The Effect of Brachytherapy Safety Education on Knowledge, Performance, and Attitude of Radiology Nurses

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ABSTRACT

Context: Brachytherapy is one of the cancer treatment modalities. Like any treatment, it can produce acute and delayed side effects. Unfortunately, patients getting brachytherapy experience many side effects that may affect their all quality of life aspect. So, nurses working in radiotherapy settings must be confident about their knowledge, competence, and technical skills. Therefore, holding continuing education programs for nurses is necessary.

Aim: This study aimed to determine the effect of brachytherapy safety education on radiology nurses' knowledge, attitude, and performance.

Methods: Quasi-experimental one group pre-posttest design was utilized to achieve this study on nurses working on Ayadi El Mostakabal Hospital, Alexandria, Egypt. Four tools were used to collect the necessary data. A self-administered questionnaire was designed to collect the necessary data about the nurses. Radiology Nurses' Knowledge Assessment Questionnaire to assess nurses' knowledge regarding nursing interventions for patients getting brachytherapy. Nurses' Performance Observational Checklist to assess the actual nurses' performance provided to patients getting brachytherapy. Radiology Nurses' Attitude Assessment Scale (RNAAS) measures nurses' professional attitude and the influence of safety training programs on nurses' attitudes.

Results: There was a statistically significant difference between nurses' knowledge, performance, and attitude between the initial assessment, immediate, two weeks later, and three months of educational program implementation at p=0.001. Regarding the relationship between studied nurses' knowledge and their characteristics, there was a relationship between nurses' knowledge in the initial assessment and their age, marital status, and nurses' years of experience at p=0.001, 0.002, and 0.0, respectively. While in the post-program implementation, the only relation was found between the nurses' knowledge score and years of experience p=0.007, 0.053, and0.011 in immediate, two weeks later, and after three months of program implementation, respectively. There was no relation found between nurses' performance and their characteristics throughout program implementation phases.

Conclusion: The current study findings concluded that radiation safety education for nurses regarding brachytherapy resulted in a statistically significant improvement in nurses' knowledge, performance, and attitude. Periodic and consistent update in-services training of nurses to improve their knowledge and practice enforces nurses to follow the approved guideline. Future studies are recommended to investigate nurses' knowledge and performance of radiation protection in the general ward or specialized departments.

Keywords: Brachytherapy, knowledge, attitude, performance, safety, education, radiology nurse

1. Introduction

In recent years, the cancer incidence rate is rising day by day, with about 60% of cancer patients receiving radiotherapy during their treatment *(Khachian, Amini-Behbahani, Haghani, Saatchi, & Moradi, 2018).* Radiotherapy is one of the essential treatment modalities in cancer in conjunction with cytotoxic drugs and surgical treatment. The purpose of radiotherapy is to offer the most considerable damage to tumors with the least side effect *(Shatrughan, Santosh, & Harindarjeet, 2017).*

Radiotherapy is used before surgery to minimize the tumor size, during operation to defend the area surrounding the tumor, and after surgery in combination with chemotherapy to damage any residual cancer cells. Radiotherapy is classified into an external beam or internal. The external beam includes an external machine outside the body that directs radiation to the cancer cells. In contrast, internal radiotherapy (Brachytherapy) aims to place radiation permanently or temporarily within the body, in or near cancer *(Suntharalingam, Podgorsak, & Tolli, 2018).* The radiation source can implant in plastic tubes, seeds, capsules, or thin wires. One of the two most important types of brachytherapy is intracavitary, where sources of radiation are put inside body cavities near the tumor size. Interstitial, the sources are set inside the tumor (*Moyo, 2019).*

There are two types of brachytherapy; low dose rate (LDR) treatment, which requires hospitalization for several days, and used seeds implant to treat oral cancer, sarcoma, prostate cancer, and uterine cancer. On the other hand, high dose rate (HDR) treatment is done outpatient and used in cancer of vaginal apex, esophagus, lungs, breast, and

