

# Development of a Scale for Measuring Perceived Competence in Ionizing Radiation Safety Among Healthcare Workers Using Dosimeters

Halil Soyal

halil.soyal@okan.edu.tr

Istanbul Okan University

Tülay Ortabağ

Istanbul Topkapi University

---

## Article

**Keywords:** Radiation, Radiation Safety, Scale Development, Healthcare Workers, Dosimeter

**Posted Date:** September 29th, 2026

**DOI:** <https://doi.org/10.21203/rs.3.rs-10878846/v1>

**License:** © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

**Additional Declarations:** No competing interests reported.

---

# Abstract

This study aims to develop a valid and reliable scale to assess the perceived competence of healthcare workers using dosimeters in ionizing radiation safety. Conducted with a methodological design, the research included 507 healthcare workers from hospitals in Istanbul and Kocaeli, Turkey. An initial item pool of 81 items, developed based on expert opinions, was reduced to 40 items following content validity analysis. Exploratory Factor Analysis (EFA) revealed a five-factor structure explaining 82% of the total variance. Confirmatory Factor Analysis (CFA) indicated a good model fit (CFI = 0.95, RMSEA = 0.06, SRMR = 0.05). Reliability analysis showed item-total correlations between 0.356 and 0.925, with a Cronbach Alpha of 0.97. Test-retest results confirmed high internal consistency, demonstrating the scale's reliability. Female healthcare workers and those aged 31–40 scored significantly higher on perceived ionizing radiation safety competence ( $p < 0.05$ ). In conclusion, this scale offers an effective tool for assessing healthcare workers' knowledge, educational needs, and compliance with radiation safety standards.

## 1. Introduction

Ionizing radiation is widely used in medical diagnostics and treatment processes today. Healthcare professionals working in radiology, nuclear medicine, and radiotherapy departments are occupationally exposed to ionizing radiation [1]. Ionizing radiation is a physical agent capable of ionizing atoms through high-energy waves or particles, potentially damaging biological tissues. Long-term exposure can lead to serious health effects [2]. Therefore, compliance with radiation protection measures and the competency of healthcare workers regarding radiation safety are critical [3].

Dosimeters are devices used to monitor the exposure levels of healthcare workers exposed to ionizing radiation. However, the effectiveness of dosimeter usage depends on healthcare workers' awareness of radiation safety and their perception of competence [4]. Studies have shown that some healthcare workers exposed to radiation lack sufficient knowledge about dosimeter use and are not adequately aware of radiation safety practices [5]. This highlights the need to develop a valid and reliable scale to measure healthcare workers' perceived competence in ionizing radiation safety.

The primary aim of this research is to develop a scientifically valid and reliable scale to measure the perceived competence of healthcare workers using dosimeters in ionizing radiation safety. The psychometric properties of the developed scale will be evaluated through factor analyses, validity, and reliability tests. By identifying healthcare workers' awareness levels, the effectiveness of individual and institutional radiation protection measures will also be assessed. Additionally, demographic factors influencing perceived radiation safety competence will be analyzed to validate the factor structure and test the scale's reliability.

Due to the potential harmful effects of ionizing radiation on health, it is crucial to monitor healthcare workers' exposure levels and enhance their awareness of radiation safety. Studies conducted in Turkey and globally have shown that a significant proportion of healthcare workers lack adequate knowledge

and do not fully apply protective measures [6]. This situation poses risks not only for healthcare workers but also for patients [7].

Scale development studies play a vital role in measuring individuals' perceptions on specific topics. The absence of a valid and reliable scale to assess radiation safety competence reduces the effectiveness of education and awareness programs in this field. The developed scale will contribute to the creation of training programs to enhance radiation safety awareness in healthcare institutions and serve as a critical evaluation tool in professional development processes. Moreover, this research will support health policies and regulations by contributing to strategies aimed at reducing healthcare workers' exposure to ionizing radiation. Establishing safe working environments and raising awareness of radiation hazards are essential for occupational health and safety [8].

## **2. Methods**

This research was conducted using a methodological design and aims to develop a scale to measure the perception of ionizing radiation safety competence of healthcare professionals using dosimeters. The study was conducted on healthcare professionals using dosimeters and working in various hospitals in Istanbul and Kocaeli provinces between April and October 2023. The sample consisted of 507 healthcare professionals working in different units and who agreed to participate in the study voluntarily. A 40-item scale, which was created in line with expert opinions and subjected to content validity analysis, was used as the data collection tool in the study.

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were applied to determine the psychometric properties of the scale. The reliability of the data was evaluated with Cronbach's Alpha coefficient, and content and construct validity analyses were conducted for the validity of the scale. In addition, the consistency of the scale over time was tested with the test-retest method. Whether the scale scores differed according to demographic variables was examined with independent sample t-test and ANOVA analyses. In terms of the ethical dimension of the study, relevant institution and ethics committee approvals were obtained, and voluntary consent forms were obtained from the participants.

