

## **EFFECT OF A DESIGNED TEACHING PROGRAM ON SAFE HANDLING OF CHEMO-THERAPY AMONG NURSES IN A SELECTED ONCOLOGY SETTING CAIRO-EGYPT**

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### **ABSTRACT**

#### **Background**

Handling chemotherapy drugs by nurses put them at a great risk due to the occupational exposure consequences. Although the published recommendations by international health organizations; nurses' use of these recommendations is not universal and exposure risks are still abundant. Lack of information may prevent many nurses from taking appropriate precautions for themselves. The aim of this study was to evaluate the effect of a designed teaching program on safe handling of chemotherapy.

#### **Methods**

An interrupted time series quasi experimental (pre-post test) design was used on a convenient sample of 30 nurses in a selected oncology setting in Cairo-Egypt. Self-administered questionnaire, knowledge pre-post test and observational performance checklists were used to collect data related to study variables. A Pre-program assessment was done to determine the baseline level of nurses' knowledge and performance. Post-program reassessment was done twice; one week immediately after program implementation and three-month later.

#### **Results**

high statistical significant differences regarding nurses' knowledge and performance mean scores were found between the pre-test, immediate post-test and three-month post-test with a t value of (32.39, 31.78, 5.63 for knowledge, &14.89, 11.69, and 8.27 for performance) respectively, at P = 0.000.

#### **Conclusions**

A relative improvement in nurses' knowledge and performance was found after implementation of the teaching program and manifested by a steady increase in the post-test mean scores which supported the study hypotheses.

## Recommendations

Continuing education, training and regular performance appraisal of nurses in oncology settings are strongly recommended to reduce the unintentional chemotherapy occupational exposure. Further studies are recommended to explore different factors that may affect nurses' compliance with safe handling of chemotherapy drugs in oncology settings.

**KEYWORDS:** Safe Handling-Oncology Nurses-Chemotherapy Drugs-Occupational Exposure Standards and Guidelines

## INTRODUCTION

Chemotherapy drugs (CDs) are the most widespread worldwide modality used in cancer treatment, and other autoimmune diseases. They are known as antineoplastics, cytotoxics, or anticancer drugs/agents which work by interrupting the cell cycle and killing cells that are rapidly dividing (cancer cells). More than 100 different CDs are currently available till date. This prevalent use has led to concerns about the hazards that they can cause among healthcare workers especially nurses involved in their handling (National Institute for Occupational Safety and Health, 2013; Rajakumari, & Soli, 2016).

Exposure to CDs is associated with many adverse outcomes for occupationally exposed healthcare workers. These outcomes depend on the number, type and frequency of handling of CDs they are dealing with, and the route of exposure to these drugs (Lawson, et al., 2012). Occupational exposure to CDs can cause both acute and chronic health effects such as skin rashes, adverse reproductive outcomes (including infertility, spontaneous abortions, and congenital malformations), possibly leukemia and other cancers. Healthcare workers can be protected from exposures to hazardous drugs (chemotherapy) through engineering and administrative controls, and proper protective equipment (Alexander et al., 2014, Boiano, et al., 2015; Dal Bello et al., 2015; Friese, et al., 2012).

Unintentional occupational exposure to CDs occurs through a variety of routes, including direct exposure to the skin and mucous membranes through spills and splashes; that are usually occur during preparation and administration of CDs (Polovich, et al., 2011). The other route is the indirect contact via contaminated surfaces or bodily fluids, needle stick injury. Inadvertent ingestion may be an additional route of exposure; when food or beverages are prepared, stored, or consumed in work areas, they may easily become contaminated with airborne particles of cytotoxic drugs or by contact with contaminated hands (Pan American Health Organization & World Health Organization, 2013).

Oncology nurses who are handling CDs usually working on protecting their patients from the undesired effects of the CDs. Nurses are experiencing the same side-effects of the CDs, but with no therapeutic benefits. Therefore, they are among the main groups of healthcare workers that are exposed to these drugs in oncology settings (Callahan, et al., 2016). Unfortunately, most of oncology nurses may not fully comprehend or realize their own health risks while handling CDs in the oncology setting (Waheida, et al., 2015).

The main purpose of the recommended guidelines is to reduce occupational exposures to CDs as stated by The Centre for Disease Control and Prevention (CDC) in the NIOSH Engineering Controls Program Portfolio that describes the Hierarchy of Controls used to implement feasible and effective controls (National Institute for Occupational Safety and Health, 2013). The hierarchy includes elimination, substitution, engineering controls (use of biological safety cabinets, needleless system ...etc); administrative controls (policies and procedures and education/in-service training) and the use of

personal protective equipment (gloves, gowns, respirator mask... etc) (Easty, et al., 2015).

Knowledge is significant to safe nursing practice in all healthcare settings, but it is especially critical when a knowledge deficit on the part of the nurse violates practice and threatens personal or patients' safety. Past research suggests that CDs may have unintentionally compromised the oncology work setting for more than thirty years. Many oncology nurses may not fully understand or appreciate their own health risks when handling CDs in the oncology setting (Hazen, et al., 2010).

