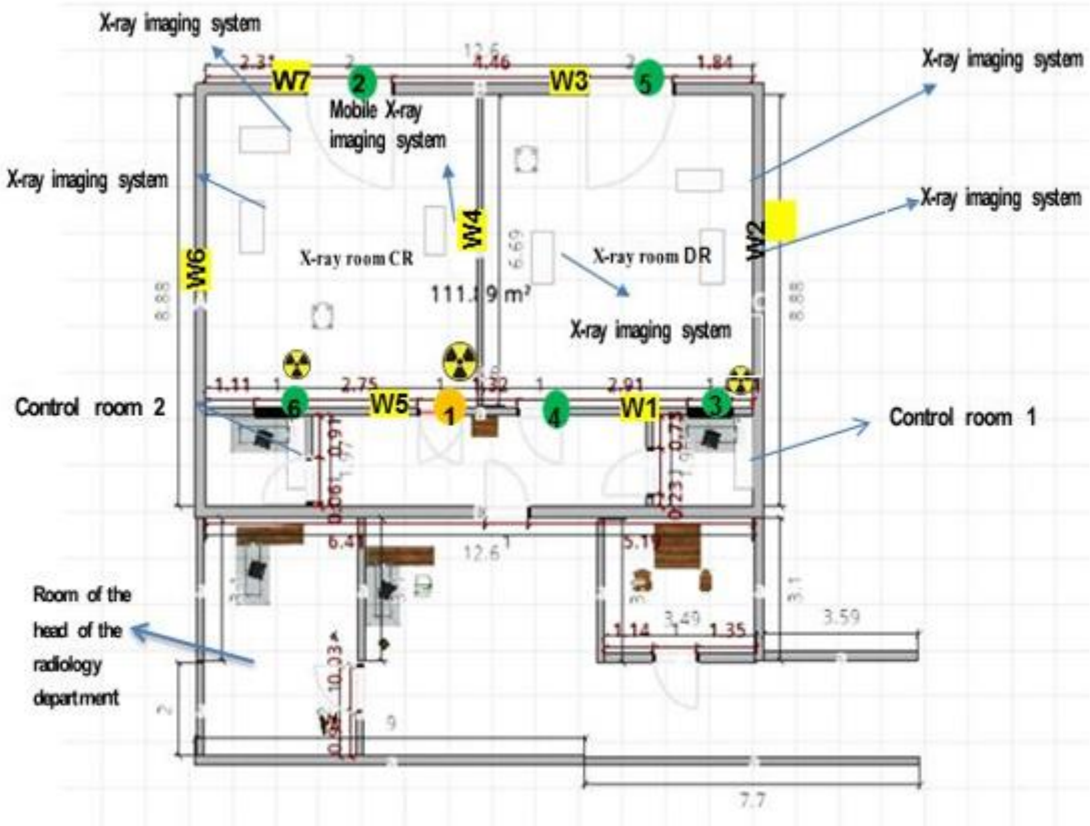
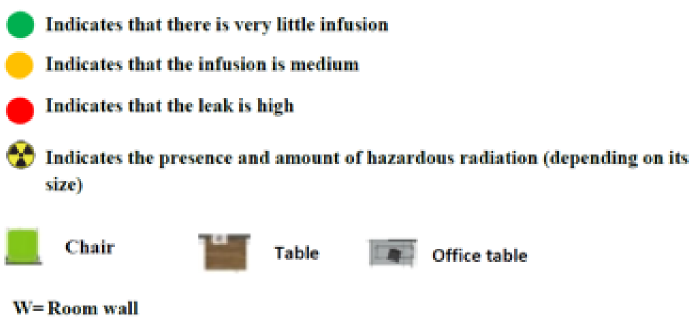


