

## Influence of Antineoplastic Safe Handling Guidelines on Enhancing Nurses' Performance

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### Abstract

**Back ground:** Chemotherapy is associated with several adverse effects not only for patients, but also for nurses who handle, prepare and administer it like hair loss, skin rash and abortion. So, nurses are in urgent need of learning how to safely handle chemotherapy drugs to protect themselves from serious complications. **Aim:** to enhance nurses' performance in safe handling of antineoplastic drugs. **Methods:** A quasi-experimental study was conducted involving a convenience sample of 40 nurses working at the Fayoum Oncology Center. Data were collected using five tools: nurses' knowledge questionnaire, nurses' practice tool, checklist of nurses' attitudes toward antineoplastic drugs, checklist of adverse effects caused by exposure to antineoplastic drugs, and checklist of nurses' opinion on the causes of noncompliance to safe handling guidelines of antineoplastic drugs. **Results:** A statistically significant difference in the overall knowledge, practices, and attitude of the nurses was observed between the pre- and post-program periods ( $p < 0.001^*$ ). Furthermore, a positive correlation was found between nurses' knowledge and practices during both the pre- and post-program periods ( $r = 0.582, p < 0.001^*$  and  $r = 0.297, p = 0.063$ , respectively). **Conclusion and Recommendations:** Based on the results presented in this study, the nurses' performance enhanced, which forced us to continue training and monitoring. Furthermore, medical surveillance for nurses should be implemented to assess the prevalence of complications of antineoplastic drugs.

**Keywords:** antineoplastic drugs; safe handling guidelines; and nurses' performance

### Introduction

Cancer, the second leading cause of death, has gained so much attention for a long time (Lei, et al. 2022). More than 11 million patients are diagnosed with cancer worldwide (Pilleron, et al., 2021). In Egypt, the number of new cancer cases is 134, 632, and the number of deaths due to cancer is 89,042 (Global Cancer Observatory [GCO], 2020). Numerous modalities are used for treatment (Hori, et al., 2022). Chemotherapy is the most effective and widely used treatment for most cancers (Abbas, & Rehman, 2018).

Chemotherapeutic drugs are described by the American Pharmacists Association as dangerous drugs. They are also known as cytotoxic or antineoplastic drugs. They can have several adverse effects not only in patients but also in healthcare workers who deal with them, particularly nurses (Simegn, Dagne, Dagne, & Weldegerima, 2021; Alehashem & Baniyasi, 2018). Approximately 8 million

healthcare workers in the United States are potentially exposed to hazardous drugs (Zakaria, Alaa, & Desoky, 2022).

Unsafe exposure to chemotherapeutic drugs can result in acute or chronic adverse effects. Acute effects include nausea, rashes, headache, sore throat, cough, dizziness, eye irritation, hair loss, and allergic reactions (Eisenberg, 2022). Among the possible chronic effects are reproductive side effects, including infertility, abortion, and fetal abnormalities (Asefa, Aga, Dinegde, & Demie, 2021). Because of the increased number of patients with cancer, the workload for nurses increased, which in turn increased their risk of unsafe exposure to occupational hazards (Soheili, Taleghani, Jokar, Eghbali- Babadi, & Sharifi, 2021). In 1979, the first evidence of nurses' exposure to hazards was discovered (Falck, et al. 1979).

Nurses may be accidentally exposed to chemotherapeutic agents and related wastes during handling at various stages—

transportation, unpacking, storage, preparation, cleaning up spills, administration, and disposal (Simegn, Dagne, Dagne, & Weldegerima, 2021). Exposure may occur because of direct contact with chemotherapeutic agents without personal protective equipment (PPE) and biological safety cabinets (BSCs), spills, needle-stick injury, and other undesired exposures (Asefa, Aga, Dinegde, & Demie, 2021). Additionally, ineffective controls, poor communication, and inadequate training may also result in unsafe exposure (Hon & Abusitta, 2016).

To ensure personal, team, and environmental protection, adhering to practices of safe handling of antineoplastic medications and using PPE are necessary. Furthermore, preparation must be performed in a suitable physical area that has been structured and built for this purpose according to engineering specifications and equipped with an air system that complies with international standards (Ness & Martins, 2022).

Furthermore, organizational support and work environments play an important role in nurses' adherence to safety guidelines for chemotherapy administration. Positive perceptions of a safe climate that confirms adherence to safety guidelines and safety-related behaviors are associated with lower work-related injuries (Kim, et al. 2019).

