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# Comparison of the effectiveness of radiation protection principles training through multimedia and instructional booklet on the awareness of operating room staff

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## Abstract:

**BACKGROUND:** Training and awareness regarding radiation protection is crucial for medical staff and operating room personnel to prevent potential hazards from radiation exposure. Various methods are employed to increase the awareness of operating room staff regarding radiation protection principles. This study aimed to evaluate the effectiveness of two training methods, multimedia presentations and instructional booklets, in enhancing the awareness of operating room staff toward radiation protection principles.

**MATERIALS AND METHODS:** In this semi-experimental study, 60 anesthesia and operating room technologists, were purposefully selected and randomly (utilizing an engineering calculator) divided into two intervention groups and one control group. The first group received multimedia-based training, while the second group was provided training through an instructional booklet. Data was collected using a researcher-designed questionnaire before the intervention and again 30 days afterward. Subsequently, the data were analyzed using SPSS version 26, employing analysis of covariance) ANCOVA (and the Bonferroni *post hoc* test to compare the outcomes among the three groups.

**RESULTS:** No significant difference in mean awareness scores was observed among the three groups before the intervention) $P = 0.075$(. After the intervention, both multimedia and instructional booklet-based education showed significant improvement in awareness scores compared to the control group) $P < 0.001$(. Furthermore, the differences between the mean awareness scores of the multimedia-based group and the instructional booklet-based group, as well as the multimedia-based group and the control group, were 26.25 and 40.95, respectively, both statistically significant ($P < 0.001$).

**DISCUSSION:** The current research findings indicate the effectiveness of both educational methods. However, the multimedia-based education method proved to be more effective in increasing the awareness levels of the study participants compared to the other two groups which is important to increase compliance with standards and implement hospital accreditation criteria to ensure the safety of operating rooms personnel against radiation. Therefore, based on this study's results, this educational approach is recommended for teaching topics related to radiation protection principles.

## Keywords:

Education, booklet, multimedia, operating room, radiation protection



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## Introduction

Technological advancements in healthcare have increased the utilization of ionizing radiation in diagnosis and treatment.[1] According to the WHO, over 3.7 billion radiological diagnostic procedures, 37 million nuclear medicine procedures, and 7.5 million radiotherapy treatments are performed globally.[2] The use of ionizing radiation has led to an increase in radiation exposure for patients and the community compared to 30 years ago. Additionally, it has resulted in higher radiation doses for healthcare workers involved in these procedures.[3] Despite the positive effects of radiation applications on health, the potential adverse effects of ionizing radiation on human health cannot be overlooked. Therefore, imaging, interventional procedures, and therapeutic applications should be carried out by specific principles aimed at minimizing potential risks for patients, healthcare workers, and the community.[4] Recent studies have made efforts to draw attention to potential hazards and raise awareness among healthcare providers regarding occupational radiation protection.[5]

In the operating room environment, healthcare workers are exposed to various radiation sources, which can pose serious risks. These radiations may originate from medical imaging devices. To safeguard the health of operating room personnel and prevent the physical and health-related consequences of working with radiation, radiation protection principles should be imparted to these professionals.[6] Studies assessing the level of knowledge and awareness about radiation safety measures among healthcare workers reveal knowledge gaps regarding the biological effects of radiation, even among groups consistently working with radiation.[6,7] Furthermore, it appears that healthcare workers who continuously work with ionizing radiation have doubts about which radiological methods involve ionizing radiation and which are genuinely nonionizing.[8] Sufficient knowledge empowers healthcare workers to conduct risk-benefit analyses, thereby protecting themselves and their patients from unnecessary radiation exposure.[9,10] Overall, studies have shown that initial training on radiation safety for personnel working with radiation is insufficient for their entire career duration.[11]

