



Research Article

Impact of Clinical Pharmacist-Led Educational Intervention on Nursing Practice of Intravenous Chemotherapy Administration: A Quasi-Experimental Design

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Received: 30 June 2025; Revised: 15 August 2025; Accepted: 18 August 2025

Abstract

Background: Intravenous chemotherapy administration is a procedure with considerable risk, inherently associated with the potential for substantial medication errors. Nurses play a pivotal role in this procedure, and having sufficient knowledge and practice is vital for ensuring patient safety. **Objective:** To evaluate the impact of clinical pharmacists' educational interventions regarding intravenous chemotherapy administration practice. **Methods:** A quasi-experimental, pre-post-test study was conducted at Kirkuk Oncology and Hematology Center and Oncology Teaching Hospital in Baghdad. A convenience sample of 50 nurses responsible for intravenous chemotherapy administration participated. The intervention consisted of educational sessions by a clinical pharmacist, covering essential aspects of safe intravenous chemotherapy administration. The baseline knowledge evaluation was done using a self-administered questionnaire, followed by the educational intervention, and then the practice evaluation phase. **Results:** Before chemotherapy, nurses failed to follow the recommended practices in 79% of observed instances (2,605 out of 3,300). This indicates a significant lack of adherence to the 22 pre-chemotherapy checklist items. Conversely, nurses were highly compliant with procedures during chemotherapy administration, with only 10.67% failing to follow proper protocol. After chemotherapy, the rate of non-compliance was extremely high. Nurses did not follow the proper procedures in most observed opportunities, with a non-compliance rate of 99.89%. This was observed across the 12 post-chemotherapy practice items. There was no significant association between nurse characteristics and practices after the administration of chemotherapy. **Conclusions:** Clinical pharmacists' educational interventions can enhance nurses' knowledge and practice in administering intravenous chemotherapy.

Keywords: Chemotherapy, Clinical pharmacist-led interventions, Intravenous administration, Nurses, Practice.

تأثير التدخل التثقيفي الذي يقوده الصيدلي السريري على الممارسة التمريضية لإدارة العلاج الكيميائي عن طريق الوريد: تصميم شبه تجريبي

الخلاصة

الخلفية: إعطاء العلاج الكيميائي عن طريق الوريد هو إجراء ينطوي على مخاطر كبيرة، يرتبط بطبيعته باحتمال حدوث أخطاء دوائية كبيرة. تلعب الممرضات دوراً محورياً في هذا الإجراء، وإتلاك المعرفة والممارسة الكافية أمر حيوي لضمان سلامة المرضى. **الهدف:** تقييم تأثير التدخلات التثقيفية للصيدلة السريرية فيما يتعلق بممارسة إدارة العلاج الكيميائي عن طريق الوريد. **الطرائق:** أجريت دراسة شبه تجريبية قبل الاختبار في مركز كركوك للأورام وأمراض الدم ومستشفى الأورام التعليمي في بغداد. شاركت عينة ملائمة من 50 ممرضة مسؤولة عن إدارة العلاج الكيميائي عن طريق الوريد. تألف التدخل من جلسات تثقيفية من قبل صيدلي سريري، تغطي الجوانب الأساسية للإدارة الآمنة للعلاج الكيميائي عن طريق الوريد. تم إجراء تقييم المعرفة الأساسية باستخدام استبيان ذاتي الإدارة، تلاه التدخل التعليمي، ثم مرحلة تقييم الممارسة. **النتائج:** قبل العلاج الكيميائي، فشلت الممرضات في اتباع الممارسات الموصى بها في 79٪ من الحالات المرصودة (2,605 من 3,300). يشير هذا إلى نقص كبير في الالتزام بـ 22 عنصراً من عناصر قائمة مراجعة ما قبل العلاج الكيميائي. على العكس من ذلك، كانت الممرضات ممتثلات للغاية للإجراءات أثناء إعطاء العلاج الكيميائي، حيث فشل 10.67٪ فقط في اتباع البروتوكول المناسب. بعد العلاج الكيميائي، كان معدل عدم الامتثال مرتفعاً للغاية. لم تتبع الممرضات الإجراءات المناسبة في معظم الفرض الملحوظة، حيث بلغ معدل عدم الامتثال 99.89٪. لوحظ هذا عبر 12 عنصراً من عناصر ممارسة ما بعد العلاج الكيميائي. لم يكن هناك ارتباط يعتد به بين خصائص الممرضة وممارستها بعد إعطاء العلاج الكيميائي. **الاستنتاجات:** يمكن للتدخلات التثقيفية للصيدلة السريرية أن تعزز معرفة الممرضات وممارساتهم في إدارة العلاج الكيميائي عن طريق الوريد.