### Significance of the study

The National Institute for Occupational Safety and Health (NIOSH) and Oncology Nurses Society has set guidelines for safe handling of antineoplastic drugs (Mahdy, Abdel Rahman, & Hassan, 2017). However, adverse effects have been recorded. In Egypt 2019, a high level of genotoxicity biomarkers, including chromosomal aberrations, among oncology nurses was found. Furthermore, an increased number of abortions and infertility was found (El Hosseini, Ghanem, & Gamal, 2019).

Thus, developing guidelines that assure safe behaviors and awareness is a key factor in changing individuals' performance (Nouri, Javadi, Iranijam, & Aghamohammadi, 2021). Therefore, organizational and environmental factors that can increase the risk of nurses'

exposure must be explored, and continuous training of nurses about the risks and safe handling of antineoplastic drugs should be provided.

### Aim of the study:

This study was designed to enhance nurses' performance toward safe handling of antineoplastic drugs, to assess the prevalence of adverse effects of exposure to antineoplastic drugs, and to assess working environmental factors that can increase exposure to antineoplastic drugs' adverse effects.

### Research hypothesis:

Antineoplastic handling guidelines will enhance nurses' performance toward safe handling of antineoplastic drugs.

### Research questions:

What is the prevalence of adverse effects among nurses handling antineoplastic drugs?

Is there any factor in the working environment that can increase the risk of exposure to antineoplastic drugs?

### Methods

#### Setting:

The study was conducted at the Fayoum Oncology Center.

#### Study design

A quasi-experimental (pre-post-test) design was used.

#### Sampling:

This study included a convenience sample of all nurses ( $n = 40$ ) who handled chemotherapeutic drugs and agreed to participate in the study, regardless of age and years of experience.

#### Data collection tools:

The five following tools were used to collect data.

#### Tool I: Nurses' knowledge questionnaire:

It was used to assess nurses' knowledge about safe handling of antineoplastic drugs. The researchers developed and wrote this tool in Arabic after reviewing the related literature

(Esmail, Qadir, Mahmood, Osman, and Omar, (2016); Mahdy, Abdel Rahman, and Hassan (2017); Nwagbo, Ilesanmi, Ohaeri, and Oluwatosin (2017); Mahdy, Abdelrahman, and Seddek (2018) and Zakaria, Alaa, and Desoky (2022). This consisted of two parts:

**Part one:** It comprised the participants' demographic data, including sex, age, marital status, years of working experience in handling antineoplastic drugs, previous attending courses about safe handling of antineoplastic drugs, and the number of preparation times of chemotherapy per day for patients.

**Part two:** It included 26 true-or-false questions related to nurses' knowledge about safe handling of antineoplastic drugs, and this part was divided into three sections. The first section was about the adverse effects of chemotherapy (3 questions). The second section was about the routes of exposure to chemotherapeutic agents (8 questions). The third section was about nurses' knowledge regarding safe handling of antineoplastic drugs, including wearing PPE, the preparation and administration of chemotherapeutic drugs, cleanup of the chemotherapy preparation site, and dealing with cytotoxic spills (15 questions).

### The scoring system

Each question was scored as follows: 1 point for a correct answer and 0 points for an incorrect answer. The total score was 26. If the score is less than 80%, it is considered an unsatisfactory level of knowledge and reflects a gap of knowledge. If the score is  $\geq 80\%$ , it is considered a satisfactory level. In this study, 80% was chosen as the cutoff point because this unit is highly specialized and requires high levels of knowledge and practice to prevent complications.

**Tool II: Nurses' practice tool:** The researchers developed this tool, which consisted of two parts.

### Part one: Checklist for safe handling of antineoplastic drugs for nurses

This was developed by the researchers to observe nurses' practices regarding safe

handling of antineoplastic drugs based on the following literature: Pan American Health Organization (2013); Alehashem and Baniasadi (2018); Liu, et al. (2022); Watheeq and Kadhim (2022). It included nurses' practice in receiving and storing "6 steps", preparing, and compounding antineoplastic drugs "7 steps"; cleaning the preparation area and spills "5 steps"; administration "8 steps"; post-administration and the disposal of antineoplastic drugs "8 steps".

### The scoring system:

Each step is scored 0 point for "not done" or 1 point for "done." The total score is 34. Scores  $\geq 80\%$  are "competent," whereas those  $< 80\%$  are "incompetent."

### Part two: Risky behaviors

It was used to assess the presence of behaviors that may put nurses at risk. It was developed by the researchers based on the following literature: Rizalar, Tural, and Altay (2012); Chen, Lu, and Lee, (2016); Koulounti, Roupa, Charalambous, and Noula (2019) and Abu Sharour, Subih, Bani Salameh, and Malak (2021). It consisted of 10 behaviors, including eating or smoking in the preparation area, improper handling of contaminated materials, and unsafe cleaning of spills.