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prostate *(Jyothi, 2018; Uyeda, Friedrich, & Pellizzon 2018).*

Brachytherapy can produce acute and delayed side effects. The main acute side effects are hair loss, tiredness, skin reactions, gastrointestinal disturbance, ulcers in the oral cavity, changes in the throat, swelling, sexual dysfunction, sterility, problems in the urinary system, and sleeping hour disturbance. The delayed side effects include fibrosis secondary to a decreased vascular supply, heart diseases, diminish cognitive functions, radiation enteropathy, and multiple peripheral nerve damage *(Poirier, 2013).* Side effects of internal radiotherapy can be influenced by the site of treatment, daily dose, characteristics of the patient, and coexisting chemotherapy *(Rose, 2016).* Furthermore, radiology nurses are exposed to potential occupational radiation hazards such as skin erythema, cataract, and cancer development. Besides, a pregnant nurse carries a risk to her fetus as well *(Purkayastha, 2018).* So, following brachytherapy safety by radiology nurses is crucial.

Brachytherapy safety for patients and staff is the primary responsibility of all radiation oncology department staff, especially radiology nurses. So, the nurse has different roles in preparing, caring, and educating patients and families undergoing brachytherapy treatment. During the brachytherapy session, the nurse's role is to ensure patient comfort, safety and help immobilize patients during the procedure for 30-60 minutes. During sessions, the nurse must prepare the environment, observe safety principles, and perform frequent skin assessments and skincare to avoid infection. Besides, assessment of nutritional patients' state and after-session provides education to the family on how to protect themselves during patient care *(Jyothi, 2018; Peifen, Miaoqing, Yushan, Peirong, & Lianying, 2017; Morishima et al., 2016)*

The nurse has an essential role in providing patient education regarding safety and risk-reducing precautions to reduce the risk posed to the community *(Chamunyonga, Edwards, Caldwell, & Burbery, 2018).* For nurse protection, the nurse wears a film badge that regularly records exposure and badges to ensure that nurses practice within safe parameters. Besides, radiology nurses should follow the radiation principle distance, time, shielding *(Jyothi, 2018)*.

Unfortunately, many nursing interventions provided to patients receiving radiotherapy are derived from custom and provider favorites rather than real evidence. Although the increased difficulty of patient care and regulatory agencies demands necessitate nursing performance to be derived from the most competent available evidence *(Rose, 2016; Peifen et al., 2017; Abdellah, Attia, Fouad, & Abdel-Halim, 2015; Piorer, 2013)*, the training of nurses regarding their safety in the brachytherapy and other oncology unit is lacking. So, the training is needed to provide the best possible care, improve self-confidence, quality of care, and reduce nurses' radiation health hazards.

Sheldon, Wise, Carlson, Dowds, Sarchet, and Sanchez (2013) developed a longitudinal cancer nursing education program in Honduras. They reported that only 4% had formal training in cancer care. The study titled "Need for radiation safety education for interventional cardiology staff, especially nurses" conducted by *Morishima et al. (2016)* reported that nurses' knowledge of radiation safety was insufficient. A high percentage of nurses were worried about radiation health hazards. Moreover, more nurses were motivated to attend continuing radiation safety seminars. Also, *Lee et al. (2016),* during their study titled "Physician and nurse knowledge about patient radiation exposure in the emergency department" in South Korea, concluded that nurses have a lower knowledge than physicians and recommended that education training regarding radiation exposure and cancer risks related to many diagnostic radiological techniques are required.

2. Significance of the study

The number of cancer patients receiving radiotherapy is rising exponentially. According to the statistical record of Ayadi-Al-Mostakbal Oncology Hospital, 3500 cases were admitted to radiology units for radiotherapy *(Harby, 2015).* African research on radiation safety among healthcare professionals is deficient (*Abdellah et al., 2015).*

One Egyptian study conducted by *Abdellah et al. (2015)* on physicians to assess their knowledge, attitude, and practices regarding radiation safety in Suez Canal University Hospital concluded that physicians had insufficient knowledge, risky practices, and negative attitudes regarding policies and precaution of radiation safety, which create an inquiry regarding the radiology nurses performance as well. In Egypt, few nursing studies are concerned with nursing knowledge and practice regarding safety precautions and management of brachytherapy. Although nurses must be confident about their knowledge, competence, and technical skills to provide quality care and maintain safety standards, holding continuing education programs is necessary. Therefore, this study investigates the effectiveness of brachytherapy safety education on radiology nurses' knowledge, performance, and attitude.

