

# A Study of Radiation Protection Standards Compliance in Hospital Radiographic Departments in Iran

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## ABSTRACT

**Background:** The X-ray is a critical diagnostic and therapeutic tool with harmful effects. The International Commission on Radiological Protection (ICRP) has some recommendations regarding applying radiation protection principles.

**Objective:** This study aimed to determine the standards of the typical radiation protection in radiographic departments of hospitals in Iran.

**Material and Methods:** In this cross-sectional descriptive study, the usual radiation protection standards in places, such as the physical environment of the control and waiting rooms, radiographic devices, the physical space of the darkroom, and shielding facilities, were investigated using a checklist in Iran. A total of 84 hospitals in 51 cities throughout Iran were randomly selected, and the checklists were distributed to the radiation protection officers. In hospitals with multiple radiography rooms, the radiation protection officers were asked to complete the checklist about the room with the highest workload as a baseline to evaluate their facilities. Finally, the authors reviewed all checklists.

**Results:** In radiology departments in control and waiting rooms, the mean of radiation protection was 71.9%. Pregnancy and radiation warning signs and labels were present in 96.1% of the parameters, while gonad shielding protocols were not presented.

**Conclusion:** The principles of observed radiation protection were unsatisfactory, and it is recommended that surveillance be conducted at frequent intervals.

## Keywords

Radiographers; Shielding; Radiography; Radiation Protection; Standards

## Introduction

However, X-rays revolutionized the medical profession and set a foundation for diagnostic radiology [1-3], and its carcinogenic was discovered. The X-ray affects the diagnosis and treatment of diseases and applies in many fields, despite its adverse health consequences [3-7]. The International Commission on Radiological Protection (ICRP) provides guidelines about radiation protection based on three principles of justification, optimization, and limitation [8] and also states “all activities that include ionizing radiation can be done only if they have sufficient benefit for the individual or community, and in each radiation method, the dose level and the number of people exposed, should be kept as low as a reasonably achievable, economic, and social factor being taken into account” [9].

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However, healthcare is critical in all countries, healthcare authorities aim to provide high-quality services considering financial constraints [10-11]. The principles of the necessary radiation protection are frequently overlooked in medical imaging departments [12, 13]. Previous research on the principles of radiation protection (RP) indicates that gonad shielding reduces radiation received by the testicles and ovaries by up to 95% and 50%, respectively [14-18]. Thyroid shields reduced direct thyroid exposure significantly [19], leading to reducing eye exposure by eye-glasses [20]. Pregnancy warning signs are vital as harmful effects of ionizing radiation can result in cancer risk and genetic mutations in the fetus [21]. Radiation protection activities and compliance with radiation protection standards play a critical role in reducing exposure to ionizing radiation [22].

The shortcomings of medical imaging departments consist of a lack of facilities and equipment and a proper and periodic quality control program [22]. The American Association of Physicists in Medicine (AAPM) introduced a protocol for providing quality assurance solutions in 1977. Quality control tests are always considered for the accuracy of the equipment and the safety of the patient and radiation staff [23], showing the implementation of quality control programs resulted in a 70% reduction in patient and staff exposure and a significant improvement in image quality in several Iranian imaging centers [22].

The current study aimed to estimate the current status of RP standards in radiology departments of hospitals and identify the strengths and weaknesses of these departments with recommended solutions to improve the practices in Iran.

## Material and Methods

This cross-sectional descriptive study aimed to determine compliance with common RP standards in radiographic departments of hospitals in Iran.

A checklist with four sections was initially created for this study as follows:

1- Five parameters to assess the physical environment of the control and waiting rooms: no radiation leakage, lead-glass windows, pregnancy warning and radiation hazard signs, a radiation warning light, and protocols and laws for gonad shielding.

2- Three questions about the radiographic device type, lifespan, and performance.

3- Six questions about the physical space of the darkroom in terms of no light leakage, ventilation system, flooring and walls condition, film processing system, and film box.

4- Six questions to assess the shielding facilities, such as lead aprons, gonad shields, thyroid shields, lead gloves, lead glasses, film badge, and the procedure of controlling the film badge evaluation.

