ORIGINAL RESEARCH

Patterns of chemotherapy exposure and adherence to safety practices among nurses: A pilot descriptive study

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ABSTRACT

Objective: The aim of the study was to describe the patterns of exposure to chemotherapy and adherence to chemotherapy safe handling practices among oncology nurses.
Methods: A cross-sectional survey design was employed. Oncology nurse participants completed online surveys assessing nurses' demographics, exposure patterns, and their chemotherapy handling practices.
Results: Participants were recruited from two medical centers in the Midwest region in the United States and social media. One hundred and twenty-three nurses completed the surveys. The study findings indicate that nurses are exposed to chemotherapy through various routes, and their use of personal protective equipment (PPE) and chemotherapy-specific equipment is less than the recommended standards. Twenty-one participants (18.1%) experienced chemotherapy exposure, primarily through skin. The participants followed safe chemotherapy handling guidelines 54.5% of the time. The adherence level was lowest during chemotherapy preparation (43.5% of the time) and highest during chemotherapy administration (63.2% of the time). Engineering control equipment (i.e., closed system transfer devices) was used most of the time during chemotherapy preparation and administration. Among PPE, chemotherapy-specific gloves and gowns were used most frequently across all handling procedures, while eye and respiratory protective equipment were used least frequently.
Conclusions: This study highlights the necessity of developing interventions to enhance adherence to safe chemotherapy handling guidelines among nurses at the individual and institutional levels and to address any potential barriers to adherence. Future research is needed to investigate organizational factors and individual factors and their relationships with the patterns of adherence to handling guidelines.

Key Words: Adherence, Antineoplastic agents, Chemotherapy, Hazardous drugs, Nurses, Occupational health

1. INTRODUCTION

Chemotherapy is a type of cancer treatment that works to suppress neoplastic cells.[1] Also, chemotherapy has been used to treat other diseases such as rheumatoid arthritis and multiple sclerosis.[2] Healthcare professionals, including oncology nurses, who are responsible for handling chemotherapy, are susceptible to adverse health effects of exposure to these drugs. This exposure happens when contacting the drugs directly during preparation, administration, and disposal procedures. Routes of exposure are dermal or mucus membrane absorption, inadvertent oral consumption, inhalation of aerosols, or incidental injection with a sharp tool.[3]

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Additionally, exposure to chemotherapy could occur while managing secretions or excretions of patients who received recent chemotherapy treatment.[3]

Examples of health problems associated with occupational exposure to chemotherapy are infertility, fetal abnormalities, low birth weight, premature deliveries, allergic reactions, and the risk of developing cancer.[4] Although the prevalence rate of chemotherapy exposure has declined among oncology nurses since the publication of chemotherapy handling guidelines, nurses continue to experience exposure to these hazardous drugs. A survey conducted with 1,814 oncology nurses revealed that 14% reported incidents of exposure through skin contact or spills within the week prior to the survey administration.[5] Another study indicated that 51 oncology nurses encountered a total of 65 incidents of exposure to chemotherapy spills over two years prior to the study.[6]

Safe handling of hazardous chemotherapy drugs in the United States is guided by the Occupational Safety and Health Administration requirements[7] and recommendations from organizations such as the National Institute for Occupational Safety and Health[3] and the United States Pharmacopeia.[8] These organizations published evidence-based guidelines for minimizing occupational exposure to hazardous drugs among healthcare workers. Based on these guidelines, healthcare institutions are required to implement engineering control measures, such as offering biological safety cabinets and closed system transfer devices.[3,7,8] Biological safety cabinets are confined, ventilated spaces used during drug manipulation to prevent the spread of drug contaminants, while closed system transfer devices are equipment used to transfer the drug during preparation and administration. These devices act as physical barriers to prevent drug leakage. Also, healthcare institutions are required to offer designated personal protective equipment (PPE) that is impermeable to chemotherapy to be used by workers who handle these drugs.[3,7,8] Equally important, healthcare workers must regularly receive education and training on safe handling of chemotherapy including topics on hazardous chemotherapy drug identification, safe handling practices, appropriate use of protective equipment and devices, and exposure incidents management.[3,7,8] On the other hand, healthcare workers' adherence to safe handling guidelines, including using the appropriate control measures and wearing PPE when handling chemotherapy, is crucial to prevent this occupational exposure. However, results from previous studies show that oncology nurses do not always follow safe handling guidelines when handling chemotherapy, such as not using the required chemotherapy-specific devices and protective equipment.[9,10]