Raising nurses' awareness towards the significant health hazards due to CDs exposure is an important aspect to improve safe handling, and reduce exposure consequences. This can be accomplished through a continuous in-service training based on accurate assessment of nurses' needs and regular performance appraisal as well as exploring the workplace facilities and resources (Ashley, et al., 2011).

The Oncology Nursing Society assumes that in order to provide quality care and maintain safety standards, nurses should be competent in the oncology nursing knowledge, skills and able to value the magnitude of risks in their workplace. A lack of education and the inconvenience of facilities and resources may prevent nurses from taking appropriate precautions for themselves (Ahmadi, et al., 2015; Polovich & Clark, 2012).

## **SIGNIFICANCE OF THE STUDY**

According to the National Cancer Registry Program (NCRP) (2014), it is estimated that there will be a 3-fold increase in the incidence of cancer by 2050 relative to 2013, which designates a significant disease burden; and a tremendous increase in the oncology nurse-to-patient ratio, and workload. In turn, this will have a negative impact on nurses' performance (Ibrahim, et al., 2014). More than 50% of patients diagnosed with cancer are treated with chemotherapeutic drugs (American Society of Clinical Oncology, 2013).

In the oncology setting where handling of CDs is a main nursing task, this exposes nurses to health risks and hazardous effects while preparing, transferring, administering, cleaning up spills, handling patients' excretions and disposing of wastes (Friese, et al., 2015 ; Nelson, 2011). In an Egyptian research study it was found that 31.4% of oncology nurses handling CDs had abortion vs. 10.3% of a control group, while infertility was 14.3% vs. 3.4% respectively. Urine samples were more mutagenic in the study group than the control (40% vs. 10.3%) (Elshamy, et al., 2010, & Ranter et al., 2010).

Lack of information and awareness of the hazards associated with improper handling of Chemotherapy among nurses in oncology departments, increases the risk of exposure to such hazards which might potentiate the seriousness of the consequences of such problem (Chaudhary & Karn, 2012). Nurses should remain informed of current issues in drug handling safety and establish means of sharing that information with members of the health care team. Health care administrations should provide information to nurses and monitor their practice. Teaching programs with innovative training methods on safe handling of cancer Chemotherapy focusing on knowledge and performance may help to prevent/minimize potential exposure hazards (Polovich & Clark, 2010).

## **MATERIALS AND METHODS**

### **Aim of the Study**

The aim of the present study was to evaluate the effect of a designed teaching program on safe handling of CDs

among oncology nurses in a selected oncology setting.

### **Hypotheses**

To fulfill the aim of this study, the following research hypotheses were formulated

**H1:** The mean post-test knowledge scores of nurses attending the designed teaching program on safe handling of chemotherapy will be significantly higher than their mean pre-test knowledge scores.

**H2:** The mean post-test performance scores of nurses attending the designed teaching program on safe handling of chemotherapy will be significantly higher than their mean pre-test performance scores.

### **Design**

One group Quazi-Experimental interrupted time series design was used to achieve the aim of the current study. In the current study, this design helped to determine the existing level of knowledge and performance of nurses regarding safe handling of chemotherapy before conducting the designed teaching program, and evaluate the effect that occurred after.

### **Setting**

The study was conducted in an Oncology and Nuclear Medicine Department at a University Hospital in Cairo-Egypt. The department consists of five floors plus basement.

### **Sample**

A convenient sample of 30 nurses who are working in an oncology and nuclear medicine department at a university hospital in Cairo-Egypt was selected as a study sample. Those who provide direct patient care were included. Nurses with a working experience less than one year and in administrative position were excluded from the study.

### **Tools**

Two data collection tools were used to collect data pertinent to the study variables. Tools were developed by the researcher guided by an extensive literature review and a panel of seven reviewers and experts in medical surgical nursing and oncology medicine. Modification of the tools was made based on feedback. The study tools consisted of:

#### **Self-Administered Questionnaire Sheet**

It covered three sections: **a)** Socio-demographic variables related to the study subjects such as: nurses' age, gender, marital status, educational qualification and years of experience in oncology field. **b)** Workplace related variables such as: previous training courses regarding safe handling chemotherapy, history of exposure during work ...etc. **c)** Nurses' knowledge about safe handling of chemotherapy (pre-post test) that covered a set of (40) multiple choice questions related to chemotherapy overview, hazardous effect, and modes of exposures (10), safety measures during handling of chemotherapy preparation (10), storage, and transferring (5) administration (10), and disposing of chemotherapy (5).

### **Scoring System**

A score of one was given for each correct answer, and zero for the incorrect or missed answer. The total scores were recorded in percentage format. Satisfactory knowledge was counted from 80%-100% and unsatisfactory from below 80%.