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Article citation: Mohammed Ali MN, Al-Hamadani FY. Impact of Clinical Pharmacist-Led Educational Intervention on Nursing Practice of Intravenous Chemotherapy Administration: A Quasi-Experimental Design. *Al-Rafidain J Med Sci*. 2025;9(1):230-237. doi: <https://doi.org/10.54133/ajms.v9i1.2277>

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INTRODUCTION

Cancer is a major global issue, accounting for almost eight million deaths annually [1]. Chemotherapy is one of the main choices for treating cancer and effectively managing this deadly illness [2]. Though chemotherapy regimens, whether given orally or parenterally, can be complicated and have been

classified as high-alert drugs by the Institute for Safe Medication Practices due to the potentially crippling effects on patients in the event of an error. However, because of its complexity and the numerous pre-administration preparations, the IV route has been associated with more errors than any other method [3]. As the backbone of cancer care, nurses' primary responsibilities include safely delivering the treatment, controlling side effects, informing patients

and their families about the negative consequences of chemotherapy, and offering patients emotional support during the course of the treatment [4]. To successfully administer IV chemotherapy, avoid problems, and prolong the life of catheters, nurses should be knowledgeable and skilled in their area and should base their practices on evidence-based recommendations and guidelines [5,6]. Thus, becoming proficient in the administration of chemotherapy is essential to putting best practices into practice for nurses to guarantee patient safety, deliver high-quality care, and shield themselves from the risks associated with cytotoxic medications [7]. Given the intricacy of managing cancer patients' medications, which involves integrating multiple agents (chemotherapy, supportive care, and medicines for comorbidities), the clinical pharmacist's role is crucial in guaranteeing the safe use of all these medications by offering thorough medication reviews and information to patients and medical staff (clinical pharmacy services) [8,9]. The deployment of closed-system cytotoxic medication reconstitution services, training sessions and seminars, and updating guidelines were among the technical, educational, and administrative support elements that included pharmacist-based interventions [10]. The literature on nurses' practice in chemotherapy continuously highlights the vital importance of continuous education and training. For instance, a study from Iraq has recommended continuous training to improve oncology nurses' adherence to safe chemotherapy administration [11]. In Egypt, nurses demonstrated good knowledge but unsatisfactory practice [4]. Nigerian research highlighted major gaps in both knowledge and practice [12]. Another Iraqi study reported improvements in knowledge and practice following an educational program [13], and a Saudi Arabian study found that training significantly enhanced adherence to chemotherapy handling guidelines [14]. Collectively, these studies highlight the fact that gaps in safe chemotherapeutic procedures persist in many settings, even with varying starting knowledge levels. However, few studies have explored the role of clinical pharmacist-led interventions in bridging these gaps, which is a major topic covered in this study. This study aimed to assess the clinical pharmacist's role in enhancing nurses' practice regarding intravenous chemotherapy administration since this route is more challenging than any other method. This is crucial to directly contributing to improved patient safety and care quality to evaluate the impact of clinical pharmacists' educational interventions on intravenous chemotherapy administration practices among nurses and to explore how these practices relate to nurses' demographic characteristics and previous training opportunities.

METHODS

Study design and settings

This study was a quasi-experimental, pre-post-testing design evaluating the effect of multiple educational

interventions provided by the researcher on nurses' practice of intravenous chemotherapy administration. The baseline evaluation was done using a knowledge questionnaire developed by the researcher based on a literature review [15,16]. The study was carried out over approximately five months. Beginning on October 27, 2024, the baseline knowledge questionnaire took around a month to complete. The second interventional part lasted approximately two months, starting on December 1st, and the post-intervention practice evaluation phase lasted around six weeks.