3. Aim of the study

This study aimed to determine the effect of brachytherapy safety education on radiology nurses' knowledge, attitude, and performance.

3.1. The research hypotheses

- Radiology nurses exposed to the safety education program will exhibit improved knowledge compared to their pre-intervention level.
- Radiology nurses exposed to the safety education program will exhibit improved performance compared to their pre-intervention level.
- Radiology nurses exposed to the safety education program will exhibit a positive attitude compared to their pre-intervention level.

4. Subjects & Methods

4.1. Research Design

A quasi-experimental one-group pre-posttest design was utilized. *Creswell and John (2014)* defined the pre-posttest design as a type of experimental research method through which a researcher determines whether the subject improves or regresses during the intervention.

4.2. Research Setting

The present study was conducted at Ayadi Al-Mostakbal Oncology Center**,** Alexandria, Egypt. Ayadi Al-Mostakbal Hospital is a specialized cancer center. It includes different departments as chemotherapy, radiotherapy, diagnostic radiology, clinical pharmacy, and internal department that provide free palliative treatment service to cancer patients. The outpatient department had the largest radiotherapy center in Egypt, and 800 medical cases are visited daily, with 300 radiotherapy cases are admitted daily for radiotherapy treatment. All services are provided free of charge.

4.3. Subjects

The study comprised all available nurses who provided direct patient care (n=30), regardless of their characteristics.

4.4. Tools of data collection

The researchers developed four tools to collect the necessary data to fulfill the study's objective.

4.4.1. Self-Administered Questionnaire

It was designed by the researcher to collect the necessary data about the nurses. It determines their age, gender, educational level, marital status, years of experience, and previous attendance of a brachytherapy training program.

4.4.2. Radiology Nurses' Knowledge Assessment Questionnaire (RNKAQ)

It was developed by the researchers based on reviewing the related literature *Alzabaiidi et al. (2017); Abdellah et al. (2015); Alotaibi, Bakir, Al-Abdulsalam, and Mohammed (2015)* to assess nurses' knowledge regarding nursing interventions for patients with brachytherapy. The researchers developed it into the Arabic language to be understandable by nurses.

The questionnaire was comprised of 50 multiple-choice questions MCQs. Nurses were asked to choose the correct answer from four possible answers. It was used four times (before applying for the educational program and after its application immediately, two weeks later, and finally after three months). The tool divided into six groups of questions distributed as follows.

The first group of questions included five questions related to the brachytherapy definition. The second group of questions consisted of five questions related to brachytherapy purposes. The third group of questions included 11 questions related to the administration technique. The fourth group of questions consisted of 12 questions related to the side effect. The fifth group of questions included 14 questions related to patient safety precautions. Finally, the sixth group of questions included three questions related to patients 'education and documentation.

Scoring system

Each multi-choice question was scored as one for the right answer, while wrong answers take zero. The total score was calculated, and the level of satisfaction was evaluated as follows:

- ≥60% considered satisfactory level
- <60% considered unsatisfactory level

4.4.3. Radiology Nurses' Performance Observational Checklist

An observational checklist was developed by researchers based on a review of the related literature *Alotaibi et al. (2015); Dianati, Zaheri, Talari, Deris, and Rezaei, (2014); Salmanvandi et al. (2015); Burmeister, Butler, Edinboro, Morrison, and Milas, (2011); University of Virginia (2016); Wong et al. (2014); Yurt, Çavuşoğlu, and Günay (2014); Sobeh and Hafez (2016); Nigam and Prakash, (2016)* to assess the actual nurses' performance regarding safety performance.