Today, there are various methods for health education, and despite the belief in the effectiveness of in-person training, there are advantages to more accessible and cost-effective methods, such as the use of instructional booklets, for health education. The use of instructional booklets is highly effective in increasing individuals' knowledge about health and improving their performance, and one of the advantages of this educational method is the uniform delivery of content to all participants in the educational program.[12] On the other hand, in recent decades the rapid development of educational technologies has increased attention to innovative methods in such a way that new approaches and teaching methods have emerged in the field of education, and faculties of medical sciences tried to use them instead of traditional methods, one of which has brought about a significant transformation, namely multimedia education. It utilizes different media types, such as images, videos, audio, text, and animations, to cater to the various learning styles of learners. This approach potentially enables the delivery of educational courses in the online space and keeps the course content dynamically updated.[13-15] Web-based education can alleviate the limitations of traditional teaching methods and provide easy and flexible learning.[16]

Recent studies in Iran have primarily focused on assessing knowledge of radiation protection and the contact status of operating room personnel with radiation. However, there wasn't sufficient attention given to implementing the necessary interventions to increase the awareness of operating room staff. Therefore, this study aimed to compare the effectiveness of radiation protection principles training using two methods: multimedia and instructional booklets.

## Materials and Methods

### Study designed and setting

This quasi-experimental study was carried out from May 2021 to September 2022 at the Iran University of Medical Sciences. First, the researcher explained the study objectives and obtained participant consent before conducting research in interventions and control groups. To assess the knowledge and gather information about the participants' awareness regarding radiation protection principles, prior to the start of the intervention, and following the informed consent process, each of the three groups was asked to complete a questionnaire. After obtaining the pre-test data, the educational intervention commenced. Similar educational content was developed in two formats, a booklet and multimedia, with the approval of experts. The educational content was tailored to the target audience and selected topics, utilizing the latest, most up-to-date, and relevant sources, as well as guidelines from the International Atomic Energy Agency. The booklet was designed and composed in a pocket-sized format spanning 45 pages. To enhance engagement and understanding, the content included color images, tables, and diagrams relevant to each topic. Additionally, the same educational content was created in a multimedia format, presented as a multimedia video file, including text, static and animated images, audio, video, animations, and diagrams, to further enhance the understanding of the material. To prepare multimedia content, software applications such as Camtasia and

PowerPoint slides were utilized. Group 1 received educational intervention through the multimedia format, while Group 2 received their training through booklets. The control group did not receive any formal training. In order to provide consistent training, the content and educational topics presented in both Group 1 and Group 2 were identical. In other words, in this study, 40 professionals from the anesthesia and operating room departments of Shafa Yihayian and Firoozgar hospitals received identical training content through two different educational methods. The control group did not receive any formal training. Finally, post-tests were conducted for the control group after 30 days of the pre-test, and for the multimedia and booklet groups after 30 days from the completion of the educational intervention.

## Study participants and sampling

The sample consisted of all operating room staff at Firouzgar, Hazrat-e Rasoul Akram, and Shafa Yehyaian hospitals who were entered into the study through non-random and accessible sampling methods. To determine the sample size, considering the study's objectives, a 95% confidence level, and an 80% power of the test, as well as previous study results, the final sample size for estimating awareness scores was determined to be 16 individuals in each group. Accounting for a 20% dropout, 20 individuals were designated for each group, resulting in a total of 60 participants.

$$n = \frac{Z_{1-\alpha/2}^{2}\sigma^{2}}{d^{2}} = \frac{1.96^{2} * 16.51^{2}}{(0.05 * 166.57)^{2}} \sim 16$$

For the selection of individuals in the intervention and control groups and to ensure blindness among the studied samples, three hospitals affiliated with IUMS, were chosen based on their significant utilization of imaging and fluoroscopy equipment in their operating rooms. Subsequently, through a random selection process (utilizing an engineering calculator), Shafa Yehyaian Hospital was chosen for intervention group 1 (multimedia-based training), Firouzgar Hospital for intervention group 2 (instructional booklet-based training), and Hazrat-e Rasoul Akram Hospital for the control group. The participants entered the study through convenience sampling (the purpose of selecting three different hospitals was to prevent individuals involved in the research from being aware of the different teaching methods and were not in contact with each other). The inclusion criteria for study participation encompassed not having participated in similar research, not attending radiation protection training courses, and having access to electronic devices capable of playing instructional video files. Exclusion criteria: lack of cooperation and participation in similar courses during the intervention.