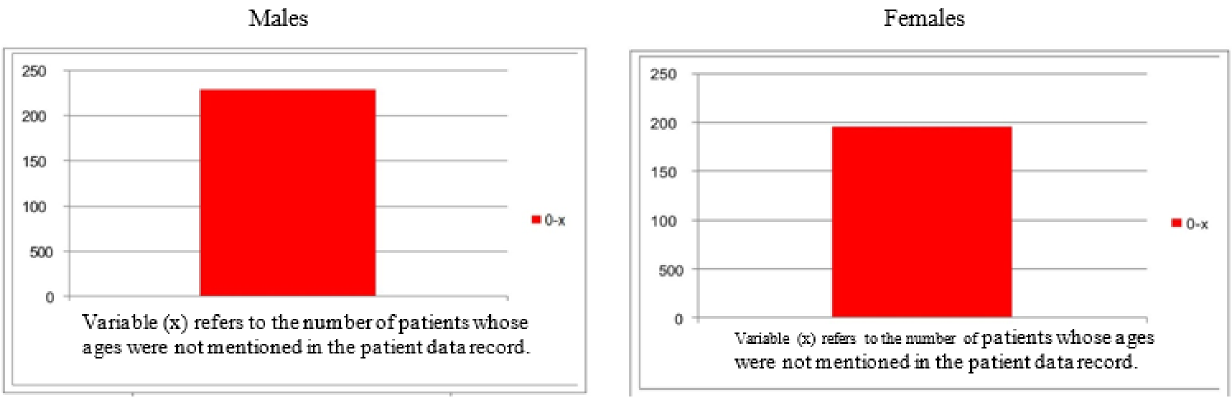
FIGURE 2. shows the design of X-ray rooms and places of radiation leakage (F.T.H).



1.1-Measured infusion ratios (F.T.H)

	Kilovoltage	Milliampere	Millisecond	
Leakage rate	Kv	mA	MS	Magnitude of leakage µSV
1	125	200	200	0.80
2	55	125	25	0.26
3	50	100	20	0.16
4	72	160	50	0.23
5	72	160	50	0.26
6	57	125	32	0.23

FIGURE 3. Table shows the amount of radiation leaking outside the room.



(a) (b)

FIGURE 4. (a) Chart showing the n [اكتب اقتباساً من المستند أو من ملخص نقطة هامة. يمكنك وضع مربع النص في أي مكان في المستند. استخدم علامة التبويب "أدوات الرسم" لتغيير تنسيق مربع نص الاقتباس.] umber of females in F.T.H.

2-Amriya General Hospital (A.G.H)(Consulting)

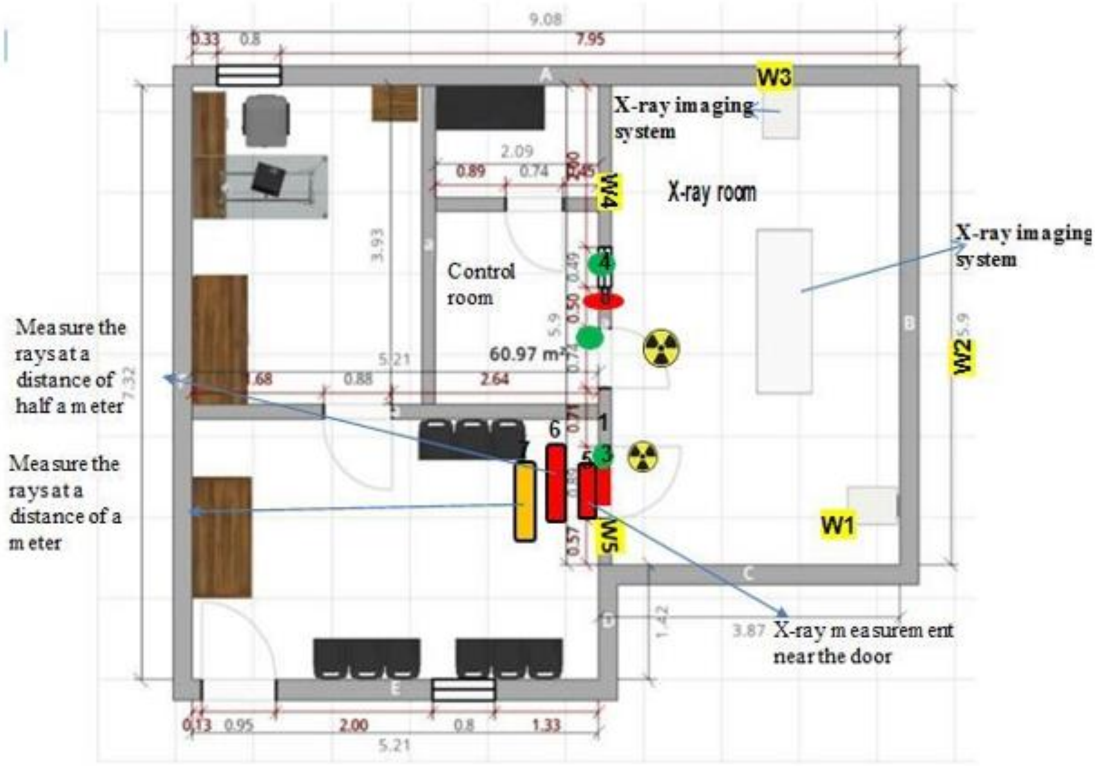
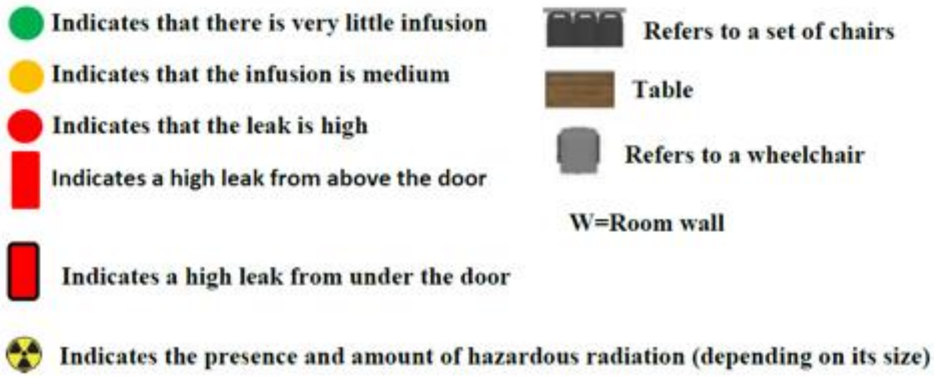