The developed tool comprised 100 items distributed into nine observed nursing performances as follows. The first procedure was assessing the provision of a safe environment. It consisted of 5procedure statements. The second procedure was concerning the proper use of personal radiation protection equipment (PPE); it consisted of 20 procedure statements. Radiation pollution prevention was the third procedure and consisted of 10 procedure statements.

The fourth procedure for I-131assessing, the safety measures, consisted of 10 procedure statements. The fifth procedure was brachytherapy adverse effect management, and Pocket Dosimeters management consisted of 10 procedure statements. The sixth procedure for spill management and consisted of 15 procedure statements. The seventh procedure focused on seed drop management and consisted of 10 procedure statements. The eight include general regulations regarding visitors consisted of 16 procedure statements. Finally, the ninth procedure about the discharge plan and consisted of 4 procedure statements.

Radiology nurses' performance observational checklist was used four times (before applying for the educational program and after its application immediately, two weeks later, and finally after three months). It was measured using a 3-points Likert scale ranging from 0 to 2, where 0 means had not done, one means done incompletely/incorrectly, and two means have done completely/correctly. The total score was summed and converted into two levels as follows:

- ≥60% considered satisfactory level
- < 60% considered unsatisfactory level

4.4.4. Radiology Nurses' Attitude Assessment Scale (RNAAS)

This tool was adopted from *Morishima et al. (2016)* to measure the professional attitude among nurses and the influence of the safety training program on nurses' attitudes. It was used four times (before applying to the educational program and after its application immediately, two weeks later, and finally after three months). It was composed of 21 statements tested against a three-point Likert scale from 0 to 2, where 0 means disagree while one means uncertain and two means agree. Nurses' attitude level was evaluated as follows:

- ≥35% considered negative
- < 35-70% considered fair
- < 70% considered positive

4.5. Procedures

Official approval to carry out the study was obtained from the responsible authorities of the identified setting after explaining the study's aims. The study tools were developed after a review of recent relevant literature. Content and construct validity of the developed tools were ascertained by a jury of 5 experts in Medical-Surgical Nursing and two experts in the fields of radiotherapy. A pilot study was conducted on 10% of the subjects for testing the clarity, applicability of the study tools, and appropriate modifications.

Internal consistency was used in ascertaining the reliability of the radiology nurses' knowledge assessment questionnaire using Cronbach Alpha; its value (r) was 0.976, which indicated a high correlation and was statistically reliable. Also, the reliability of the radiology nurses` performance observational checklist was done using an inter-rater reliability test, and its result was 0.92. Finally, the radiology nurses' attitude assessment scale (RNAAS) using Cronbach Alpha, its value (r) was 0.985, which indicated a high correlation and was statistically reliable. The study was conducted in four phases (assessment phase, developing the educational program phase, implementation phase, and evaluation phase). Data collection extended from January 2019 to April 2019.

Assessment phase: Nurses were assessed individually for their knowledge about nursing interventions for patients with brachytherapy. The questionnaire was answered in the presence of the researchers to provide nurses with any needed clarification. Performance assessment was done using the radiology nurses' performance observational checklist, and the observation was performed in the morning and evening shifts by the researchers.

Development of the educational program phase: Program general objective is to improve nurses' knowledge, skills, and attitude regarding brachytherapy nurses' safety. The researchers developed the educational program based on the identified needs of nurses attended in the initial assessment and on the recent literature review. The educational program has consisted of four sessions; each session was two hours. The first session content included a definition of brachytherapy and its purposes. The second session included the brachytherapy side effect, patients' education, and treatment documentation.

The third session involved personal radiation protection equipment (PPE), radiation pollution prevention, the management of adverse brachytherapy effects, and Pocket Dosimeters management.

The fourth session comprised seed drop management, general regulations regarding visitors, and the patient discharge plan.

