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The Factors That Influence Chemotherapy Exposure Among Nurses: An Integrative Review

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Abstract

Background: Exposure to chemotherapy is an occupational hazard predisposing nurses to severe health effects. The purpose of this integrative review was to identify the recent literature describing the risk factors for occupational exposure to chemotherapy among nurses.

Methods: The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was employed to conduct the review. The databases searched were Scopus, PubMed, and CINAHL using the search terms “chemotherapy”, “drugs”, “exposure” and “nurses”. Included articles were published between January 2010 and February 2022, were published in peer-reviewed journals for research conducted in the United States, and written in English language. Excluded articles were studies that did not involve nurses in their samples. Review articles, books, theses, and dissertations were excluded as well. Johns Hopkins Nursing Evidence Based Practice Model was used to assess the level of evidence from the reviewed studies.

Findings: Fourteen studies were included in this review. Ten studies were rated on evidence level III, two on evidence level II, one on evidence level I, and one on evidence level V. The main risk factors for occupational exposure were nurses’ knowledge of chemotherapy handling guidelines, nurses’ adherence to using the personal protective equipment, nurses’ health beliefs regarding chemotherapy exposure, and workplace related factors such as workload and managerial support.

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Contributions:

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Conclusion: Addressing the identified risk factors would protect nurses from chemotherapy exposure. More research on nurses' health beliefs regarding chemotherapy exposure and the cues to adhere to chemotherapy handling guidelines in the work environment is needed.

Keywords

chemotherapy; drugs; exposure; integrative review; nurses

Background

Chemotherapeutic drugs have been increasingly prescribed to treat patients with cancerous and non-cancerous conditions. (Centers for Disease Control and Prevention [CDC], 2018). The serious side effects of chemotherapy on patients are well documented (American Cancer Society, 2020) and nurses and other healthcare workers who handle chemotherapy are at risk for severe health effects due to exposure to these drugs (Polovich, 2016). Exposure to chemotherapy occurs through skin or mucus membrane contamination, hand to mouth ingestion, sharp object injection, or through inhalation. Exposure to chemotherapeutic drugs usually occurs during the drug handling procedures including preparation, administration to patients, disposing, or managing spills (United States Pharmacopeial Convention [USP], 2020).

According to the National Institute for Occupational Safety and Health (NIOSH, 2009), the approximate number of healthcare workers who were exposed to hazardous agents including chemotherapy in the United States was 8 million. These estimates have not been updated in the recent literature. However, there are research studies to assess the rate of chemotherapy exposure among oncology nurses. For example, in 2011, the study by Friese and colleagues shows that 16.9% of the nurse participants reported that they had been exposed to chemotherapy at least one time in the previous year. The findings of a survey of chemotherapy exposure among nurses who administer chemotherapy show that 14% of 1,814 nurse participants reported being exposed to chemotherapy or experiencing spills in a period of seven days (Dejoy et al., 2017). Additionally, a more recent study indicates that across 12 oncology settings, 61 chemotherapy spill incidents and 11 chemotherapy exposure incidents while cleaning the spills were reported by 51 nurse participants over a period of two years (Friese et al., 2020).

Since chemotherapy is among the treatments of choice for cancer disease (CDC, 2018), it is rationally expected that the rate of chemotherapy exposure among nurses increases, as the number of cancer cases is rising. According to Weir et al. (2021), the estimated number of cancer cases will increase by 49% in 2050 relative to that number in 2015. The serious health effects of exposure to chemotherapy on nurses and other healthcare professionals are well documented and include genotoxicity (Bouraoui et al., 2011), frequent miscarriages, infertility, congenital abnormalities (Connor, et al., 2014), and the increased the risk to develop cancer (NIOSH, 2016).

The first safe chemotherapy handling guidelines were published by Occupational Safety and Health Administration in 1986 (OSHA,1986). Over the years, these guidelines have been updated and additional guidelines for hazardous drugs handling were published by other

organizations such as the Centers for Disease Control and Prevention, the National Institute of Health, Oncology Nursing Society, and the United States Pharmacopeial Convention (NIOSH, 2004). Generally, chemotherapy handling guidelines include strategies at various levels in the hierarchy of control to prevent chemotherapy exposure among oncology healthcare workers such as, hazard identification, practices for hazardous drug storage, preparation, administration, and disposal, correct procedures for managing spills, and using the personal protective equipment appropriately (USP, 2020). Despite the presence of chemotherapy handling guidelines, nurses report incidents of chemotherapy exposure (Dejoy et al., 2017; Friese et al., 2015, Friese et al., 2019). The purpose of this integrative review was to identify the recent literature describing the risk factors for occupational exposure to chemotherapeutic agents among nurses.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021), was used to review the literature on the factors that affect nurses' exposure to chemotherapy. The databases searched were Scopus, PubMed, and CINAHL using the search terms "chemotherapy", "drugs", "exposure" and "nurses". The search was done in February 2022.

Articles were included in the review if they were published in peer reviewed journals for research studies conducted in the United States and published between January 2010 to April 2022. Studies published in this range were included to reflect the most recent conditions in the United States healthcare system in the light of the current guidelines for chemotherapy handling. The reason to include United States only studies is to study the factors that influence chemotherapy exposure among nurses who follow consistent guidelines to handle chemotherapy drugs. Additionally, included articles were published in the English language for original research studies. Excluded articles were for studies on chemotherapy exposure that involved samples of healthcare workers without including nurses. Books, review articles, conference abstracts, theses, and dissertations were excluded as well.

Results

The PRISMA chart (figure 1) illustrates the process of this literature review (Page et al., 2021). The initial search returned 124 articles in PubMed, 90 articles in Scopus, and 67 articles in CINAHL. Excluding duplicates (n=59) resulted in 222 articles. The titles and the abstracts for the remaining 222 articles were screened. Of them, 86 were studies on topics not related to chemotherapy exposure, 55 were not original research studies, 59 were studies conducted outside the United States, 4 were not published in the English language, and 4 were study articles did not involve nurses in the studies' samples. Therefore, the articles that were covered in this review were 14 articles that met all the inclusion criteria. Record screening and data synthesis were done by the principal investigator and then reviewed by the other investigators independently. Data extraction was done in the light of the focus of this review. Extracted data were presented in table 1. This table presents information

related to the studies' purposes, samples' characteristics, the studies' research designs, the instruments used, the quality of evidence for each study, and the significant findings.