## **3. Results**

In this section, analyses related to the scale developed for the perception of ionizing radiation safety competence among healthcare workers using dosimeters are presented. Within the scope of the findings, the validity and reliability analyses of the scale, factor analyses and scale results according to demographic variables were examined.

### **3.1 Content Validity**

The content validity of the scale was determined based on expert opinions. As a result of the evaluations, the Content Validity Ratio (CVR) was calculated as 0.778, and the Content Validity Index

(CVI) was calculated as 0.961. These values indicate that the scale has sufficient content validity. The content validity results are presented in Table 1.

Table 1  
Minimum CVR Values

| Item No | CVR Value |
|---------|-----------|
| 1       | 0.80      |
| 2       | 0.78      |
| 3       | 0.79      |
| 4       | 0.77      |
| 5       | 0.76      |

### 3.2 Construct Validity

To determine the construct validity of the scale, Exploratory Factor Analysis (EFA) was conducted. According to the EFA results, the Kaiser-Meyer-Olkin (KMO) value was found to be 0.869, and Bartlett’s Test of Sphericity result was  $p < 0.001$ . These findings indicate that factor analysis is appropriate for this data set. The KMO and Bartlett’s test results are shown in Table 2.

Table 2  
KMO and Bartlett’s Test of Sphericity Results

| Test                          | Value       |
|-------------------------------|-------------|
| Kaiser-Meyer-Olkin (KMO)      | 0.869       |
| Bartlett’s Test of Sphericity | $p < 0.001$ |

As a result of the factor analysis, the scale was found to have a five-factor structure, explaining 82% of the total variance. This factor structure indicates that the scale provides a multidimensional evaluation. As shown in Fig. 1, the scree plot indicates a five-factor structure.

### 3.3 Confirmatory Factor Analysis (CFA)

According to the CFA results, the fit indices of the scale are presented below:

Table 3  
CFA Fit Indices

| Fit Index | Value |
|-----------|-------|
| CFI       | 0.95  |
| RMSEA     | 0.06  |
| SRMR      | 0.05  |

The CFA fit indices are presented in Table 3. These values support that the model has a good fit.

### 3.4 Reliability Analysis

The reliability of the scale was determined by calculating the Cronbach's alpha coefficient. The overall reliability of the scale was found to be 0.97. Additionally, internal consistency was tested using the test-retest method. Reliability results are presented in Table 4.

Table 4  
Cronbach's Alpha Reliability Coefficients

| Sub-dimensions | Cronbach's Alpha |
|----------------|------------------|
| Factor 1       | 0.89             |
| Factor 2       | 0.91             |
| Factor 3       | 0.87             |
| Factor 4       | 0.88             |
| Factor 5       | 0.90             |
| Overall Scale  | 0.97             |

### 3.5 Results by Demographic Variables

The distribution of scale scores based on the demographic characteristics of participating healthcare workers is presented in the table below:

Table 5  
Socio-Demographic Characteristics of Participants (N = 317)

|               | Variable     | Frequency (n) | Percentage (%) |
|---------------|--------------|---------------|----------------|
| <b>Gender</b> | Female       | 180           | 56.8           |
|               | Male         | 137           | 43.2           |
| <b>Age</b>    | 20–30        | 90            | 28.4           |
|               | 31–40        | 110           | 34.7           |
|               | 41–50        | 78            | 24.6           |
|               | 51 and above | 39            | 12.3           |

Demographic characteristics are presented in Table 5. Significant differences were found in the sub-dimension scores of the scale according to the demographic characteristics of the participants. The average scores of female participants were higher compared to male participants ( $p < 0.05$ ). In addition, healthcare workers aged 31–40 had higher levels of perceived competency in ionizing radiation safety compared to other age groups. Analysis results are shown in Table 6.

Table 6  
Analysis Results of Total and Sub-Dimension Scores

|               | Variable | Total Score Mean $\pm$ SD | p-value |
|---------------|----------|---------------------------|---------|
| <b>Gender</b> | Female   | 78.4 $\pm$ 12.5           | 0.02*   |
|               | Male     | 75.2 $\pm$ 11.8           |         |
| <b>Age</b>    | 20–30    | 74.1 $\pm$ 11.9           | 0.03*   |
|               | 31–40    | 79.3 $\pm$ 12.8           |         |
|               | 41–50    | 76.5 $\pm$ 12.1           |         |

\* $p < 0.05$  indicates a statistically significant difference.

