

# HEALTHCARE PROFESSIONALS' PERCEPTION OF THE RISK OF EXPOSURE: OCCUPATIONAL EXPOSURE TO IONIZING RADIATION

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## ABSTRACT

**Background:** Ionizing radiation (IR) is an indispensable tool in modern medicine; however, its occupational risks are often neglected, requiring a robust culture of Radiation Protection (RP) to ensure worker safety. **Objectives:** This study assessed healthcare professionals' perception of the risk of occupational exposure to IR and their adherence to safety protocols in Cardiology and Gastroenterology units, in order to propose evidence-based strategic recommendations for hospital management. **Methodology:** A cross-sectional survey was conducted in a hospital centre in Northern Portugal. Data were collected from a convenience sample (n=60; response rate = 49.6%) using a validated 29-item structured questionnaire. Perceptions and practices were measured using a 5-point Likert scale (1 = Not important/Never; 5 = Extremely important/Always). **Results:** Although the perceived importance of Personal Protective Equipment (PPE) was high (M = 4.53), critical safety gaps were identified: 91.67% of the professionals were unaware of radiological emergency procedures, and 45.00% had received no specific training in RP. Regarding individual monitoring, 45.00% did not use dosimeters systematically, and 55.00% did not know how to access their dose records, which was the lowest-rated dimension in terms of perceived importance (M = 3.65). **Conclusions:** A significant gap persists between theoretical perception and practical knowledge. To mitigate these occupational risks, it is essential to reinforce the organizational culture of RP through a strategic action plan that prioritizes mandatory periodic training and increases transparency in dosimetric monitoring.

**Keywords:** Healthcare Professionals, Ionizing Radiation, Risk Perception, Radiation Protection, Occupational Safety.

## 1. INTRODUCTION

### 1.1. FRAMING THE TOPIC

Since the discovery of X-rays by Roentgen in 1895, IR has become an indispensable pillar of modern medicine. According to the World Health Organization (WHO, 2023), medical procedures are the largest man-made source of radiation exposure, with over 4.2 billion diagnostic examinations performed annually. Its application in diagnostic imaging and interventional radiology forms the basis for most clinical decisions (Matsubara, 2021). However, this technological evolution introduces significant challenges regarding occupational health and safety (OHS). In hospital settings, the interaction between IR and biological tissue can induce cellular damage through DNA mutations (stochastic effects) or cell death (deterministic effects), requiring a rigorous ethical and technical approach (Hall & Giaccia, 2024; Raposo *et al.*, 2022). Radiological Protection (RP) is traditionally governed by the principles of Justification, Optimization, and Dose Limitation (ICRP, 2007; *Decreto-Lei n.º 108/2018*). Nevertheless, recent

literature suggests that regulatory compliance alone is insufficient to ensure safety. The effectiveness of RP protocols is heavily mediated by risk perception, a subjective construct where cognitive knowledge and emotional responses converge (Paek & Hove, 2017). Insufficient training and a fragmented safety culture often lead to a cognitive disconnect between risk perception and effective preventive behaviour (Rodrigues *et al.*, 2024; Alharbi *et al.*, 2025). From this perspective, professionals tend to consider danger on a theoretical level, neglecting, however, protective measures in practice due to a lack of an institutionalized safety culture. Given that environmental risks are a critical threat to health, the topic has seen increasing scientific and regulatory development, substantiated by the development of international standards and guidelines (National Research Council, 2006; *Gabinete de Estratégia e Planeamento* [GEP], 2024). The difficulty in recognizing the risks present in the work environment by workers can compromise the adoption of safe practices, contributing to an increase in the incidence of workplace accidents, occupational diseases, and organizational losses (Areosa, 2009). In this context, the results obtained reinforce the importance of investigating the perception of risk related to exposure to RI among healthcare professionals, with special attention to the hospital sector, corroborating the need for active surveillance as advocated by Pinela *et al.*, 2024.

## 1.2. STUDY OBJECTIVES

The primary objective of this study was to evaluate the perception of occupational IR risk among healthcare professionals. To address the gaps identified in current literature, the following specific objectives were defined:

1. To determine the behaviour of healthcare professionals in relation to collective and individual protective equipment (PPE);
2. To analyse the behaviour of healthcare professionals in the context of individual dosimetry;
3. To propose an evidence-based strategic action plan to strengthen the institutional safety culture.

## 2. LITERATURE REVIEW

### 2.1. BIOLOGICAL EFFECTS AND OCCUPATIONAL RISKS

IR is an indispensable tool in modern medicine, yet its interaction with biological tissues can induce serious cellular damage through DNA mutations or cytotoxicity (Hall & Giaccia, 2024). Biological effects are categorized into deterministic (dose-dependent with a threshold, such as cataracts and radiodermatitis) and stochastic (probabilistic, with no safe threshold, such as carcinogenesis) (McLean *et al.*, 2017).