Generally, the purposes of the studies were to describe chemotherapy handling practices among healthcare workers, identify the trends of using PPE when handling chemotherapy among healthcare workers, identify the factors that influence these workers' adherence to the chemotherapy handling guidelines, test interventions targeted to promote the adherence to chemotherapy handling guidelines among healthcare workers, and examine the extent of chemotherapy contamination in oncology settings. The designs for the reviewed studies are quantitative (n=11), mixed methods design (n=2), and case report analysis (n=1). The quantitative designs are randomized control trial (n=1), pretest and post-test quasi experimental design (n=2), and descriptive cross-sectional designs (n=8). The size of samples recruited in the reviewed studies ranged from 34 to 40,420. All the studies' samples were recruited through convenience sampling.

In the cross-sectional design studies, questionnaires were used to collect data related to the studies' variables. These studies describe nurses' practices during chemotherapy handling and the factors influencing them. The studies by Boiano et al. (2014), Boiano et al. (2015), and Polovich, and Martin (2011), identified the pattern of work practices and using the PPE while handling chemotherapy among nurses as well as the factors that affect these practices and result in chemotherapy exposure. These studies show that nurses' adherence to the guidelines while handling chemotherapy is lower than the recommended level. The factors influencing the exposure identified are insufficient knowledge on chemotherapy exposure, and non-adherence to applying PPE according to the guidelines (Boiano, et al., 2014; Boiano, et al., 2015; Polovich, & Martin, 2011).

The studies by Callahan et al. (2016), He et al. (2017), Polovich, and Clark (2012), and Reeves et al. (2013) addressed the factors that influence nurses' exposure to chemotherapy. According to these studies, some of the factors influencing the exposure are managerial support, interpersonal influences, nurses' health beliefs, workload, knowledge on chemotherapy exposure, nurses' self-efficacy to adhere to the guidelines, and the presence of institutional policies that reflect the current guidelines (Callahan et al. 2016; He, et al., 2017; Polovich, & Clark, 2012; Reeves, et al., 2013). The study by Lawson et al., (2019) identified the practices of pregnant and non-pregnant nurses during chemotherapy handling that could lead to exposure; this study found that not all pregnant and non-pregnant nurses adhere to the guidelines when handling chemotherapy. Additionally, the study by Menonna-Quinn et al. (2019) identified the pattern of using the PPE during chemotherapy handling on a sample of inpatient and outpatient oncology nurses. They found that the usage of PPE among inpatient and outpatient nurses is lower than the recommended level with more adherence to the recommendations was noted in the inpatient oncology nurse group. Additionally, they found that the most frequently used PPE in both groups was the disposable gloves and the lowest frequently used PPE among them is the eye protection equipment.

Crickman and Finnell (2017) conducted a quasi-experimental study that tested an evidence-based program which included an educational component on chemotherapy exposure to promote nurses' safe handling of chemotherapy. The program also included placing

standardized signs to identify chemotherapy drugs as well as showing messages to nurses within the electronic health record (HER) system providing information on the correct PPE to use when handling specific chemotherapy drugs. The intervention program improved nurses' knowledge on chemotherapy exposure and their adherence to the correct sequence when removing PPE as compared to before the intervention.

The mixed methods study by Colvin et al. (2016) aimed to assess nurses' awareness on the degree they adhere to safe chemotherapy handling guidelines. In this study, the authors compared observation findings regarding nurses' practices when handling chemotherapy with nurses' self-report findings. The nurse participants in this study perceived the frequency of themselves performing chemotherapy handling practices different from the observed frequencies.

In the randomized controlled trial by Friese et al. (2019), an online educational intervention was tested on a sample of oncology nurses who handle chemotherapy. The results of the study show that there was no difference between the intervention and control groups in the scores for personal protective equipment (PPE) usage, chemotherapy exposure knowledge, or the perceived barriers to adhere to using the PPE.

In the case report study, Friese et al. (2020) conducted analysis of unpublished data from a previous study (Friese et al., 2019) to characterize the incidents of chemotherapy spillage and to assess the usage of PPE among oncology nurses when managing these spills. The result of this study indicates that oncology nurses experience frequent chemotherapy spills. However, the level of adherence to using the PPE is less than the optimal level. Moreover, the availability and the functionality status of the chemotherapy-specific transfer devise is a factor influencing nurses' exposure to chemotherapy.

Graeve et al. (2017) tested a quality improvement intervention which involved making modifications in the work environment to protect healthcare professionals against chemotherapy exposure. For example, they moved the location of chemotherapy gowns from a single locked room to several more accessible locations in the unit. Also, they posted alert signs to remind the staff on safe practices when handling chemotherapy. The intervention resulted in improving staff's self-efficacy to use PPE, their perceived risks of chemotherapy exposure, and their knowledge on safe chemotherapy handling guidelines.

Data Evaluation

The quality of the studies was evaluated using Johns Hopkins Nursing Evidence Based Practice Model. In this system, the level of evidence for studies' designs ranges from level I to level V; where level I refers to the highest level of evidence, and level V refers to the lowest level of evidence among study designs. According to this system, the quality of the studies in each level is either high, good, or low quality (Dang et al., 2022). The quality of the studies is evaluated based on a set of criteria such as, identifying the gap in the literature, presenting the purpose of the study, sample size, describing the data collection instruments, the reliability and validity of the instruments used, and others. In this review, ten studies were rated on evidence level III, two on evidence level II, one on evidence level I, and

one on evidence level V, and they were all of good quality. None of the studies were of high quality due to insufficient reported details related to the reliability and validity of the studies' instruments. Additionally, the majority of the articles do not list detailed criteria for including and excluding participants. Moreover, the mixed methods studies do not contain enough descriptions on the exploratory component.