Implementation phase: The researchers planned with the head nurses the time and duration of the training program a week before conducting the training. Program sessions were conducted in groups at the end of the morning or evening shift. Various teaching methods were used in group discussion, demonstration and re-demonstration, PowerPoint presentation, and printable version of an educational program given to every participant. The researchers demonstrated all the procedure steps in front of the nurses while discussing the rationale and precautions for each step.

Evaluation phase: Assessment of nurses' knowledge and performance was done four times during the educational program's implementation: before educational program implementation, immediately after two weeks of education, and finally after three months of educational program implementation.

Ethical consideration included a written consent obtained from the subject after the explanation of the study's aim. Anonymity and confidentiality of nurse's responses and privacy were assured. Study subjects were informed that their participation is voluntary, and they can refuse participation in the study at any time.

4.6. Data Analysis

After data were collected and transferred into specially designed formats for computer feeding, data were analyzed using a computer with a statistical package for social sciences (SPSS) version 17. Descriptive statistics: Count and percentage were used for describing and summarizing data. Analytical statistics included mean and stander deviation used for describing and summarizing data. A Cochran Q test for related samples is a non-parametric statistical test to verify if treatments have identical effects. The student t-test was used to test the association between two means. Fisher's Exact Test (FET) was used for tables with a cell or more with an expected frequency of less than 5. The level of significance for the study was $p \leq 0.05$.

5. Results

Table 1 shows the frequency and percentage distribution of studied nurses according to their characteristics. It was found that more than half of the studied nurses (60%) were in the age group less than 40 years old. In contrast, 6.7% of the studied nurses were in the age group 40 to ≤50 years old. As regards gender, the highest percentages of studied nurses (73.3%) were females. For their level of education, nearly half of the

studied nurses (46.7%) had technical health institute certificates, and only 13.3% had a university degree.

Regarding marital status, the highest percentage of studied nurses (63.3%) were married. Concerning experience, 50.0% of the studied nurses had less than five years' experience. While 40.0% had 5-10 years of experience, and 10.0 % had more than ten years of experience. The result also revealed that 76.7% of the studied nurses did not attend previous training regarding brachytherapy.

Table 2 illustrates the studied nurses' knowledge throughout the program implementation phases. The result revealed that 0% of the studied nurses had a satisfactory level of knowledge in the initial assessment. This percentage increased to be 86.6% immediately after implementing the program, then decreased to 83.3% after two weeks and 73.3% after three months. There was a statistically significant difference between nurses' knowledge in the initial assessment, immediate, two weeks later, and three months of educational program implementation at p= 0.001.

Table 3 illustrates a comparison of the studied nurse's performance throughout the program implementation phases. The result revealed that 83.3%of the studied nurses had an unsatisfactory performance in the initial assessment. While 83.3%of nurses achieved a satisfactory level in the immediate post-program, their percentage increased to 93.3%, 100 % after two weeks and three months following the program, with a statistically significant difference between nurses' performance throughout program implementation phases at p<0.001.

Table 4 illustrates the comparison of studied nurses' attitudes throughout the program phases. The result reveals that 13.3% of the studied nurses had a positive attitude in the initial assessment. This percentage increased to be 83.3%immediately after implementation of the program, then 86.6% after two weeks and 93.3% after three months with a statistically significant difference between nurses' attitude in the initial assessment, immediate, two weeks later, and after three months of educational program implementation at p= 0.001.

Table 5 shows a statistically significant relationship between nurse's total knowledge score in the initial assessment and their age, marital status, and nurses' years of experience at p<0.001, p=0.002, and p=0.0, respectively. While in the post-program implementation, the only relation was found between the nurse's total knowledge score and years of experience at p=0.007, p=0.053, p= 0.011 in immediate, two weeks later, and after three months of program implementation, respectively.

Table 6 shows a non-statistically significant relationship between nurses' performance and their characteristics throughout program implementation phases.

Table (1): Frequency and percentage distribution of sociodemographic characteristics of the studied nurses.