### The scoring system:

Each step is scored 0 point for "not present" or 1 point for "present." The total score is 10.

### Tool III: Checklist of nurses' attitudes toward antineoplastic drugs:

This tool was adapted from Taghizadeh Kermani, Hosseini, Salek, and Pournali (2015). This was formulated to discover nurses' attitude toward dealing with antineoplastic drugs, such as fear to deal with side effects of chemotherapy, and not helping patients to decrease psychological effect of chemotherapy.

### Scoring system:

Each item that indicated positive attitude is scored 1 point, whereas those indicating negative attitudes are scored 0 points.

**Tool IV: Checklist of antineoplastic adverse effects caused by nurses' exposure:**

The researchers formulated this tool to assess the adverse effects to which nurses may be exposed during handling of antineoplastic drugs based on Ratner, et al. (2010); Mahdy, Abdel Rahman, and Hassan (2017) and Momeni, Askarian, Azad, and Danaei (2021).

**Tool V: Checklist of nurses' opinion on the causes of noncompliance to guidelines for safe handling of antineoplastic drugs:**

The researchers developed this tool to explore the causes of non-adherence to guidelines for safe handling of antineoplastic drugs based on Boiano, Steege, and Sweeney (2014); Elshaer (2017) and Mahdy, Abdel Rahman, and Hassan (2017).

**Validity and reliability:**

Validity of the tools were tested through 3 experts of Medical- Surgical nursing. Reliability testing was estimated using Cronbach's Alpha test to measure the internal consistency of the tools. It was found that Cronbach's Alpha test for tool I was 0.789, for Tool II 0.780, and 0.738 for tool III, 0.786 for tool IV and 0.813 for tool V, which reflects reliable tools.

**Ethical Considerations:**

Ethical approval was obtained from faculty of nursing Helwan university. Formal permission obtained from director of hospital and director of nurses after explanation of nature and purpose of the study. Researchers explained the study objectives for nurses, confirmed that joining the study is voluntarily and they have the right to withdraw at any time, and obtained a written consent for participation. Also, the researchers pledged to keep the data confidential and respect nurses' culture and ethics.

**Data collection "field work":**

Data were collected from the beginning of July 2022 to October 2022. Data collection was divided into three phases:

**Pre-implementation "assessment phase":**

The researchers collected data to assess the nurses' level of knowledge and practices before teaching safe handling guidelines through the following:

The researchers used tool II to observe the nurses' practices from receiving chemotherapeutic drugs to disposal and observe their risky behaviors. Then, the researchers assessed the nurses' knowledge about handling antineoplastic drugs safely (pre-test), which encompassed 20 min for the nurses to fill tool I. After that, they assessed the nurses' attitude toward dealing with antineoplastic drugs (tool III) and evaluated the presence of adverse effects of exposure to antineoplastic drugs (tool IV). Finally, they asked the nurses about the causes of noncompliance to safe handling guidelines (tool V).

**Implementation**

After the initial assessment, the nurses were divided into small groups (n = 6–8 nurses in each group). Each group engaged in a two-day workshop about safe handling of antineoplastic drugs. The researchers explained the training package content in the form of lectures, group discussions, demonstrations and redemonstrations. Educational booklets were provided to the nurses. Each group had the same strategy of teaching. The researchers began each session with general and specific objectives, and at the end of the session, the researchers highlighted the most important points of educational content using a clear and simple language.

An antineoplastic safe handling guidelines booklet was developed to teach the nurses the guidelines about how to safely deal with antineoplastic drugs. This was written in Arabic. The content of the training course was extracted from Joshi (2007); NIOSH (2009); Gilani and Giridharan (2014); Boiano, Steege, and Sweeney (2014); Easty et al. (2015); NIOSH (2016); Elshaer (2017); Oncology Nursing Society (ONS) (2018); Devi and Sharma (2019); and Simegn, Dagnew, and Dagne (2020). This booklet consisted of the definition and exposure routes of antineoplastic drugs, risky behaviors, adverse effects of exposure to antineoplastic drugs, and essential recommendations for safe handling of antineoplastic drugs, including the use of PPE; receiving, preparing, and administering drugs; dealing with spills; unintentional exposure to chemotherapeutic drugs; and disposal of wastes. Furthermore, special consideration was

provided to pregnant nurses and those who needed medical surveillance.

### Evaluation

The nurses' knowledge, practices, and attitudes were re-evaluated at the end of the training course using tools I, II, and III; then, scores were compared between pre and post the administration of the antineoplastic handling guidelines.

### Statistical Analysis:

IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp) was used to analyze data. Description of qualitative data by using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, and standard deviation. Significance of the obtained results was judged at the 5% level. McNemar Test used to analyze the significance between different stages, Paired t-test used for normally distributed quantitative variables, to compare between two periods, and Pearson coefficient used to correlate between two normally distributed quantitative variables.