Discussion

The purpose of this integrative review was to describe the state of science on the factors that influence the exposure to chemotherapeutic drugs among nurses who handle them. By analyzing the current literature on the factors that influence nurses' exposure to chemotherapy, this integrative review would help to provide an explanation of the high rate of exposure despite the presence of the guidelines. The reviewed studies discussed the factors that influence nurses' exposure to chemotherapy. Most of the studies had consistent findings on the topic. The two most frequently reported factors that influence nurses' exposure to chemotherapy are nurses' knowledge on the precautionary guidelines and nurses' adherence to use the personal protective equipment (PPE) when handling chemotherapy (Boiano, et al., 2014; Boiano, et al., 2015; Callahan et al., 2016; Crickman & Finnell, 2017; Friese et al., 2019; Friese et al., 2020; He, et al., 2017; Polovich, & Clark, 2012; Polovich, & Martin, 2011; & Reeves, et al., 2013).

Other discussed factors are nurses' health beliefs, and workplace-related factors, such as nurses' high workload, presence of cues to adhere to the recommendations in the work environment, presence of institutional policies on chemotherapy handling precautions, presence of medical monitoring programs for chemotherapy exposure, using closed-system transfer devices when preparing and administering chemotherapy, interpersonal influences, managerial support and participating in decision making (Boiano, et al., 2014; Boiano, et al., 2015; Callahan et al. 2016; Friese et al., 2019; Friese et al., 2020; He, et al., 2017; Polovich, & Clark, 2012; Reeves, et al., 2013).

Nurses Knowledge on Chemotherapy Handling Guidelines

Nurses' knowledge on chemotherapy handling precautions is critical to control the rate of exposure to these hazardous drugs. Half of the studies discussed the importance of educating nurses on the precautionary guidelines, as this enhances their adherence to these guidelines (Boiano, et al., 2014; Boiano, et al., 2015; Callahan et al. 2016; Crickman & Finnell, 2017; Friese et al., 2019; Friese et al., 2020; Polovich, & Clark, 2012; Polovich, & Martin, 2011). Crickman & Finnell (2017) provided an example of an educational program that was effective in improving nursing knowledge on chemotherapy exposure; their program included modules related to the ways of identifying hazardous drugs, the routes of exposure to them, side effects of the exposure, and the recommended precautions on handling them. Equally important, this emphasized the importance of combining training and debriefing feedback pertaining to the nurses' performance. (Crickman & Finnell, 2017)

Education and training should include all safe chemotherapy handling guidelines, such as storing chemotherapy drugs in special cabinets, using closed system transfer devices when preparing and administering chemotherapy, the procedure to manage chemotherapy spills,

and other measures (USP, 2020). Central to training nurses on handling chemotherapy is the correct technique of applying and removing PPE. According to NIOSH (2016), using PPE is one of the important measures to protect against chemotherapy exposure. In the study by Crickman and Finnell (2017), all the observed nurses applied the chemotherapy PPE correctly, but only 11% of them removed the PPE using the correct sequence. Interestingly, after the introduction of the educational program intervention, the percent of nurses who showed the correct sequence of PPE removal improved to 80%.

Nurses' Adherence to Using the Personal Protective Equipment

Using personal protective equipment is the least effective method to control exposure to hazards in the hierarchy of control as it does not eliminate the risk of exposure, consumes time and resources, requires training on using them, affects human sensation and performance, and requires workers' adherence to using them (Morris & Cannady, 2019). However, using personal protective equipment (PPE) is one of the primary preventive strategies to protect against the exposure to chemotherapy among nurses. When handling chemotherapy, essential PPE includes chemotherapy gloves, chemotherapy gowns, face shields, respiratory protection, and eyes and face protection (USP, 2020). In the reviewed studies, several barriers have been found preventing nurses from using PPE when handling chemotherapy. For example, insufficient knowledge on the precautionary guidelines makes some nurses underestimate the importance of applying PPE (Crickman & Finnell, 2017)or underestimate the importance of applying all of them when handling chemotherapy. In the study by Chaudhary and Karn (2012), 92% of nurse participants reported using chemotherapy gloves when handling chemotherapy, but less than 5% reported using face shields or respiratory masks. Moreover, the study by Menonna-Quinn et al. (2019) shows that during chemotherapy handling, the disposable gloves are the most frequently used PPE by oncology nurses, while eye protection is the lowest PPE used by them.

Furthermore, the respondents in the study by Boiano et al. (2014) reported that considering the exposure to chemotherapeutic drugs as minimal was the most significant barrier to wearing PPE. However, they would not underestimate using PPE if they knew that there is no safe level of exposure to chemotherapy (Boiano, et al., 2014). This points out the importance of educating nurses on chemotherapy hazards and how to protect themselves from the exposure. Another significant barrier to use PPE is the high workload (He, et al., 2017). In cases of high workload, nurses may not be able to apply all required PPE when handling chemotherapy under the pressure of time. In addition, negative interpersonal influences are considered barriers to using PPE (He, et al., 2017). These two factors will be discussed further in later sections.

Nurses' Health Beliefs

Three of the reviewed studies investigated the relationship between nurses' health beliefs with regard to adherence to the guidelines as preventive health behaviors and their adherence to these guidelines when handling chemotherapy. According to the Health Belief Model, nurses' health beliefs regarding chemotherapy exposure influence their adherence to these guidelines when handling chemotherapy. These beliefs include the perceived seriousness of chemotherapy exposure, the perceived susceptibility to experience the side effects of the

exposure, the perceived benefits of adhering to the safe chemotherapy handling guidelines, the perceived barriers to adhere to these handling guidelines, as well as the perceived self-efficacy to follow to these guidelines (Becker, & Maiman, 1975; Champion & Skinner, 2008; Rosenstock, 1974). Moreover, according to the model, the modifying factors such as knowledge, gender, age, and level of education influence an individual's health beliefs (Becker, & Maiman, 1975; Champion & Skinner, 2008; Rosenstock, 1974).