These findings demonstrate that the scale measuring the perceived competency in ionizing radiation safety among healthcare workers using dosimeters is a valid and reliable measurement tool. Furthermore, it was determined that variables such as gender and age have an impact on this perception.

## 4. Discussion

The "Ionizing Radiation Safety Competence Perception Scale" developed in this study draws attention with both its comprehensive structure and methodological strength when compared to similar studies in the literature. In particular, the content validity and factor analysis findings show that the scale is

compatible with the theoretical framework and offers a multifaceted assessment with its different sub-dimensions [9, 10].

In the literature, it is seen that scales measuring radiation safety perception usually focus on a specific occupational group or a limited number of factors. However, the scale developed in this study was designed to cover the multidisciplinary healthcare team and a 5-factor structure was presented. This increases the potential of the scale to be adaptable to different occupational groups and work environments.

In addition, the high Cronbach Alpha value and test-retest consistency obtained from the reliability analysis of the developed scale show that the measurement tool can provide stable results over time. This finding strengthens the usability of the scale in long-term follow-up studies and post-intervention evaluations [11].

Another important contribution of the study is that the items included in the scale were prepared for direct application. The scale included the individual safety perceptions of the employees, as well as the use of equipment, compliance with procedures and training needs. This will ensure that the scale can be used not only in academic research but also in the quality management processes of healthcare institutions [12].

However, the study also has certain limitations. Since the study was conducted only in Istanbul and Kocaeli, the generalizability of the results is limited. In addition, since the majority of the participants were radiology and nuclear medicine workers, reflections in other health fields should be addressed in future studies.

In conclusion, the scale developed with this study has made a significant contribution to the literature by providing both methodological and application-oriented contributions. It can be aimed to make the tool usable at an international level with future scale adaptation and validity studies.

## **5. Conclusion and Recommendations**

In this study, a valid and reliable scale was developed to assess the perception of ionizing radiation safety competence of healthcare workers using dosimeters. The findings of the study show that healthcare workers have different levels of awareness and perception of competence regarding radiation safety. The factor analysis and reliability tests of the scale revealed that the developed scale is a reliable and valid measurement tool. In addition, it was determined that variables such as gender, age and professional experience created significant differences in the perception of ionizing radiation safety.

The data obtained as a result of the study show that the knowledge level of healthcare workers regarding radiation safety should be increased. In this context, it is recommended that regular radiation safety trainings are provided in hospitals and healthcare personnel should be informed about the measures that will minimize radiation exposure. In addition, increasing the effectiveness of personal dosimeter use

and raising awareness of employees on this issue are of great importance in terms of monitoring exposure.

Healthcare institutions and managers should strengthen training programs and awareness campaigns to increase compliance with radiation safety standards. It is recommended that employees undergo radiation safety tests periodically and that encouraging practices be developed in this regard. In addition, inspections should be increased to ensure the effective use of radiation safety equipment and the full implementation of protective measures. Finally, it is recommended that future research should comparatively examine the radiation safety perceptions of individuals working in different health institutions and different professional groups. Thus, more comprehensive policies can be developed to ensure more effective protection of health workers against risks caused by ionizing radiation.

## **Abbreviations**

CFA

Confirmatory Factor Analysis

CVI

Content Validity Index

CVR

Content Validity Ratio

EFA

Exploratory Factor Analysis

KMO

Kaiser-Meyer-Olkin

## **Declarations**

### **Availability of data and materials**

The datasets used and analysed during the current study are available from the corresponding author upon reasonable request.

### **Competing interests**

The authors declare that they have no competing interests.

### **Funding**

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### **Authors' contributions**

HS designed the study, collected and analysed the data, and drafted the manuscript.

TO contributed to the study design, supervised the research process, interpreted the findings, and critically revised the manuscript.

All authors read and approved the final manuscript.

## Acknowledgements

The authors would like to thank all healthcare professionals who voluntarily participated in this study.

## 7. Ethics Approval and Consent to Participate

Ethics approval was obtained from the Ethics Committee of Istanbul Gedik University (Approval No: 406, Date: 06/12/2023). Written informed consent was obtained from all participants. This study was conducted in accordance with the Declaration of Helsinki.

