



Research Article

Assessment of the Knowledge and Practice on Safe Handling of Anticancer Drugs among Pharmacists in Iraqi Healthcare Settings

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Received: 24 May 2024; Revised: 17 July 2024; Accepted: 19 July 2024

Abstract

Background: Occupational exposure to hazardous drugs occurs in all aspects of anticancer drug handling. Proper recommendations and guidelines should be applied to control and reduce exposure. **Objective:** To assess pharmacists' knowledge and practice regarding the safe handling of anticancer drugs. **Methods:** A cross-sectional study was conducted at seven major hospitals in Baghdad City, Iraq, from December 2023 to February 2024. A pre-designed questionnaire was given to pharmacists who handled anticancer drugs in chemotherapy units. The questionnaire comprises sociodemographic data, knowledge of the safe handling of cytotoxic drugs and thoughts about exposure and risk, practices for safely handling cytotoxic drugs, and challenges for safely handling cytotoxic drugs. **Results:** A total of 126 pharmacists were enrolled in the study. Less than half of the participants (46%) received training on anticancer drugs. While more than a third (42.9%) of the pharmacists were handling more than 100 cytotoxic preparations weekly, the total knowledge score was 7.14, while the total practice score was 73.36, with less than half of the pharmacists having good knowledge (44.44%) or practice (48.41%). Pharmacists who received training had significantly higher total practice scores than those who did not. Pharmacists with more than 100 weekly preparations were more knowledgeable than those with 50–99 preparations. **Conclusions:** The majority of participating pharmacists had fair to excellent knowledge and practice regarding safe handling of cytotoxic medications. However, there were some gaps regarding important knowledge and practice issues. To improve knowledge and practices regarding anticancer handling, training is necessary.

Keywords: Anticancer drugs, Knowledge, Pharmacists, Safe handling practices.

تقييم المعرفة والممارسات المتعلقة بالتعامل الآمن مع الأدوية المضادة للسرطان بين الصيادلة في مؤسسات الرعاية الصحية

الخلاصة

الخلفية: التعرض المهني للأدوية الخطرة يحدث في جميع جوانب التعامل مع الأدوية المضادة للسرطان. وينبغي تطبيق التوصيات والمبادئ التوجيهية المناسبة للسيطرة على التعرض والحد منه. **الهدف:** تقييم معرفة وممارسات الصيادلة فيما يتعلق بالتعامل الآمن مع الأدوية المضادة للسرطان وارتباطاتها المحتملة مع المتغيرات المختلفة المتعلقة بالصيدلي. **الطرائق:** أجريت دراسة مقطعية في سبعة مستشفيات رئيسية في مدينة بغداد، العراق، في الفترة من ديسمبر 2023 إلى فبراير 2024. تم تقديم استبيان مصمم مسبقاً للصيادلة الذين يتعاملون مع الأدوية المضادة للسرطان في وحدات العلاج الكيميائي. يشتمل الاستبيان على بيانات اجتماعية ديموغرافية ومدى المعرفة بالتعامل الآمن مع الأدوية السامة للخلايا وأفكار حول التعرض والمخاطر وممارسات التعامل الآمن مع هذه الأدوية السامة للخلايا والتحديات التي تواجه التعامل الآمن معها. **النتائج:** تم تسجيل 126 صيدلانيا في الدراسة. تلقى أقل من نصف المشاركين (46%) تدريباً على التعامل مع الأدوية المضادة للسرطان. بينما كان أكثر من ثلث (42.9%) الصيادلة يحضرون أكثر من 100 مستحضر سام للخلايا أسبوعياً. وكانت مجموع نقاط المعرفة 7.14 في حين كانت مجموع نقاط الممارسة 73.36 وكان أقل من نصف الصيادلة لديهم معرفة جيدة (44.44%) أو ممارسة جيدة (48.41%). حصل الصيادلة الذين يتلقون التدريب على درجات ممارسة إجمالية أعلى بكثير من أولئك الذين لم يحصلوا على تدريب. الصيادلة الذين يحضرون أكثر من 100 مستحضر أسبوعياً كانوا أكثر معرفة من أولئك الذين لديهم 50-99 مستحضر. **الاستنتاجات:** الصيادلة في وحدة الأورام لديهم معرفة وممارسات غير مقبولة حول التعامل مع الأدوية المضادة للسرطان. هناك حاجة إلى التدريب لتحسين المعرفة والممارسات المتعلقة بالتعامل مع الأدوية المضادة للسرطان.

