JSR Publications

Available Online

J. Sci. Res. **18** (1), 201-209 (2025)

JOURNAL OF SCIENTIFIC RESEARCH

www.banglajol.info/index.php/JSR

Status of Radiation Protection Measures in Private Medical Facilities in Pirojpur District of Bangladesh

E. Ahmed*[1], M. T. Hossain[1], B. K. Sarker[1], F. Hossain[1], S. Ahmed[1], R. C. Karmkar[1], M. Akramuzzaman[2]

[1]Nuclear Safety, Security and Safeguard Division, Bangladesh Atomic Energy Regulatory Authority (BAERA), E-12/A, Agargaon, Dhaka-1207, Bangladesh

[2]Radiation, Transport and Waste Safety Division, Bangladesh Atomic Energy Regulatory Authority (BAERA), E-12/A, Agargaon, Dhaka-1207, Bangladesh

Received 7 July 2025, accepted in final revised form 14 October 2025

Abstract

Radiation safety is a key concern to protect workers, patients, and the public from ionizing radiation. This study investigates the status of radiation protection in 35 private medical facilities in Pirojpur district through field inspections, structured interviews, and radiation dose measurements, in accordance with national safety standards (BAER Act-2012, NSRC Rules-1997, and Regulatory Guides). The results show that 60 % of facilities lack a certified RCO, and 34 % of facility operators do not use a personal monitoring device, violating Sections 54.0, 58.1, and 59.1 of the NSRC Rules-1997. While most of the X-ray rooms are undersized, 86 % meet wall thickness requirements (Regulatory Guide for Diagnostic X-ray). 80 % of facilities have radiation warning signs and 88.5 % of facilities use PPE, which are safety requirements according to Sections 55.2 (a), 18.2 (22), and 83.1 (b) of NSRC Rules-1997. Radiation doses at control panels were within the limit in most cases, but the doses at the entrance doors were not satisfactory. The use of shielding materials was sufficient in most facilities. Compared with the previous regulatory survey, notable progress has been observed. However, to foster safe and effective radiological practice, awareness needs to increase by providing proper guidance, training, and regulatory support.

Keywords: Ionizing radiation; Radiation safety; X-ray facilities; Regulatory compliance; Occupational exposure.

doi: https://dx.doi.org/10.3329/jsr.v18i1.82740 J. Sci. Res. 1**8** (1), 201-209 (2026)

1. Introduction

Radiological facilities have an important role in the present healthcare system to provide the required images of different parts of the body through X-rays, CT scans, and fluoroscopy, etc. These technologies are indispensable for early disease detection and treatment planning [1]. The uncontrolled use of ionizing radiation, such as X-rays, poses potential health hazards to occupational workers, medical professionals, patients, and the

* *Corresponding author*: eliasahmedarko94@gmail.com

general public [2,3]. These risks include deterministic effects, which manifest in the short term, and stochastic effects, which can lead to long-term consequences such as genetic mutations and cancer [4,5].

X-ray technology, a cornerstone of diagnostic radiology, has been used in Bangladesh for over eight decades. But these facilities were limited to big cities or government hospitals only. But day by day, the number of private medical facilities is on an increasing trend, which gives the rural people of Bangladesh access to better health services. However, despite its widespread application and advantages, there remains a lack of awareness and adherence to radiation safety protocols, which is necessary to protect individuals from unintended exposure [6].

Developed nations have implemented stringent regulatory frameworks since the mid-20th century to ensure radiological safety and limit radiation exposure to acceptable levels [7]. Developing nations like Bangladesh face challenges with unregulated radiological services, especially in rural districts [8].

In Bangladesh, the Nuclear Safety and Radiation Control Rules-1997 and the Bangladesh Atomic Energy Regulatory (BAER) Act-2012 were developed to regulate export, import, and use of radioactive materials and radiation-emitting devices [9,10]. The Bangladesh Atomic Energy Regulatory Authority (BAERA) is responsible for overseeing radiation protection standards and for ensuring that radiological facilities adhere to national and international safety guidelines [11,12]. Under these rules, some regulatory guidelines were introduced to provide detailed instructions about regulatory requirements [13]. However, challenges such as inadequate monitoring, lack of awareness among facility operators, and insufficient enforcement of licensing requirements persist [14]. Many private radiological facilities operate with outdated or improperly maintained equipment, exposing both patients and healthcare workers to potential radiation hazards [15,16].