In interventional radiology (Cardiology and Gastroenterology), professionals are primarily exposed to scattered radiation. Tissues with high mitotic rates or specific vulnerability, such as the ocular lens and hematopoietic system, require rigorous clinical and epidemiological surveillance (Shore *et al.*, 2024). The legal framework in Portugal, established by Decreto-Lei N.º 108/2018, stipulates strict dose limits (e.g., 20 mSv/year for workers) and mandates a systematic approach to risk management to prevent occupational diseases (Table 1).

**Table 1:** Occupational diseases associated with IR and indicative timeframe.

| Diseases or other clinical manifestations and characterization                               | Indicative timeframe |
|----------------------------------------------------------------------------------------------|----------------------|
| Acute radiodermatitis and acute radioepithelitis of the mucous membranes                     | 2 months             |
| Blepharitis or conjunctivitis                                                                | 1 year               |
| Anemia, leukopenia, thrombocytopenia, or hemorrhagic diathesis (following acute irradiation) | 1 year               |
| Chronic radiolesions of the mucous membranes                                                 | 5 years              |
| Bone radionecrosis                                                                           | 5 years              |
| Chronic radiodermatitis                                                                      | 10 years             |
| Keratitis                                                                                    | 10 years             |
| Cataract                                                                                     | 10 years             |
| Leukemoid states                                                                             | 10 years             |
| Leukemia                                                                                     | 18 years             |
| Malignant skin tumors                                                                        | 30 years             |
| Bone sarcoma                                                                                 | 30 years             |
| Inhalation bronchopulmonary carcinoma                                                        | 30 years             |

Source: Adapted from Decreto Regulamentar n. ° 76/2007, of July 17

## 2.2 PRINCIPLES AND PRACTICES OF RP

The international safety framework relies on three pillars: Justification (net benefit), Optimization (ALARA principle – As Low As Reasonably Achievable), and Dose Limitation (ICRP, 2007; IAEA, 2026). Operationally, protection is achieved through the management of three variables:

**Time:** Minimizing exposure duration.

**Distance:** Utilizing the Inverse Square Law to decay radiation intensity.

**Shielding:** Using high-atomic-number materials (lead) for collective (screens/walls) and individual protection (PPE).

While lead aprons and thyroid shields can attenuate exposure by over 90%, their effectiveness depends on systematic use and physical integrity (Soares *et al.*, 2011). Furthermore, individual dosimetry is essential for monitoring cumulative doses, although it serves as a surveillance tool rather than a prophylactic measure (DGS, 2016).

## 3. RESEARCH METHODOLOGY

### 3.1. DESIGN AND SETTING

A cross-sectional survey was conducted among healthcare professionals in the Cardiology and Gastroenterology departments of a hospital in Northern Portugal. Data collection occurred between January and May 2025.

### 3.2. POPULATION AND RESPONSE

The target population comprised 121 healthcare professionals exposed to IR (Cardiology, n=69; Gastroenterology, n=52). A convenience sample of 60 valid responses was obtained (35 from Cardiology and 25 from Gastroenterology), representing a response rate of 49.6%.

### 3.3. INSTRUMENT AND SCALE

The data collection instrument was a structured questionnaire containing 29 items divided into five sections: (I) socio-professional characterization; (II) RP perception and training; (III) knowledge of individual dosimetry; (IV) PPE practices; and (V) radiological emergency knowledge and familiarity with the institutional RP manual. The development followed a six-phase process, including a pilot test with 10 participants that refined wording, branching logic, and visual aids for dosimeter placement. Importance and frequency were rated on a 5-point Likert scale (1 = Not important/Never; 5 = Extremely important/Always).

### 3.4. ETHICS AND PROCEDURES

The study received Ethics Committee approval (May 2024) and DPO validations (June and September 2024). Participation was voluntary, anonymous, and preceded by informed consent. Initially, an online distribution via Microsoft Forms was attempted (December 2024); however, due to a null response rate, the strategy was adjusted to a paper-based format, which ensured the final sample size.

### 3.5. STATISTICAL ANALYSIS

Data were processed using IBM SPSS Statistics (v.29.0) and Microsoft Excel 365. The analysis was primarily descriptive, employing frequencies and percentages for categorical variables, and means (+SD) for Likert-scale items. This approach was chosen to characterize the sample's profile and to identify primary trends and literacy gaps in RP within the studied institutional context.