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Article citation: Kadhim MQ, Kadhim DJ. Assessment of the Knowledge and Practice on Safe Handling of Anticancer Drugs among Pharmacists in Iraqi Healthcare Settings. *Al-Rafidain J Med Sci.* 2024;7(1):85-92. doi: <https://doi.org/10.54133/ajms.v7i1.1040>

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INTRODUCTION

The term "hazardous drugs" was initially coined by the American Society of Health-System Pharmacists (ASHP) in 1990 [1]. In 2004, the National Institute for Occupational Safety and Health (NIOSH) revised the term to be recognized as a drug that has carcinogenicity, genotoxicity, teratogenicity, organic toxicity at low doses, and reproductive toxicity [2]. Furthermore, NIOSH released an alert that included a list of drugs recognized as hazardous to healthcare providers; these lists have been published and updated periodically [3–7]. More than half of the drugs in these lists were antineoplastic agents. Antineoplastic agents have various terms, such as anticancer drugs, cytostatic drugs, and chemotherapeutic agents [8,9]. Since NIOSH issued its alert, several professional practice organizations have published or updated their guidelines for protecting workers who handle hazardous anticancer drugs [10–12]. Every individual dealing with hazardous drugs faces potential exposure; nevertheless, oncology pharmacists who are involved in drug preparation and oncology nurses responsible for administering them to patients are at the highest risk of exposure [13,14]. Occupational exposure to anticancer drugs can occur through direct contact, inhalation, injection, and ingestion, or indirectly through dermal absorption from contaminated surfaces [15]. Occupational hazards negatively impact health, so exposure-related acute effects include headache, skin rash, allergic reactions, sore throat, hair loss, dizziness, cough, and eye irritation [16]. Chronic effects include reproductive effects (infertility, spontaneous abortion, miscarriage, and premature births), leukemia, other cancers, and organ toxicity [17,18]. Therefore, proper recommendations and guidelines should be applied to control and reduce exposure. These recommendations include using engineering controls, administrative controls, and personal protective equipment (PPE) [12]. In 2015, Al-Azzam *et al.* conducted a study to assess the adherence of pharmacists and nurses in Jordanian hospitals to standard safety protocols for preparing and administering antineoplastic medications. The study revealed that the participants had a satisfactory level of knowledge regarding the risks associated with exposure to these drugs. However, the protocols implemented in their hospitals needed to be consistent with established guidelines and enhancements [19]. In 2017, a pilot study was performed in Turkey to evaluate the chemotherapeutic drug preparation process in chemotherapy preparation units by pharmacists. The study found that pharmacists have sufficient knowledge about the safe preparation and handling of chemotherapeutics [20]. In 2020, a study in Saudi Arabia included pharmacists and nurses evaluating educational interventions' effect on healthcare providers' adherence to chemotherapy handling guidelines. The study showed that education and safety training increase compliance with guidelines in preparing and administering chemotherapy [16]. To our knowledge, no previous studies in Iraq have evaluated pharmacists' handling of chemotherapy. Therefore, this study aimed to

assess pharmacists' knowledge and practice on safely handling anticancer drugs.