### Results:

**Table 1** shows that more than two-thirds (77.5%) of the participants were females. More than half of the nurses (55.0%) were in the 25 to < 35 year age group. Regarding marital status, more than two-thirds (72.5%) were married. Half of the nurses (50.0%) graduated from institute of nursing, whereas 25.0% had a bachelor's degree. Regarding years of experience, more than one-third (37.5%) of the nurses had 2 to <3 years, whereas 35.0% had 3 to <5 years. Only one-third of the nurses (32.5%) attended training courses about safe handling of antineoplastic drugs.

A statistically significant difference in the nurses' knowledge was observed between pre and post-program ( $p \leq 0.05$ ) (**Table 2**).

**Table 3** shows a statistically significant difference in the practices of the nurses between pre- and post-program ( $p \leq 0.05$ ).

**Table 4** reveals that the nurses' attitude changed from negative to positive during the post-program period with statistically significant differences in terms of fear of dealing with chemotherapy, psychologically helping patients receiving chemotherapy, and motivation to respond to patient questions ( $p = 0.004, 0.043,$  and  $<0.001$ , respectively).

**Table 5** shows that the nurse's risky behaviors changed from the pre-program period to the post-program period with statistically significant differences in some items, such as expel air from syringe, unsafe handling of contaminated materials, touching tablets with bare hands, poor use of PPE, and reuse of PPE from previous day ( $p \leq 0.05$ ). Additionally, a statistically significant difference in the total score was observed between the pre- and post-program periods ( $p < 0.001^*$ ).

**Figure 1** shows a positive correlation between knowledge and practice during the pre-program period with a statistically significant difference ( $r = 0.582; p < 0.001^*$ ). Furthermore, a positive correlation was observed between the two factors during the post-program period; however, this correlation was not statistically significant ( $r = 0.297; p = 0.063$ ).

In **Figure 2**, the risk of exposure to antineoplastic drugs was 87.5%, and the percentage of nurses who perform regular checkups was 27.5%. Dizziness, headache, and flushed face were the most frequent adverse effects that the nurses experienced (90%, 82.5%, and 67.5%, respectively). Moreover, 57.5%, 50%, 45%, and 35% of the nurses experienced influenza, nausea, difficult breathing, and hair loss, respectively. Meanwhile, the less frequent adverse effects were bleeding or nasal discharge, abortion, and early birth (5%, 5%, and 2.5%, respectively). Congenital anomalies were not observed in this study.

**Figure 3** reveals an inverse correlation between adverse effects and knowledge ( $r = -0.352$ ) with a statistically significant difference ( $p = 0.026$ ). Furthermore, an inverse correlation was observed between adverse effects and practice ( $r = -0.263$ ) without a statistically significant difference ( $p = 0.102$ ) during the pre-program period.

**Table 6** shows the causes of noncompliance; more than two-thirds (80%) of the nurses were unaware of the safety measures when handling antineoplastic drugs. More than two-thirds were noncompliant to the guidelines because of the unavailability of masks, gowns, and eye protection (72.5%, 82.5%, and 82.5%, respectively). Furthermore, 95% and 60% of the nurses were noncompliant because of increased number of patients and the unavailability of a procedure book in the work area, respectively.

**Table (1):** Distribution of the nurses under study according to demographic data (n = 40).

Demographic data	No.	%
<b>Gender</b>		
Female	31	77.5
Male	9	22.5
<b>Age (years)</b>		
18 to <25	5	12.5
25 to <35	22	55.0
35 to <45	10	25.0
≥45	3	7.5
<b>Marital status</b>		
Single	9	22.5
Married	29	72.5
Divorced	2	5.0
<b>Education</b>		
Nursing diploma	9	22.5
Nursing institute	20	50.0
Bachelor of nursing	10	25.0
Others "master degree"	1	2.5
<b>Experience</b>		
<2 years	4	10.0
2 to <3 years	15	37.5
3 to <5 years	14	35.0
≥5	7	17.5
attended courses about safe handling of antineoplastic drugs		
Yes	13	32.5
No	27	67.5