Socio-demographic characteristics	(n=30)	
	No.	%
Age (years)		
20-	10	33.3
30-	18	60.0
40-≤50	2	6.7
Gender		
Male	8	26.7
Female	22	73.3
Educational level		
Secondary	12	40.0
Technical	14	46.7
University	4	13.3
Marital status		
Single	11	36.7
Married	19	63.3
Divorced	0	0
Years of experience		
Less than5	15	50.0
5-10	12	40.0
More than10	3	10.0
Previous attendance of a brachytherapy training program		
Yes	7	23.3
No	23	76.7

Table (2): Comparison of the studied nurses' Knowledge throughout the program implementation phases (no. =30).

Knowledge level	Knowledge before		Knowledge after		Knowledge after 2w		Knowledge after 3m		Q-Test	p-value
	No.	%	No.	%	No.	%	No.	%		
Unsatisfactory	30	100	4	13.3	5	16.6	8	26.7	72.155	0.001
Satisfactory	0	0	26	86.6	25	83.3	22	73.3		
Mean±SD	15±10.3923		15±14		15±13.22876		15±11.13553			

Table (3): Comparison of the studied nurses' performance throughout the program implementation phases (no.=30).

Performance level	Performance before		Performance after		Performance After2w		performance after 3m		Test Q	Significance level
	No.	%	No.	%	No.	%	No.	%		
Unsatisfactory	25	83.3	5	16.7	2	6.7	0	0	150.42	0.001
Satisfactory	5	16.6	25	83.3	28	93.3	30	100		
Mean ± SD	15±13.22876		15±21.2132		15±18.38478		15±14.14214			

Table (4): Comparison of the studied nurses' attitude throughout the program implementation phases (no.=30).

Attitude	Attitude before (n=30)		Attitude after (n=30)		Attitude after 2w		Attitude after 3m		Test Q	Significance level
	No.	%	No.	%	No.	%	No.	%		
Negative	22	73.3	0	0	0	0	0	0	72.156	0.001
Fair	4	13.3	5	16.6	4	13.3	2	6.7		
Positive	4	13.3	25	83.3	26	86.6	28	93.3		
Mean ± SD	10±10.3923		10±14.21		10±13.22876		10±18.38478			

Table (5): Relationship between studied nurses' knowledge and their characteristics (no.=30).

Demographic data	Nurse's Knowledge							
	Pre		Immediate		Two weeks		Three months	
	Un*	Sa	Un	Sa	Un	Sa	Un	Sa
Age (in years)								
>30	10	0	2	8	2	8	3	7
30-50	18	0	2	16	3	15	5	13
<50	2	0	0	2	0	2	0	2
F (p)	8.213 (0.001)		1.509 (0.230)		0.386 (0.682)		0.564 (0.572)	
Gender								
Male	8	0	1	7	1	7	2	6
Female	22	0	3	19	4	18	6	16
t (p)	0.917 (0.363)		0.437 (0.664)		0.481 (0.633)		1.408 (0.164)	
Marital status								
Single	11	0	1	10	1	10	3	8
Married	19	0	3	16	4	15	5	14
t (p)	10.761(0.002)		0.742(393)		0.150(0.700)		0.132(0.718)	10.761(0.002)
Educational level								
Diploma	12	0	1	11	1	11	1	11
Technical	14	0	2	12	3	11	5	9
Bachelor	4	0	1	3	1	3	2	2
F (p)	1.464 (0.240)		1.067 (0.351)		0517 (0.599)		996 (0.376)	
Experience								
<5	15	0	4	11	4	11	4	11
5-	12	0	0	12	0	12	2	10
10+	3	0	0	3	1	2	2	1
F (p)	24.940 (0.0)		5.502 (0.007)		3.096 (0.053)		4.918 (0.011)	
Having a training program								
Yes	7	0	0	7	1	6	2	5
No	23	0	4	19	4	19	6	17
t (p)	0.416 (0.521)		0.001 (0.970)		0.113 (0.738)		1.18 0.281)	

*Sa: satisfactory, Un: Unsatisfactory

6. Discussion

Radiation oncology advanced practice nurses are becoming essential members of the multidisciplinary team. Nursing care of cancer patients undergoing brachytherapy is a balancing act between technical, intensive, and psychological support tasks *(Carper & Haas, 2006).* Nurses who prepare or administer hazardous drugs of brachytherapy are at the risk of exposure to these drugs' side effects through contaminated work surfaces, containers, contaminated medical equipment, clothing, and patient excreta. This study aimed to determine the effect of brachytherapy safety education on radiology nurses' knowledge, attitude, and performance.