METHODS

Study design and setting

The current study, a cross-sectional study using a self-administered questionnaire, was conducted from December 2023 to February 2024. It was conducted in seven major hospitals in Baghdad City, Iraq. These included the Oncology Teaching Hospital, Al-Imamain Al-Kathimain Medical City, Al-Yarmouk Teaching Hospital, Children Welfare Teaching Hospital, Al-Amal National Hospital for Tumor Treatment, the Central Teaching Hospital of Pediatrics, and the Hematology and Bone Marrow Transplant Center.

Ethical consideration

The scientific and ethical committee of the College of Pharmacy, University of Baghdad, approved the study (approval name: RECAUBCP201020236, date: October 20, 2023). Ethical approval was obtained to conduct the study from the Baghdad Medical City Health Directorate (number 44262, date 21/11/2023) and Baghdad Al-Karkh Health Directorate (number 86328, date 23/11/2023). Additionally, we verbally obtained the participants' consent to participate in this study and embedded it at the beginning of the questionnaire.

Inclusion criteria

The pharmacists eligible for inclusion criteria were all pharmacists who handled anticancer drugs in chemotherapy units with at least one month of experience in handling anticancer medications and consented to complete the questionnaire.

Exclusion criteria

We excluded pharmacists who did not meet these inclusion criteria and those who provided incomplete responses to the study questionnaire.

Data collection and outcome measurements

The questionnaire was developed from several sources to achieve the study aim [21–25]. Face validation was done by four academic pharmacists who have good experience in pharmacy practice research. They had experience in research for more than 10 years. All their comments were taken into consideration and the final version of the questionnaire was amended depending on their recommendations. The questionnaire form is composed of four major sections. The first section involved pharmacists' characteristics, such as hospital name, gender, level of education, duration of experience in handling cytotoxic drugs, weekly preparation, and formal training. The second section

involved ten questions that measured the pharmacists' knowledge of the safe handling of cytotoxic drugs and their thoughts about exposure and risk. The third section involved an assessment of the practices for the safe handling of cytotoxic drugs. This section contains four subsections (receiving and storage practices, preparation practices, cleaning of the preparation area and spill practices, and disposal practices). If the pharmacist is not responsible for receiving and storage, cleaning, and/or disposal practices, he or she may skip these questions and move on to others. The last section contains one question about the challenges of safely handling cytotoxic drugs. All questions were presented as closed-ended questions: yes, no, and do not know, except the question in the last section, which was multiple choice. Regarding knowledge score calculation, each correct answer was scored one point, while incorrect and "do not know" answers scored zero. Accordingly, the total knowledge score will range from 0 to 10. The level of knowledge was divided into three categories: good, fair, and poor. Participants scoring 7.5 and above were classified as having good knowledge, while those scoring between 5 and 7.5 were considered to have fair knowledge. Scores below five indicated poor knowledge [23]. Regarding the practice score, each "yes" answer was scored one point, while "no" and "do not know" answers scored zero. The overall score for each participant was calculated as follows:

Total practice score = (sum of points for correct answers/total number of questions that apply to the pharmacist) x 100

A score of 75 or above was considered good, 50 to 75 was considered fair, and below 50 was considered poor [23]. The questionnaire was established in English. It was given to pharmacists after explaining the purpose and assuring them that it was voluntary participation. After consenting, the pharmacists filled out questionnaires and returned them to the researcher.

Statistical analyses

The completed questionnaires were entered into a Microsoft Office Excel sheet. The Statistical Package for the Social Sciences (SPSS) software version 25 analyzed the data. The software calculates the frequency, percentage of pharmacist characteristics, and items related to knowledge and practice. We used an independent t-test, or one-way ANOVA with a Tukey post hoc test, to measure the association between the pharmacist characteristics (education level, duration of experience, receiving formal training, and number of operations weekly) and their knowledge and practice (receiving and storing, preparing, cleaning, and disposing) related to anticancer medications.