### Nurses' Performance Observation Checklist Regarding Safe Handling of Chemotherapy

It was developed to collect observed data related to: **a)** Chemotherapy Preparation phase that included: cleaning and disinfecting the anterior surface of BSC, preparing Personal Protective Equipment (PPE), preparation of chemotherapy in (vials, ampoules, and admixture in IV solutions) ...etc. **b)** Chemotherapy Administration phase that included: double checking doctor's order, washing hands, inspecting CDs in the transport device, checking patency of the IV access device ...etc. **c)** Chemotherapy Waste Disposal that included: Discarding all materials that have come into contact with CDs in the labeled waste bin, placing non-breakable contaminated materials in sealed labeled plastic bags, removing and discard PPE ...etc.

### Scoring System

Nurses' performance regarding safe handling of chemotherapy was quantified as percentage [the denominator (expected) is the total number of standards practice throughout the phases of preparation, administration, and disposing; and the nominator is the actual (observed) nurses' practice that was performed correctly. The correct performance of each step was given a score of 1, and zero for the incorrect step or not done (according to CDC & NIOSH standards 2015), getting 80% and more was considered accepted (satisfactory) while below 80% was considered not accepted (unsatisfactory).

### Tools Validity and Reliability

Study tools were designed by the researcher after extensive literature review and submitted to a panel of seven reviewers and experts in medical surgical nursing and Oncology and Nuclear Medicine Department. Each one of the experts on the panel was asked to examine the instrument for content coverage, clarity, wording, length, format, and overall appearance. Modifications of tools were done according to panel judgment. Reliability of the tools were tested using Cronbach's Alpha which showed satisfactory level of reliability for the pre-post test, and nurses performance tools represented (0.759, and 0.846) respectively.

### Procedure

The study was conducted through the following phases:

- **Assessment Phase.** In which specific needs/problems (knowledge & performance/dependent variable) related to safe handling of CDs among the target population were identified, as well as an assessment of the environmental facilities was done, and extensive literature review was carried out to explore different aspects of the research area and problem.
- **Planning Phase.** Through which the study design, sample size, inclusion and exclusion criteria, tools for data collection were selected and developed. Face and content validity of the study tools were tested by a panel of experts in the field of medical surgical nursing and oncology medicine. Developing a preliminary draft of the designed teaching program was done.
- **Implementation Phase.** In which a pilot study, pre-program assessment of nurses' knowledge and performance baseline profile, and implementing the designed teaching program were conducted. The pre-program assessment included assessment of the socio demographic variables of the study sample and work related variables as well as

the institutional facilities were done using the self-administered questionnaire. Pre-program nurses' knowledge and skills related to safe handling of CDs were assessed prior to program implementation through pre-test and observational checklists.

- The study sample was divided into five subgroups equally, and randomly. The teaching program was implemented on ten sessions (covering both knowledge and related skills) for each subgroup separately. The estimated time for each session was 30 minutes approximately; the total time required for the whole program was 25 hours distributed over 50 days, (three days/week). The designed teaching program was implemented through seminars, group discussion and demonstration/re-demonstration using audiovisual aids such as booklet, video films, and power point presentations.
- **Evaluation Phase.** Within one week after the completion of the implemented teaching program, reassessment of nurses' knowledge and performance was done; and again after three-month later using the same study tools (except the socio-demographic and work related variables data sheet).

### Statistical Analysis

The Statistical Package for Social Sciences (SPSS ver. 19) was used for data analysis. Descriptive statistics for some data such as gender, age, educational qualification... etc were computed using frequencies, percentages, mean and standard deviation. For numerical data such as nurses' knowledge and performance scores; mean and standard deviation was generated. Comparison of the oncology nurses' knowledge and performance scores were done using ANOVA and paired t-test to compare the means "before and after" implementation of the designed teaching program, and to determine any significant differences between variables. Pearson correlation "r" was used to determine the relationship between the nurses' knowledge and performance mean scores.