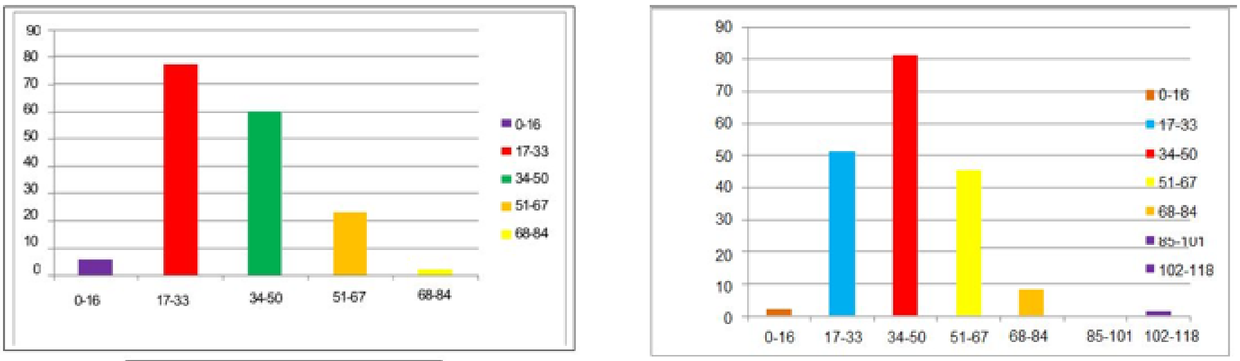
FIGURE 5. shows the design of the X-ray room and the places of radiation Leakage (consulting).



2.1- Measured infusion ratios (A.G.H)

	Kilovoltage	Milliampere	Millisecond	
Leakage rate	Kv	mA	MS	Magnitude of leakage µSV
1	74	100	10	0.43
2	50	20	0.9	0.36
3	90	100	9	8.66
4	90	160	9	0.13
5	95	100	16	18.33
6	95	100	16	1.03
7	95	100	16	0.90
8	90	100	12.5	1.40

FIGURE 6. Table shows the amount of radiation leaking outside the room (Consulting).



Al Amriya Hospital (consulting) plan for adult female patients

Al Amriya Hospital (consulting) plan for adult male patients

(a) **(b)**

Figure 7. (a) Chart showing the number of adults (males) in the A.G.H (Consulting) , (b) Chart showing the number of adults (females) in A.G.H (Consulting).

Conclusions

Fallujah Teaching Hospital (F.T.H):

Disadvantages in these rooms: Directly above the second chamber (CR) there is a laboratory. Examiners do not wear protective jackets due to their heavy weight. There is a hole under the door in the second room (CR) that led to a leak.