RESULTS

The study recruited 126 pharmacists from seven public hospitals in Baghdad. Most pharmacists were

female (59.5%). The vast majority of the participants (89.7%) had a bachelor's degree in pharmacy and 83.3 percent had less than three years of experience handling cytotoxic medications. Less than half of the participants (46%) received formal training to deal with cytotoxic medications. While more than a third (42.9%) of the participating pharmacists were handling more than 100 cytotoxic preparations weekly (Table 1), only two knowledge items received less than half of pharmacists correct answers.

Table 1: Characteristics of the participating pharmacists

Categories	Variable	Results n(%)
Gender	Male	51(40.5)
	Female	75(59.5)
	Bachelor	113(89.7)
Educational level	Diploma	3(2.4)
	Master	8(6.3)
	Board	2(1.6)
Duration of experience in handling cytotoxic drugs (year)	< 1.0	60(47.6)
	1-3	45(35.7)
	> 3	21(16.7)
Number of preparation weekly	<50	38(30.2)
	50-99	34(27)
	≥100	54(42.9)
Formal training	Yes	58(46)
	No	68(54)

Values are presented as frequencies and percentages.

These two items with the lowest correct answers were "a surgical mask provides protection from cytotoxic aerosols" (38.9%) and "oral anticancer chemotherapy is safer compared to IV chemotherapy" (31.0%) (Table 2). The total knowledge score was (7.14±1.68) while the total practice score was (73.36±14.64), with less than half of the pharmacists having good knowledge (44.44%) or practice (48.41%) (Table 3). Regarding the handling and storage of cytotoxic drugs, only 52.78% of pharmacists were wearing PPE when handling cytotoxic medications. In contrast, the majority of pharmacists were conducting the correct practice in terms of "segregating other medicines from cytotoxic drugs while storage" (80.56%) and "washing hands after handling cytotoxic drugs" (88.89%). Regarding preparation practices, over 90% of the participating pharmacists adhered to the correct practices for three key areas: 97.62% of the participating pharmacists wore personal protective equipment (PPE) when preparing cytotoxic drugs, 94.44 percent immediately changed their torn gloves when handling cytotoxic drugs, and 90.48 percent prepared cytotoxic drugs in the Biological Safety Cabinet (BSC). In contrast, only 28.57% of them were wiping vials or ampules after removing the outer packaging material before reconstitution. On the other hand, 50% were changing their gloves every 30 minutes when reconstituting cytotoxic drugs. With respect to cleaning the cytotoxic preparation area and/or cytotoxic spills, more than half of pharmacists were following five out of six good practices related to the cleaning of the preparation and spill areas. It is worth mentioning that only 27.14% of the pharmacists indicated the availability of cytotoxic spill kits in their hospitals.

Table 2: Item related to knowledge of safe handling of cytotoxic drugs and thoughts about exposure and risk

Item	Subgroups	Results
Gloves should be worn when handling cytotoxic drugs.	Yes*	125(99.21)
	No	1(0.79)
All types of gloves provide the same level of protection when handling cytotoxic drugs.	Yes	15(11.90)
	No*	101(80.16)
	Don't know	10(7.94)
	Yes	67(53.17)
A surgical mask provides protection from cytotoxic aerosols.	No*	49(38.89)
	Don't know	10(7.94)
	Yes	22(17.46)
A disposable safety gown for handling cytotoxic drugs can be re-worn.	No*	100(79.37)
	Don't know	4(3.17)
	Yes*	96(76.19)
There is a separate disposal method for cytotoxic drugs.	No	14(11.11)
	Don't know	16(12.70)
	Yes	57(45.24)
Oral anticancer chemotherapy is safer compared to IV chemotherapy.	No*	39(30.95)
	Don't know	30(23.81)
	Yes	30(23.81)
Alcohol hand sanitizer is as effective as soap and water in removing chemotherapy residue.	No*	80(63.49)
	Don't know	16(12.70)
	Yes*	99(78.57)
	No	13(10.32)
Cytotoxic drugs can enter the body through skin contact with drug-contaminated surfaces.	Don't know	14(11.11)
	Yes*	103(81.75)
	No	15(11.90)
	Don't know	8(6.35)
Chemotherapy gas and vapor in air can enter the body through skin and mucous membranes.	Yes*	108(85.71)
	No	5(3.97)
	Don't know	13(10.32)

Values are presented as frequencies and percentages. * Correct answers.