**Table (2):** Comparison between pre- and post-program according to the nurses' knowledge (n = 40).

	Pre	Post	Test of sig.	p
<b>1. Chemotherapy exposure</b>				
<b>Total score</b>				
Range	0.0–3.0	1.0–3.0	t = 2.831*	0.007*
Mean ± SD	2.30 ± 0.69	2.68 ± 0.53		
<b>2. Exposure routes</b>				
<b>Total score</b>				
Range	0.0–7.0	4.0–8.0	t = 9.517*	<0.001*
Mean ± SD	3.73 ± 1.60	6.60 ± 1.08		
<b>3. Safe handling</b>				
<b>A. PPE</b>				
<b>Total score</b>				
Range	1.0–4.0	1.0–4.0	t = 10.334*	<0.001*
Mean ± SD	1.80 ± 0.79	3.33 ± 0.80		
<b>B. Handling of chemotherapy</b>				
<b>Total score</b>				
Range	0.0–3.0	1.0–3.0	t = 8.107*	<0.001*
Mean ± SD.	1.10 ± 0.87	2.55 ± 0.68		
<b>C. Cleaning of spills</b>				
<b>Total score</b>				
Range	0.0–7.0	3.0–8.0	t = 9.563*	<0.001*
Mean ± SD.	2.95 ± 1.87	6.48 ± 1.24		
<b>Over all knowledge</b>				
<b>Total score</b>				
Range	2.0–12.0	9.0–15.0	t = 13.802*	<0.001*
Mean ± SD	5.85 ± 2.48	12.35 ± 1.58		

McN, McNemar test; t, paired t-test.

p: p-value for comparing between pre-and post-program.

\*: statistically significant at  $p \leq 0.05$ .

**Table (3):** Comparison between pre- and post-program according to the nurses' practices (n = 40).

	Pre	Post	Test of sig.	p
<b>1. Practice in receiving and storage</b>				
<b>Total score</b>				
Range	0.0–4.0	2.0–6.0	t = 8.587*	<0.001*
Mean ± SD	2.05 ± 0.99	3.93 ± 1.12		
<b>2. Preparation and compounding of antineoplastic drugs</b>				
<b>Total score</b>				
Range	1.0–5.0	4.0–7.0	t = 11.003*	<0.001*
Mean ± SD	3.30 ± 0.99	5.73 ± 0.91		
<b>3. Cleaning of the preparation area and spills</b>				
<b>Total score</b>				
Range	0.0–4.0	2.0–5.0	t = 9.721*	<0.001*
Mean ± SD	2.05 ± 0.81	3.95 ± 0.99		
<b>4. Administration:</b>				
<b>Total score</b>				
Range	2.0–7.0	2.0–8.0	t = 6.024*	<0.001*
Mean ± SD	4.58 ± 1.13	6.10 ± 1.39		
<b>5. Post-administration and disposal of antineoplastic drugs:</b>				
<b>Total score</b>				
Range	0.0–8.0	0.0–8.0	t = 5.073*	<0.001*
Mean ± SD	3.98 ± 1.66	5.78 ± 1.54		
<b>Overall practice</b>				
<b>Total score</b>				
Range	11.0–23.0	19.0–30.0	t = 19.249*	<0.001*
Mean ± SD	15.95 ± 2.54	25.48 ± 2.59		

McN: McNemar test

t: Paired t-test

p: p-value for comparing between pre and post \* : Statistically significant at  $p \leq 0.05$ **Table (4):** Comparison between pre- and post-program according to the nurses' attitude (n = 40)

Q	Attitude	Pre				Post				McN <sub>p</sub>
		Negative		Positive		Negative		Positive		
		No.	%	No.	%	No.	%	No.	%	
1	I believe that safe handling principles of chemotherapy must be educated to all undergraduate nurses	6	15.0	34	85.0	1	2.5	39	97.5	0.125
2	I know that chemotherapy drugs could lead to an adverse effect in nurses	8	20.0	32	80.0	4	10.0	36	90.0	0.344
3	Working in chemotherapy wards is safe if all precautions are taken	18	45.0	22	55.0	9	22.5	31	77.5	0.078
4	I am afraid of dealing with side effects of chemotherapy	29	72.5	11	27.5	16	40.0	24	60.0	0.004*
5	I cannot help patients receiving chemotherapy to reduce their psychological distress	24	60.0	16	40.0	13	32.5	27	67.5	0.043*
6	I have enough time and motivation to respond to patient questions about chemotherapy	26	65.0	14	35.0	5	12.5	35	87.5	<0.001*
	Total score	3.23 ± 1.31				4.80 ± 0.79				t = 5.684*
	Mean ± SD									p < 0.001*

McN, McNemar test; t, paired t-test.

p-value for comparing between pre- and post-program \* statistically significant at  $p \leq 0.05$ .