## Data collection tool and technique

The data for this research were collected using a researcher-designed questionnaire which was completed by the participants before and after intervention. The questionnaire consisted of two sections: 1. demographic information including items such as name, age, gender, work experience, and educational level and 2. an evaluation of the knowledge and awareness of anesthesia and operating room technologists comprising 30 items divided into three distinct sections (7 items related to the physics and biology of radiation, 14 items related to radiation protection, and 9 items related to the safe use of ionizing radiation). To assess the level of awareness for each item, a 5-point Likert scale was used. To generate the questionnaire items, various sources, including the latest and most up-to-date articles related to the research topic, and similar English questionnaires were studied and reviewed. Taking into account the linguistic and cultural aspects of the country, 34 items were initially extracted. To ensure the questionnaire's validity, the researcher sought the opinions of ten experts. The importance scores for all items ranged from 90% to 100%. According to Lawshe's table, all items were deemed acceptable as their Critical Value Ratio (CVR) exceeded the minimum threshold of 0.62 (CVR > 0.8), with the exception of four items that were subsequently removed. Items with a Content Validity Index (CVI) score below 0.79 were considered to have unsatisfactory indices and were consequently eliminated from the set. However, apart from the four specific items that were excluded, all remaining items attained satisfactory CVI scores (CVI > 0.9). To determination of reliability, the same questionnaire was administered twice at a two-week interval to 30 anesthesia and operating room technologists for data completion. Subsequently, the results of the completed questionnaires were compared to assess the repeatability of the items. The results indicated that the components were adequately reliable, with all items having a Cronbach's alpha of greater than 0.79.

## Data analysis

After collecting the data and inputting it into SPSS version 26, the data were analyzed. Descriptive statistical methods, including frequency distribution tables and the presentation of descriptive statistics, were employed. Inferential statistical methods, including paired t-tests to compare the means before and after, as well as analysis of covariance (ANCOVA) and Bonferroni's *post hoc* test to compare the three groups and pairwise group comparisons, were conducted. All tests were performed with a confidence level of 95%.

## Ethical consideration

The study was conducted with the approval of the Research Ethics Committee of the Iran University

**Table 1: Demographic characteristics of the study population in three groups**

| Variables | Multimedia method | Booklets | Control | Test results |
|---|---|---|---|---|
| Gender (*n*,%) | | | | |
| Female | 14 (70) | 12 (60) | 14 (70) | $\chi^2$=0.600, df=2, *P*=0.741 |
| Male | 6 (30) | 8 (40) | 6 (30) | |
| Education (*n*,%) | | | | |
| Bachelor | 18 (90) | 17 (85) | 18 (90) | *P*=1.000 |
| Master | 2 (10) | 3 (15) | 2 (10) | |
| Age (Mean±SD) | 32±1.49 | 36±1.27 | 34.25±1.28 | *P*=0.110 |
| Work Experience (Mean±SD) | 9.40±7.18 | 12.95±5.78 | 11.00±6.26 | *P*=0.226 |

of Medical Sciences (IUMS), under the ethical code IR.IUMS.REC.1402.262. Before starting the intervention, the participants were informed about the objectives of the project, and their informed consent was obtained. The research units were assured that their personal information and scores would be kept confidential.

## Results

The results showed that approximately 67% of all participants in the study were female, and statistically, there was no significant difference between the participant groups in terms of gender (*P* value = 0.600). Furthermore, the majority of participants in all three groups had a bachelor's degree, and no statistically significant difference was observed between the participant groups in terms of educational level (*P* value = 1.000). Other demographic information is presented in Table 1.