## References

1. International Commission on Radiological Protection (ICRP). The system of radiological protection. (2021). Available from: <https://www.icrp.org>
2. National Council on Radiation Protection and Measurements (NCRP). Radiation protection guidelines for medical workers. (2020). Available from: <https://www.ncrp.org>
3. World Health Organization (WHO). Radiation protection in health care. (2019). Available from: <https://www.who.int>
4. Bourguignon, M., Seuntjens, J., Dehandschutter, B. & Vanhavere, F. Occupational radiation exposure in medical settings: A review. *Radiat. Prot. Dosimetry*. **181** (2), 96–105. 10.1093/rpd/ncy068 (2018).
5. Santos, P. M., Almeida, S. M. & Tavares, J. M. Awareness and compliance with radiation safety among healthcare professionals. *Health Phys.* **122** (1), 55–63. 10.1097/HP.0000000000001537 (2022).
6. Smith, D. R., Takahashi, K. & Yamaguchi, N. Knowledge and attitudes towards radiation safety: A comparative study. *J. Occup. Health.* **63** (4), 278–289. 10.1002/1348-9585.12123 (2021).
7. Fernández, M. L., Ginjaume, M. & Vano, E. Radiation protection training and monitoring in medical imaging: European perspectives. *J. Radiol. Prot.* **40** (3), 723–737. 10.1088/1361-6498/ab9f6c (2020).
8. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources, effects and risks of ionizing radiation. (2021). Available from: <https://www.unscear.org>
9. Yılmaz, S. & Demir, C. Sağlık çalışanlarında radyasyon güvenliği algısı: Ölçek geliştirme çalışması. *Occup. Health Saf. J.* **28** (3), 89–104 (2020).
10. Kaya, A. Radyasyon güvenliği farkındalık düzeyleri: Sağlık çalışanları örneği. *İş Sağlığı ve Güvenliği Dergisi*. **25** (2), 113–125 (2019).

11. International Commission on Radiological Protection (ICRP). Occupational radiological protection in interventional procedures. ICRP Publication 139. *Ann. ICRP*. **51** (2–3), 1–56. 10.1177/01466453221084087 (2022).
12. Korkmaz, H. & Çelik, N. Sağlık çalışanlarının iyonize radyasyondan korunmaya yönelik bilgi, tutum ve davranışları: Bir ölçek geliştirme çalışması. *Tıp ve Sağlık Bilimleri Dergisi*. **7** (1), 25–34 (2021).

## Figures

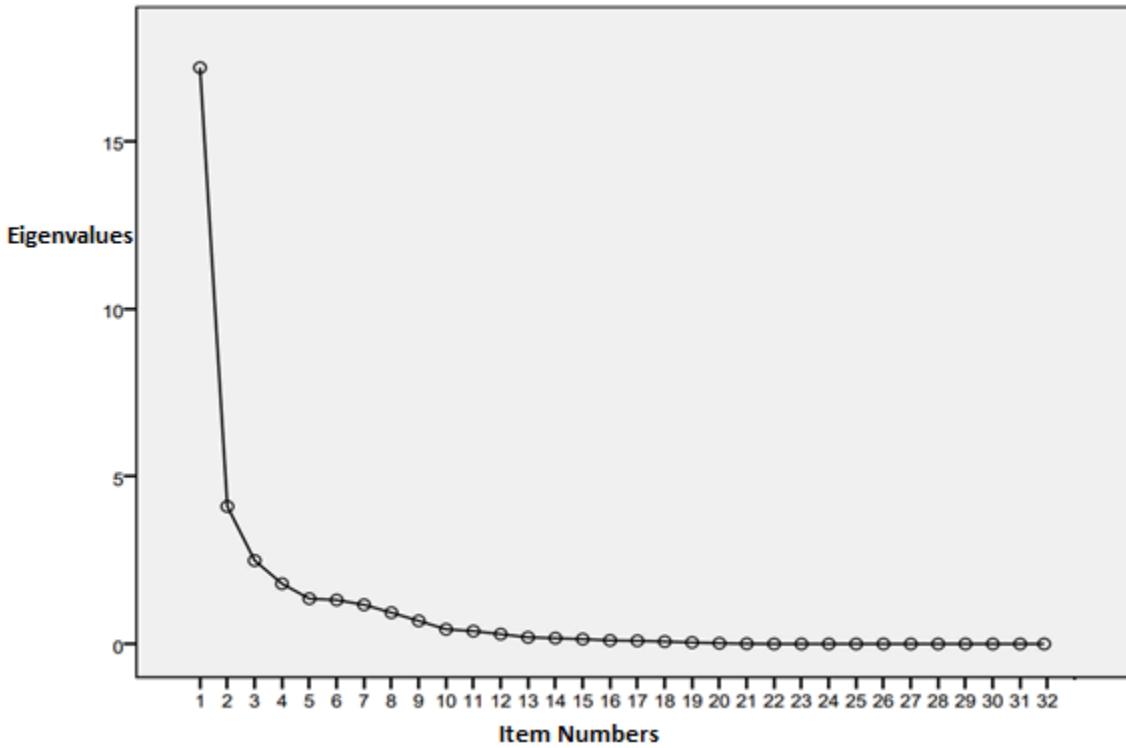


Figure 1

### Scree Plot

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [EK4.pdf](#)