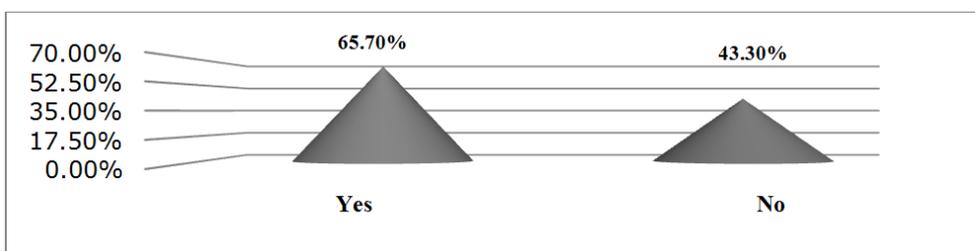
## RESULTS

**Table 1: Frequency and Percentage Distribution of Socio-Demographic Characteristics of Oncology Nurses (n=30)**

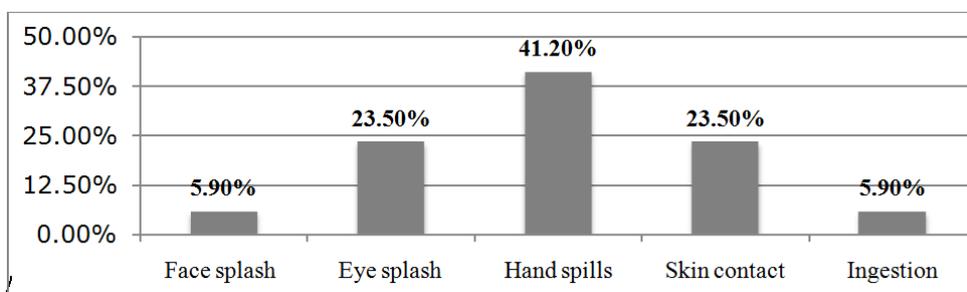
Socio-demographic Characteristics	No.	%
<b>Age Group (yrs.)</b>		
30-	19	63.3%
40-	9	30%
50 years and above	2	6.7%
Mean $\pm$ SD	39.83 $\pm$ 5.36	
<b>Gender</b>		
Male	0	0%
Female	30	100%
<b>Marital Status</b>		
Single	3	10%
Married	27	90%
<b>Education Qualification</b>		
Secondary School Nursing Diploma	21	70%
Technical Institute Nursing Diploma	5	16.7%
Bachelor degree in Nursing	4	13.3%

**Table 2: Frequency and Percentage Distribution of Work Experience of Oncology Nurses (n=30)**

Variables Related to Work Experience	No.	%
<b>Nurses' Work Experience in Oncology field</b>		
10 –	16	53.3%
20 –	12	40%
30 years and above	2	6.7%
Mean ± SD	20.7 ± 5.32	
<b>Previous In-service Training</b>		
Yes	7	23.3%
No	23	76.7%
<b>Nurse to Patient Ratio/Shift</b>		
One to seven	7	23.3%
One to eight	5	16.7%
One to nine	4	13.3%
One to ten	9	30%
One to eleven	3	10%
One to twelve	2	6.7%
Mean ± SD	9.07±1.57	



**Figure 1: Percentage Distribution of Oncology Nurses' Exposure to Chemotherapy Drugs**



**Figure 2: Percentage Distribution of Modes of Occupational Exposure to Chemotherapy Drugs**

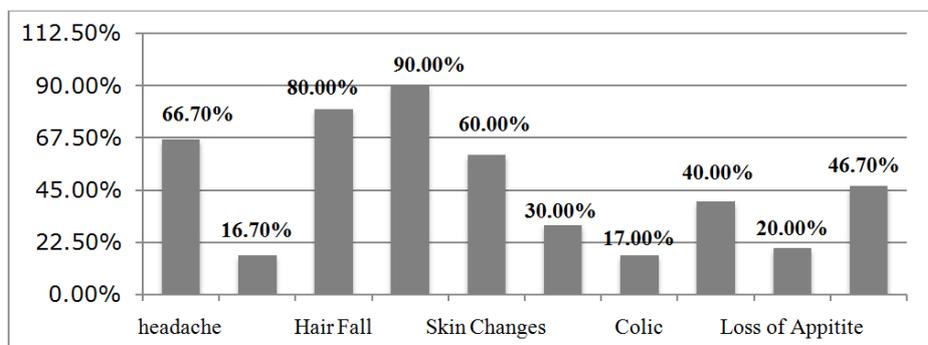


Figure 3: Percentage Distribution of Oncology Nurses' Symptoms Due to Chemotherapy Drugs Exposure (n=30)

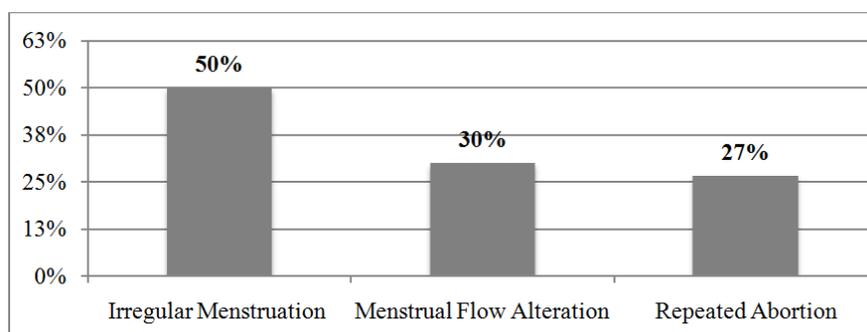


Figure 4 Percentage Distributions of Female Oncology Nurses' Reproductive Symptoms Due to Chemotherapy Drugs Exposure (n=30)

Table 3: Mean Scores and Standard Deviation of Oncology Nurses' Knowledge Regarding Safe Handling of Chemotherapy Drugs (n=30)

Nurses' Knowledge	Pre-Test	Post-Test	Three-Month Post-Test
	Mean ± SD	Mean ± SD	Mean ± SD
Overview	69.33 ± 14.84	81.67 ± 9.49	72.67 ± 11.42
Preparation	50.67 ± 16.59	80 ± 9.47	71 ± 10.29
Storage and Transferring	30.67 ± 17.21	72 ± 20.74	63.33 ± 14.93
Administration	41.33 ± 13.58	72. ± 15.84	67.67 ± 13.31
Disposing	56 ± 24.86	70 ± 19.48	68 ± 19.37
<b>Total</b>	<b>51.99 ± 10.58</b>	<b>76.67 ± 7.02</b>	<b>69.58 ± 6.47</b>