The results of Polovich and Clark (2012) study show that there are relationships between nurses' adherence to the guidelines when handling chemotherapy and each of the nurses' health beliefs; the perceived risks of chemotherapy exposure, the perceived self-efficacy to use the PPE, and the perceived barriers to use the PPE. Interestingly, the study found that the level of nurses' knowledge on chemotherapy exposure is high, but it is not associated with the adherence to the guidelines when handling chemotherapy. According to their study, nurses' health beliefs are what influence the adherence to the guidelines not the exposure knowledge itself. This could be interpreted in the light of the Health Belief Model. According to the model, knowledge is a modifying factor that influences the health beliefs, not the health behaviors. The health beliefs, in turn, influence the health behaviors.

Similarly, the study by Callahan et al. (2016) indicates that nurses who have high perceived self-efficacy to use the PPE and those who have high perceived risks to chemotherapy exposure effects are more likely to adhere to the guidelines when handling chemotherapy. Thus, the interventions that positively influence these health beliefs would help in decreasing the rates of chemotherapy exposure among nurses. An example of these interventions is the quality improvement program that was implemented in the study by Graeve et al. (2017) and resulted in increasing nursing self-efficacy to use the PPE and the perceived risks of exposure.

Two of the reviewed studies addressed the relationship between nurses' demographic characteristics and the adherence to chemotherapy handling guidelines, both studies found no relationship between nurses' demographic characteristics and nurses' adherence to chemotherapy handling guidelines (Polovich, & Clark, 2012; Polovich, & Martin, 2011). In the light of the Health Belief Model, these demographics are modifying factors that influence nurses' health beliefs. However, no studies have been found focusing on the relationships between nurses' demographics and nurses' health beliefs. Also, no study has been identified investigating the effects of other health beliefs in the Health Belief Model such as the perceived benefits of adhering to the guidelines, and the perceived susceptibility to acquire the negative health effects of chemotherapy exposure.

Workplace Related Factors

Workplace related factors has been mentioned in several of the reviewed studies (n=6). These factors include:

Nurses' high workload.—This factor has been identified in three of the reviewed studies (Callahan et al. 2016; He, et al., 2017; Polovich & Clark, 2012). High workload resulting from nursing shortage is associated with an increased risk for chemotherapy exposure

(Friese et al., 2011); nurses with a high workload would have less time to adhere to all the recommendations when handling chemotherapy.

Presence of cues to adhere to the recommendations in the work environment.—As stated in the Health Belief Model, these cues are important and can influence nurses to adhere to the recommendation when handling chemotherapy (Becker, & Maiman, 1975; Champion & Skinner, 2008; Rosenstock, 1974). Examples of these cues are many, but few have been identified in the reviewed studies. In the study by Crickman and Finnell (2017), the authors implemented an intervention program and used signs to help nurses in identifying chemotherapy drugs as well as using e-reminders for nurses on the correct PPE to apply when handling chemotherapy. The program improved nurses' knowledge on chemotherapy exposure and their adherence to using the correct technique when removing the PPE. Similar strategy was implemented in the quality improvement program in the study by Graeve et al. (2017), where alerts were posted in the oncology department to remind nurses to use the disposable chemotherapy gowns only one time. The program was effective in improving nurse self-efficacy to use PPE, perceived risks, and the knowledge on chemotherapy precautions.

The study of Polovich and Cark (2012) revealed that there is insufficient formal monitoring from nursing managers for nurses' adherence to the guidelines, this could be a contributing factor that makes nurses undermine the importance of adherence to the guidelines when handling chemotherapy. Another example of the cues to action in this context has been identified in the study by Reeves et al. (2013); in this example, nurses were required to put contact precaution alerts for patients who received chemotherapy.

Presence of institutional policies on chemotherapy handling guidelines.—These policies are considered the guide for nurses during their practice, and upon which their practice will be evaluated. This factor has been identified in two of the reviewed studies (Polovich & Clark, 2012; Reeves, et al., 2013). Unfortunately, both studies revealed that some institutional policies were not updated to reflect the current guidelines. Therefore, systematic updating to these guidelines as well as sharing them with nurses are necessary to protect nurses against the risk of chemotherapy exposure.

Presence of medical monitoring programs for chemotherapy exposure.—Medical monitoring programs are recommended by USP (2020) as a strategy to protect healthcare workers against chemotherapy exposure. These programs include assessment of physical symptoms and blood and urine tests to assess the extent of chemotherapy exposure among nurses (Boiano, et al., 2015). The reasons why some nurses and other healthcare workers do not participate in these programs are the lack of these programs in their work institutions or the decline in participation in these programs by the healthcare workers (Boiano, et al., 2015). Declining from participating in these programs could be due to individual factors and health beliefs that make them underestimate the importance of these health preventive behaviors.

Despite the importance of the medical monitoring programs to control occupational exposure to hazardous substances, controversy exists on many aspects of these programs.

Certain criteria should be considered to initiate monitoring programs to guarantee the efficacy of these programs such as the sensitivity, specificity, the predictive values of the tests that will be performed, and the prevalence of the health conditions of concern (Gochfeld, 2009). Often, the decision to perform medical monitoring programs is based on a risk-benefit analysis. Examples of risks associated with the implementation of these programs are the side effects of the screening tests and unnecessary early treatment on the workers and the time and monetary costs of these programs on the industry (Vearrier & Greenberg, 2017). However, consensus on the benefits of these programs is present as a preventive public health activity (Vearrier & Greenberg, 2017). In the context of oncology nurses who regularly handle several types of hazardous chemotherapy drugs at work, these programs are essential to detect and treat early signs of chemotherapy exposure (USP, 2020).

Using closed-system transfer devices when preparing and administering chemotherapy.—Using closed systems to prepare and administer chemotherapy is important to decrease the risk of exposure to chemotherapy (USP, 2020). This factor was mentioned in three of the reviewed studies (Boiano et al., 2015; Friese et al., 2020; Menonna-Quinn et al., 2019). The studies by Boiano et al. (2015) and Menonna-Quinn et al. (2019) reveal that nurses do not use these devices consistently when preparing and administering chemotherapy. Moreover, Friese et al. (2020) study indicates that oncology nurses' experience technical problems while using these devices which decreases the effectiveness of the devices in protecting against chemotherapy exposure.