The current study's findings show that the subject consists of 30 nurses who worked in the radiology unit. Regarding their sociodemographic characteristics, the result reveals that the age of the nurses was more than half in age group (30-40 years), the highest percentage of the subject were females, graduated from the technical nursing institute, married; half of the nurses have more than five years of employment in nursing at oncology and radiology

Table (6): Relationship between studied nurse's performance and their characteristics.

Demographic data	Nurses' performance							
	Pre		Immediate		Two weeks		Three months	
	un	Sa	un	sa	un	sa	un	sa
Age								
>30	10	0	2	8	1	9	0	10
30-50	18	0	3	15	1	17	0	18
<50	2	0	0	2	0	2	0	2
F (p)	0.146 (0.865)		0.186 (0.831)		1.445 (0.244)		0.795 (0.456)	
Gender								
Male	8	0	1	7	1	7	0	2
Female	22	0	4	18	1	21	0	28
t (p)	1.156 (0.253)		0.750 (0.458)		0.528 (0.599)		0.577 (0.566)	
Marital status								
Single	11	0	1	10	1	10	0	11
Married	19	0	4	15	1	18	0	19
t(p)	0.32 (0.729)		0.77 (0.467)		0.507 (0.605)		0.15 (0.861)	
Educational level								
Diploma	12	0	1	11	1	11	0	12
Technical	14	0	3	11	0	14	0	14
Bachelor	4	0	1	3	1	3	0	4
F (p)	0.97 (0.432)		2.9 (0.129)		2.257 (0.075)		0.85 (0.498)	
Experience								
<5	15	0	4	11	2	13	0	15
5-	12	0	0	12	0	12	0	12
10+	3	0	1	2	0	3	0	3
t (p)	0.14 (0.869)		3.1 (0.150)		2.380 (0.102)		0.05 (0.952)	
Having a training program								
Yes	7	0	1	6	0	7	0	7
No	23	0	4	19	2	21	0	23
t(p)	1.446 (0.234)		5.783 (0.019)		0.664 (0.522)		2.738 (0.103)	

*Sa: satisfactory, Un: Unsatisfactory

units. Concerning training courses in nursing care and safety in brachytherapy, most nurses had not had training courses. This shed light on the neglected part of the nurses' training, although it could expose many nurses to radiology hazards, mainly they are young females with insufficient experience. *Majeed and Al-Attar (2015)* mention that, third of the nurses that participated in their study were between (30 and 35) years of age; most of them were females, married, and had a technical nursing degree. Their experience in oncology nursing was less than five years, and most of them had not had training courses.

The present study finding shows a statistically significant improvement in nurses' knowledge regarding brachytherapy between pre and post-test. The pretest score results reveal that none of the nurses had a satisfactory level of knowledge at the initial assessment. This result is expected as long as nurses do not receive specific training programs concerning safety measures when dealing with radiation hazards. They do not have updated information about the care they give or the treatment they provide. This result was agreed with a study titled "Adherence to precautionary guidelines for compounding antineoplastic drugs: A survey of nurses and pharmacy practitioners" conducted by *Boiano, Steege, and Sweeney (2015),* who reported nurses lacked training concerning handling hazardous drugs.