To compare the types of training, the variable "Group" was entered into the ANCOVA model as a categorical variable with three levels (Control, Multimedia Training, and Booklet Training), and the Control Group was considered the reference group. The beta coefficient in the ANCOVA model for Multimedia Training was 46.34, and for Booklet Training, it was 13.98, which was statistically significant at the 0.05 level. This means that, on average, the participants in the Multimedia Training group scored 40.95 points higher than the Control Group, and participants in the Booklet Training group scored 14.7 points higher than the Control Group. Additionally, the adjusted R-squared value was 0.96, indicating that the ANCOVA model explains 96% of the variation in the response variable [Table 2].

Considering the results of the intergroup test and subsequently analyzing the ANCOVA, the *post hoc* Bonferroni test was also calculated [Table 3].

The results showed that the difference between the mean awareness levels of the two groups using the multimedia method compared to using the instructional book method, and also the multimedia method compared to the control group, were 26.25 and 40.95, respectively. Both of these differences were statistically significant

**Table 2: Comparison of the effectiveness of multimedia training and booklet training on the awareness level in the research units using ANCOVA**

| | Before intervention | After intervention | |
|---|---|---|---|
| Awareness | 73.67±13.31 | 98.00±19.60 | |
| **Variables** | ***B*** | **SE** | ***P*** |
| ANCOVA Model | | | |
| Before intervention | 0.70 | 0.04 | <0.001 |
| Multimedia | 40.95 | 3.09 | <0.001 |
| Booklet* | 14.7 | 3.09 | <0.001 |

Adjusted $R^2$=0.96. *The control group is considered as the reference group

(*P* value < 0.001). This means that the effectiveness of education using the multimedia method in increasing the awareness levels of the research units is higher compared to the other two groups, and this increase in awareness level in the multimedia instruction group is greater than that in the control group (40.95).

## Discussion

The purpose of this study was to determine and compare the effectiveness of two methods, multimedia and instructional booklet, in educating operating room staff in Iranian medical university-affiliated hospitals about radiation protection principles.

The results of the present study showed that the multimedia method was significantly more effective than both the instructional booklet method and the control group in increasing the awareness levels of the research units. This highlights the importance of multimedia-based educational methods in various fields of education, especially in healthcare. By improving the knowledge and awareness of healthcare workers, the quality of medical services is enhanced, leading to better patient outcomes and improved performance, ultimately promoting community health.

In support of the above findings, the study by Mohamadirizi and colleagues on women's awareness of pregnancy care demonstrated that both multimedia and illustrated booklet educational methods were effective in enhancing awareness, but the multimedia method was more effective.[17] Furthermore, the study by Abbasi and

**Table 3: Pairwise comparison of the effectiveness of intervention types on research participants' awareness using the bonferroni test**

| Group | Comparison | M | | SD | | Mean difference | SE | *P* |
|---|---|---|---|---|---|---|---|---|
| Multimedia | Booklet | 120.4 | 94.15 | 8.56 | 9.36 | 26.25 | 3.09 | <0.001 |
| | Control | | 79.45 | | 11.23 | 40.95 | 3.09 | <0.001 |
| Booklet | Multimedia | 94.15 | 120.4 | 9.36 | 8.56 | 26.25- | 3.09 | <0.001 |
| | Control | | 79.45 | | 11.23 | 14.7 | 3.09 | <0.001 |
| Control | Booklet | 79.45 | 94.15 | 11.23 | 9.36 | 14.7- | 3.09 | <0.001 |
| | Multimedia | | 120.4 | | 8.56 | 40.95- | 3.09 | <0.001 |

colleagues compared the impact of electronic education and instructional booklets on childbirth self-efficacy, showing a significant increase in the average self-efficacy score in the electronic education group compared to the booklet group.[18] Badiei *et al*.'s[19] study showed that e-learning can significantly improve the knowledge of nurses compared to the booklet and the control group. Keshtkaran *et al*.[20] found that using multimedia training methods can enhance the communication skills of nurses such as" ability to receive and send messages, emotional control, listening, insight into the communication process. These studies are consistent with the results of the current study. The use of multimedia methods in the education of operating room staff holds significant importance. This method provides a multisensory learning experience for employees by presenting diverse content, including videos, images, charts, and audio.[21] This content diversity captures the attention and increases the focus of employees, as well as presents complex concepts clearly and straightforwardly. In addition, the multimedia approach also allows for providing an experiential learning experience. For example, through videos, practical steps can be demonstrated, enabling employees to experience real processes and gain a better understanding of them.[22] Moreover, the flexibility of this method allows employees to access training at their convenience, which can contribute to improved focus and comprehension. Furthermore, the use of videos and images can convey emotions and experiences more effectively than text and strengthen employees' connection to educational topics.[23,24] This method can also aid in better retention of information and help employees recall what they've learned. In general, the use of multimedia methods in training operating room staff not only provides a better learning experience but can also enhance skills, promote a deeper understanding of complex subjects, and prepare employees to face practical challenges.[25,26]