\* Satisfactory level 80% – 100% and Unsatisfactory level from 0 - < 80%

Table 4: Mean Scores and Standard Deviation of Oncology Nurses' Performance Level Regarding Safe Handling of Chemotherapy Drugs (n=30)

Nurses' Performance	Pre-Test	Post-Test	Three-month Post-Test	Level of Performance
	Mean ± SD			
Preparation	23.14 ± 3.31	51.95 ± 4.14	34.07 ± 2.69	Unsatisfactory
Administration	32.67 ± 6.39	44 ± 8.14	41.33 ± 8.99	Unsatisfactory
Disposing	46.68 ± 51.14	63.65 ± 8.05	59.49 ± 10.66	Unsatisfactory
<b>Total</b>	<b>28.04 ± 3.54</b>	<b>51.87 ± 4.08</b>	<b>49.87 ± 3.33</b>	<b>Unsatisfactory</b>

\* Satisfactory level 80% – 100% and Unsatisfactory level from 0 - < 80%

Table 5: Paired t-Test and ANOV/F Test Comparing Oncology Nurses' Total Knowledge and Performance Scores Regarding Safe Handling of Chemotherapy Drugs. Pre-Test, Post-Test, and Three-month Post-Test (n=30)

Assessment Time	Knowledge			Performance		
	Mean ± SD	t-Value	p-Value	Mean ± SD	t-Value	p-Value
Pre- Test	51.99 ± 10.58	14.99*	0.000	28.04 ± 3.54	32.39*	0.000
Post-Test	76.67 ± 7.02			51.87 ± 4.08		
Pre- Test	51.99 ± 10.58	11.69*	0.000	28.04 ± 3.54	31.78*	0.000
Three-month Post-Test	69.58 ± 6.47			49.87 ± 3.33		
Post- Test	76.67 ± 7.02	8.27*	0.000	51.87 ± 4.08	5.36*	0.000
Three-month Post-Test	69.58 ± 6.47			49.87 ± 3.33		
ANOVA/F	136.58*			168.63*		

\* The result Significant at  $p \leq 0.05$  probability level

## DISCUSSIONS

As shown in table (1), all the nurses were females with a mean age of  $39.83 \pm 5.36$  years old. The majority of them were married. In Egypt, nursing is a female occupation; this gives a reason why the entire study sample was female. It is worth mentioning that the total number of nurses in Egypt is 161.949 nurses; (96%) are female, while only (4%) are males (Egyptian Nursing Syndicate, 2012).

Regarding the education qualification of the study sample, the same table represented that more than two thirds had secondary school nursing diploma. This finding is consistent with many Egyptian studies, such as Mohamed (2015); and Mohsen, and Fareed (2013), who reported that more than two thirds of their study sample under the study were diploma nurses. In addition Elshamy, El-Hadidi, El-Roby and Fouda (2010), mentioned that the majority of the study sample in their study had a diploma degree. In Egypt diploma nurses are 139.249 (86%) nurses of the total nursing manpower that is why the majority of the study sample were diploma nurses (Egyptian Nursing Syndicate Report, 2012).

As can be seen in table (2), more than half of the oncology nurses had experience ranged from ten to twenty years as an oncology nurse, the majority of nurses reported that they didn't receive any type of in-service training courses regarding safe handling of CDs. Oncology nurses are responsible for providing care for patients receiving CDs; they should have enough experience in the oncology field. Developing nursing competencies related to oncology field needs time and training to be well established. So et al., (2016) reported that oncology nurses in low and middle-income countries don't have the chance to undertake in-service training to enrich their knowledge and skills in the oncology nursing field due to high workload, lack of time and unavailability of those programs.

Al-Attar, and Al-Gannem, (2015); Shahrabi, et.al., (2014); Mohsen, and Fareed (2013), as well as Shokier, Shaban, Gadiry, and Seif Elden (2012), reported that most of their studies sample had a work experience in the oncology field and administration of CDs, but there was a lack or almost absence of in-service training regarding safe handling of CDs provided to nurses in the oncology settings.

The findings of previous studies are in agreement with the results of the current study which showed that more than half of the oncology nurses had a work experience ranged from ten to twenty years in the oncology field and administration of CDs. Also, it was found that more than three quarters of the study sample had no previous in-service training related to safe handling of CDs throughout their work experience. Mohamed (2015) added that oncology nurses should mandatory cover certain number of training hours annually, as nursing education and in-service training are the two complementary segments critical to build efficient and competent nursing staff as well as to develop safe and high quality oncology nursing workforce.

In accordance with the results of the present study Kampitsi, Papa, Papadouri, Papageorgiou, Papara, and Katsaragakis (2012) agreed with the findings of their study on oncology nurses' knowledge and practices about safety handling and administration of chemotherapy agents on 199 nurses they found that nurses who attended the educational program regarding safe handling of chemotherapy used to take special precautions measurements while they didn't do before attending the program.

