JOURNAL OF INTERNATIONAL CRISIS AND RISK COMMUNICATION RESEARCH
ISSN: 2576-0017
2024, VOL 7, NO S6

# Knowledge and Practices of Physicians about Radiation Protection of Patients during Prescription of Computed Tomography (CT) scan Procedures in Saudi Arabia 2024

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## Abstract:
**Background:** Radiation safety is a concern for patients, physicians, and staff in many departments, including radiology, interventional cardiology, and surgery. Radiation emitted during fluoroscopic procedures is responsible for the greatest radiation dose for medical staff. Radiation from diagnostic imaging modalities, such as computed tomography, mammography, and nuclear imaging, are minor contributors to the cumulative dose exposures of healthcare personnel. However, any radiation exposure poses a potential risk to both patients and healthcare workers alike. **The aims of study:** To evaluate the knowledge and practices of physicians in terms of radioprotection of patients when prescribing computed tomography (CT) procedures. **Methods:** A cross-sectional study in which a questionnaire with 23 multiple-choice questions was sent to prescribers of CT examinations such as radiotherapists (RMs), other medical specialists (OMSs), general practitioners (GPs) and residents/interns (R/Is). The first eight questions asked about the demographics of the participants, while the remaining questions asked about knowledge of ionizing radiation examinations, doses received, relative risks, and patient radiation safety training. **Results:** 223 physicians in all took part in a survey. The reference group, radiation therapists, knew more about irradiating and non-irradiating imaging than the other groups (P ¼ 0.003). In contrast to the other groups, 67% of the reference group stated that they consider the number of scans the patient has had in the past year (P ¼ 0.002). Additionally, just 2% of the various groups had a worldwide understanding of the dangers of ionizing radiation exposure (P ¼ 0.73). Just 12% of the participants, regardless of their seniority or area of expertise, told the patient about the hazards of X-rays at the time of prescription. Finally, only 21% of the participants declared having had training in radiation protection, with no significant differences between the subgroups (*P* ¼ 0.832). **Conclusions:** The results are comparable to those of earlier research. They demonstrate that prescribers are not well-informed on the dangers of CT exams. Physicians' ongoing professional development should be strengthened, and interns' introductory curriculum should include training on patient radiation protection.
**Keywords:** CT, Ionizing radiation, Radiation protection, X-rays, Radiation risks

## Introduction:

In order to decrease the negative consequences of ionizing radiation, radiation shielding attempts to avoid needless radiation exposure [1]. Ionizing radiation is now a necessary instrument in the medical sector for the diagnosis and treatment of a wide range of illnesses. The total lifetime radiation doses that patients and healthcare professionals get have changed along with its use [2]. Fluoroscopic imaging, which employs X-rays to produce dynamic and cinematic functional imaging, is the primary source of radiation exposure in medical settings. Patients and medical personnel are exposed to less radiation when they receive formal radiation protection training [3].

However, applying radiation safety guidelines can be difficult process, and many interventions a list do not receive formal training in either residency or fellowship on radiation dose reduction [4]. In particular, there is a lack of compliance with radiation safety regulations, especially among physicians or medical personnel that employ fluoroscopic imaging outside of specialized radiology or interventional departments [5]. Numerous fields, such as vascular surgery, gastroenterology, orthopedics, urology, interventional radiology, and interventional cardiology, use fluoroscopy. A comprehensive understanding of radiation exposure dangers and dose reduction strategies will be crucial as radiation exposure increases in frequency [3-5].

Additionally, a significant role in the patient's life is played by medical imaging. It is essential for both diagnosing illnesses and tracking how treatment outcomes change over time. Ionizing radiation (IR) based medical imaging is extensively utilized [6]. The third radiation protection principle limitation does not apply to patients in the medical field [7]. However, more rigorous application of the first two principles justification and optimization is required [8]. The International Commission on Radiological Protection (ICRP) first proposed the idea of diagnostic reference level (DRL) in 1996 to help imaging specialists apply the principle of optimization for the use of ionizing radiation on their patients [6-8].

The risk associated with the use of imaging for diagnostic purposes would potentially increase the radiation dose received by patients. Indeed, exposure to IR for diagnostic purposes accounts for 90% of the total dose received by the UK population [9]. Furthermore, in the USA, public exposure to IR has increased sevenfold due to medical imaging during the years 1980–2006. There has also been a more than 100% increase in the number of patients receiving both very high annual doses from IR (>50 mSv) and low doses (<20 mSv) [10]. Studies have estimated that the uncertainties associated with low dose levels induced by medical imaging are large [11, 12].