The rapid expansion of private radiological facilities in Bangladesh, particularly in rural districts, has raised significant concerns about regulatory compliance and radiation safety. According to the Hospital Service Management portal of DG Health, there are 124 radiological facilities in Pirojpur district, and 48 of them are licensed and under regulatory control [17]. This study examines the private diagnostic facilities in Pirojpur, a district characterized by limited healthcare oversight, to understand their compliance with safety and operational guidelines. Radiological imaging is pivotal in modern healthcare, yet its safe deployment depends on adherence to regulatory standards [18].

This study seeks to evaluate the current status of private medical facilities in Pirojpur district by examining compliance with licensing regulations, availability of protective equipment, and adherence to radiation safety protocols. By identifying key shortcomings, this research aims to provide actionable recommendations to improve the regulatory landscape and enhance radiation protection measures in the district.

2. Methodology

A cross-sectional study was conducted to assess the radiation safety standards and compliance status of private radiological facilities in the Pirojpur district. The research methodology involved a combination of field inspections, structured interviews, and review of regulatory documents to gather comprehensive data on the operational conditions of these facilities.

2.1. *Inspection and data collection*

Primary data were collected through on-site inspections of radiological facilities in seven upazilas of Pirojpur district: Pirojpur Sadar, Bhandaria, Nazirpur, Kaukhali, Nesarabad, Mathbaria, and Indurkani. The inspection was carried out from 06 December 2024 to 15 December 2024. A total of 35 facilities were randomly selected for this study.

A standardized inspection checklist was used to evaluate compliance with licensing status, licensing requirements, room specifications, equipment type, radiation dose rates, availability of radiation shielding, presence of warning signs, and use of protective equipment for operators, such as thyroid collars, eye shielding glass, and lead aprons. Facility inspections also included evaluations of X-ray machine specifications, such as the installation year, manufacturer details, machine type, serial number, tube current (mA), model, light beam diaphragm status, tube potential (kV), and total tube filtration. The number of radiation workers, including technologists and technicians, was also recorded. Interviews were conducted to assess the knowledge, awareness, and practice of the facility operators and technicians (with their consent) at the associated radiological facilities. The study examined the physical condition of personal monitoring devices, ensuring that occupational workers are using dosimetry devices correctly. The adherence of facility personnel to safety protocols and their effectiveness in minimizing radiation exposure were also evaluated. Facility codes are used for this study to ensure the data privacy of the facilities.

2.2. *Radiation measurement*

To assess radiation exposure levels, calibrated dosimeters were used to measure radiation doses at critical points within each facility, including the control panel (CP), entrance door (ED), computed radiography (CR) room, and any additional access points. Measurements were compared against national and international safety limits to determine compliance with recommended exposure thresholds.

Levels of radiation exposure were identified using a portable Geiger-Muller survey meter (LUDLUM, Model: 3000, Calibrated: 06/06/2024) and scintillation-based micro-Roentgen meters (LUDLUM, Model: 26-3, Calibrated: 12/04/2024), along with a pressurized ion-chamber radiation dose rate meter (LUDLUM, Model: 9DP, Calibrated: 12/04/2024). The measuring tools are quality assurance certified and calibrated from the

Secondary Standard Dosimetry Laboratory (SSDL) (As per IAEA requirement) [19] at the Atomic Energy Research Establishment (AERE) in Savar, Dhaka. The readings from GM or scintillation-based survey meters, initially recorded in μR/h, were converted to μSv/h using standard conversion factors. Two individual measuring tools were used to measure the radiation dose at each point. If the difference in the measured dose was within 0.20 μSv/h, the average dose was recorded in the checklist and if the difference was more than 0.20 μSv/h, the radiation dose was measured from the third measuring tool to get the accurate radiation dose.