A five-point Likert scale was used to score the responses: Very Good, Good, Acceptable, Poor, and Very Poor exchanged into a percentage by dividing the total score by the maximum possible score multiplied by 100.

## Hospitals

Based on the latest report of the Statistical Center of Iran (SCI) in 2016, 429 counties, 31 provinces, and 1243 cities were studied in Iran. Additionally, 210 and 380 hospitals were in provincial centers and other cities affiliated with the health and medical education ministry.

According to the Cochran formula with  $\alpha$  equal to 0.05 and a probability of 0.5, the sample size was 83 by stratified random among the hospitals from 51 cities in Iran; the inclusion criteria to select a hospital was at least one radiography room.

## Data Collection

The checklists were given to the radiation protection officers of hospitals, and in hospitals with multiple radiography rooms, the checklist was completed in the room with the highest workload as a baseline. Finally, 74

checklists were received after five months, and the Authors reviewed all checklists.

### Data analysis

Based on adjacent provinces, Iran was divided into five regions to display the data in a chart as follows: 1) Tehran, Ghazvin, Mazandaran, Semnan, Golestan, Alborz, and Ghom provinces, 2) Isfahan, Fars, Bushehr, Chahar Mahalo Bakhtiari, Hormozgan, and Kohgiluyeh VA Boyer Ahmad province, 3) Azarbaijan Sharghi, Azarbaijan Gharbi, Ardabil, Zanjan, Gilan, and Kordestan province, Region, 4) Kermanshah, Ilam, Lorestan, Hamadan, Markazi, and Khuzestan province, and 5) Khorasan Razavi, Khorasan Jonoobi, Kho-

rasan Shomali, Kerman, Yazd, and Sistan va Baluchestan province.

Data were analyzed by SPSS software (version 24) using descriptive statistics, such as mean, standard deviation, and frequency.

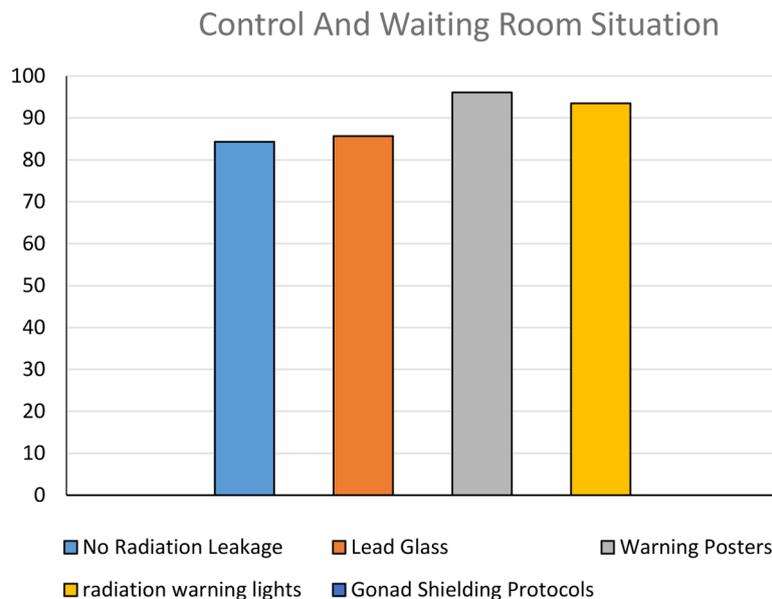
### Results

The type, number and lifespan of radiography devices in different hospitals in Iran are shown in Table 1. Analog devices were the most common (58.1%) with a mean lifespan of  $17.2 \pm 9.4$ . This is while the mean lifespan of digital devices was  $2.35 \pm 2.10$ .