Various factors affect the adherence to the safe-handling guidelines among nurses, such as knowledge about chemotherapy safety, the availability and functionality of necessary protective equipment, workload, and the presence of institutional policies related to chemotherapy safety.[6,11] Identifying oncology nurses' patterns of exposure to chemotherapy and handling practices is the first step towards promoting greater adherence to safe handling guidelines. Although prior research has described adherence to safe chemotherapy handling practices among nurses,[9,10] it has not described routes of exposure, or detailed patterns of adherence to safety practices across all chemotherapy handling procedures (i.e., preparation, administration, disposal, and handling of patient fluids). Therefore, the purpose of this study was to describe the patterns of exposure to chemotherapy and adherence to chemotherapy safe handling practices among oncology nurses.

2. METHODS

2.1 Design

A cross-sectional survey design was employed to examine the patterns of exposure to chemotherapy and the handling practices of chemotherapy among oncology nurses. The cross-sectional survey design was selected as it provides an efficient method to collect self-reported data from oncology nurses on their handling practices. Ethical approval was obtained from the university institutional review board. A waiver for consent documentation (signature) was granted. The study procedures and reporting are in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.[12]

2.2 Settings, sample and recruitment

Participants were recruited from two healthcare centers in the Midwest region of the United States. The inclusion criteria were: being an oncology nurse aged 18 years or older, working in oncology departments for a minimum of 3 months, and handling chemotherapy. There were no exclusion criteria. Administrative personnel in participating healthcare institutions were asked to send the study flyer that contained a link to the study information sheet and online surveys to their oncology nurses. Additionally, participants were recruited through social media (i.e., Facebook). A Facebook page was created in which the study flyer with a link to the online survey was posted. This page was broadcasted to reach oncology nurses across the United States.[13] REDCap (Research Electronic Data Capture), a secure application, was used to develop and manage the surveys and collect the data.[14]

2.3 Measures and data collection

Participants completed a questionnaire to assess demographic characteristics and patterns of exposure to chemotherapy. Demographic variables assessed in this survey included age, gender, race, level of education, and years of experience. Patterns of chemotherapy exposure include the number of incidents in the last 12 months and the routes of exposure. Also, participants completed the Revised Hazardous Drug Handling Questionnaire to assess their adherence to chemotherapy guidelines. This questionnaire was initially developed by Martin and Larson[15] and revised by Polovich and Cark[16] to reflect the guidelines for the handling of hazardous drugs by the National Institute for Occupational Safety and Health (NIOSH). The response scale for this questionnaire is a five-point scale (5 = always, 4 = 76%–99% of the time, 3 = 51%–75%, 2 = 26%–50%, 1 = 1%–25%, and 0 = never). The total score was measured by calculating the mean score for all handling procedures with a possible range (0%-100%). The Revised Hazardous Drugs Handling Questionnaire had evidence of reliability and validity.[15, 16] Both questionnaires took approximately 15 minutes to be completed. Each participant was paid $15 as compensation for their time. Data collection occurred between March 2023 and June 2023.

2.4 Data analysis

The Statistical Package for Social Sciences (SPSS) version 28[17] was used to conduct the analysis. Descriptive statistics were conducted to describe the demographic characteristics of the participants, patterns of exposure to chemotherapy, and patterns of handling practices. Missing values were less than 10% for each of the variables. Missingness in the Revised Hazardous Drugs Handling Questionnaire variables were replaced with the mean of the respective variable.

3. Results

3.1 Demographic characteristics

The study involved 123 oncology nurses with an average age of 36.9 (SD = 11.2) years, 12.2 (SD = 11.3) years of nursing experience, and 8.5 (SD = 8.8) years of oncology experience. The majority of participants were female (n = 118, 95.9%), White (n = 113, 91.9%), and had a bachelor's degree (n = 79, 65.3%). Table 1 displays the characteristics of the sample.

Table 1. Participant demographics (n = 123)

Demographic	n	Percent (%)	M	SD
Age			36.86	11.17
Years of nursing experience*			12.17	11.26
Years of oncology experience**			8.51	8.83
Race				
Asian	5	4.1		
White	113	91.9		
Other	5	4.1		
Gender				
Female	118	95.9		
Male	5	4.1		
Education*				
Diploma	5	4.1		
Associate degree	21	17.4		
Bachelor's degree	79	65.3		
Master's degree or post Master's degree or certification	16	13.2		

*Number of missing values = 2; **Number of missing values = 3.