These results seem to be contradictory with other more recent studies. Indeed, Preston et al., (2007) [13] in a study on the occurrence of solid cancers in a population exposed to radiation from the Hiroshima atomic bomb, noted that there was a linear increase in the relative risk of cancer for doses between 0 and 2 Gy. They also reported some flattening of the relative cancer risk at higher doses [13].

In addition, they found a statistically significant dose response when the analyses were restricted to cohort members who received doses of 0.15 Gy or less [13]. Its risks also showed significant variations by gender, attained age, and age at exposure [13, 14]. In addition, other studies have estimated that low-dose IR exposure during medical imaging could cause harm and account for up to 2% of cancers in the US in the future [15-17]. In the UK, 100 to 250 cases of death occur each year due to radiological exposures [18, 19].

Recently, concerns about physicians' awareness of the ionizing radiation exposure dose during diagnostic radiological procedures are increasing [20, 21]. Therefore, it is essential that physicians pay particular attention to the dose delivered to the patient when prescribing the radiological imaging examination. One study has shown that radiation dose awareness among radiologists is insufficient and among non-radiologists is dramatically low [22]. In general, various assessments indicate that physicians have low to moderate levels of knowledge about ionizing radiation exposure doses and the expected health risks to the patient [23-27].

In Saudi Arabia, 51 nuclear medicine centers operate under the Ministry of Health, governmental sectors, and private hospitals [28]. These centers conduct approximately 37,655 general nuclear medicine investigations and 12,387 cardiac scans annually. According to a 2018 survey, the country is equipped with 21 positron emission tomography/computed tomography (PET/CT) machines, 55 single-photon emission computed tomography/computed tomography (SPECT/CT) machines, and 35 SPECT and gamma cameras [28]. By minimizing unnecessary radiation exposure, radiation protection seeks to lessen the negative effects of ionizing radiation. Therefore, this study aimed to evaluate the knowledge and practices of physicians in the field of patient radiation protection during the prescription of CT procedures.

## Methods:

This is a retrospective descriptive-analytical study carried from January to May 2024, involving radiotherapists (RMs), other medical specialists (OMSs), general practitioners (GPs) and residents/ interns (R/Is) practicing in Saudi Arabia. In order to evaluate the physician's knowledge related to X-ray exposure and radiation protection practices in CT, an anonymous standardized questionnaire with 3 sections and a total of 23 questions was developed with reference to the literature [29, 30]. It was created on the platform (Google form) and then sent to physicians via a social network linked to their email address. This questionnaire contains 3 sections and a total of 23 questions.

The first section focused on the socio-professional and personal characteristics of the participants: age, gender, practice area, status, and length of professional experience. The second section consisted of 16 questions concerning knowledge of radiation protection: characteristics of X-rays, frequency of use of CT examinations, the use of the Medical Imaging Examination Guide prior to prescription, information to the patient on the possible risks of such exposure, knowledge of the relative risks of exposure to ionizing radiation during CT procedures, and the tissue most sensitive to damage by ionizing radiation. The third section was devoted to whether or not they had received basic radiation safety training, patient radiation safety training, and whether they felt the need for such training.

Radiotherapists were considered as the reference group for the comparative study with the other groups. Descriptive statistics were produced for the characteristics of the participants, namely age and sex, seniority, sector of activity and status. The categorical variables are expressed as percentages and the participants' scores were classified according to their level of professional experience. To compare responses between the four groups of prescribers, Fisher exact test of the statistical package for the social sciences (SPSS version 28.0) were used. The value $P < 0.05$ indicated the difference was statistically significant.

## Results

**Table (1)** showed Socio-professional characteristics of the study population. In total, two hundred and twenty-three questionnaires were collected and analyzed. General practitioners represented more than a quarter of the participants with 28.2%, followed by interns and residents with 26.5%, then other specialists with a percentage of 23.3%, and finally radiotherapists who represented 22.0%. Furthermore, 28.85% of the specialists exercise in the private sector, 51.92% in the public sector and 19.23% in university hospital centers. There was a slight female predominance (38.1% men versus 61.9% women with a sex ratio of 0.615). Sixty-five participants were over 45 years of age (29.1%), whereas participants under 25 years of age represented only 6.3% and were in their majority interns. Indeed, about 52.0% of the participants had less than 10 years of professional experience, mainly among radiotherapists, residents and interns, whereas 32.7% of the specialists and 44.4% of the generalists had more than 20 years of experience.