Figure 1 shows the control and waiting rooms of radiology departments in hospitals with 71.9% compliance with conventional RP

**Table 1:** Type, number and life span of radiographic devices in different hospitals in Iran

Device Type	Number of devices	Minimum life span (year)	Maximum life span (year)	Mean life span (year)
Analog	43	7.0	30.0	$17.2 \pm 9.4$
Digital	31	0.2	5.0	$2.35 \pm 2.01$



**Figure 1:** The status of no radiation leakage, existence of lead glass, warning posters, radiation warning lights, and gonad shielding protocols in control and waiting room of radiography departments of hospitals in Iran.

standards. This score could have increased to 89.9% without considering gonadal RP standards. The highest score in comply with RP standards is related to pregnancy and radiation warning signs and labels (96.1%), while the lowest score of 0.0% was assigned to the availability of gonad shielding protocol with an extremely low score. Following pregnancy and radiation warning labels, the highest levels of compliance were with radiation warning lights (93.5%), lead glass windows (85.7%), and no radiation leakage (based on a quality control program) (84.3%).

The percentage of compliance with RP standards in the hospital darkroom was 64.9%. As shown in Figure 2, the best score was for film boxes (79 percent), followed by film processing systems (74.4 percent), darkrooms without light leakage (67.4 percent), flooring and walls (52.7%), and finally ventilation (51.1%).

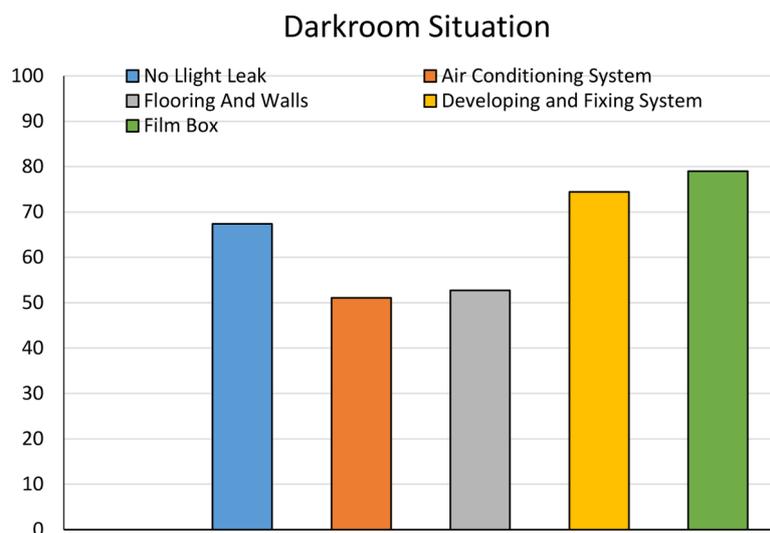
Figure 3 shows the control and waiting rooms, the X-ray device performance, the darkroom, and the protective facilities of the radiographic section of hospitals, classified based on regional geographical division. The score for observing the protection principles in control and waiting rooms for regions 1

to 5 were 75.8%, 70.8%, 71.7%, 71.1%, and 70.2%, respectively. The scores for the darkrooms were 67.8%, 63.2%, 65.0%, 66.1%, and for the protective facilities were 63.1%, and 69.8%, 79.2%, 74.3%, 76.8% and 82.0%, respectively. Regarding radiographic device performance, scores ranged from 57.5% for region 3 to 71.4% for region 5. The radiographic device performance score for regions 1, 2, and 4 were 62.8%, 65.7%, and 66.6%, respectively. The score for observance of RP principles in radiographic rooms for different regions was as follows: 69.0%, 69.7%, 67.1%, 70.2% and 71.7% for regions 1 to 5, respectively.

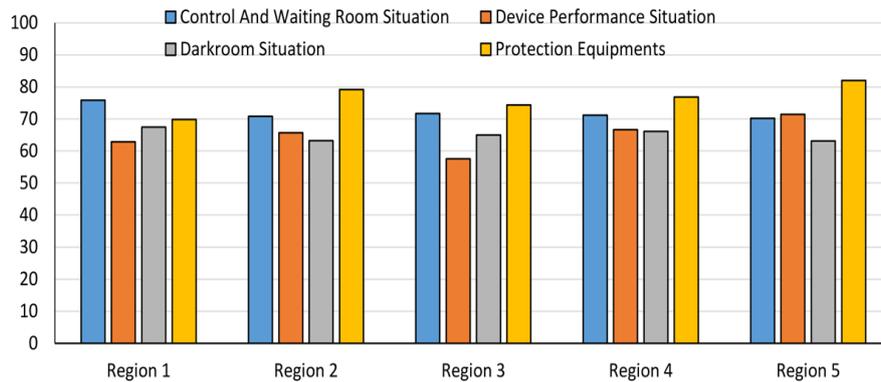
Figure 4 shows the radiation protection situation of radiography departments in terms of the accessibility of radiation protection equipment. As can be seen, most accessible equipment is related to lead apron (100%).