Oncology nursing has unique features, and oncology nurses may suffer from more work-related stressors such as heavy workload compared with nurses in other specialties owing to the worldwide increased cancer incidence and a grow-

ing staff shortage. This makes oncology nurses more vulnerable to work-related stresses and face challenges in their professional life (Yu, et al, 2016). In Egypt the National Cancer Registry Program (NCRP) (2014), expected a three-fold increase in cancer incidence, relative to 2013 which designates a significant disease burden, this will lead to increase in the oncology nurse-to-patient ratio, and workload that in turn will have a negative impact on nurses' performance and even will lead to job burnout (Ibrahim, et al., 2014).

In this study, oncology nurses had a high workload; the nurse-to-patient ratio was ranged from one to seven to one to twelve among the study group table (2). In the same context, Polovich and Clark (2012), in their cross-sectional survey study that was examining factors that promote or interfere with safe handling use of CDs, found that the majority of nurses were providing care for an average of seven patients approximately. Also, Khan, Khowaja, and Ali, (2012) in their study entitled assessment of knowledge, skill and attitude of oncology nurses in chemotherapy administration in tertiary hospital Pakistan, reported that in the same setting, the nurse-to-patient ratio was one to thirty in one unit, while it was only one to eight in the other unite.

The discrepancy between those ratios was explained by the American Society of Clinical Oncology (ASCO) and Oncology Nursing Society (ONS), (2016) which reported that there are currently no available standards for nurse-to-patient ratios in oncology settings, due to discrepancy in oncology settings technology, type of the required patient care, and availability of nurses. Moreover, Polovich and Clark (2010) emphasized that a higher nurse-to-patient ratio in oncology settings was associated with lower use of safe handling precautions of CDs, and consequently put nurses at a great risk of occupational exposure.

The National Institute for Occupational Safety and Health (2008) estimated that the number of workers at risk of hazardous chemotherapy exposure was closer to eight million only in US. This estimate included healthcare workers who are directly or indirectly handling chemotherapy agents (Conner, et al., 2010). Exposure to chemotherapy drugs can occur by various activities as by direct contact when preparing & administering chemotherapy drugs & cleaning chemotherapy spills, inhalation, storage and at the time of doing disposal of chemotherapy waste (Friese et al., 2015, National Institute for Occupational Safety and Health, 2014).

In fact, published studies have shown that workplace exposures to hazardous drugs can cause both acute and chronic health effects such as skin rashes, adverse reproductive outcomes (including infertility, spontaneous abortions, and congenital malformations), and possibly leukemia and other cancers. The health risk depends on how much exposure a healthcare worker has to these drugs and how toxic they are. Healthcare workers can be protected from exposures to hazardous drugs (chemotherapy) through engineering and administrative controls, and proper protective equipment (Alexander et al., 2014; Boiano, et al, 2015; Dal Bello et al., 2015; Friese, et al, 2012).

Exposure through cytotoxic drug spills which commonly occurs during reconstitution and dilution of cytotoxic drugs poses a significant risk to the person handling without adequate protection. Cytotoxic drug spillages can be categorized as small spillages (less than 5ml) and larger spills (more than 5ml). Oncology nurses are more vulnerable due to their frequent handling of CDs, and low adherence to safe handling measures (Friese, et al, 2012).

The current study found that two thirds of the study sample reported direct exposure of CDs figure (1) through direct spill on skin, especially on hands, as well as eyes and face via splashes figure (2). Due to this exposure, figure (3) showed the majority of oncology nurses were suffering from fatigue, and more than three quarters reported hair fall,

headache, while loss of appetite was reported by more than half of them as acute symptoms. Regarding the female reproductive symptoms, the current study revealed that half of the study sample reported irregular menstruation, while one third of them reported alteration in menstrual flow figure (4).

These findings come in consistence with many studies concerning the occupational exposure to CDs and their hazardous effects on healthcare workers. Waheida, Abd-Elgaffar, and Atia (2015), Al-Attar, and Al-Gannem, (2015), Shahrabi, et al. (2014), Momeni, Danaeil and Askarian (2013), and Mohsen, and Fareed (2013) reported that hair loss, headache, skin irritation, fatigue and menstrual irregularity were the most common side effects mentioned by oncology nurses who are actively handling CDs.

In addition, Kyperianous, Kapsou, Raftopoulos, and Soteriades (2010) in their cross-sectional survey to evaluate the knowledge, attitudes and safe behaviors of handling cytotoxic drugs reported that more than one third of the study sample were suffering from several symptoms that were getting worse during working hours such as headache, skin problems, menstrual alteration and abortions; they added that more than half of those who reported abortion, mentioned that abortion occurred during the time they were handling cytotoxic drugs. Other symptoms were added by ElShamy, El-Hadidi, El-Roby and Fouda (2010) such as infertility and sub-fertility, premature labor, congenital anomalies, low birth weight, fetal loss, developmental and behavioral abnormalities which had about ten-fold increase after CDs exposure in the control group.