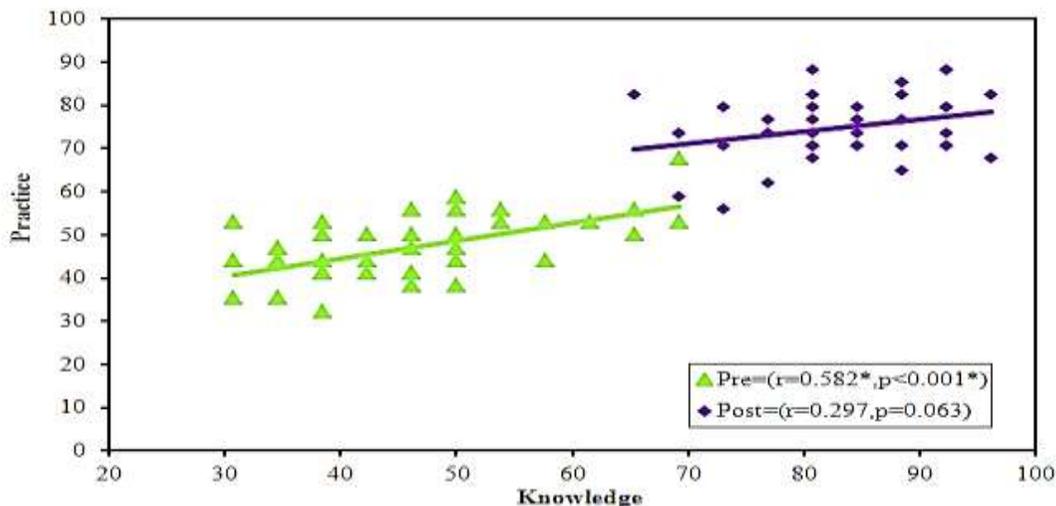
**Table (5):** Distribution of the nurses under study according to the prevalence of risky behaviors in the pre- and post-program periods (n = 40).

Q	Risky behaviors	Pre				Post				McN <sub>p</sub>
		Not present		Present		Not present		Present		
		No.	%	No.	%	No.	%	No.	%	
1	Eating food in drug handling areas	36	90.0	4	10.0	39	97.5	1	2.5	0.375
2	Use of improper place for preparing and handling of antineoplastic drugs.	36	90.0	4	10.0	34	85.0	6	15.0	0.754
3	Expelling air from syringes filled with drugs.	17	42.5	23	57.5	34	85.0	6	15.0	<0.001*
4	Needle-stick injuries.	26	65.0	14	35.0	34	85.0	6	15.0	0.077
5	Unsafe handling of contaminated material and unsafe cleaning of spills.	8	20.0	32	80.0	23	57.5	17	42.5	0.001*
6	Touching antineoplastic tablets with bare hands.	7	17.5	33	82.5	22	55.0	18	45.0	0.004*
7	There was poor use of PPE.	7	17.5	33	82.5	22	55.0	18	45.0	0.001*
8	Reuse of PPE from previous day.	11	27.5	29	72.5	33	82.5	7	17.5	<0.001*
9	Smoking at areas of drug administration.	37	92.5	3	7.5	40	100.0	0	0.0	0.250
10	Doing make up at areas of drug administration.	37	92.5	3	7.5	39	97.5	1	2.5	0.625
Total score Mean ± SD		4.45 ± 1.36				2.00 ± 1.50				t = 7.701 <sup>‡</sup> p < 0.001*

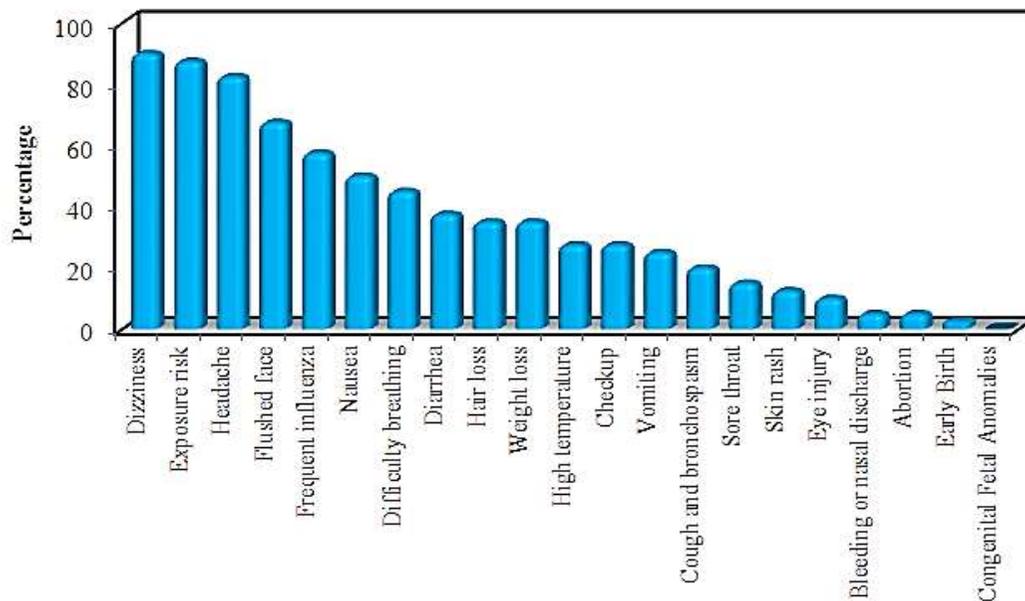
McN, McNemar test; t, paired t-test.

p: p-value for comparing between pre- and post-program.