## Discussion

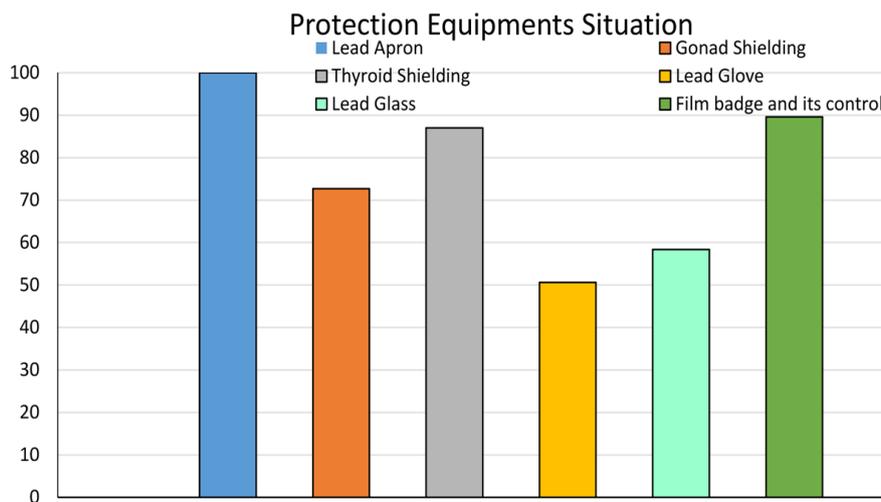
This study aimed to assess the current state of common radiation protection standards in diagnostic radiology departments of hospitals in Iran. The results indicate that the mean compliance to radiation protection standards



**Figure 2:** Observance of protection principles in the darkroom of radiography departments of hospitals in Iran.

Control And Waiting Room, Device Performance, Darkroom  
And Protection Equipments Situation

**Figure 3:** Observance of protection principles in control and waiting room, device performance, darkroom, and protection equipment of radiography departments of hospitals in Iran. Region 1: Tehran, Ghazvin, Mazandaran, Semnan, Golestan, Alborz, and Ghom provinces. Region 2: Isfahan, Fars, Bushehr, Chahar Mahalo Bakhtiari, Hormozgan, and Kohgiluyeh VA Boyer Ahmad province. Region 3: Azarbaijan Sharghi, Azarbaijan Gharbi, Ardabil, Zanjan, Gilan, and Kordestan province. Region 4: Kermanshah, Ilam, Lorestan, Hamadan, Markazi, and Khuzestan province. Region 5: Khorasan Razavi, Khorasan Jonoobi, Khorasan Shomali, Kerman, Yazd, and Sistan va Baluchestan province.



**Figure 4:** Observance of protection principles in protection equipment of radiography department hospitals in Iran.

was 71.9% in control and waiting rooms and 64.9% in darkrooms. The protective facilities received a score of 76.4%, showing the standardization in radiographic sections is accept-

able; of course, we investigated the common standards in this study and expected the minimum standards to be met. The findings also showed that the radiology departments are not

in an unfavorable situation in this respect, and the minimum international requirements for radiation protection are met.

This survey established that all radiography and waiting rooms had defensible warning signs and lights, consistent with those of other comparable studies [22, 24, 25]. Only a few centers had resolvable issues, such as a lack of specific and recolored signs. Additionally, it was determined that particular departments could use newer posters with more understandable information.