Nevertheless, in the study by M A Lopez-Olivo and colleagues, the results showed that Receiving the booklet alone was more effective than adding the multimedia tool in reducing decisional conflict after 6 months for women with limited health literacy.[27] Some experts believe that multimedia education can quickly fill individuals' working memory due to its rich content. However, static images that display a process step by step engage individuals in processing the images. While static images do not increase cognitive load, booklets help learners easily connect with the content, compare different components of it, and create long-term learning using simple images that teach a skill or content step by step.[28] This study is not consistent with the results of the current study. Perhaps the reason for this difference may be attributed to the different study populations and the time elapsed after training. Furthermore, the study by Dehghan and colleagues on the enhancement of nurses' knowledge level regarding stroke [CVA] care in the emergency department demonstrated a significant difference in knowledge scores two weeks after the training compared to before the training in both groups. The average knowledge score in the workshop group was significantly higher than the non-interactive multimedia learning group.[29] Dehghan mentions that in the workshop teaching method, there is more interaction between the teacher and the learner, and other methods such as providing examples, sharing experiences, and questions and answers can be used. In the study by Dehghan and colleagues, an electronic package was provided to the non-interactive multimedia group. The electronic package included stroke care education comprising text, images, animation, audio, videos, and slide presentations on disease description, causes, signs and symptoms, nursing assessment, nursing diagnosis, and nursing interventions in stroke care. In contrast, in the current study, the educational content was tailored to the target audience and focused on fundamental concepts related to the hybrid operating room, radiation physics, units and quantities in radiation protection, radiation biology, and radiation protection, using the latest and most up-to-date articles, resources, and guidelines from the International Atomic Energy Agency. Another study compared the impact of an educational software and instructional booklet on self-efficacy and infant care behavior in Iranian mothers. This research demonstrated a significant increase in the average self-efficacy score of mothers in the booklet and software group compared to the control group. However, no significant difference was observed between the two intervention groups.[30] These results are not consistent with the findings of the current study. Perhaps the difference can be attributed to the different study populations and methodologies used in these studies compared to the current study.

The results showed that the effect of the pre-training score on the response variable (post-training score) was significant. Additionally, the statistical model used, the ANCOVA model (with an adjusted R-squared of 96%), was able to explain and clarify nearly 96% of the variance in the response variable (knowledge of operating room staff). In other words, this model has been able to justify a very significant portion of the changes in the knowledge of operating room staff and demonstrate how different variables such as pre-training scores and the type of training (multimedia or instructional booklet) may have played a role in the differences in the knowledge of operating room staff. This indicates that the educational model used effectively justified and explained the changes in the knowledge of operating room staff.

### Limitation and recommendation

Study limitations include the short duration of education and the specificity of the educational content evaluated, which may affect the generalizability of the results. Therefore, it is recommended to conduct this study for a longer duration and across various educational subjects.

## Conclusion

Using multimedia methods to teach radiation protection principles significantly increases the awareness of operating room staff compared to booklets. This highlights the importance of using multimedia-based educational methods in healthcare environments to improve the safety and knowledge of staff, ultimately improving the quality of healthcare services, increasing compliance with standards, and facilitating the implementation of hospital accreditation criteria for policymakers and health authorities. The use of these methods is recommended for staff training, and future research can explore their effectiveness further.

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### Conflicts of interest

There are no conflicts of interest.

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