2.3. *Data analysis*

The collected data was analyzed using charts, tables, and graphs to represent the radiation safety structure of those facilities and compare their safety standard with each other. Microsoft Office 2024 and Origin Pro 2019b were used to represent the data of this study.

3. Results and Discussion

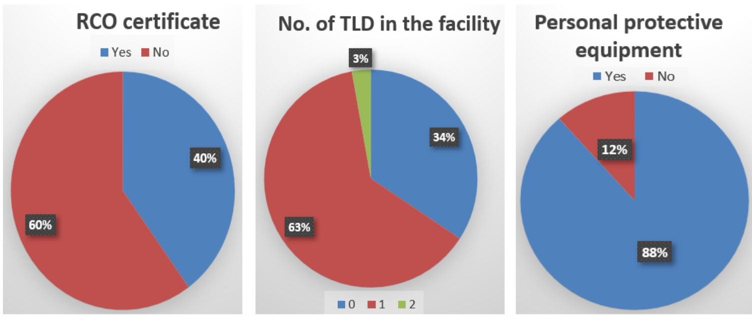
All the medical facilities that have radiation-generating equipment shall come under the regulatory supervision by taking the required license according to Section 18 of the BAER Act-2012 and Section 10 of the NSRC Rules-1997 [9,10]. Out of 35 facilities taken for this study, 26 facilities have a license for radiation generation equipment (Class-C) from the regulatory body.

The status of radiation monitoring equipment and knowledge about radiation-related activities for personnel are shown in Fig. 1. Here, in Fig. 1a, we found that about 60% Radiation Control Officers (RCOs) of medical facilities in Pirojpur district do not have RCO certificates, which is a requirement according to Section 54 of NSRC rules-1997.

Thermoluminescent dosimeter (TLD) is a radiation measuring device used for personnel radiation monitoring, which is recommended for operators by Sections 58.1 and 59.1 of NSRC rules-1997. As shown in Fig. 1b, 63 % medical facilities in Pirojpur district have one TLD Badge, 03 % have two TLD Badges, and 34 % do not have any TLD Badge.

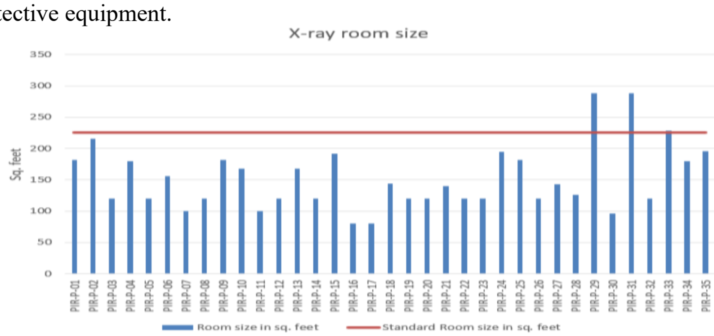
Personal protective equipment like Lead Apron, Lead Thyroid Collar, Eye Goggles is very important for operating personnel's safety from ionizing radiation, and the use of personal protective equipment is a mandatory safety requirement according to Section 18.2 (22) and 83.1 (b) of NSRC Rules-1997. From the Fig. 1c, it can be observed that about 88.5 % medical facility in the Pirojpur district has this type of protective equipment.

The room where the radiation-generating equipment is installed should follow some direction to protect patients and attendants from radiation. Chapters 8 and 9 of the Regulatory Guide on Radiation Protection in Medical Diagnostic X-ray specify regulatory standards for room dimensions and wall shielding of X-ray rooms of medical facilities, where the minimum room size is 225 square feet and the minimum wall thickness of X-ray rooms is 10-inch brick wall [13]. In Fig. 2a, it is clear that most of the radiation facilities in the Pirojpur district have not met the standard room size requirements [13]. A significant improvement is required in this area. About 86 % facilities in this district meet the wall thickness requirement, as shown in Fig. 2b. The presence of radiation warning signs outside the X-ray room is another regulatory requirement according to section 55.2 (a) of NSRC Rules-1997. From Fig. 2c, it has been observed that about 80 % radiation facilities in the Pirojpur district have radiation warning signs, which indicates a good practice.