3.2 Patterns of exposure to chemotherapy

During the 12 months prior to data collection, twenty-one (18.1%) participants experienced an exposure incident. Of them, 12 participants reported one chemotherapy exposure incident. The highest number of exposure incidents was 20 incidents reported by one participant. The most frequent routes of exposure were skin absorption (n = 18, 14.6%) and inhalation (n = 9, 7.3%), followed by direct injection with a sharp object (n = 7, 5.7%) and inadvertent hand to mouth ingestion (n = 6, 4.9%). Five (4.1%) participants reported exposure through mucus membrane absorption. Table 2 presents more details on the patterns of exposure to chemotherapy.

3.3 Patterns of handling practices

The participants reported the frequency of their adherence to chemotherapy guidelines using the percent of the time they adhered to each of these guidelines. In general, the par-

ticipants adhere to safe chemotherapy handling guidelines 54.5% of the time (SD = 21.6; range 0.0%-100%). Nurse participants adhere to the guidelines 43.5% of the time (SD = 38.1) while preparing chemotherapy, 63.2% of the time (SD = 21.1) while administering chemotherapy, 49.8% of the time (SD = 26.1) when disposing of chemotherapy, and 45.3% of the time (SD = 26.4) when handling contaminated patient secretions and excretions. Thirteen nurse participants (10.6%) reported that they prepare chemotherapy drugs, 118 participants (95.9%) administer chemotherapy, 89 participants (72.4%) dispose chemotherapy waste, and 87 participants (70.7%) handle chemotherapy contaminated patient body fluids.

Table 2. Patterns of exposure to chemotherapy

Variable	n	Percent (%)
Frequency of exposure in the past 12 months*		
0	95	81.9
1	12	10.3
2	1	0.9
3	1	0.9
4	1	0.9
5	1	0.9
6	3	2.6
10	1	0.9
20	1	0.9
Skin absorption		
No	105	85.4
Yes	18	14.6
Mucous membrane absorption		
No	118	95.9
Yes	5	4.1
Hand to mouth ingestion		
No	117	95.1
Yes	6	4.9
Inhalation		
No	114	92.7
Yes	9	7.3
Direct injection with a sharp object		
No	116	94.3
Yes	7	5.7

*Number of missing values = 7

During chemotherapy preparation, participants reported using engineering control devices such as the closed system transfer devices at 84.6% of the time and biological safety cabinets at 60.0% of the time. Regarding the PPE, nurse participants use chemotherapy-specific gloves at 61.6% of the time, chemotherapy-specific gowns at 58.4% of the time, eye protection at 21.6% of the time, and respiratory protection at 32.4% of the time. Approximately half of the instances, participants reported using double gloves when preparing chemotherapy. Unfortunately, they reported practices that should not be performed when preparing chemotherapy, such as using gloves or gowns that are not chemotherapy-specific (50.8% of the time) and reusing disposable gowns (24.6% of the time).

With regard to chemotherapy administration, the most frequently followed guideline was using closed system transfer devices (96.8% of the time), followed by wearing gowns specific for chemotherapy (91.2% of the time) and wearing gloves specific for chemotherapy (86.2% of the time). At 69.0% of instances, nurse participants wear double gloves when administering chemotherapy. The least performed safety practices were wearing eye protection at 40.6% of instances and wearing respiratory protection at 29.2% of instances. Unsafe practices reported during chemotherapy administration were reusing disposable gowns (36.6% of the time) and using gowns and gloves that are not specific for chemotherapy (13.2% and 21.6% of the time respectively).

The percentage of time nurses adhered to safety practices when disposing chemotherapy was as follows: 81.2% for wearing chemotherapy-specific gloves, 59.6% for wearing chemotherapy-specific gowns, 58.2% for using double gloves, 25.2% for applying respiratory protection, and 25.0% for using eye protection. In 31.2% of instances, nurses mentioned that they reused disposable gowns, and in 38.6% of instances, they reported using gowns or gloves that were not specific for chemotherapy.

When handling contaminated patient excretions, the most frequently followed guideline is wearing chemotherapy-specific gloves (82.0% of the time), followed by wearing double gloves (50.8% of the time). Participants mentioned wearing chemotherapy-specific gowns at 45.0% of the time, respiratory protection at 24.6% of the time, and eye protection at 24.2% of the time. The nurse participants indicated that they use non-chemotherapy specific gowns (23.4% of the time), non-chemotherapy specific gloves (26.0% of the time), and reused disposable gowns (16.0% of the time), when handling contaminated patient excretions. Table 3 displays the patterns of chemotherapy handling practices across all handling procedures.