In an attempt to explain how the direct exposure to chemotherapy occurred, Friese, Siefert, Frost, Walker, & Ponte, (2016) stated that unsuitable workplace environment are associated with several adverse outcomes such as increased unintentional nurses' exposure to CDs. Moreover, some recent studies investigated the oncology nurses working conditions that might lead to direct contact with CDs such as Waheida, Abd-Elgaffar and Atia, (2015) who illustrated that oncology nurses are responsible for certain risky clinical activities while caring for patients receiving CDs such as using sharps during preparation and administration, as well as handling contaminated patients' clothes and linens.

Also, Rioufol, Ranchon, Schwiertz, Vantard, Joue, Gourc, and Favier; and NIOSH (2014) emphasized that handling injectable CDs that requires cutting, crushing, handling sharps during preparation and administration through Cannulation and changing IV lines are the most risky clinical activities performed by the oncology nurses. In the same line was the study done by Chaudhary and Karn (2012) who reported that the majority of direct CDs exposures occurred during changing IV lines and/or cannula, followed by one third that occurred during changing the bed sheets. An increasing number of nurses' exposure to chemotherapy will increase the opportunity for hazardous health effects consequently (Polovich & Calrk, 2010).

Unfortunately, there was little previous research investigating the patterns of CDs spillage among nurses. In a 2010 study of outpatient oncology nurses found a high (seventeen percent approximately) rate of self-reported unintentional kin or eye exposure to CDs and owing this to workplace factors that were associated with lower exposure risk fewer patients cared for per shift, favorable staffing and resource adequacy, and performance of two-nurse verification of all chemotherapy doses. These findings lead to conclude that handling of potentially hazardous drugs remains a substantial problem for nurses, and there are important workplace factors that influence nurses' safety and health (Friese, et al, 2012).

The literature review illustrated that the dermal route of exposure is considered to have the predominant role in the uptake of anticancer agents by health care workers. Multiple environmental wipe sampling studies have documented widespread contamination of work surfaces, including the outer surface of vertical laminar air flow cabinets, walls, floors, shelves, workbenches and equipments such as drug vials, syringes and control pads of infusion pumps, in both preparation and administration areas.

Nurses' knowledge regarding safe handling of CDs is crucial. Nurses must be acquainted with the formidable inherent hazardous effects of CDs in order to be able to protect patients, themselves and their family from the risky health consequences of those hazardous chemicals, and it is also important in rising standards of safety (Mohsen & Fareed, 2013; Polovich & Clarck, 2012, 2010; Shokier, et al, 2012).

In relation to the level of oncology nurses' knowledge of safe handling of CDs table (4) revealed that in the initial assessment (pre-test), the results of this study delineated that the majority of the nurses had unsatisfactory total mean knowledge scores, which were far from the required and satisfactory level. The highest knowledge scores were in chemotherapy overview area which was far short from the required level. While the least knowledge scores were found in the area of chemotherapy storage and transferring, preparation and administration that indicating significant need for improvement.

The previous findings were supported by Ali, Arif & Pesnani (2015) who conducted a study to identify the association of knowledge on the attitude and practice of registered nurses regarding handling of cytotoxic drugs in a tertiary care hospital in Karachi, Pakistan and reported limited nurses' knowledge regarding safe handling of cytotoxic drugs which may lead to unsafe practice and increased chance of medication errors for the patients as well as increasing the chance of occupational exposure. Also the study recommended continuous education and in-service training for the nurses to raise their awareness regarding hazardous effects of the inappropriate handling of antineoplastic drugs. Chaudhary and Karn (2012) were in agreement with the results of the current study and addressed the importance of providing in-service training for all nurses handling CDs.

The unsatisfactory level of nurses' knowledge in the initial assessment (pre-test) might be due to the inadequate educational preparation level of the majority of the oncology nurses under study and lack of in-service training provided from the healthcare organization. In the line with the previous researcher's view, the studies of Osman and Bayoumy (2016); and Mohamed (2015) concluded that the pre-program level of nurses' knowledge were unsatisfactory and added that this was due to the lack of the scientific preparation of the oncology nurses, unavailability of in-service training provided to them, and the absence of guidelines/standards or any formal source of information regarding safe handling of CDs. Also, the study of Polovich and Clark (2012) was in agreement with this explanation as they found that well educated nurses got higher knowledge scores.

In respect to the mean post-test total knowledge scores of oncology nurses, the results of the current study (table (4) noted a significant increase in nurses' mean scores which were near the required satisfactory level. Satisfactory knowledge levels were found in chemotherapy overview and preparation. Although, other knowledge areas such as chemotherapy drug storage, transferring, administration, and waste disposal were unsatisfactory, but they showed a steady increase compared with the pre-test scores.

Furthermore, the data analysis of the current study revealed highly statistically significant differences of nurses'

total mean knowledge scores related to safe handling of CDs between the different assessment times; pre-test, post-test, and three-month post-test, although it was unsatisfactory. The researcher of the current study argues that this difference in nurses' knowledge scores might be due to the implemented designed teaching program that fit their needs for CDs related information.