Another important issue to be considered when preparing and administering chemotherapy intravenously is priming the intravenous tubes with solutions other than chemotherapy drugs. Unfortunately, in the study of Boiano et al. (2014), 38% of nurses reported that they have primed intravenous tubes with antineoplastic drugs. This would increase the risk of exposure when the drug dips from the end of the tube and contaminates the surroundings.

Interpersonal influences.—Interpersonal influences at workplace were reported as a factor influencing nurses' exposure to chemotherapy in three of the reviewed studies. These studies described different aspects of the interpersonal influences; the study by He et al. (2017) shows that more collegial interpersonal relationships between nurses and physicians are associated with decreased adherence to wearing the PPE when handling chemotherapy. The interpretation of this was made as informal relationships between workers were associated with practices that did not reflect adherence to the guidelines. On the other hand, Polovich and Clark (2012) study shows that nurses are more likely to adhere to the recommendations when handling chemotherapy when their coworkers value these recommendations and show adherence. Additionally, Callahan et al. (2016) found that stronger interpersonal relationships are related to reduced chemotherapy exposure among nurses. Although they did not provide interpretations to such findings, it could be the safe working environment was influenced by positive interpersonal influences. A Safe working environment is found associated with enhanced nurses' adherence to chemotherapy handling guidelines (Callahan et al., 2016).

Managerial support and participating in decision making.—Managerial support and participating in decision making affect nurses' exposure to chemotherapy. The study

by He et al. (2017) shows that encouraging the communication between nurses and their managers, and nurses' involvement in making decisions regarding work practice issues are associated with increased usage of PPE and decreased reported spills incidents. More specifically, allowing nurses to make decisions regarding the type of PPE offered to them would further help in promoting their adherence use the PPE while handling chemotherapy (He, et al., 2017).

Limitations

One of the limitations of this review is that most of the studies reviewed are of similar design, cross-sectional studies, which would affect the diversity of findings from these studies. Another limitation is the quality of the studies reviewed. While all the studies were classified as good quality, none was rated as high quality; raising some caution regarding the quality of evidence derived from this review. Moreover, including only online published studies in the English language would limit the comprehensiveness of the information resulted from this review.

Implications for Occupational Health Nursing Practice and Research

Education on chemotherapy safe handling should start in the undergraduate education for nurses to prepare them with the knowledge and skills of occupational safety management when handling hazardous substances. In oncology healthcare institutions, providing continuous education and training for nurses on the safe chemotherapy handling guidelines followed by feedback and debriefing are essential. This education is particularly important for newly hired nurses in oncology settings. Equally important, nurses' health beliefs toward the adherence to the guidelines should be assessed, as knowledge itself would not guarantee the adherence if it does not result in influencing nurses' health beliefs.

Moreover, oncology healthcare institutions should use standardized signs and alerts for nurses in the work environment and within the electronic system are required to help nurses in identifying chemotherapy drugs as well as the appropriate PPE to apply when handling them. These institutions should offer nurses all the required PPE and chemotherapy closed transfer devices with good functionality and place them in accessible locations. Furthermore, all healthcare institutions that administer chemotherapy should have policies on chemotherapy handling to influence nurses to adhere to the guidelines of safe chemotherapy handling. These policies should be revised regularly to reflect the current standards. Also, institutions should consider formal and systemic monitoring of nurses' practice when they handle chemotherapy. On the other hand, building a supportive work environment and allowing nurses to have input in the decision-making process are essential administrative activities that support nurses who handle hazardous drugs.

These findings have implications for research. It is recommended that future studies focus on the identification of factors that influence nurses' exposure to chemotherapy to help in developing interventions to address them, thereby protecting nurses against the exposure to chemotherapy. Research could be directed to study some of the insufficiently addressed factors such as nurses' health beliefs toward the adherence to the guidelines when handling chemotherapy. Thus, interventions to influence these beliefs could be implemented if

needed. Besides that, research on the effects and forms of cues in the work environment that influence nurses' adherence to the guidelines warrants further attention.

Conclusion

Chemotherapy drugs are sources of occupational hazards to nurses and other healthcare workers. There are several factors that influence nurses' exposure to chemotherapy. Some of these factors are nurses' knowledge on the precautionary guidelines, nurses' use of personal protective equipment (PPE) when handling chemotherapy, nurses' health beliefs, and workplace-related factors.

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In Summary

- Chemotherapy exposure is an occupational risk that affects nurses' health.
- Knowledge on chemotherapy handling guidelines, adherence to using the personal protective equipment, nurses' health beliefs, and workplace related aspects are significant factors affecting nurses' exposure to chemotherapy.
- More research on nurses' health beliefs toward the adherence to the guidelines when handling chemotherapy and methods to assess these beliefs are needed.
- The cues to adhere to the recommendations in the work environment to help protect nurses against the exposure should be investigated.