Table 3: Total scores of knowledge and practice and their categories

Categories	Variable	Results
Good	Knowledge	56(44.44)
	Practice	61(48.41)
Fair	Knowledge	64(50.79)
	Practice	56(44.44)
Poor	Knowledge	6(4.76)
	Practice	9(7.14)
Total score		
Knowledge	7.14±1.68	
Practice	73.36±14.64	

Values are presented as frequencies, percentages, and mean±SD.

In terms of disposal practice, more than 87% of pharmacists followed the three good practices regarding the appropriate disposal of cytotoxic drug waste (Table 4). Both academic degrees and the duration of experience of pharmacists had no significant influence on their knowledge and practice related to cytotoxic medications. However, pharmacists who received formal training had a significantly higher total practice score than those who did not. Additionally, according to a one-way ANOVA, there were significant ($p<0.05$) differences in the knowledge score according to the number of anticancer preparations per week. (Table 5). According to the Tukey *post hoc* test, pharmacists with more than 100 preparations weekly were more knowledgeable compared to those with 50–99 preparations (Table 6). Regarding the challenges or barriers pharmacists face that may prevent them from safely handling cytotoxic drugs, the main two challenges facing hospital pharmacists regarding the safe handling of cytotoxic medications were the high workload (57.1%) and the unavailability of PPE in the hospitals (38.9%) (Table 7).

DISCUSSION

Pharmacists play a crucial role in the chemotherapy preparation unit. However, the admixture process exposes them to the potential health risks of anticancer drugs. In addition, various work activities, such as spill management, waste disposal, and area cleaning, increase the risk of occupational exposure. For adequate knowledge and safe practices, they required a training program that covered all aspects of their responsibilities and practical needs. The current study was conducted to assess the pharmacists' knowledge about the safe handling of anticancer drugs and their thoughts about exposure and risk. Additionally, the study evaluated the methods pharmacists employ when handling these drugs. According to the study results, more than half of the pharmacists studied were female. This finding is congruent with Ness *et al.* in Brazil and Hon *et al.* in Canada, who found that most participants were female [26,27]. In contrast, this was inconsistent with Ogbaghebriel *et al.* in Saudi Arabia and Al-Azzam *et al.* in Jordan, who reported that the majority of the participants were male [14,19]. It is important to point out that the occupational safety of workers is essential for females because they are the most exposed to adverse pregnancy outcomes, especially at reproductive age [18]. The International Society of Oncology Pharmacy Practitioners (ISOPP) standards mandate that any worker who becomes pregnant, plans to become pregnant, or is breastfeeding should transition to a different job role to reduce the reproductive risk associated with anticancer drugs [12]. However, the educational level complies with the results of Ogbaghebriel *et al.*, and Al-Azzam *et al.* reported that the majority (87.7%) of the participants had a bachelor's degree [14,19].