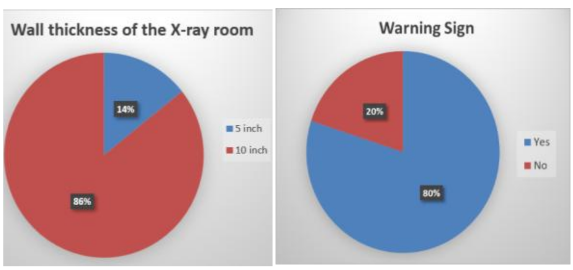


1(a) 1(b) 1(c)

Fig. 1. Status of operating personnel's qualification, availability of radiation measuring device, and personal protective equipment of the radiation facilities in Pirojpur district. (a) Radiation Control Officer (RCO) certificate, (b) availability of thermoluminescent dosimeter (TLD), (c) availability of personal protective equipment.



2(a)



2(b) 2(c)

Fig. 2. Assessment of room size, wall depth, and warning signal of the radiation-generating room of X-ray facility in Pirojpur district. (a) X-ray room size, (b) Wall thickness of X-ray room, (c) warning signs outside the room.

The thickness of the aluminium filter of the X-ray tube plays an important role in beam quality control and patient safety. The aluminium filter is used to perform filtration to remove low-energy X-rays from the beam before it exits the X-ray tube. Low-energy X-rays are absorbed by superficial tissues, thereby increasing patient dose without contributing to image formation [20]. The minimum required thickness for an aluminium filter for an X-ray tube is 1.5 mm according to the national standard. Fig. 3 shows that most of the facilities of the Pirojpur district fulfil this requirement.

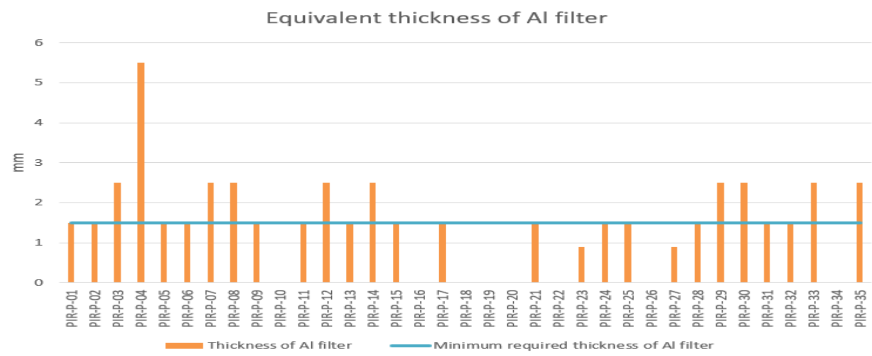


Fig. 3. Thickness of aluminium filter in X-ray tube of X-ray facility in Pirojpur district.

A clear assessment of shielding for radiation protection of radiation-generating equipment in the Pirojpur district has been presented in Fig. 4. Most of the facility in this district has good radiation protection structures [13]. The entrance door of 57 % facilities and the Control panel of 63 % facilities have led as shielding material. Some facilities use steel-lined shielding at the control panel and entrance door. A few facilities have a wooden structure, which does not fulfil the regulatory requirement.