Sample selection

A non-probability convenient sample of 50 nurses responsible for administering intravenous chemotherapy at Kirkuk Oncology and Hematology Center and Oncology Teaching Hospital. In the absence of official data from the Iraqi Ministry of Health concerning the number of nurses employed in oncology departments at the time of the study, the sample size was estimated based on a literature review of methodologies from previously published studies with similar scope and objectives [4,13].

Inclusion criteria

Nurses with vocational high school or bachelor's degrees, active in intravenous cancer chemotherapy medication administration, with at least six months' experience, and with verbal consent were eligible for the study.

Exclusion criteria

We excluded nurses who did not meet the inclusion criteria, who did not administer IV cancer chemotherapy medications during the study period, and nurses who refused or did not consent to participate in the study or related training.

Baseline knowledge evaluation

The baseline knowledge evaluation was done using a self-administered questionnaire by the researcher based on a literature review [15,16]. The questionnaire had two sections and 19 questions. The first segment included nine questions about sociodemographic details (age, gender, educational level, general nursing experience, oncology experience, chemotherapy training courses, undergraduate training, awareness of policy, and awareness of spill kit). The second section consisted of 10 multiple-choice questions (with a maximum score of 10). The total knowledge scores were categorized into three levels based on Bloom's cutoff: good level (80–100%), moderate level (60–79%), and poor level (less than 60%). These cutoff values were also based on previously published KAP studies [17–20]. The knowledge evaluation was used as a baseline to ensure ethical conduct, allowing for the identification of knowledge gaps and receiving education before being observed.

Survey administration process

The survey was completed in person and was in English. Unclear topics were clarified in the nurse's native tongue, either Kurdish or Arabic. To clarify the ambiguous points for nurses who did not receive specific points, the Kurdish version of the questionnaire underwent face validation. Three pharmacists and two nurses who spoke Kurdish fluently performed the face validation procedure. One nurse who participated in the face validation process was present during the in-person interview. The researcher clarified the ambiguous English points in Arabic when necessary. Therefore, there was no issue for Arabic nurses. As mentioned previously, the baseline knowledge questionnaire took around a month to complete; each interview lasted about 20-30 minutes.

Educational sessions

The nurses received educational sessions concerning intravenous chemotherapy administration, and at the end of each session, they received flashcards summarizing the topics discussed. The education sessions covered topics rooted in up-to-date, globally recognized standards and best practices in training, as presented in the Anti-Cancer Drug Administration Course (ADAC) developed by eviQ Education, a program of the Cancer Institute NSW [21]. They were performed during four different periods (30 min. to one hour each), followed by question-and-answer activities and cases concerning the topics involved. Flashcards summarizing the topics learned at the session were the instructional material used in addition to question-and-answer and case

activities. The training session covered topics such as safe preparation and administration of IV chemotherapy, management of extravasation, PPE compliance, and documentation standards. It was delivered by a clinical pharmacist with seven years of experience.

Post-intervention practice evaluation

Post-intervention practice evaluation was conducted to measure the impact of the educational session on practice. This was conducted by using a validated observational checklist for intravenous chemotherapy administration consisting of three parts [11]. The first was a pre-administration practice part concerned with the crucial verification procedures that nurses must follow before administering chemotherapy, such as patient identification, communication, vital sign assessment, use of personal protection equipment, and medication verification procedures. The second part of the checklist outlines nurses' actions during intravenous chemotherapy administration, including patient identification, IV line preparation, infusion setup, monitoring, and post-infusion care to ensure safety and therapeutic delivery. The third part of the checklist was the post-administration part, which included items primarily focused on psychosocial assistance, post-chemotherapy education, and advice on safe self-care, which was not implemented. By putting patient safety and ethical responsibility first, the researcher was permitted to intervene directly during the observational period to avoid any harm to the patient and the nurse. Table 1 provides representative instances of pharmacist-led interventions to demonstrate the kinds of activities done and their effects.