Table 4: Details answers of pharmacists to practice-related questions

Receiving and storage of cytotoxic drugs			Cleaning of cytotoxic preparation area and/or cytotoxic spills		
Items	Subgroups	Results	Items	Subgroups	Results
Are you responsible for receiving cytotoxic drugs	Yes	72(57.14)	Are you responsible for cleaning of cytotoxic preparation area and cytotoxic spills	Yes	70(54.8)
	No	5 (42.86)		No	56(45.2)
	Yes	38(52.78)		Yes	19(27.14)
Wear PPE when receiving cytotoxic drugs	No	31(43.06)	Cytotoxic spill kit available	No	47(67.14)
	Not know	3(4.17)		Not know	4(5.71)
Segregate other medicines from cytotoxic drugs while storage	Yes	58(80.56)	Wear PPE when cleaning cytotoxic spill/cytotoxic preparation area	Yes	62(88.57)
	No	14(19.44)		No	7(10)
Label cytotoxic drugs with a product identifier and hazard statement/signal word?	Yes	47(65.28)	Demarcate the area of the cytotoxic spill before cleaning	Not know	1(1.43)
	No	25(34.72)		Yes	39(55.71)
Wash your hands after handling cytotoxic drugs	Yes	64(88.89)		No	28(40)
	No	8(11.11)		Not know	3(4.29)
Preparation of cytotoxic drugs			Cleaning from outside the spill area gradually towards the centre	Yes	37(52.86)
Are you responsible for preparation of cytotoxic drugs	Yes	126(100)		No	27(38.57)
Reconstitute cytotoxic drugs in a designated room	Yes	111(88.1)	Use cleaning reagents when cleaning the cytotoxic preparation area	Not know	6(8.57)
	No	15(11.9)		Yes	61(87.14)
	Yes	123(97.62)		No	7(10)
Wear PPE when preparing cytotoxic drugs	No	2(1.59)	Wash your hands with soap and water immediately after cleaning cytotoxic spills	Not know	2(2.86)
	Not know	1(0.79)		Yes	67(95.71)
	Yes	114(90.48)		No	3(4.29)
Prepare cytotoxic drugs in BSC	No	8(6.35)	Disposal of cytotoxic drugs waste		
	not know	4(3.17)	Are you responsible for disposal of cytotoxic drugs waste	Yes	49(38.9)
	Yes	87(69.05)		No	77(61.1)
No	38(30.16)	Yes		43(87.8)	
Wash your hands before wearing PPE	Not know	1(0.79)	Wear PPE when disposing cytotoxic drugs	No	6 (12.2)
	Yes	36 (28.57)		Yes	45(91.8)
	No	87(69.05)		No	4(8.2)
Wipe vials or ampules after removing the outer packaging material before reconstitution	Not know	3(2.38)	Wash your hands with soap and water immediately after disposal of cytotoxic spills	Yes	48(98)
	Yes	63(50)		No	1(2)
	No	61(48.41)			
Change your gloves every 30 min when reconstituting cytotoxic drugs	Not know	2(1.59)			
	Yes	119(94.44)			
	No	6(4.76)			
Change torn gloves immediately when handling cytotoxic drugs	No	6(4.76)			
	Not know	1(0.79)			

BSC: biological safety cabinet; **PPE:** personal protective equipment. Values are presented as frequencies, and percentages.

Table 5: The difference in the knowledge and practice scores according to different variables

	Variables	n	Results	p-value
Total knowledge score	Education			
	BSc	113	7.04±1.67	0.051
Total practice score	Post-graduate	13	8.00±1.53	
	BSc	113	73.87±14.06	0.251
Total knowledge score	Post-graduate	13	68.92±19.12	
	Total practice score	Formal training		
Yes		58	7.05±1.55	0.575
No	68	7.22±1.79		
Total practice score	Yes	58	77.66±13.37	0.002*
	No	68	69.69±14.77	
Total knowledge score	Duration (year)			0.963
	< 1.0	60	7.10±1.70	
	1-3	45	7.18±1.64	
	> 3.0	21	7.19±1.75	
Total practice score	< 1.0	60	74.97±13.33	0.207
	1-3	45	73.53±14.29	
	> 3.0	21	68.38±18.23	
Total knowledge score	Preparation weekly			0.023 ¥
	<50	38	7.03± 1.64	
	50-99	34	6.59± 1.86	
	≥100	54	7.57± 1.49	
Total practice score	<50	38	77.00±13.00	0.128
	50-99	34	73.47±13.92	
	≥100	54	70.72±15.83	

Values are presented as mean±SD. *: Significant according to independent t-test; ¥: Significant according to One-Way ANOVA.