4. Discussion

This study provides insights into the patterns of exposure to chemotherapy and handling practices among oncology nurses. Generally, the study findings indicate that nurses are exposed to chemotherapy through various routes, and their use of PPE and chemotherapy-specific equipment is less than

the recommended standards.

Table 3. Patterns of chemotherapy handling practices

Safe Handling Practices	Percentage of the Time Nurses Adhere to Safe Practices When Handling Chemotherapy	
	M (%)	SD
Chemotherapy Preparation		
Biological safety cabinet	60.0	2.48
Closed system transfer device	84.6	1.88
Gloves specific to chemotherapy	61.6	2.53
Gloves not specific to chemotherapy	26.2	2.02
Double gloves	50.8	2.26
Gowns specific to chemotherapy	58.4	2.47
Gowns not specific to chemotherapy	24.6	1.92
Re-using disposable gowns	24.6	1.88
Eye protection	21.6	1.75
Respiratory protection	32.4	2.26
Chemotherapy Administration		
Closed system transfer device	96.8	0.69
Gloves specific to chemotherapy	86.2	1.59
Gloves not specific to chemotherapy	21.6	1.87
Double gloves	69.0	1.88
Gowns specific to chemotherapy	91.2	1.03
Gowns not specific to chemotherapy	13.2	1.42
Re-using disposable gowns	36.6	2.06
Eye protection	40.6	2.04
Respiratory protection	29.2	1.87
Chemotherapy Disposal		
Gloves specific to chemotherapy	81.2	1.75
Gloves not specific to chemotherapy	25.2	1.96
Double gloves	58.2	2.04
Gowns specific to chemotherapy	59.6	2.13
Gowns not specific to chemotherapy	13.4	1.40
Re-using disposable gowns	31.2	2.02
Eye protection	25.0	1.85
Respiratory protection	25.2	1.77
Handling Chemotherapy-Contaminated Secretions and Excretions		
Gloves specific to chemotherapy	82.0	1.75
Gloves not specific to chemotherapy	26.0	2.00
Double gloves	50.8	2.12
Gowns specific to chemotherapy	45.0	2.28
Gowns not specific to chemotherapy	23.4	1.64
Re-using disposable gowns	16.0	1.63
Eye protection	24.2	1.71
Respiratory protection	24.6	1.68

The rate of exposure to chemotherapy among nurses in this study (18.1%, n = 116) is similar to the rate reported by nurses in previous studies . In a study conducted by Friese et al. in 2012,[18] 16.9% (n = 1,339) of nurses indicated that they were exposed to chemotherapy in the previous year. In a more recent study completed in 2017 by Dejoy et al.,[5] 14% of 1814 nurses reported incidents of chemotherapy exposure or spills in the week prior to the study. This relatively consistent rate of exposure to chemotherapy reported by nurses' overtime warrants evaluating implemented control measures and adopting more effective interventions to reduce this hazardous exposure among nurses. Among different routes of exposure, skin absorption and inhalation were the most frequent routes of exposure in this study, which corresponds to what is presented in the literature.[3] These findings highlight the need for interventions to address the causes of these exposures and to prioritize training on inhalation and dermal exposure prevention.

A safe minimum limit of exposure has not been established yet for all hazardous drugs, including chemotherapy. Therefore, an approach to keep exposure as low as possible is recommended.[3] Adhering to all safety practices including the use of appropriate PPE and chemotherapy-specific equipment is essential to minimize the exposure to the lowest level possible. Unfortunately, the adherence to the guidelines reported in this study is not optimal (approximately 55% of the time), and it is lower than that reported by nurses in a prior work by Abu-Alhaija et al.,[19] which was 65.8% of the time. Given the level of adherence to the guidelines in the present study, the rate of chemotherapy exposure in this sample is not surprising. This points out the importance of healthcare organizations ensuring compliance with chemotherapy handling guidelines, which could be achieved by stressing the use of PPE, ensuring chemotherapy equipment is readily available, and conducting structured training programs to help nurses follow the guidelines properly and reduce occupational exposure. Although there were no large variations in the adherence level to the guidelines across chemotherapy handling procedures, the adherence level was lowest during chemotherapy preparation (43.5% of the time) and highest during chemotherapy administration (63.2% of the time), with unsafe practices reported by participants in all handling procedures (e.g., reusing disposable gown, using non-chemotherapy specific equipment). Although a low percentage of nurses prepare chemotherapy drugs, training programs that emphasize safe handling guidelines during preparation are important for ensuring proper use of PPE and appropriate equipment selection. Engineering control equipment (i.e., closed system transfer devices) was used most of the time during chemotherapy preparation and administration. Among PPE, chemotherapy-specific gloves and gowns were used most frequently across all handling procedures, while eye and respiratory protective equipment were used

least frequently. These practice patterns are similar to the patterns observed in previous studies.[9, 10, 20, 21] These results suggest the need to emphasize the use of eye and respiratory protection as important protective equipment in chemotherapy handling procedures to protect nurses from inhalation and splash risks.