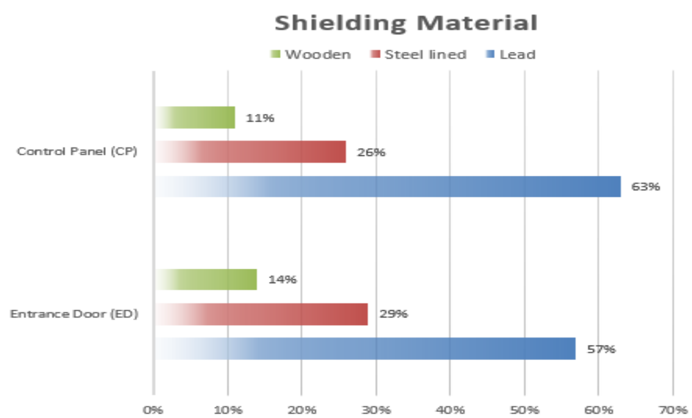
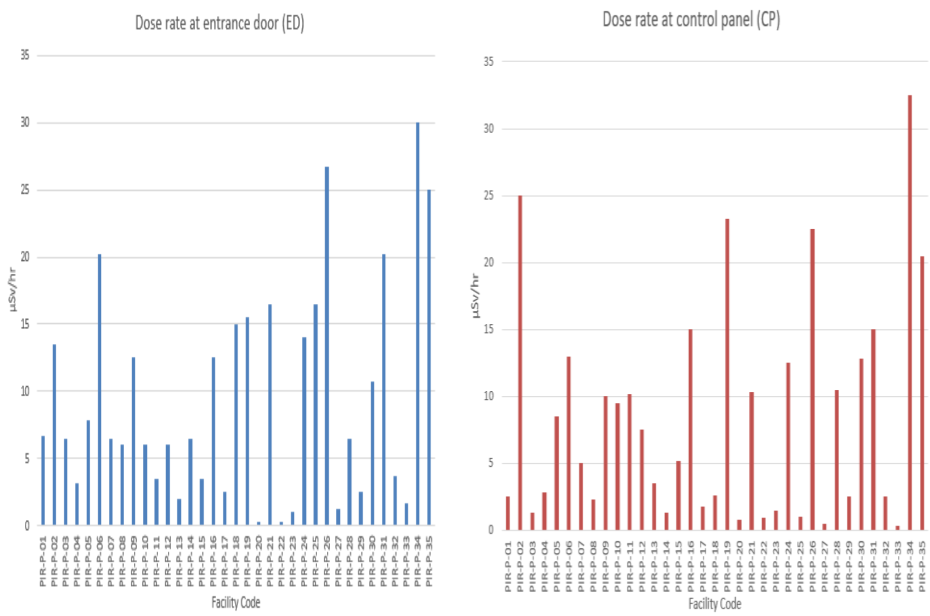


Fig. 4. Radiation shielding assessment for radiation protection of the radiation facility in Pirojpur district.

Radiation dose rate measurement in various locations of the X-ray room is the most important part to ensure the safety standard of that room against radiation. Dose rate of the entrance door, control panel, wall of the room, window, etc., is carefully evaluated. Since occupational workers operate the X-ray machine from near the control panel, the radiation dose at the control panel is considered occupational exposure. Similarly, the dose at the entrance door is considered as public exposure. In Fig. 5a, we found that the shielding condition at the entrance door in most of the facilities of Pirojpur district is not adequate to fulfill the requirements. The highest dose rate at the entrance door is recorded as 30 μSv/h (PIR-P-34), where the permissible dose limit for public exposure is 0.5 μSv/h according to the national standard [9,21,22]. From Fig. 5b, it has been observed that the control panel shielding in 71 % facilities is good and within the permissible limit for occupational exposure (10 μSv/h) according to the national standard [9,21,22]. Although the dose rate in the control panel of some of the facilities is higher than the regulatory requirement.



5(a) 5(b)

Fig. 5. Measured radiation dose in various locations of the radiation facility in Pirojpur district. (a) dose rate at entrance door (ED), (b) dose rate at control panel (CP).

Dose rate at some other location of these facilities is also evaluated and the result of that evaluation is satisfactory in most of the facilities.

4. Conclusion

In the field of medical science and research, ionizing radiation has a prominent role. But unwanted or excess radiation exposure can be harmful to the radiation professional, patient, and public. This study reveals the radiation protection structure and implementation of regulatory requirements of the medical facilities of the Pirojpur district. A majority of the facilities have adopted essential safety measures, including the use of personal protective equipment, standard wall thickness of the room, proper thickness of aluminium filters, and radiation warning signs. Most of the facilities have standard shielding in the entrance door and control panel, which demonstrates growing awareness and implementation of safety protocols. But a considerable number of facilities operate without following the regulatory requirements and guidelines, and their radiation safety conditions are below national and international standards. NSRC rules-1997 and the BAER Act-2012 are in place to provide valuable insights and proper guidance for radiation safety. With continuous guidance, training, and regulatory support, safe and effective radiological practice can be grown in rural areas in Bangladesh.