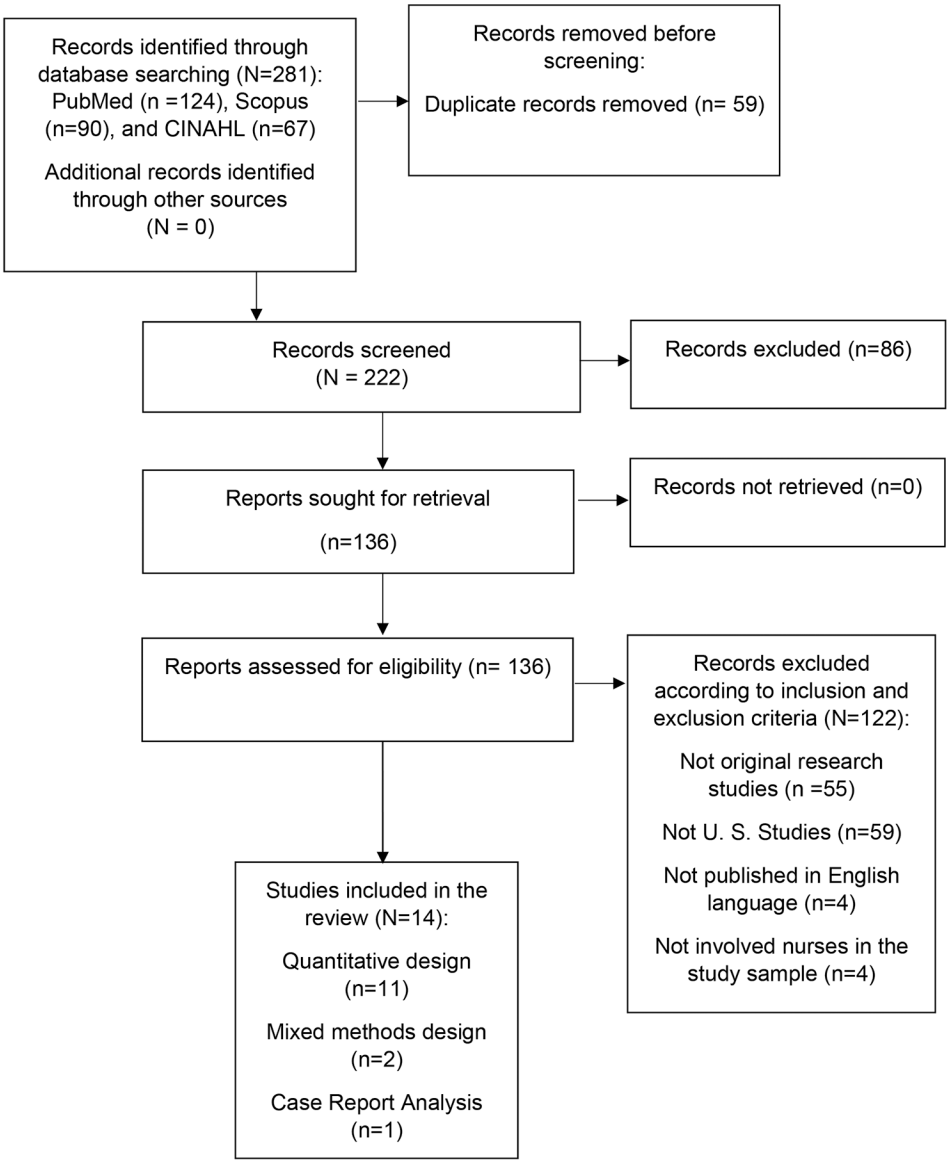

Figure 1.
PRISMA flowchart.

Table (1)

Summary of the Studies

Author(s) Year	Purpose of the Study	Sample Characteristics	Research Design and the Instruments Used with Their Psychometrics, if Reported,	Level of Evidence	Significant Findings
Boiano, et al. (2014)	To identify chemotherapy administration practices, as well as the degree of adherence to the precautionary guidelines, and the barriers to use PPE among health care workers who routinely handle chemotherapy.	The population surveyed were health care workers who were members in one of six professional organizations representing health-related professions that use hazardous drugs. The respondents were 2069, 98% of them were nurses	Cross-sectional survey research The National Institute for Occupational Safety and Health (NIOSH) Health and Safety Practices Survey of Healthcare Workers was used to measure the study variables.	Level III-Good quality	The respondents reported that they do not wear chemotherapy gowns (42%), do not wear chemotherapy gloves (12%), and they prime intravenous tubes with chemotherapy drugs rather than other solutions (6%). They reported spills occur during administration (12%). The respondents reported that they do not have the enough required education (4%). The most significant barrier to use PPE is considering the amount of exposure as minimal (4%).
Boiano, et al. (2015)	To examine self-reported work practices for health care workers when handling chemotherapy	The health care workers of 6 organizations were invited to complete a survey; 241 nurses and 183 pharmacists responded	Cross-sectional design The National Institute for Occupational Safety and Health (NIOSH) Health and Safety Practices Survey of Healthcare Workers was used to measure the study variables.	Level III-Good quality	The respondents reported that they do not wear double chemotherapy gloves (85% of nurses, 47% of pharmacists) or single pair (8% of nurses, 10% of pharmacists), do not use the closed system for chemotherapy administration (75% of nurses, 53% of pharmacists), flush the intravenous lines with chemotherapy (19% of nurses, 30% of pharmacists), do not store the drugs in the safety cabinet (9% of nurses, 15% of pharmacists). They also reported the barriers: not all the respondents received training programs on the hazards of chemotherapy (9% of nurses, 13% of pharmacists), and some employers do not offer medical monitoring program for chemotherapy exposure (61% of nurses, 45% of pharmacists), or some employee chose not to participate in these programs if available.
Callahan et al., (2016)	To identify the factors that influence nurses' adherence to guidelines when handling hazardous drugs including chemotherapy	115 registered nurses who work in hazardous drugs administration departments	Cross-sectional correlational study The Hazardous Drug Handling Questionnaire (Cronbach alphas 0.7-0.93) was used to measure variables: nurses' adherence to the recommendations when handling hazardous drugs, perceived barriers, perceived self-efficacy, perceived risk, exposure knowledge, workplace safely factors, interpersonal influences, and conflict of interest.	Level III-Good quality	Factors that enhance nurses' adherence to chemotherapy handling guidelines are high self-efficacy to adhere to use PPE ($p < 0.001$), high perceived risks to chemotherapy exposure side effects ($p < 0.05$), lower nurse to patient ratio ($p=0.001$), safe working environment climate ($p < 0.05$).
Colvin, et al. (2016)	To examine observed and self-reported oncology nurses' adherence to chemotherapy handling precautions	A convenient sample of 33 oncology nurses working in Cleveland Clinic	A prospective, mixed-methods design Observations were measured using a15-items investigator-developed instrument. Nurses' self-assessment was measured using a 9-items investigator-developed instrument.	Level III-Good quality	The observed precautionary practices did not match the self-reported practices for many PPE recommendations. Adherence to guidelines was lower than expected (100% adherence to NIOSH guidelines for all nurses)
Crickman and Finnell (2017)	To implement an evidence-based program targeted to promote proper handling of chemotherapy	A convenient sample of 34 nurses from oncology units (13 nurses were oncology certified and 26	pre-/post-test, quasi-experimental design Chemotherapy Exposure Knowledge scale (Cronbach alpha 0.7) was used to measure oncology nurses' knowledge on	Level II-Good quality	Nurses average knowledge scores improved after the intervention; from 10.5 to 11.2 ($SD = 0.75$, $p < 0.001$). Correct sequence for removing the PPE improved from 11% of nurses used the correct sequence for the PPE