Table 1: Examples of interventions performed by clinical pharmacists during the study

Type of Intervention	Stage	Description	Intervention description	Outcome
Chemotherapy spill	During administration	Endoxan drops was accidentally spilled during injection.	Warned nursing staff orally to start the spill control procedure, avoiding possible exposure.	Remained unattended
PPE issue	During administration	Gloves rupture	Notify the nurse	Not replaced
Contamination	Before administration	contaminated the cannula by using the same syringe to puncture the saline bottle	Notify the nurse	no response initiated
PPE, Sterilization	During administration	Neglecting hand hygiene and the use of PPE	Notify the nurse	Reminded and corrected

The chemotherapy administration process was observed during weekdays, as during weekends (Fridays and Saturdays), the number of IV administrations was limited. The researcher undertook observation of nurses who administered chemotherapy drugs and were involved in the previous survey. The researcher was able to observe the nurses one by one as they administered the IV chemotherapy, rather than attempting to observe multiple nurses simultaneously. This allows for detailed documentation of the administration process and identification of errors. Each nurse was observed

three times on three separate occasions to guarantee data reliability and take performance variability into consideration. During each observation, the step was recorded as either "applied correctly" or "not applied," based on the standard intravenous chemotherapy administration protocol. All chemotherapy was administered during shift A (i.e., 9 a.m.–3 p.m.). All types of IV chemotherapy drug administration, including bolus injection (push), intermittent, and continuous infusion, were observed in the study. The observer introduced herself and recorded details of administration according to her

observation based on the pre-printed checklist. The observer (Hawthorne) effect may influence the way that nurses behave during the study. However, previous observational studies showed that error rates were unlikely to be affected by the observer [22].

Ethical consideration

Approval was obtained from the Scientific and Research Ethics Committee at the College of Pharmacy, University of Baghdad (approval number: REC0624105). Additionally, approval from the Ministry of Health was obtained. Consent to participate in the current study was obtained verbally.

Statistical analysis

A statistical program, SPSS (Statistical Package for Social Science) version 25, was used. For Descriptive statistics, frequency, percentage, mean, and standard deviation were used to describe the demographic characteristics of the nurses and their knowledge and practice level (before, during, after) chemotherapy administration. One way ANOVA was used to assess the difference in the nurse practices before and during the administration of chemotherapy according to the nurse characteristics. Fisher's exact test was used to

assess the association between demographic variables (e.g., age, education level, years of experience) and the nurses' practices after administration of chemotherapy. Fisher's exact test was applied for categorical variables with small subgroup sizes where expected cell counts were less than five, as it provides more accurate results than the chi-square test under these conditions. A p -value of less than 0.05 was considered statistically significant.

RESULTS

In the current study, more than half of the participating nurses were female (60%), with the great majority in their 20s to 30s. Ninety percent of them had worked on the cancer ward for three years or less and had five years or less of experience. After graduation, most of the nurses (62%) did not receive training on how to administer chemotherapy at all. Even during their undergraduate studies, more than three-quarters (80%) have lacked chemotherapeutic training. In addition, they did not know anything about the chemotherapy spill kit. Furthermore, more than half of the participating nurses (56%) had poor knowledge regarding chemotherapy administration, while only 16% had good knowledge (Table 2).

Table 2: The characteristics and awareness of the participating nurses

Characteristics	Categories	n(%)
Age (year)	20-30	46(92)
	31-40	3(6)
	41-50	1(2)
Gender	Male	20(40)
	Female	30(60)
Education level	Diploma degree	46(92)
	Bachelor's degree	4(8.0)
Years of nursing experience	6 months – 5 years	45(90)
	5-10 years	3(6)
	10-15 years	1(2)
	> 15 years	1(2)
Oncology experience (year)	6 months -3 years	43(86)
	4-7 years	5(10)
	8-11 years	2(4)
Training in chemotherapy	Once	11(22)
	Twice	1(2)
	More than twice	7(14)
	Never	31(62)
Undergrad training sufficiency	Enough	1(2)
	Not enough	9(18)
	Never received	40(80)
Aware of Chemotherapy Policy	Yes	37(74)
	No	13(26)
Aware of spill kit	Yes	0(0)
	No	50(100)
Level of knowledge	Poor	28(56)
	Moderate	14(28)
	Good	8(16)