**Table (1):** Demographic data of physicians consulted in this study

| Items | MRs | OMSs | GPs | R/Is | Total | P-value |
|---|---|---|---|---|---|---|
| Total | 49 | 52 | 63 | 59 | 223 | |
| **Age range (years old)** | | | | | | <0.001 |
| < 35 | 38 (77.6) | 3 (5.8) | 10 (15.9) | 50 (84.7) | 101 (45.3) | |
| ≥ 35 | 11 (22.4) | 49 (94.2) | 53 (84.1) | 9 (15.3) | 122 (54.7) | |
| **Sex** | | | | | | 0.210 |
| Male | 16 (32.7) | 25 (48.1) | 26 (41.3) | 18 (30.5) | 85 (38.1) | |
| Female | 33 (67.3) | 27 (51.9) | 37 (58.7) | 41 (69.5) | 138 (61.9) | |
| **Sector of activity** | | | | | | <0.001 |
| Private | 1 (2.0) | 15 (28.8) | 28 (44.4) | 1 (1.7) | 45 (20.2) | |
| Public | 8 (16.3) | 27 (51.9) | 33 (52.4) | 5 (8.5) | 73 (32.7) | |
| University Hospital Center | 40 (81.6) | 10 (19.2) | 2 (3.2) | 53 (89.8) | 105 (47.1) | |
| **Seniority (years old)** | | | | | | <0.001 |
| < 10 | 43 (87.8) | 10 (19.2) | 15 (23.8) | 48 (81.4) | 116 (52.0) | |
| ≥ 10 | 6 (12.2) | 42 (80.8) | 48 (76.2) | 11 (18.6) | 107 (28.0) | |

Note: MRs: radiotherapists; OMSs. Other medical specialists; GPs: General practitioners; R/Is: residents or interns.

**Table (2)** shows the proportions of correct answers for the questions by group asked for the clinicians in this study. Concerning the distinction between irradiating and non-irradiating examinations, the correct response rate of our prescribers ranged from 41.3% for coronary angiography to 100% for ultrasonography without significant difference between the four groups. For the irradiating examinations, it was 41.3%, 53.8%, 70.0%, 77.1% and 82.9%, respectively for coronary scintigraphy, PET scan, radiography and CT scan. For non-irradiating examinations, the correct response rate of our clinicians was 72.2% for MRI and 100% for ultrasound.

The majority of our participants were prescribers of CT scans, 95.1%, with no significant differences between the different groups (*P* ¼ 0.524). Regardless of their status, the majority of our clinicians reported that they did not use any good practice guide to establish the indications for imaging examinations and to prescribe the least radiating examination (*P* ¼ 0.155). When prescribing a CT examination, 42.9% of the radio- therapists took into account the benefit/risk ratio related to X-rays, with a non-significant difference with the other groups (*P* ¼ 0.426).

Also less than 12% informed their patients of the risks associated with their exposure to X-rays during CT procedures and the resulting benefit/risk ratio (*P* ¼ 0.793). The number of scans performed by the patient in the last year was only taken into account by 21.5% of our clinicians before ordering the examination, with a significant difference between the group of general practitioners and the other groups (*P* ¼ 0.004). On the other hand, no significant difference (*P* ¼ 0.126) was reported on the patients' interest in the risk of X-ray exposure. Indeed, 57.8% of our clinicians reported that patients never asked them about X-ray risks with rates between 44.9% and 71.4% depending on the group. When patients asked about the risk of ionizing radiation exposures, 75.4% of prescribing physicians explained the expected risk to them based on the benefit/risk ratio. As a result, 12.1% of the specialists changed their prescriptions compared to 2.0% of the radiotherapists (*P* ¼ 0.006).