Author(s) Year	Purpose of the Study	Sample Characteristics	Research Design and the Instruments Used with Their Psychometrics, if Reported,	Level of Evidence	Significant Findings
		nurses were chemotherapy competent -who have a chemotherapy provider card from Oncology Nursing Society) 1 left before the intervention 2 did not complete the knowledge assessment 6 standard sample sites were tested for contamination in the work area	chemotherapy exposure. An investigator-developed tool was used to observe nurses' adherence to PPE recommendations.		removal to 80%. Despite the strict safety precautions, the risk for occupational exposure remained; after the intervention, one of the 24 wipes samples tested positive.
Friese et al., (2020)	To assess the level of adherence to using the PPE when managing chemotherapy spills among oncology nurses and to characterize the incidents of chemotherapy spills	This study is an analysis of unpublished data collected in Friese et al. (2019) study for 393 nurses working in ambulatory settings and administering chemotherapy	Case report analysis of unpublished data collected in a previous study (Friese et al., 2019) In Friese et al. (2019) study, nurse participants reported the characteristics of the spill incidents (the type of the drug, the amount of the spills, whether a closed transfer device used or not, if exposure to chemotherapy occurred, hand hygiene after the cleanup, and the type of PPE used when managing the spills). Nurses' personal characteristics were collected using a baseline survey.	Level V Good quality	Sixty-one incidents of drug spills were reported by 51 nurses. The spills involved drugs that are considered very hazardous. The average amount of the spills was approximately 29 ml. Eleven nurses reported chemotherapy espouse through skin contact while managing the spills. PPE usage among nurses was less than the recommended level. The closed- system chemotherapy transfer devices were not used all times, and some technical difficulties in these devices hindered nurses from using them when handling chemotherapy.
Friese et al., (2019)	To test if an online educational intervention improved the adherence to using the PPE among oncology nurses when handling chemotherapeutic agents.	396 oncology nurses working in ambulatory settings. Of them, 257 completed the study	Randomized controlled trial Revised Hazardous Drug Handling Questionnaire was used to measure PPE usage among nurses. A baseline survey was used to assess nurses' demographics. Practice Environment Scale of Nursing Work Index and Safety Organizing Scale were used to measure specific workplace related factors. Nurses' knowledge on chemotherapy exposure was measured using an investigator-developed knowledge scale. Nurses perceived risk to chemotherapy exposure was measured using the Occupational Dermal Exposure Survey. At the primary end point, nurses were asked to evaluate the experience of being participated in the study.	Level I Good Quality	No differences found in the scores of PPE usage, the exposure knowledge, or the perceived barriers before and after the intervention. Both intervention and control groups reported less than the recommended level of adherence to using the PPE.
Graeve, et al. (2017)	(1) To test an intervention which is making quality changes in the working area to provide protection for health care personnel against chemotherapy exposure (2) To test workplace areas' contamination of chemotherapy drugs (3) To identify the factors that	A convenient sample of 163 health care workers who are at risk for chemotherapy exposure, the sample includes nurses, pharmacy technicians, and pharmacists. 27 sites sampled for surface chemotherapy contamination testing	pre-/post-test, quasi-experimental design Adapted questions from the Revised Hazardous Drug Handling Questionnaire were used to measure the adherence to recommendations when handling chemotherapy. Chemotherapy Exposure Knowledge Scale and items adapted from NIOSH survey of safe handling for workers were used to measure the knowledge of hazardous drugs.	Level II-Good quality	Self-efficacy to use PPE ($p < 0.05$), and perceived risks ($p < 0.05$) increased after the intervention. The use of PPE improved for all units except one, and the improvement was significant for the outpatients unit ($p < 0.05$) post-intervention. Five surfaces pretest and 3 surfaces posttest tested positive for contamination (in outpatients chemotherapy administration unit, inpatients oncology and bone marrow transplantation units and one pharmacist location)