Furthermore, the gadgets of most accessible radiation protection gadgets were lead aprons with 100%, while the least accessible gadgets with the lowest score of 50.6% were lead gloves in each radiography unit (Figure 4). The film badge and its control (89.6%), thyroid shields (87.0%), gonad shields (72.7%), and lead eyeglasses (58.4%) ranked second to fifth in these protective facilities of hospitals, respectively. In a similar study by Rostamzadeh *et al.* lead aprons were the most readily available gadgets in radiology rooms [24].

It seems that the personnel of the radiology departments have the largest population among the radiation staff, and their protection against ionizing radiation must be ensured. Compliance with the principles of radiation protection in control rooms is one of the guarantees of achieving this goal. Radiographers spend the majority of their time in control rooms. The door and glass windows are more susceptible to radiation leakage due to the lead shielding on the walls. Thus, appropriate lead glass windows and fully shielded doors minimize radiation leakage with better protection for radiographers. According to Rostamzadeh *et al.* 68% of radiology control rooms lacked appropriate lead glass windows, and 50% had a defect in their lead-lined doors [24]. Another survey by Keikhai Farzaneh *et al.* in Sistan and Baluchestan, Iran, demonstrated that no lead glass window is used in 50% of the radiology departments [25].

The harmful effects of ionizing radiation on

gonad, one of the most radiosensitive organs, can be transmitted to the next generations [26]. Therefore, radiographers and patients must be aware of the risks of gonad irradiation and the importance of using gonad shields for patients during imaging [26]. Keikhai Farzaneh *et al.* revealed that 80% of the centers had gonad shields, and only 30% used the gonad shields [25]. However, according to Figure 3, the condition of the radiography departments is acceptable in terms of gonad shielding equipment, but unfortunately, in the radiography departments, no attention has been paid to the preparation of brochures related to the use of gonad protection protocols.

According to Table 1, the principles of radiation protection in darkroom rooms are less observed in 5 regions because the darkroom room is related to analog radiography, and today, when most radiology departments are equipped with digital radiography systems, they need fewer darkroom protection protocols. A total of 58.1% of hospital radiography devices are analog, showing that darkrooms retain a significant role. Some examples, such as light leakage, ventilation, flooring, walls, accurate film processing systems, and film boxes should be monitored in all darkrooms closely. According to the results, lead aprons were available in all radiography rooms, and only half of these hospitals had a functioning ventilation system, floors, and walls in good condition.

Once protective facilities are provided, some measures such as the development of radiation protection culture, training, and requiring compliance with RP protocols should be followed [27]. All radiography rooms were equipped with lead aprons [27]. Although all radiography rooms were equipped with lead aprons and some radiography rooms also had thyroid and gonadal shields, this equipment was rarely used. According to Fawcett *et al.* RP gadgets are used in 70% of cases, but only 38% of patients are used correctly [26]. Gloves and lead glasses were not placed in more than

half of the radiography rooms. Of course, this was predictable, but it is expected that lead gloves and glasses will be available to meet the standard requirements.

Film badges are a personal monitoring tool that is critical to check periodically. The findings indicate that the film badge is used acceptably in radiography departments, but their periodic check was insufficient in 20% of the radiology departments and some departments, and the preparation of the film badge for new employees has been delayed. In 2015, Rostamzadeh et al. found that 71.7% of radiologists in Kermanshah, Iran used the film badges daily [24].

## Conclusion

The compliance with the principles of radiation protection in Iranian hospitals was not satisfactory. It is strongly recommended that the RP authority bodies monitor and visit radiation medicine centers at regular and close intervals and consider more binding rules and guidelines for the radiation protection program. It is also suggested that compliance with radiation protection standard protocols be investigated in more detail and in radiation centers.

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## Authors' Contribution

All members of our team have different contributions to the research work. More specifically, S. Asadian and H. Zarghani designed and extracted the checklist, and with the help of N. Hamzian sent the checklist to the selected hospitals and analyzed the results. All the authors read, modified, and approved the final version of the manuscript.

## Ethical Approval

The Birjand University of Medical Sciences Ethics Committee approved the study's protocol (Ethic code: IR.BUMS.REC.1396.8).

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## Conflict of Interest

None

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