In contrast, the posts test score revealed that around three-fourths of the studied nurses had satisfactory performance after three months of implementing educational program. There is a significant difference in nurses' knowledge of immediate evaluation, two weeks, and three months to post-test after brachytherapy education. This finding suggests that education significantly improved knowledge in this area. The same result was reported by *Dauer, Kelvin, Horan, and Germain (2006)*. They confirmed the effectiveness of a radiation safety training intervention for oncology nurses. There was a significant difference in nurses' cognitive knowledge as measured by the post-test. These findings are supporting the first research hypothesis.

Regarding the studied nurses' performance, the current study result reveals statistically significant improvement in nurses' performance pre and post brachytherapy educational program implementation; before the educational program, most of the nurses' performance in brachytherapy were unsatisfactory; while after three months of applying for the educational program, 100% of nurses had satisfactory performance. This improvement in nurses' performance maybe because the educational program stressed the practicality of safety measures deployment when providing the nursing intervention in brachytherapy using adequate information, demonstration, and re-demonstration, which is needed for the achievement of the desired level of performance.

This finding is in line with *Jeong and Jang's (2016)* study titled "Correlation between knowledge and performance of radiation protection among operating room

nurses" and reported that nurses who experienced a high level of knowledge concerning radiation protection showed higher performance levels toward radiation protection. Therefore, enhanced education on radiation safety can improve safety management levels among radiology workers. These findings are supporting the second research hypothesis.

Regarding nurses' attitudes of the studied nurses, the result reveals that only more than a tenth of the nurses had a positive attitude. It may be due to their inadequate preparation in working in the high-risk area as brachytherapy. However, after the educational program, a significant change in nurses' attitudes to positive three months after safety education. Inconsistent with findings other studies; *Khan, Khowaja, and Ali (2012)* reported in a study about "Assessment of knowledge, skill, and attitude of oncology nurses in chemotherapy administration in tertiary hospital Pakistan" that the nurses were inadequately prepared to care for cancer patients and consequently, held negative views about the disease and its treatment.

This result in line with *Shokier, Shaban, Gadiry, and SeifEldin's (2012)* study titled "Quality ambulatory oncology nursing practice for chemotherapeutic patients" and reported that a definite improvement was detected in the nurse's knowledge practice and attitude. While *Dauer et al. (2006)* study title "Evaluating the effectiveness of a radiation safety training intervention for oncology nurses: A pretest – intervention – post-test study" found that oncology nurses displayed a generally positive attitude concerning radiation and radiation safety, even before the training intervention, nursing attitudes became more positive after the interventions. These findings are supporting the third research hypothesis.

The current study finds that middle-aged nurses with technical education and less than ten years in the radiology unit in all post-intervention phases have improved knowledge, performance, and attitude compared to other nurses. This finding is expected because the technical nurses receive teaching in their academic years about oncology diseases and their treatments. These were in line with a study by *Alotaibi et al. (2015)* titled "Radiation awareness among nurses in nuclear medicine departments" that stressed the importance of formal education for nurses concerning the risk of radiation and its protection. *Polovich and Clark's (2012)* study titled "Factors influencing oncology nurses' use of hazardous drug safe-handling precautions' reported that continuing education should be provided for nurses as it affects the nurses' level of knowledge and attitudes.

Also, this finding was consistent with the result of *Mahendran et al. (2014)* study titled "Knowledge, attitudes, and practice behaviors of nurses and the effectiveness of a training program in psychosocial cancer care" found that the training program was successful in improving the applied knowledge and practice behaviors of nurses in providing psychosocial care for cancer patients.

7. Conclusion

The current study findings concluded that the radiation safety education for nurses in brachytherapy resulted in a statistically significant improvement in the nurses' knowledge, performance, and attitude.

8. Recommendations

The current study recommended a periodic and consistent update in-services training of nurses to improve their knowledge and practice. It enforces nurses to follow the approved guideline, offers a safe work environment, and conducts periodic screening programs to monitor potential exposures deliver needed equipment/supplies for a safe brachytherapy environment.

Future studies should investigate nurses' knowledge and performance of radiation protection in the general ward or specialized departments, and educational needs should also be studied to develop customized radiation protection and safety education programs in oncology hospitals.

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