## 4. ANALYSIS AND DISCUSSION OF THE RESULTS

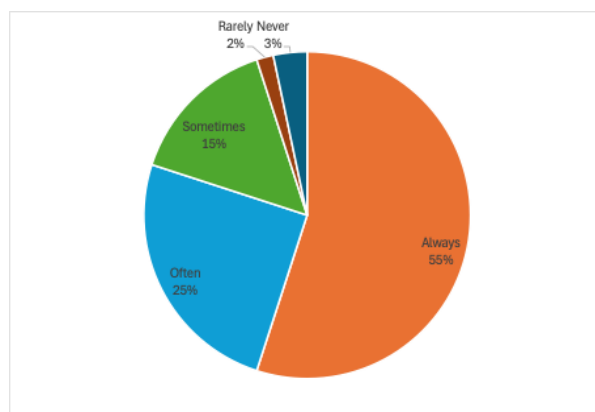
The study sample was composed by 58.33% of Cardiology professionals, most had ages between 41 and 50 years (50.00%) and 68.33% were female. Regarding professional groups, 61.67% were nurses and 23.33% were physicians.

### 4.1. PPE AND TRAINING DEFICIENCIES

Regarding the first specific objective, the data reveal a very positive perception regarding the importance of PPE. Most of the n=60 respondents (61.67%) consider PPE use "extremely important," and 100% stated they use it during exposure to IR. These results contrast with Picano *et al.* (2012), who identified a tendency toward negligence in PPE use due to undervalued risk perception. Regarding the type of PPE, there is a predominance of the two-piece lead suit (vest and skirt) (91.67%), followed by the thyroid protector (51.67%), lead apron (8.33%), and leaded glasses (3.33%). This distribution differs from Alharbi *et al.* (2025) and Costa *et al.* (2024), where the lead apron usage exceeded 96%. However, both configurations offer equivalent protection to targeted anatomical zones.

## 4.2. INDIVIDUAL DOSIMETRY BEHAVIOUR

Analysis of the second objective — behaviour in individual dosimetry — reveals gaps in the appreciation of monitoring instruments. Despite national legislation (Decreto-Lei n. ° 108/2018; DGS, 2016), 45.00% of professionals do not use their dosimeters consistently. Only 38.33% consider its use "extremely important," aligning with Zielinski *et al.* (2009) regarding the limited understanding of dosimetry's relevance.



**Figure 1:** Analysis of individual dosimeter use.

Technically, 96.67% of professionals place the dosimeter in the chest area, with 86.67% wearing it under the PPE, following DGS (2016) guidelines for accurate effective dose estimation. However, 55.00% do not know how to access their dose records, and only 18.33% value this access as "extremely important." This lack of transparency and appreciation hinders the implementation of effective RP strategies (R. Moura & Bacchim Neto, 2015).

## 4.3. ANALYSIS OF PERCEPTIONS AND STATISTICAL SIGNIFICANCE

The analysis of perceptions was structured around four fundamental dimensions: (1) importance of RP training; (2) relevance of dosimeter use; (3) importance of access to dose records; and (4) valuation of PPE use. Overall, no substantial disparities were observed in perceptions across different demographic or professional factors (Figure 2). This suggests that, regardless of age, exposure time, or clinical specialty, the healthcare professionals in this sample share similar views regarding the essential aspects of RP.

The descriptive analysis of safety perception revealed a slight numerical variation by gender, with female professionals presenting a more positive overall average (4.20) compared to 3.98 for males. Regarding professional categories, Nursing recorded the highest perception (4.26), followed by Medicine (3.98) and Diagnostic Staff (3.94), while Operational Assistants had the lowest average (3.65).

As noted by Santos (2020), risk perception can be influenced by multiple variables, including academic training levels, which are strongly correlated with professional categories. The overall averages confirm that while PPE use is highly valued (mean of 4.53), access to dose records is the least valued dimension (mean of 3.65), falling below the "very important" threshold. This result highlights a critical need to improve transparency and literacy regarding dose monitoring. Furthermore, the widespread unawareness of the institutional RP Manual (81.67%) is particularly concerning, as the availability and dissemination of this document are mandatory requirements for the licensing of radiological facilities by the *Agência Portuguesa do Ambiente* (APA). Failure

to ensure this knowledge not only compromises the safety culture but also represents a gap in regulatory compliance under *Decreto-Lei n.º 108/2018*.