The barriers that contribute to poor adherence to chemotherapy guidelines among nurses are multifactorial and are related to knowledge and training on safe handling practices, personal health beliefs, perceived workplace safety climate, workload,[11, 22] and the availability of and functionality of chemotherapy-specific equipment.[6] Accordingly, future research needs to develop multilevel intervention programs to address these factors and promote adherence to chemotherapy handling guidelines. These interventions need to include approaches that target individual risk perception and the organizational safety climate to improve compliance with the guidelines.

4.1 Limitations

Several limitations should be acknowledged in this research study. This study focused on describing nurses' practices when handling chemotherapy and did not examine factors and barriers affecting nurses' adherence to these safety practices, which would limit the interpretability of the results. Further, recruiting a small sample in this study would limit the generalizability of the findings. Particularly, only a small number of participants reported preparing chemotherapy drugs (n = 13), which likely reflects institutional practices in which chemotherapy preparation is performed by pharmacy personnel. Consequently, the descriptive statistics for chemotherapy preparation should be interpreted cautiously. Selection bias is a potential limitation because participants were recruited using convenience sampling through administrative personnel and social media. Another limitation is the potential for social desirability bias, as data were collected through self-report.

In addition, most participants were White Female nurses, which would further limit the generalizability of the study findings to nurses with different demographic characteristics. Recall bias and inaccuracies in reporting are limitations because of asking the participants to recall incidents of chemotherapy exposure over the past 12 months. Also, the responses related to chemotherapy exposure may reflect only the incidents that the participants perceived as exposure incidents.

4.2 Implication for practice and research

This study investigated the patterns of exposure to chemotherapy and handling practices among oncology nurses. The reported exposure to chemotherapy among participants highlights the presence of ongoing occupational hazards in oncology nursing units. Based on the results, the most frequent exposure routes, skin absorption and inhalation, indicate the necessity for tailored interventions to decrease the risks of exposure through these routes. Adherence to chemotherapy handling guidelines is still suboptimal. This emphasizes the need for developing and establishing comprehensive training programs, stricter enforcement of safety protocols, and enhanced accessibility to and availability of PPE, especially chemotherapy-specific gloves, gowns, eye protection, and respiratory protection.

The findings revealed unsafe practices during chemotherapy handling, such as reusing disposable gowns and using non-chemotherapy-specific PPE. These unsafe practices should warrant healthcare institutions to implement robust monitoring systems to ensure compliance with handling guidelines and to address any potential barriers, such as insufficient availability of PPE or knowledge deficit about safe handling.

Future research needs to examine the possible barriers for poor adherence to safe handling guidelines. Also, research efforts should be directed to develop a comprehensive model that illustrates organizational factors as well as individual factors and how they interact to explain the pattern of adherence to safe chemotherapy handling guidelines. Research studies on this area need to use sampling and recruitment methods that encompass diverse settings and participant demographics to enhance the generalizability of the findings.

5. Conclusion

Despite the presence of the chemotherapy handling guidelines, nurses are still exposed to chemotherapy through various routes. Their use of PPE and chemotherapy-specific equipment is less than the recommended standards. Future efforts should be directed to reduce chemotherapy exposure among nurses, including adopting initiatives, developing policies, and ensuring the availability and functionality of necessary protective equipment to promote adherence to safe chemotherapy handling guidelines. Further research is needed to develop conceptual models that explain how organizational and individual factors interact and their relationships with the pattern of adherence to safe handling guidelines.

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Authors contributions

Dr. Abu-Alhaija contributed to the conceptualization and design of the study, data acquisition, data analysis, inter-

pretation of the data, project administration, and drafting and revising the manuscript. Dr. Al-Faraj contributed to the interpretation of the data and drafting and revising the manuscript. Dr. Almallah contributed to the interpretation of the data and drafting and revising the manuscript. Dr. Gillespie contributed to the conceptualization and design of the study, interpretation of the data, overall supervision, and revising the manuscript. All authors read and approved the final manuscript.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

INFORMED CONSENT

Obtained.

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The Publication Ethics Committee of the Association for Health Sciences and Education. The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

DATA SHARING STATEMENT

No additional data are available.

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