In this study, less than half of the participants had received formal training to deal with anticancer medications. However, this result contradicts previous studies on pharmacists in Saudi Arabia (88%) and Canada (66.7%), who reported receiving training on safe drug handling [14,27]. Meanwhile, the current result is cause for concern because it conflicts with safe handling guidelines, which emphasize that all healthcare workers potentially exposed to hazardous drugs must receive safe handling training. The guidelines further state that training should start as

soon as health workers are assigned to an area where hazardous drugs are present and should be updated annually, highlighting the urgency of addressing this issue [12]. Most pharmacists in this study showed fair to good knowledge regarding the safe handling of anticancer drugs. A study in Turkey by Bayraktar-Ekincioglu *et al.* found that more than 50% of pharmacists have sufficient knowledge of cytotoxic drugs and exposure risk [20]. In the Hon *et al.* study in Canada, the level of knowledge ranged between 85.7% and 100% [27]. Despite this knowledge, less

than half of pharmacists answered correctly about using surgical masks that do not protect against cytotoxic aerosols. We need to educate pharmacists on the proper selection and use of PPE to protect against exposure to anticancer drugs, as respiratory protection is an important protection tool. When handling

hazardous drugs, one must not use surgical masks, as they do not provide respiratory protection. Therefore, NIOSH guidelines strongly recommend using a surgical N95 respirator when handling anticancer drugs [17].

Table 6: Multiple comparisons of total scores according to the pharmacist anticancer preparations per week

Dependent Variable	(I) Preparation weekly	(J) Preparation weekly	Mean Difference (I-J)	SE	p
Total knowledge score	1	2	0.43808	0.39	0.496
	2	3	-0.54776	0.35	0.259
		3	-0.98584*	0.36	0.019

* Significant according to Tukey *post hoc* test. <50 preparations/week= 1; 50-99 preparations/week= 2; ≥100 Prep/week= 3.

Additionally, less than half of pharmacists reported that oral anticancer drugs are not safer than intravenous chemotherapy. Therefore, we must implement more education about oral anticancer agents, as they can have similar adverse health effects to injectable agents and require safe handling [28–32].

Table 7: Challenges to safe handling of cytotoxic drugs

Challenges	Results
High workload	72(57.1)
Unavailability of PPE	49(38.9)
Lack of knowledge	29(23)
Comfortability of PPE	22(17.5)

PPE: personal protective equipment. Values are presented as frequencies, and percentages.

In terms of pharmacists' practice, their total practice score ranged from 73.36 to 14.64, with the majority reporting fair to good practices in the safe handling of cytotoxic medications. With respect to the receiving and storage part of practice, the majority of the pharmacists in this study correctly followed the guidelines concerning segregating other medicines from cytotoxic drugs during storage, labeling cytotoxic drugs, and washing their hands after handling cytotoxic drugs. However, only half of the pharmacists reported using PPE while receiving and storing anticancer drugs. This finding is inconsistent with the recommendations and increases the risk of exposure. Gloves must always be worn to avoid occupational exposure to cytotoxic drugs [33–37]. Regarding the preparation aspect of the practice, the majority of pharmacists correctly adhered to the guidelines, which included wearing personal protective equipment (PPE) when preparing cytotoxic drugs, preparing them in a BSC, reconstituting them in a designated room, and immediately changing tattered gloves when handling cytotoxic drugs. However, the majority of pharmacists did not follow the practice of wiping vials or ampules after removing the outer packaging material before reconstitution. Several studies have demonstrated the presence of drug residues on the exterior surfaces of drug vials, indicating the possibility of contamination during cytotoxic drug preparation, even with strict adherence to safety guidelines. Therefore, surface decontamination (i.e., wiping down) of the cytotoxic drug vials may reduce this contamination [36–41]. Additionally, only half of the pharmacists adhered to the recommended practice of changing gloves every 30 minutes. The ISOPP and ASHP standards