Conversely, there was no statistical significant difference between pre-test and three-month post-test mean knowledge scores related to the areas of CDs overview and waste disposal. These findings are inconsistent with Osman and Bayoumy (2016) who reported a statistical significant improvement of the nurses' knowledge related to CDs safety after implementation of the study protocol. Also Keat, Sooaid, Yun, and Seriaman, (2013) who conducted a prospective intervention study on sixty nine Malaysian nurses to evaluate the change of their safety-related knowledge and attitude regarding handling of cytotoxic drugs, and found a significant difference of nurses' knowledge mean scores between the pre-test and post-test.

According to the forgetting curve theory, there is a correlation between memory retention and length of time. So, it is suggested that there is a rapid decline in knowledge and skills during the months following a training course (Aliakbari, et al, 2015; Charalampopoulos et al., 2016). This is in the same line with the finding of the current study that found some decline in the nurses' mean knowledge scores at the three-month post-test. Similarly, Osman and Bayoumy (2016) who found some deterioration of the nurses' knowledge scores two months after implementing the study protocol. In addition, Shokier, Shaban, Gadiry, and Seif Elden (2012) reported a drop in mean scores of nurses' knowledge in three-month post-test compared to the immediate post-test mean scores. This revealed the importance of continuous provision of in-service training for nursing to maintain the required level of their knowledge regarding safe handling of CDs.

In health care settings, CDs have been mainly handled by nurses for about three decades. Oncology nurses are working at the point of care for CDs preparation, storage, transferring, administration, spill management, and waste disposal in most healthcare settings. So, they serve as the safety net for themselves and their patients (Keat, et al, 2013; Polovich & Clark, 2012).

In respect to the oncology nurses' performance scores regarding safe handling of CDs, statistical data analysis of the current study table (5) denoted that the total post-test mean performance scores, as well as chemotherapy preparation, administration, and disposal were the highest comparing to pre-test and three-month post-test. While the least nurses' mean performance scores found in initial assessment (pre-test) in phases of chemotherapy preparation and administration.

Also, this study revealed that there were high statistical significant differences between pre-test, post-test and three-month post-test in total mean performance scores, and in chemotherapy preparation phase. Another statistical significant difference appeared between the oncology nurses' mean pre-test and post test performance in the phase of chemotherapy administration. While, no statistical significant differences were found between the oncology nurses' mean post-test and three-month post-test scores in the phases of chemotherapy administration, and waste disposal.

These findings come in consistence with Osman, and Bioumy, (2016) who found that the mean performance scores of the oncology nurses' pre-test were very low, and there was an increase in the nurses' performance scores after implementation of the study protocol as shown by the significant differences between results of pre-test and post-tests, followed by decline in the two-month post assessment. Also, Keat, Sooaid, Yun, and Seriaman, (2013) reported that before

the implementation of the pharmacist-based interventions the nurses' practices were relatively poor, comparing with other studies findings of Kyprianou et al., 2010; Polovich and Clark, (2010). A sixty percent improvement was achieved in the mean post-test nurses' practices scores after implementation of the intervention.

In contrast to the present study findings, Mohamed (2015) found that the baseline mean scores for total nurses' practice were high pre implementing of designed nursing protocol, and a great improvement in the practice score levels obtained by nurses after the application of the designed nursing protocol. This has been concluded by the presence of significant difference between results of pre-test and post-tests.

## CONCLUSIONS

Based on the results of the current study, it can be concluded that although the oncology nurses' knowledge and performance level regarding safe handling of CDs were unsatisfactory before the implementation of the designed teaching program. Nurses who attended the designed teaching program showed a relative improvement in their knowledge and performance but they didn't reach the satisfactory level. This relative improvement was manifested by a steady increase in the post total mean knowledge and performance scores.

The current study demonstrates that there is an apparent gap between what is recommended for safe handling of CDs in guidelines/standards and what is actually practiced in the oncology settings. A knowledge deficit may contribute to current discrepancies in recommended practice. Lack of compliance with CDs safe handling, contribute to poor overall awareness of nurses' risk for exposure and adverse outcomes. The current study results showed that workplace environment should be changed to improve safety, developing policies and procedures and using PPE.

Data analysis of the current study revealed that there were high statistical significant differences related to oncology nurses' total mean knowledge and performance scores between the pre-test, post-test and three-month post-test.

## RECOMMENDATIONS

On the light of the findings of this study, the following recommendations are suggested as implications for future research:

- Continuous and mandatory in-service training for healthcare workers who are handling CDs with updating knowledge based on new information should be provided.
- Regular performance appraisal and feedback on compliance with safe- handling policies and procedures of hazardous drugs are of paramount importance.
- Oncology nurses' awareness of the importance of following the guidelines of safe handling of chemotherapy drugs should be disseminated on the national level.
- Nursing students should be taught the competencies of safe handling of hazardous drugs.
- Further studies are recommended to explore the correlates of the oncology nurses' knowledge, practice and other variables such as socio-demographics, previous work experiences...etc.
- Longitudinal studies recommended determining the impact of low-level exposure to chemotherapy among healthcare workers in the oncology settings over a period of time.

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