Concerning the estimation of dose limits, only 11.2% of our prescribers correctly estimated the dose limit recommended by the International Commission on Radiological Protection (ICRP) for the public (1 mSv), the majority of whom were radiotherapists (44.0%, *P* ¼ 0.04). As for the recommended dose limit for pregnant women (1 mSv), only 6.3% of our practitioners had correctly estimated it, with a slightly higher percentage for radiation therapists (12.2%, *P* ¼ 0.190). The ratio between the dose received by a patient during a thoracic scan and that received during a thoracic radiography was correctly estimated by only 6.3% of our prescribing physicians with a difference in favor of the specialist physicians but which was not significant (*P* ¼ 0.054). For the dose delivered to the patient during an abdominal-pelvic scan, only 11.8% of the prescribers had estimated it correctly (7 and 11 mSv) without significant difference between the four groups.

Concerning the radio sensitivity of organs to ionizing radiation, 70.9% of our prescribers answered that the gonads are the most sensitive human tissue to ionizing radiation without significant difference between the four groups. Only 6.8% of our clinicians systematically requested a serum β-HCG assay when prescribing an abdominal-pelvic scan to a woman of childbearing age. Whereas, 31.1% of our prescribers considered that there were no particular precautions to be taken when prescribing a skull scan to a woman of childbearing age.

For the risk of induction of radiation-induced cancer following a single scan, 64.1% of our prescribers answered that there was no risk, without significant difference between the four groups. On the other hand, only 20.0% of our clinicians confirmed that they had received training in radiation protection without significant difference between the four groups (*P* ¼ 0.506). Finally, 90.1% of our practitioners estimated their need for continuous training sessions in radiation protection (*P* ¼ 0.112).

**Table (2):** Summary of physicians' answers participating on their radiation protection practices according to the question

| Questions | Suggestions | MRs | OMSs | MGs | R/Is | Total | *P*-value |
|---|---|---|---|---|---|---|---|
| Q1 | Yes | 48 (98.0) | 50 (96.2) | 60 (95.2) | 54 (91.5) | 212 (95.1) | 0.524 |
| | No | 1 (2.0) | 2 (3.8) | 3 (4.8) | 5 (8.5) | 11 (4.9) | |
| Q2 | Yes | 8 (16.3) | 2 (3.8) | 9 (14.3) | 10 (16.9) | 29 (13.0) | 0.155 |
| | No | 41 (83.7) | 50 (96.2) | 54 (85.7) | 49 (83.1) | 194 (87.0) | |
| Q3 | Always | 21 (42.9) | 29 (55.8) | 39 (61.9) | 30 (50.8) | 119 (53.4) | 0.426 |
| | Sometimes | 23 (46.9) | 17 (32.7) | 16 (25.4) | 22 (37.3) | 78 (35.0) | |
| | Never | 5 (10.2) | 6 (11.5) | 8 (12.7) | 7 (11.9) | 26 (11.7) | |
| Q4 | Always | 6 (12.2) | 4 (7.7) | 1 (15.9) | 5 (8.5) | 25 (11.2) | 0.793 |
| | Sometimes | 17 (34.7) | 17 (32.7) | 25 (39.7) | 26 (44.1) | 85 (38.1) | |
| | Never | 11 (22.4) | 15 (28.8) | 13 (20.6) | 11 (18.6) | 50 (22.4) | |
| | If requested | 15 (30.6) | 16 (30.8) | 15 (23.8) | 17 (28.8) | 63 (28.3) | |
| Q5 | Always | 11 (22.4) | 13 (25.0) | 22 (34.9) | 2 (3.4) | 48 (21.5) | 0.004 |
| | Sometimes | 18 (36.7) | 16 (30.8) | 19 (30.2) | 25 (42.4) | 78 (35.0) | |
| | Never | 20 (40.8) | 23 (44.2) | 22 (34.9) | 32 (54.2) | 97 (43.5) | |
| Q6 | Once a week | 4 (8.2) | 2 (3.8) | 1 (1.6) | 1 (1.7) | 8 (3.6) | |
| | Once a week | 6 (12.2) | 6 (11.5) | 3 (4.8) | 7 (11.9) | 22 (9.9) | |
| | Once a week | 17 (34.7) | 13 (25.0) | 14 (22.2) | 20 (33.9) | 64 (28.7) | |
| | Never | 22 (44.9) | 31 (59.6) | 45 (71.4) | 31 (52.5) | 129 (57.8) | |
| Q7 | Change the procedure | 1 (2.8) | 4 (12.1) | 1 (2.6) | 0 (0.0) | 6 (4.2) | 0.006 |
| | Reassure if no risk | 1 (2.8) | 1 (3.0) | 0 (0.0) | 1 (2.9) | 3 (2.1) | |
| | Talk about the benefit/risk ratio | 30 (83.3) | 20 (60.6) | 32 (82.1) | 25 (73.5) | 107 (75.4) | |
| | Explain that the risk is negligible | 4 (11.1) | 1 (3.0) | 2 (5.1) | 0 (0.0) | 7 (4.9) | |
| | Change the subject | 0 (0.0) | 7 (21.2) | 3 (7.7) | 7 (20.6) | 17 (12.0) | |
| | Ask the Radiologist | 0 (0.0) | 0 (0.0) | 1 (2.6) | 7 (2.9) | 2 (1.4) | |
| Q8 | True | 11 (22.4) | 5 (9.6) | 4 (6.3) | 5 (8.5) | 25 (11.2) | 0.040 |
| | False | 38 (77.6) | 47 (90.4) | 59 (93.7) | 54 (91.5) | 198 (88.8) | |
| Q9 | True | 6 (12.2) | 4 (7.7) | 2 (3.2) | 2 (3.4) | 14 (6.3) | 0.190 |
| | False | 43 (87.8) | 48 (92.3) | 61 (96.8) | 57 (96.6) | 209 (93.7) | |
| Q10 | True | 4 (8.2) | 7 (13.5) | 2 (3.2) | 1 (1.7) | 14 (6.3) | 0.054 |