recommend changing gloves at least every 30 minutes to enhance protection against skin contact with cytotoxic drugs [12,42]. Another concerning finding in the current study is that compliance with washing hands before wearing PPE was fair. However, it is crucial to practice proper hand hygiene both before donning and after removing any PPE [42]. Regarding the cleaning aspect of their practice, nearly all pharmacists demonstrated good practices by wearing personal protective equipment (PPE) and using cleaning reagents when cleaning areas affected by cytotoxic spills or preparations. Furthermore, most pharmacists reported that they wash their hands immediately after cleaning. Despite these good practices, only 27.14 percent of participating pharmacists reported the availability of cytotoxic kits, which is lower than the result of a Jordanian study by Al-Azzam *et al.*, where 88.1 percent of pharmacists reported using cytotoxic kits [19]. All areas routinely handling cytotoxic drugs should have readily available spill kits containing all necessary materials for cleaning up cytotoxic drug spills [12,42]. Additionally, 55.71% of pharmacists marked the boundary of the cytotoxic spill before starting the clean-up, and 52.86% cleaned from outside the spill area, moving gradually towards the center. As a result, all pharmacists should receive formal cytotoxic spill management training so that they can follow the correct procedure during a cytotoxic drug spill and protect themselves and the environment from contamination [12,42]. In terms of disposal practice, most pharmacists reported segregating cytotoxic waste before disposal. According to ISOPP standards, cytotoxic and contaminated waste are considered hazardous. Therefore, this waste should be placed in separate chemotherapy waste containers that are separate from general waste to safeguard workers from the risk of injury and exposure [12]. Some of pharmacists' demographic characteristics, such as formal training and weekly preparation, significantly influenced their practice and knowledge, respectively. The training can provide and improve safe practices for handling anticancer drugs during receipt, storage, compounding, dispense, transport, administration, cleaning, and disposal. In addition, consider spill management and the correct use and removal of PPE to avoid workplace contamination. Alaraidh *et al.* conducted a study on pharmacists and nurses in Saudi Arabia and found that training positively impacted compliance with safety guidelines during the

preparation and administration of cytotoxic drugs [16]. Another study in Jordan by Al-Azzam *et al.* reported that training on handling chemotherapy was associated with significantly greater compliance with safe practices [19]. Therefore, the results of the current study highlight the necessity of providing training to pharmacists. Pharmacists with more than 100 weekly preparations were more knowledgeable than those with 50–99 preparations. This reflects the positive influence of the number of drug preparations to enhance pharmacists' knowledge about anticancer drugs. Pharmacists identified the high workload as the major challenge or barrier that may prevent them from safely handling cytotoxic drugs, followed by the unavailability of PPE in hospitals. Previous studies found that the high workload prevents workers from adhering to safe handling controls [27, 43]. Ogbaghebriel *et al.* conducted a study in Saudi Arabia, where 38% of pharmacists reported that PPE was not always available [14]. Bayraktar-Ekincioglu *et al.* conducted a study in Turkey, which revealed that 72.9% of pharmacists faced issues with PPE availability [20]. Although the hierarchy of controls for the level of protection puts PPE in the last line of protection, it is necessary to be available to ensure complete protection for healthcare workers in the workplace [17,44].

Study limitations

Some potential limitations of this study include the self-reported nature of the questionnaire data, which may not provide a precise assessment of pharmacists' practices compared to observation and objective recording methods. Also, the study only examined PPE usage in general and did not specify the type of PPE used to handle anticancer drugs.

Conclusion

The majority of participating pharmacists had fair to good knowledge and practice regarding safe handling of cytotoxic medications. However, despite their knowledge and practice in handling cytotoxic medications, some important knowledge and practice gaps exist. To improve knowledge and practices regarding anticancer handling, formal training is necessary.

Conflict of interests

No conflict of interests was declared by the authors.

Funding source

The authors did not receive any source of fund.

Data sharing statement

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

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