When turning to the observation phase, it can be seen that during the three observations of nurses in practice, approximately 18 out of 22 recommended pre-administration practices for intravenous chemotherapy were not followed. Only four practices mainly were implemented: "Makes sure from the physician's orders accurately" (64%), "makes sure from patient's name, bed number and room number" (50.7%), "gives patient antiemetic as prescribed by the physician" (98%), and "puts patient in comfortable position (71.3%). Less frequently, they noted the

drug's appearance (46%), as shown in Table 3. In contrast, almost all recommended practices (17 out of 18) during administration of intravenous chemotherapy were implemented by the nurses except "Put patient in comfortable position while reassuring him and removing his fear" (29.3%), as seen in Table 4. In the post-administration phase, adherence to all recommended practices was 0%, indicating that none of the observed nurses followed these practices, as seen in Table 5.

Table 3: Frequency distribution of the nurses according to their practices before the administration of intravenous chemotherapy (three observations per nurse)

Items	Levels of performance	
	Not applied	Applied correctly
1. Make sure from the physician's orders accurately.	54(36)	96(64)
2. Make sure of the patient's name, bed number and room number.	74(49.3)	76(50.7)
3. Introduces himself to the patient and explains the procedure.	141(94)	9.0(6)
4. Performs hand hygiene	145(96.7)	5.0(3.3)
5. Wears sterile mask	124(82.7)	26(17.3)
6. The nurse wears a head cap.	137(91.3)	13(8.7)
7. Wear sterile gloves.	116(77.3)	34(22.7)
8. Measures patient's body temperature	150(100)	0(0.0)
9. Takes patient's pulse rate	147(98)	3.0(2)
10. Takes patient's respiration rate	149(99.3)	1.0(0.7)
11. Measures a patient's blood pressure.	145(96.7)	5.0(3.3)
12. Clarifies to patient the necessity of taking the dose within the prescribed time.	148(98.7)	2.0(1.3)
13. Clarifies to patients the side effects of chemotherapy	143(95.3)	1.0(0.7)
14. Advise patient not to eat anything at least 4 hours before taking a chemotherapy dose.	143(95.3)	7.0(4.7)
15. Gives patient antiemetic as physician's prescription	3.0(2)	147(98)
16. Put patient in comfortable position	43(28.7)	107(71.3)
17. Matches the prescribed drug with the patient's health file	90(60)	60(40)
18. Notes on drug appearance	81(54)	69(46)
19. Make sure from expiration date	149(99.3)	1.0(0.7)
20. Performs hand hygiene again.	146(97.3)	4.0(2.7)
21. Wear personal protective equipment.	141(94)	9.0(6)
22. Wear new sterile gloves	136(90.7)	14(9.3)

Values were expressed as frequency and percentage, n(%).

Table 4: Frequency distribution of the nurses according to their practices during the administration of intravenous chemotherapy (three observations per nurse)

Items	Levels of Performance	
	Not applied	Applied correctly
1. Asks patient about his name to match it with the patient's health file.	57(38)	93(62)
2. Keeps patient's privacy	2.0(1.3)	148(98.7)
3. Put patients in right position	10(6.7)	140(93.4)
4. Takes a comfortable position	10(6.7)	140(93.3)
5. The nurse provides good lightning for vision.	1.0(0.7)	149(99.3)
6. Checks patient's arms	0(0.0)	150(100)
7. Choosing superficial veins	0(0.0)	150(100)
8. Sterilizes skin with alcohol swap in circular form from inside to outside	35(23.3)	115(76.7)
9. Put a cannula in the non-dominant hand.	5.0(3.3)	145(96.7)
10. Hung chemotherapy in suitable height for better infusion	3.0(2)	147(98)
11. Make sure of cannula work by pushing amount of normal saline through the cannula.	38(25.3)	112(74.7)
12. Gets rid of air bubbles from infusion set and connects it to cannula.	5.0(3.3)	145(96.7)
13. Adjust the number of drops per minute according to prescribed time and dosage.	1.0(0.7)	149(99.3)
14. Monitor patient during chemotherapy infusion.	9.0(6)	141(94)
15. Close infusion valve after chemotherapy infusion finish.	2.0(1.3)	148(98.7)
16. Gets rid of chemotherapy container.	3.0(2)	147(98)
17. Documents all the nursing intervention	1.0(0.7)	149(99.3)
18. Put patient in comfortable position with reassuring him and removing his fear.	106(70.7)	44(29.3)

Values were expressed as frequency and percentage, n(%).