Acknowledgment

The authors are highly grateful to the Bangladesh Atomic Energy Regulatory Authority (BAERA) for its cooperation and for providing logistic support during the time of work. The authors would also like to sincerely thank M. Nahar, S. Mahbub, and M. Islam for their support and advice throughout the study.

References

1. M. Chalkia, N. A. Arkoudis, E. Maragkoudakis, S. Rallis, I. Tremi, A. G. Georgakilas, V. Kouloulias, E. Efstathopoulos, and K. Platoni, Cells **11**, 467 (2022). https://doi.org/10.3390/cells11030467
2. S. S. Naqvi, S. Batool, S. Rizvi, and K. Farhan, Cureus **11**, ID e4756 (2019). https://doi.org/10.7759/cureus.4756
3. E. Burgio, P. Piscitelli, and L. Migliore, Int. J. Environ. Res. Public. Health **15**, 1971 (2018). https://doi.org/10.3390/ijerph15091971
4. Recommendations of the International Commission on Radiological Protection, ICRP, Publication 60 annals ICRP **21**, (1-3) (1991).
5. Basic Safety Standards for Radiation Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115 (IAEA, Vienna, Austria, 1996).
6. M. Haider, M. A. Imtiaz, A. Hannan, and M. Akramuzzaman, Bang. J. Med. Sci. **13**, 109 (2010).
7. C. G. Jones, J. Radiol. Prot. **39**, R51 (2019). http://dx.doi.org/10.1088/1361-6498/ab1d75
8. Main Report on Regulatory Survey-Inspection of Diagnostic X-ray Machines in Bangladesh (2000).
9. Republic of Bangladesh Government. Nuclear Safety and Radiation Control Rules-1997, SRO No. 205-Law/97 (Bangladesh Gazette, 1997).
10. Republic of Bangladesh Government, Bangladesh Atomic Energy Regulatory Act 2012 No. 19. (Bangladesh Gazette, 2012).
11. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. IAEA Safety Standards Series No. GSR Part 3 (IAEA, Vienna, Austria, 2014).
12. Establishing the Infrastructure for Radiation Safety. IAEA Safety Standards Series No. SSG-44, (IAEA, Vienna, Austria, 2018).
13. Regulatory guide on Radiation Protection in Medical Diagnostic X-ray, NSRC-XR-G-01 (2002).
14. K. H. Do, J. Korean Med. Sci. **31**, S6-S9 (2016). https://doi.org/10.3346/jkms.2016.31.S1.S6

15. Report on Regulatory Survey/Inspection of Ionizing Radiation Sources in Bangladesh, NSRC/X-R/PIR(D)-A/2000,70/78 (2000).
16. M. K. Ahmed, M. Nahar, M. Akramuzzaman, and N. A. Mokta, J. Sains Nukl. Malays. **36**, 42 (2024).
17. Approval/Renewal of Private Hospital/Diagnostic Centre/Blood Bank, Hospital Service Management of DG Health. http://103.247.238.81/hsmdghs/registration/hsm_facility_show_public.php
18. Regulatory Control of Radiation Sources. IAEA Safety Standards Series No. GS-G-1.5 (IAEA, Vienna, Austria, 2004).
19. Calibration of Reference Dosimeters for External Beam Radiotherapy, IAEA Technical Reports, Series No. 469 (IAEA, Vienna, Austria, 2009).
20. M. Sandborg, C. A. Carlsson, and G. A. Carlsson, Medical Biol. Eng. Comput. **32**, 384 (1994). http://dx.doi.org/10.1007/BF02524689
21. M. Haider, A. Akter, R. A. Amiree, and Y. N. Jolly, IEEE-SEM **8**, 15 (2020).
22. M. Haider, S. Shill, Q. M. R. Nizam, and M. Akramuzzaman, Sci. Res. J. **2** (2014).