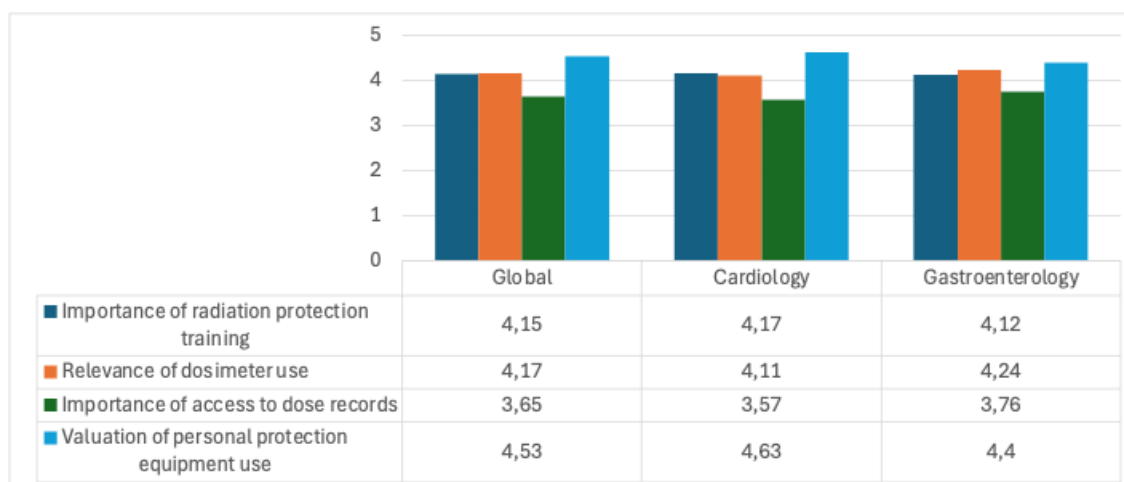


Figure 2: Analysis of perceptions around the four studied dimensions globally and by specialty.

#### 4.4. EVIDENCE-BASED RECOMMENDATIONS

Based on the diagnosis, the intervention plan focuses on four strategic areas to mitigate the risks identified in the Cardiology and Gastroenterology services:

1. **Training and Risk Literacy:** Implementation of biannual refresher sessions on RP and emergency procedures (addressing the 91.67% knowledge gap). Additionally, the digitalization of the institutional RP Manual is recommended to overcome the 81.67% unawareness rate.
2. **Monitoring and Dosimetry Transparency:** Launch of the "Dosimeter Always" campaign to combat the 45% non-compliance rate. This should be supported by the creation of an internal digital portal for quick and private consultation of individual dose records.
3. **Optimization of PPE:** Acquisition and mandatory use of leaded glasses (addressing the critical 3.33% adhesion) and establishing an annual radiographic inspection protocol for all shielding equipment.
4. **Organizational Culture and Communication:** Designation of "RP Liaison Officers" within each specialty to bridge the gap between staff and safety protocols, alongside updating safety signage in controlled areas.

Designation of Liaison Officers in each specialty and updating safety signage in controlled areas. Implementing this plan involves Direct Financial Investment (PPE modernization and IT infrastructure for dose records) and Operational Investment (clinical governance and training time). Although training implies a temporary reduction in "productive time," it is offset by lower litigation risks and health-related absenteeism. Prioritizing dose record access — the lowest-rated dimension (3.65) — is the primary catalyst for transforming dosimetry into a proactive self-protection tool.

#### 5. CONCLUSIONS

This study provided a critical diagnosis of risk perception and RP practices within a hospital centre in Northern Portugal. The findings reveal a concerning dichotomy: while there is a high

perceived importance of safety and a declared 100% adherence to basic PPE, systemic gaps persist regarding dosimetry monitoring and emergency preparedness.

The investigation found that 45.00% of the sample does not use dosimeters systematically. This behaviour compromises epidemiological surveillance and has direct legal implications under *Decreto-Lei n.º 108/2018*. The absence of reliable records in the Central Dose Registry (CDR) may hinder the recognition of occupational diseases and the establishment of the causal links necessary for labour rights and compensation. Furthermore, the fact that 91.67% of professionals are unaware of emergency protocols suggests that radiological safety in this context is often based on empiricism rather than validated institutional protocols. This reinforces the urgent need to improve internal communication and consolidate a safety culture that transcends mere regulatory compliance.

### 5.1. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The main limitations of this study are its single-centre nature and the use of a non-probabilistic convenience sample (n=60). These factors prevent the generalization of results to the entire Portuguese national context and limit the statistical power to detect subtle differences between professional categories.

Future research should broaden the geographic and institutional scope, employing probabilistic sampling methods across multiple hospital centres to allow for a robust national comparison. Additionally, integrating objective data from actual dose records with survey-based self-reports is recommended to validate the reliability of professional behaviours. In conclusion, these findings serve as a valuable indicator of the need to transition from reactive practices to a proactive safety culture, where monitoring and training are recognized as both fundamental worker rights and institutional responsibilities.

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