Table 5: Frequency distribution of the nurses according to their practices after the administration of intravenous chemotherapy (three observations per nurse)

Items	Levels of performance	
	Not applied	Applied correctly
1. Relief the effect of chemotherapy through giving Palliative medications	150(100)	0(0.0)
2. Provides patient and his family with sufficient information about chemotherapy and its side effect	148(98.7)	2(1.3)
3. Provides patients with information concerning patients' health and prevention of infections	150(100)	0(0.0)
4. Patient advice to be far away from crowded areas	150(100)	0(0.0)
5. Advice patients to be far away from invasive instruments to prevent bleeding.	150(100)	0(0.0)
6. Advice patients to avoid psychological and physical stress.	150(100)	0(0.0)
7. Teaches patient how to measure his body temperature.	150(100)	0(0.0)
8. Advice patient to take care of his nutrition by eating small and soft frequent meals.	150(100)	0(0.0)
9. Advice patient to avoid soft and caffeinated drinks, spicy foods, uncooked foods, fruits and vegetables.	150(100)	0(0.0)
10. Advice patient to eat foods with dietary fiber to prevent constipation.	150(100)	0(0.0)
11. Instructs patients to eliminate his body waste in a safe manner.	150(100)	0(0.0)
12. Notifies patient with his next date of chemotherapy dose.	150(100)	0(0.0)

Values were expressed as frequency and percentage, n(%).

Table 6 demonstrates that nurses' oncology experience and chemotherapy training significantly influenced their practices during chemotherapy administration ($p < 0.05$). Conversely, only chemotherapy training significantly affected nurses' practices before

chemotherapy administration ($p < 0.05$). Further analysis using Fisher's exact test has revealed that there was no significant association between nurse characteristics and practices after administration of chemotherapy ($p < 0.05$) (Table 7).

Table 6: The difference in the nurse practices before and during the administration of chemotherapy according to the nurse's characteristics

Variables	Nurses' practices before chemotherapy			Nurses' practices during chemotherapy		
		n	Mean±SD	p	n	Mean±SD
Age (year)‡	20-30	46	13.48±3.95	0.642‡	46	48.11±3.95
	31-50	4.0	12.5±4.8		4.0	50±2.83
Sex ‡	Male	20	13.50±3.20	0.886‡	20	48.55±3.63
	Female	30	13.33±4.47		30	48.07±4.09
Education ‡	Diploma degree	46	13.46±4.081	0.737‡	46	48.54±3.914
	Bachelor's degree	4	12.75±2.754		4	45.00±1.155
Years of Nursing Experience ‡	6 months-5 years	45	13.42±3.97	0.907‡	45	48.09±3.97
	> 5 years	5.0	13.20±4.44		5.0	49.80±2.86
Oncology Experience*	6 months-3 years	43	13.09±3.70	0.39*	43	48.70±3.14
	4-7 years	5.0	15.00±6.16		5.0	43.40±6.77
	8-11 years	2.0	16.00±4.24		2.0	51.00±1.41
Training in Chemotherapy*	Once	11	15.82±4.94	.033*	11	45.64±6.12
	Twice or more	8.0	11.25±1.98		8.0	48.25±2.19
	never	31	13.10±3.65		31	49.19±2.76
Undergrad Training Sufficiency*	enough	1.0	10.0±0.0	0.675*	1.0	52.00±0.0
	Not enough	9.0	13.78±2.64		9.0	48.67±3.16
	Never received	40	13.40±4.25		40	48.08±4.06

Values were expressed as mean±SD. * One-Way ANOVA test; ‡ Independent t-test.