| Questions | Suggestions | MRs | OMSs | MGs | R/Is | Total | *P*-value |
|---|---|---|---|---|---|---|---|
| | False | 45 (91.8) | 45 (86.5) | 61 (96.8) | 58 (98.3) | 209 (93.7) | |
| Q11 | True | 8 (16.7) | 5 (9.8) | 6 (9.5) | 7 (11.9) | 26 (11.8) | 0.658 |
| | False | 40 (83.8) | 46 (90.2) | 57 (90.5) | 52 (88.1) | 195 (88.2) | |
| Q12 | True | 38 (77.6) | 34 (65.4) | 41 (65.1) | 45 (76.3) | 158 (70.9) | 0.299 |
| | False | 11 (22.4) | 18 (34.6) | 22 (34.9) | 14 (23.7) | 65 (29.1) | |
| Q13 | True | 4 (8.3) | 3 (5.8) | 4 (6.3) | 4 (6.8) | 15 (6.8) | 0.966 |
| | False | 44 (91.7) | 49 (94.2) | 59 (93.7) | 55 (93.2) | 207 (93.2) | |
| Q14 | True | 20 (40.8) | 15 (28.8) | 9 (14.3) | 25 (43.1) | 69 (31.1) | 0.002 |
| | False | 29 (59.2) | 37 (71.2) | 54 (85.7) | 33 ((56.9) | 153 (68.9) | |
| Q15 | True | 20 (40.8) | 16 (30.8) | 22 (34.9) | 22 (37.3) | 80 (35.9) | 0.756 |
| | False | 29 (59.2) | 36 (69.2) | 41 (65.1) | 37 (62.7) | 143 (64.1) | |
| Q16 | | | | | | | |
| MRI | True | 28 (57.1) | 41 (78.8) | 54 (85.7) | 38 (64.4 | 161 (72.2) | 0.003 |
| | False | 21 (42.9) | 11 (21.2) | 9 (14.3) | 21 (35.6) | 62 (27.8) | |
| Radiography | True | 39 (79.6) | 42 (80.8) | 48 (76.2) | 43 (72.9) | 172 (77.1) | 0.754 |
| | False | 10 (20.4) | 10 (19.2) | 15 (23.8) | 16 (27.1) | 51 (22.9) | |
| Ultrasound | True | 49 (100.0) | 52 (100.0) | 63 (100.0) | 59 (100.0) | 223 (100.0) | |
| | False | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| CT | True | 42 (85.6) | 41 (78.8) | 53 (84.1) | 48 (82.8) | 184 (82.9) | 0.815 |
| | False | 7 (14.3) | 11 (21.2) | 10 (15.9) | 10 (17.2) | 38 (17.1) | |
| Coronary angiography | True | 33 (67.3) | 29 (55.8) | 31 (49.2) | 27 (45.8) | 120 (53.8) | 0.123 |
| | False | 16 (32.2) | 23 (44.2) | 32 (50.8) | 32 ((54.2) | 103 (67.3) | |
| Scintigraphy | True | 26 (53.1) | 25 (48.3) | 22 (34.9) | 19 (32.2) | 92 (41.3) | 0.077 |
| | False | 23 (59.2) | 27 (51.9) | 41 (65.1) | 40 (67.8) | 131 (58.7) | |
| Mammography | True | 26 (53.1) | 25 (48.3) | 22 (34.9) | 19 (32.2) | 92 (41.3) | 0.077 |
| | False | 23 (59.2) | 27 (51.9) | 41 (65.1) | 40 (67.8) | 131 (58.7) | |
| PET/CT | True | 35 (71.4) | 36 (69.2) | 48 (76.2) | 37 (62.7) | 156 (70.0) | 0.440 |
| | False | 14 (28.6) | 16 (30.8) | 15 (23.8) | 22 (37.3) | 67 (30.0) | |
| Q17 | Yes | 10 (20.4) | 6 (11.5) | 11 (17.5) | 13 (22.0) | 40 (17.9) | 0.506 |
| | No | 39 (79.6) | 46 (88.5) | 52 (82.5) | 46 (78.0) | 183 (82.2) | |