Author(s) Year	Purpose of the Study	Sample Characteristics	Research Design and the Instruments Used with Their Psychometrics, if Reported,	Level of Evidence	Significant Findings
	influence the exposure to chemotherapy among health care workers				
He, et al. (2017)	To examine the trends and the organizational factors that are related to the usage of PPE and the report of hazardous contamination among nurses	A convenient sample of 252 oncology Nurses who have membership in the Oncology Nursing Society and administer chemotherapy.	Cross-sectional survey research Hazardous Drug Handling Questionnaire was used to assess oncology nurses' adherence to the recommendations when handling chemotherapy. The reporting of hazardous drugs spills variable was measured using a binary response (yes/no). The Safety Organizing Scale was used to measure the safety behaviors of the clinicians (has high internal consistency reliability and validity). Nurses workplace related factors were measured using the revised Practice Environment Scale of the Nursing Work Index (Cronbach alphas ranged from 0.8–0.9). Barriers to applying the PPE were measured using Geer's Dermal Exposure Survey.	Level III-Good quality	Increased nurse's usage of PPE is related to their contributions in decision making in their practice environment ($p= 0.001$), working in nonprivate institutions ($p< 0.01$), high workload ($p< 0.01$), and more formal relationships between nurses and physicians ($p=0.02$). Lower rates of spills are related to higher managerial support (OR=0.68, $p=0.04$) and increased nurse to patient ratio (OR=1.03, $p=0.01$).
Lawson et al., (2019)	To identify the trends in using gloves and gowns among pregnant and non-pregnant nurses who handle chemotherapy	Secondary data analysis from an earlier study (The Nurses' Health Study 3) on Canadian and U.S. Nurses who were born on or after January 1, 1965. 40,420 female nurses' data included in the analysis; of them 39,124 provided data while they were not pregnant, and 4,269 provided data when they were pregnant	Secondary data analysis from a cross-sectional survey research Nurses' Health Study 3 survey which used in the original study contains a module on chemotherapy drugs administration.	Level III-Good quality	Among non-pregnant nurses, 36% of them have administered chemotherapy, while 7% of pregnant nurses administered chemotherapy during the first 20 weeks of the pregnancy. Regarding the usage of PPE during chemotherapy administration, the percent of non-pregnant and pregnant nurses who do not apply gloves all times are 20% and 14% respectively. And the percent of non-pregnant and pregnant nurses who do not apply gowns all times are 59% and 48% respectively. Higher percent of nurses do not wear gloves when administering chemotherapy in oral form than when administering them intravenously
Menonna-Quinn, et al. (2019)	To assess the usage of PPE among nurses who administer chemotherapy in inpatients and outpatient units	Convenience sample of 95 inpatient and outpatient oncology nurses who work in a large medical center and administer chemotherapy	Cross-Sectional descriptive design The Revised Hazardous Drug Handling Questionnaire was used to measure adherence to the precautions when handling chemotherapy.	Level III-Good quality	The level of adherence to the guidelines when handling chemotherapy and wearing the PPE are lower than the recommended level. 69% of time the closed systems used to administer chemotherapy. 37% of inpatient and 1% of outpatient nurses use the respiratory mask during chemotherapy administration ($F = 17.695$, $p < 0.01$), and 33% of inpatient and 4% of outpatient nurses use the mask during chemotherapy disposal ($F = 30.064$, $p < 0.01$). 93% of inpatient nurses and 72% of outpatient nurses do not reuse the gown ($F = 5.059$, $p < 0.05$). The most frequently used PPE among nurses during chemotherapy handling is the disposable gloves, and the lowest frequently used PPE is the eye protection.
Polovich, and Clark (2012)	To determine the factors that affect nurses' adherence to the precautions when handling chemotherapy, and	165 registered nurses and 20 nurses' managers who worked in oncology settings and, and who are members	Cross sectional, mixed methods design Revised Hazardous Drug Handling Questionnaire (Cronbach alpha= 0.83) was used to measure nurses' adherence	Level III-Good quality	Nurses' adherence to the precautions is associated with safe workplace climate ($p < 0.01$), lower nurse to patient ratio, high self-efficacy to apply PPE ($p < 0.01$), fewer barriers to apply PPE ($p < 0.01$), high perceived risk of

Author(s) Year	Purpose of the Study	Sample Characteristics	Research Design and the Instruments Used with Their Psychometrics, if Reported,	Level of Evidence	Significant Findings
	to identify nurse managers perspectives on adhering to the recommendations when handling chemotherapy	of the Association of Community Cancer Centers	to the recommendations when handling chemotherapy. other instruments used are the Chemotherapy Exposure Knowledge Scale (CVI=1, Cronbach alpha=0.7), the Barriers to Using PPE scale (CVI=1, test retest reliability=0.72, Cronbach alpha=0.88), a self-efficacy scale (CVI=1, test retest reliability=0.7, Cronbach alpha=0.79), and three items on perceived risk (CVI=1, test retest reliability=0.78, Cronbach alpha=0.72), The Workplace Safety Climate (test retest reliability=0.86, Cronbach alpha=0.93), six items adapted from the Healthcare Worker Questionnaire to measure the conflict of interest (test retest reliability=0.7, Cronbach alpha=0.89), four items adapted from McCullagh, Lusk, and Ronis (2002) instrument to measure the interpersonal influences (test retest reliability=0.92, Cronbach alpha=0.8). Semi-structured interviews were conducted with the nurse managers through phone		harm ($p < 0.05$), and positive interpersonal influences ($p < 0.01$). The significant predictors of nurses' adherence to the precautions are: nurse to patient ratio, workplace safety climate, and the barriers to use the PPE. Nurses' age, years of experience, or level of education are not associated with using PPE. There are policies for chemotherapy handling in the manager participants institutions, but some of the policies are not updated to reflect the current guidelines. Few managers reported monitoring nurses' adherence to the guidelines while handling chemotherapy
Polovich, and Martin (2011)	To describe the pattern of using the PPE among nurses when handling chemotherapy, to examine the relationship between nurses' demographic characteristics with nurses' adherence to usage PPE, and to assess nurses' knowledge of NIOSH alert on chemotherapy exposure	330 nurses who attended the Oncology Nursing Society 31st Annual Congress in May 2006	Cross-sectional Descriptive, correlation The Hazardous Drug Handling Questionnaire was used to measure adherence to the precautions (Test-retest reliability= 0.8, content and construct validity were established).	Level III-Good quality	Almost all nurses (95-100%) use the gloves when handling chemotherapy, but very few of them (11%) use double gloving. 62% use gown for chemotherapy preparation and 52% of them use gowns for administration. 47% of the nurses received 2004 NIOSH guidelines alert. Not all the chemotherapy-specific PPE are available at work settings; the respiratory and eye PPE were less often available. Using PPE was significantly less in private settings. Nurses' demographics were not associated with using PPE
Reeves, et al. (2013)	To describe the patterns of prescribing oral chemotherapy in health care institutions, and to identify the patterns of using the PPE among nurses and pharmacists when handling and disposing oral chemotherapy	123 participants from several pharmacy and nursing society lists. 72% of the participants were pharmacists and 28% were nurses	Cross-Sectional survey research An investigators-developed survey was used to assess the trends of prescribing chemotherapy, chemotherapy handling practices, and participants demographics.	Level III-Good quality	Oncologist in 98% of the institutions and all physicians in 42% of the institutions are allowed to prescribe oral chemotherapy. 76% of the participants reported that they have polices on handling chemotherapy in their institutions, however, some these policies do not reflect the current guidelines. 98% were required to use PPE, but 70% require a single pair of gloves, and few of them require masks, eyes google, gowns, and face shields. 89% of the respondents are required to label oral chemotherapy. 79% of participants put contact precaution alerts for patients who receive chemotherapy