Table 7: The association between the nurse practices after administration of chemotherapy and the nurse's characteristics

Variables	Subcategories	Not implemented	Implemented	p*
Age (year)	20-30	18(37.5)	2(100)	0.155
	31-40	30(8.3)	0(0.0)	
Sex	Male	4(50)	5(35.7)	0.851
	Female	4(50)	9(64.3)	
Education Level	Diploma degree	44(91.7)	2(100)	0.845
	Bachelor's degree	4(8.3)	0(0.0)	
Years of Nursing Experience	6 months - 5 years	43(89.6)	2(100)	0.808
	5-10 years	5(10.4)	0(0.0)	
Oncology Experience	6 months - 3 years	41(85.4)	2(100)	0.737
	4 - 7 years	5(10.4)	0(0.0)	
	8 - 11 years	2(4.2)	0(0.0)	
Training in Chemotherapy	Once	10(20.8)	1(50)	0.620
	Twice	1(2.1)	0(0.0)	
	More than twice	7(14.6)	0(0.0)	

Values were expressed as frequency and percentage. * Fisher's Exact test.

DISCUSSION

A robust workforce of oncology nurses can significantly impact patients' quality of care and their overall prognosis and health status [23]. A practical approach to building a competent and robust nurse workforce in chemotherapy administration is to leverage the expertise of skilled clinical pharmacists in identifying and preventing drug-related issues [23]. This can be done through conducting an education program, taking into account that a multidisciplinary team framework can enhance clinical outcomes. Thus, this study was conducted to evaluate the impact of clinical pharmacists' educational interventions on intravenous chemotherapy administration practices among nurses. At baseline, more than half of the participating nurses (56%) had poor knowledge regarding chemotherapy administration. In comparison, only 16% had good knowledge, and 28% had moderate knowledge. These findings are consistent with a Nigerian study conducted by Amy Winn, which found that nurses lack formalized oncology training, leading to knowledge gaps and inconsistent practice in oncology units [12]. However, the current findings were in contrast with the study by Mamdouh Zakaria *et al.*, which showed that more than half of the studied nurses had a good total knowledge score regarding intravenous chemotherapy [4]. These findings may be explained by the fact that most of the nurses in the current study have never received training in chemotherapy administration. This could

be attributed to the unavailability of in-service training in hospitals [15]. This clarifies that a lack of continuing education may cause low clinical competency and nursing skills. For instance, a study in Iraq evaluated nurses' practices toward safe intravenous chemotherapy infusion by Fadhil and Hassan, who recommended the implementation of continuous training programs for all workers in oncology units related to the correct rules in chemotherapy administration and infection control [11]. Table 2 shows that participants' lack of knowledge about chemotherapy spill kits is probably caused by the fact that these kits are not available in the clinical settings under investigation, which is further exacerbated by a lack of official training and institutional rules pertaining to spill control. Regarding the pre-administration practice part of the checklist used in the study, nurses only followed four items out of twenty-two, which means 85.7% of the items were not applied. These findings are consistent with Fadhil and Hassan study, which reported that 73% of crucial nursing procedures for safe chemotherapy infusion were not observed [11]. Additionally, these findings show partial agreement with the Egyptian study by Mamdouh Zakaria *et al.*, which found that more than half of the studied nurses didn't handle chemotherapeutic drugs safely through using personal protective equipment (PPE) [4]. Another study by Martin S. found that only 31% of nurses wore protective gowns during chemotherapy administration, despite the availability of all personal protective equipment, including gowns [24]. In fact,