Advantages: The walls of the X-ray rooms, their doors and windows are armored with bullets with a thickness of 2 mm. Radiation measurement bags are worn by examiners and examined every 6 months. It is located on the ground floor.

Amriya General Hospital (A.G.H)(Consulting):

Disadvantages of these rooms: Examiners do not wear protective jackets due to their heavy weight. The consultation room is chaotic and its building is very old, which led to measuring high leakage rates The device identification card is free of specifications. A loophole in the consultation room. The presence of a gap in the consulting room in the door handle. The presence of an opening above the door of the consulting room in led to a large percentage of leakage. The presence of an opening under the door of the consulting room in led to a large percentage of leakage.

Advantages: The walls of the radiology room and its door and window are studded with lead with a thickness of 2 mm. The radiation bag worn by the examiners is examined every 6 months to find out the radiation to which it was exposed. This room is located on the ground floor and isolated from the rest of the Hospital.

Recommendations

Recommendations for Future Research comparing X-ray rooms in different hospitals, including both public and private institutions, to determine the uniformity of safety standards.

1. Analyze the Impact of Radiation Leakage on Workers and Patients Conduct studies on the potential health effects of radiation leakage on radiographers, especially in areas where high levels of leakage were recorded.
2. Develop Standards for Room Design Investigate ways to improve radiation shielding in rooms with leakage issues, particularly by enhancing door and window quality and sealing gaps in walls and ceilings.
3. Evaluate the Efficiency of Protective Vests Research lightweight and more comfortable alternatives to lead aprons to encourage regular use by radiographers.
4. Assess Workload Distribution for Radiographers Study the impact of the high number of daily examinations on the health and performance of radiographers and suggest solutions for a more balanced workload.
5. Conduct Comparative Studies Between Hospitals Perform future research

Thanks, and appreciation

We would like to extend our sincere thanks and appreciation to Assistant Professor Dr. "Mohammed Shaalan Essa" for all the valuable guidance and information he provided us, which contributed to enriching the subject of our study in its various aspects. We would also like to extend our sincere thanks and gratitude to the Anbar Health Department, Fallujah Teaching Hospital, and Al-Amiriya General Hospital for their support in completing our scientific research.

References

1. (Utomo et al., 2022) .
2. (Hiroyuki et al., 2019).
3. (Kazuyuki & Takashi, 2019).
4. E. Vano, et. al., Staff Radiation Doses in Interventional Cardiology:Correlation with
5. Patient Exposure, Pediatric Cardiology, Vol. 30, No. 4 ,2009.
6. J. A. S. Lie, K.a Kjaerheim and T. Tynes, Ionizing radiation exposure and cancer risk among Norwegian nurses, European Journal of Cancer Prevention, Vol. 17 pages 369–375, 2008.
7. Radiation (UNSCEAR). 2008 report to the General Assembly: annex on medical exposures, New York; 2010.
8. O. Holmberg, R. Czarwinski, F. Mettler, The importance and unique aspects of radiation protection in medicine, European Journal of Radiology, Vol,2010.
9. S. A. Terezakis, et. al., What the Diagnostic Radiologist Needs to Know about Radiation Oncology, Radiology, 2011.
10. T. Vehmas and E. Kuosma, Influence of radiologists' sex and training on fluoroscopy doses during barium enema, The British Journal of Radiology, 2001.

11. Canada. Health Canada., C. Lavoie, and N. Martel, Safety Code 35. 2008.
12. Wang et al., 2012).
13. (Wang et al., 2012).
14. (Jianshao, 2014).
15. J. Lalrinmawia, K.S. Pau, R.C. Tiwari 30 Sep 2019.
16. Abdullah T. Naji 15 Jun 2022-ARID international journal for science and technology.
17. Joseph Dlama Zira, Uba Sani Zikirulahi, Idris Garba, Mohammed Sidi. Mohammed Sani Umar, Shem Silas Bature - Show less 18 Oct 2020.
18. (Nilantha et al., 2015).
19. (Nilantha et al., 2015).
20. (Nilantha et al., 2015).
21. (Bibbo, 2017).
22. (Bing, 2018).
23. (Hanlin et al. (2019).
24. (Liping et al., 2017).
25. (kim wakhrun, 2024).
26. (González-López, 2024).