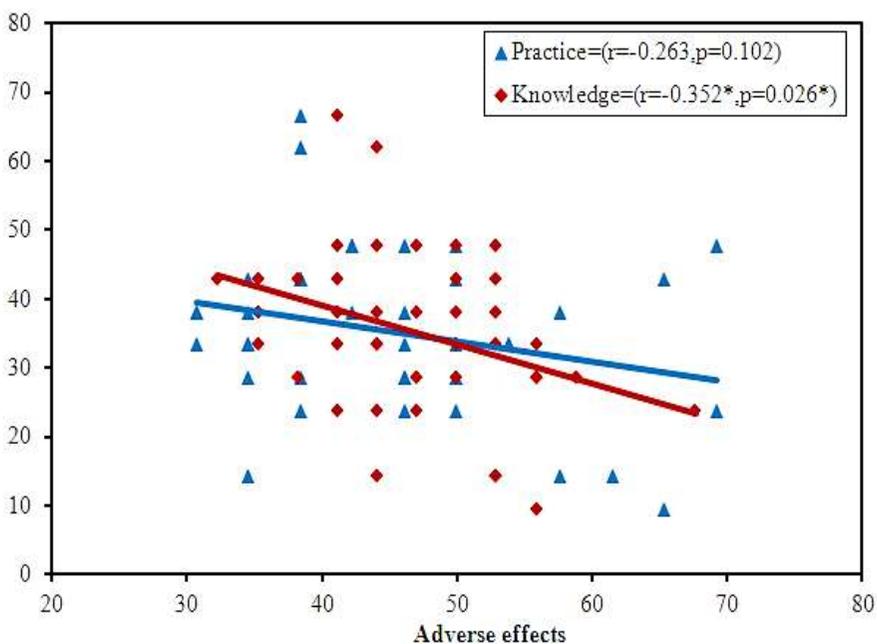
\*: statistically significant at p ≤ 0.05.



**Figure (1):** Correlation between the nurses’ knowledge and practices in the pre- and post-program periods (n = 40).



**Figure (2):** Distribution of the nurses under study according to the prevalence of adverse effects during the pre-program period (n = 40).



**Figure (3):** Correlation between the nurses' knowledge and practices in terms of adverse effects in the pre-program period (n = 40).

**Table (6):** The nurses' opinion about the causes of noncompliance to guidelines for safe handling of antineoplastic drugs (n = 40).

Q	Causes	No		Yes	
		No.	%	No.	%
1	<b>Safe handling awareness of antineoplastic drugs:</b>				
	Unaware of the safety measures when handling antineoplastic drugs.	8	20.0	32	80.0
	Inadequate in-service training and education.	15	37.5	25	62.5
2	<b>Adequacy of equipment</b>				
	Nurses were not encouraged for compliance with wearing the personal protective equipment.	21	52.5	19	47.5
	Unavailability of masks.	11	27.5	29	72.5
	Unavailability of gowns.	7	17.5	33	82.5
	Unavailability of eye protective.	7	17.5	33	82.5
3	<b>Working environment</b>				
	Unavailability of gloves.	18	45.0	22	55.0
	Unavailability of safe boxes for drug transportation.	40	100	0	0.0
3	Availability of only one safety cabinet for drug preparation in the cancer center.	0	0.0	40	100.0
	No cooperation among the health team members.	26	65.0	14	35.0
4	<b>Workload</b>				
	Limited time to wear PPE.	13	32.5	27	67.5
	Heavy work load.	7	17.5	33	82.5
	Wearing the protective equipment is uncomfortable and hinders work.	2	5.0	38	95.0
	Increasing numbers of patients.	2	5.0	38	95.0
5	<b>Administrative</b>				
	The nurses are responsible for preparation and administration of antineoplastic drugs for many patients daily.	9	22.5	31	77.5
5	Lack of supervisors monitoring.	18	45.0	22	55.0
	Unavailability of a procedure and policy book in the work area.	16	40.0	24	60.0
	The protection of nurses from exposure to hazards effect of antineoplastic drugs is not a priority for the administration.	10	25.0	30	75.0

## Discussion

This study revealed that more than two-thirds of the nurses were female and half of them graduated from the institute of nursing. These results are supported by Zakaria, Alaa, and Desoky (2022). This may be due to the increased number of female nurses compared with male nurses worldwide, not only in Egypt.