recent studies suggest that although hazardous drug policies are in place in many workplaces, existing practices may not reflect current recommendations for safe chemotherapy handling and are not enforced or monitored by managerial staff [13]. The lack of adherence of nurses in patients' verification of chemotherapy medications before administration in the current study may reflect a dependence on the roles and checks performed by pharmacists. In other words, in this study, the clinical pharmacists performed initial drug checks and labeling and sequentially numbered chemotherapy before transferring it to nursing personnel, which leads to overreliance of nurses on prior verification and the assumption that rechecking is not necessary. Unlike verification gaps driven by team dependence, problems of improper use of personal protective equipment (PPE) may be attributed to the lack of suitable PPE, including chemotherapy-tested gloves and gowns, as the gloves provided are generally non-sterile and not explicitly intended for cytotoxic drug administration. Regarding the checklist part of nurses' actions during intravenous chemotherapy administration, three observations per nurse for this part revealed satisfactory practice for nearly all the recommended procedures. In contrast to the study by Fadhil and Hassan, which found that more than half of nurses' practices during chemotherapy introduction were not applied [11]. The high application rate of practice items during intravenous chemotherapy administration in this study may be attributed to regular exposure, strict institutional procedures, or a reliance on real-world experience, despite the fact that most nurses in this study had never received training on chemotherapy. It is also possible that self-reporting bias affected the outcomes, as nurses may have behaved differently during observation, which could have resulted in an underestimation of non-compliance or an overestimation of appropriate practices. Regarding the practice of nurses after administering intravenous chemotherapy, it shows that the participating nurses implemented none of the recommended post-administration practices. This matches the Iraqi study, which found that 92.3% of practices were not applied by nurses, indicating that a high percentage of nurses' practices after chemotherapy infusion were not implemented [11]. This may be due to a lack of training or a lack of focus on these psychological and post-chemotherapy education areas. These findings suggest that the hospital nursing team should support all patients undergoing chemotherapy to alleviate their fears [25]. Additionally, noncompliance with post-administration procedures could also be attributed, in part, to time pressures in the clinical setting. Concerning the association between the nurses' practices and their demographics and previous training opportunities, our findings have shown that nurses' oncology experience and training in chemotherapy were the only factors that significantly influenced nurses' practices during chemotherapy. On the other hand, training in chemotherapy was the only factor that significantly influenced nurses' practices after chemotherapy administration, and there was no

significant association between nurse characteristics and practices after the administration of chemotherapy. The finding of the current study approximately agrees with an Iraqi study by Fadhil and Hassan, which reported that there was no significant relationship between nurses' practices for chemotherapy infusion and nurses' level of education and years of experience, and there was a significant relationship between the nurses' practices and their training course related to chemotherapy infusion [11]. Additionally, a study in Egypt by Mamdouh Zakaria *et al.* reported that no statistically significant differences were found between nurses' practice mean scores and nurses' sex, level of education, years of experience, and years of experience in the oncology department. However, there was a positive statistically significant difference between nurses' practice mean scores and age, working department, and attendance of training workshops [4]. The observed variations in nurses' characteristics and practices across studies may be expressed via the Sociodemographic differences in the nurses studied.

Study limitations

The study has several limitations. First, the results may not be as generalizable to different healthcare settings, as the study was conducted in a specific environment (Kirkuk Oncology and Hematology Centre and Oncology Teaching Hospital). Second, the generalizability of the non-probability convenience sampling used in the current study may be limited. Furthermore, due to ethical concerns, the study design did not include pre-intervention observation without first providing an educational intervention, as this could expose patients to avoidable risks. For the same reason, the post-intervention observation was conducted with immediate pharmacist intervention to assure patients' safety. Lastly, the brief intervention and the nurses' requirement for additional time and sessions to fully process the material.

Conclusion

This study found that clinical pharmacists' educational interventions can improve nurses' knowledge and, consequently, their practice in administering intravenous chemotherapy. There was a significant educational impact on nurses' practices during the administration of chemotherapy. Additionally, experience in oncology and training had a significant impact on their practices during administration. Additionally, experience in oncology and training had a significant impact on their practices during administration. It is recommended that ongoing training be conducted to ensure that nurses are adequately prepared to administer intravenous chemotherapy, including the correct use of PPE and sterilization techniques, necessary pre-chemotherapy steps, psychological support, and post-chemotherapy patient education. Also conducting periodic monitoring of nurses' knowledge and practice to evaluate the level of nurses' knowledge working in the chemotherapy field. However, behavioral change in

clinical practice may not be achieved solely through education. A lack of reinforcement may be one of the primary causes of the knowledge-practice gap, which occurs when nurses acquire knowledge but are unable to apply it in their daily work. Other factors include a high workload, organizational barriers, and resistance to change. It is also advisable to employ tactics such as ensuring a sufficient supply of personal protective equipment (PPE) and spill kits. To evaluate the long-term effects and suitability of such interventions, future research should concentrate on longitudinal studies and randomized controlled trials in a variety of healthcare settings.

Conflict of interests

The authors declared no conflict of interest.

Funding source

The authors did not receive any source of funds.

Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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