## Discussion:

Radiological tests have become increasingly important in medical diagnosis over the last 20 years. CT exams are being used more often, and the risks and harm are widely known and contentious. According to the results of this study, only 11% of our prescribing physicians were aware of diagnostic imaging examinations that use ionizing radiation. This result is much lower than that reported in a Canadian study (91%) [(31)]. In addition, the group of radiation therapists had the highest score and the group of interns and residents the lowest score in terms of knowledge of radio-diagnostic examinations.

The correlation between the knowledge of radiation imaging and the level of education of our prescribers was not significant ($P < 0.07$) in contrast to a similar study that showed a correlation between the medical specialties that used radiation and their level of education [(32)]. It is also surprising that 27.8% of our prescribers thought that magnetic resonance imaging (MRI) is a radiating imaging test (especially in the intern and resident group).

In terms of radiation-induced risk, 57.8% of our prescribers reported that their patients never showed any interest in the risks of X-rays. These results are similar to those reported in the literature. Indeed, in a Canadian study, 50% of the prescribers reported that none of their patients asked about the risk of radiation [(31)]. On the other hand, less than 12% of our clinicians informed their patients about the X-ray risks to which they would be exposed. This finding is slightly higher than that reported by a Canadian study which has showed that only 8% of patients were informed by their prescribers of the risks of exposure to ionizing radiation during radiological examinations [(31)].

Regarding knowledge of the dose limits recommended by the ICRP for the public and pregnant women, less than 20% of our prescribers had correctly recognized them without significant differences between the different groups. In addition, the correct estimation of the ratio between the effective dose received during a thoracic scan and that received during a thoracic X-ray and the average dose delivered during an abdominal-pelvic scan was made respectively by only 11% and 6% by our prescribers. Also, 64% of our practitioners underestimated the potential risk associated with low doses of X-rays, particularly the risk of radiation-induced cancer.

This low awareness of radiation risks is also common for the group of radiotherapists despite the fact that they are traditionally more aware of the effects of ionizing radiation. These results are similar to those reported by several previous similar studies (31-33). These low levels of knowledge were confirmed by a study of final year medical school students in Norway and also by a recent study of radiographers in Iran, but are lower than those shown by a recent study of radiographers in the central region of Ghana (34-36). These low levels of knowledge were also confirmed by a study of final year students at a medical school in Norway. Indeed, 35.55% of the students reported correct answers despite having radiation safety training during their curriculum (29).

Even more surprisingly, only 20% of our clinicians confirmed that they had undergone patient radiation safety training, including radiation therapists. This result is slightly lower than the 28.65% reported by Saeed et al., (2018) (37) in a similar survey of physicians practicing in Saudi Arabia. In this survey, only 60% of the radiation therapists reported having received radiation safety training, yet it is part of their training curriculum from the first year of residency. This training is also integrated in the form of a training module during the first semesters of medical studies in Saudi Arabia.

## Conclusion:

This study shows that the level of knowledge and practices of physicians in terms of radiation protection is insufficient. This should urgently call upon the competent authorities in this field to integrate more in-depth training on radiation protection of patients into the medical education curriculum, as well as to require qualified and accredited training in radiation protection for practicing physicians. Finally, a guide of radiological procedures and others for regular quality control of radiological equipment are needed to optimize diagnostic procedures and prevent adverse events.

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