Moreover, approximately one-third of the nurses had 2 to <3 years of experience. This finding agrees with those of Simegn, Dagne, Dagne, and Weldegerima (2021). Meanwhile, this finding disagrees with those of Koulounti, Roup, Charalambous, and Noula, (2019), who found that more than half of the sample had up to five years of experience, and Abdullah and Rasheed (2018), who reported that most nurses had experience ranging from 1 to 5 years at the oncology unit. This result may be due to the young age of the nurses as more than half of them were in the 25 to <35 year age group.

Furthermore, nurses refused to work for a long period in this unit to decrease adverse effects.

Only one-third of the nurses attended training courses about safe handling of antineoplastic drugs, and the other two-thirds did not receive any training courses. This result agrees with the findings of Karius and Colvin (2021). However, this result disagrees with the findings of Orujlu et al. (2016), who found that most nurses received training for safe handling of chemotherapeutic drugs in their workplace. This finding may be due to the high workload, the lack of time of nurses, inadequate in-service training, and the lack of motivation for training, as the study findings illustrated in Table 6.

This study clarified that there was a statistically significant difference between pre- and post-program in terms of knowledge of nurses and satisfactory improvement. This finding is supported by Abd El-Salaheen et al.

(2022). Furthermore, a statistically significant difference was observed between pre- and post-program practices of the nurses. This finding agrees with those of Nouri, Javadi, Iranijam, & Aghamohammadi, (2021), but disagrees with those of Zakaria, Alaa, and Desoky (2022), who found that the practice of safe administration of intravenous chemotherapeutic agents among oncology nurses was unsatisfactory. This result may be because of the effectiveness of the training package in enhancing the nurses' knowledge and practices. Furthermore, the nurses tended to gain knowledge and improve their performance in safe handling of antineoplastic drugs to protect themselves.

This study revealed that the nurses' attitude changed from negative to positive during the post-program period. This finding is supported by Zayed et al. (2019), who found improvement in nurses' attitude toward safe handling of antineoplastic drugs after the training program. However, this was contradicted with the findings of Simegn, Dagne, Dagne, and Weldegerima, (2021), who found that several healthcare workers did not have a desirable attitude toward handling antineoplastic drugs. This result may be due to increasing knowledge and awareness regarding safe handling of antineoplastic drugs and workplace safety, which is a better way for enhancing the attitude of health professionals.

The nurse's implementation of risky behaviors changed from the pre-program period to the post-program period with a statistically significant difference in the total score. This result may be because of the improvement in their knowledge regarding safe handling of antineoplastic drugs after the implementation of the program, which helped in changing the risky behavior.

There was a correlation between the nurses' knowledge and practices in the pre-and post-program periods. This result agrees with the findings of Asefa, Aga, Dinegde, and Demie (2021) and Mansour (2019), who found that nurses who have scored higher knowledge points were more likely to practice safe handling of antineoplastic drugs. However, this contradicts the findings of Esmail, Qadir,

Mahmood, Osman, and Omar, (2016), who found a significant negative association between oncology nurses' knowledge and practices. This result may be due to the nurses' assimilation of the training package content and the tendency to follow the best recommended practices. However, this level needs frequent monitoring to ensure compliance with safe handling guidelines.

The results of this study clarified that nurses exposed to antineoplastic drugs during the pre-program period experience adverse effects. The most frequent adverse effects that nurses experienced were dizziness, headache, and flushed face. This result is supported by Alehashem & Baniyadi (2018) b. This may be due to the absence of an in-service education program, heavy work load, and ineffective PPE usage, as shown in Table 6, which forced the researchers to implement the training program.

Furthermore, this study revealed an inverse correlation between adverse effects and nurses' knowledge and practices during the pre-program period. Thus, the prevalence of adverse effects increased when the nurses' knowledge and practices decreased. This result is supported by Mansour (2019), who found that when nurses' knowledge and practices increased, the adverse effects decreased. This proves the importance of developing and implementing training programs regarding the safe handling of antineoplastic drugs to increase and improve the nurses' knowledge and practices, which in turn decreases the adverse effects of these drugs.

### **Conclusion and recommendations**

Nurses' performance enhanced post the administration of the antineoplastic handling guidelines compared with that pre the program. Because working in the medical or nursing field requires continuous education to update knowledge and practices and decrease adverse effect, we recommend providing continuous training and monitoring of nurses. Moreover, compliance with the updated guidelines for handling of antineoplastic drugs is needed.

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