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SYSTEMATIC REVIEW OPEN ACCESS

Global Cancer Nurse's Experiences and Perceptions of Potential Occupational Exposure to Cytotoxic Drugs: Mixed Method Systematic Review With Framework Synthesis

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ABSTRACT

Aim: To conceptualise experiences and perceptions of cancer nurses' potential for occupational exposure when dealing with cytotoxic drugs (CDs).**Design:** A mixed methods systematic review with framework synthesis.**Methods and Data Sources:** A literature search was conducted in February 2022 in CINAHL PubMed, Web of Science, Ovid Nursing, and PsycINFO, and it was reported using the PRISMA guidance.**Results:** A synthesis of 38 studies revealed new categories of perceived solutions, side effects, and risky behaviour as well as three levels of experience and perception: individual, shared, and cultural, rather than the a priori theory.**Conclusions:** The review conclude that individuals espouse safe handling and administration of CDs. Synthesis highlights a complex interplay between self-reported perception and the observed experience of potential occupational exposure to cytotoxic drugs.**Implications for Professional Practice:** The framework synthesis highlights the difference between the perception of espoused practice and the experience of practice. Observation and risk assessment must be used to enhance safe practice. Organisations must take seriously the perception and experience of the adverse effects of administering cytotoxic drugs to support cancer nurses.**Reporting Method:** Joanna Briggs Institute's (JBI) methodology for systematic reviews and framework synthesis indexed studies deductively and inductively.

No patient or public contribution.

Trial Registration: PROSPERO: CRD42022289276

1 | Introduction

Cytotoxic drugs are hazardous (Control of Substances Hazardous to Health Regulations (COSHH) 2002; NIOSH 2004). Therefore, occupational exposure to cytotoxic drugs, also known as anti-neoplastic or chemotherapy drugs, can pose significant safety issues for cancer nurses involved in their handling, preparation, administration, and disposal, regardless of the healthcare setting (Eisenberg and Klein 2021).

Occupational exposure is a reality because cytotoxic drugs, administered by any route, either oral (Lester 2012; Rudnitzki and McMahon 2015), intravenous or intrathecally, can be absorbed through the skin, inhalation, or ingestion (Eisenberg and Klein 2021). Direct contact with the drug or exposure to drug-contaminated surfaces, equipment, or air can result in absorption into the body. Skin contact is a standard route of exposure particularly when handling contaminated surfaces or during drug administration (Connor and McDiarmid 2006;

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Summary

- What problem did the study address?
 - The perception and experience of handling cytotoxic drugs by cancer nurses translate into future policy and practice.
- What were the main three findings?
 - The research is based on self-reported practice, and solutions focus on education and implementing guidelines. Studies report adverse events, including hair loss, reproductive issues, and cancer. The availability of monitoring and closed-system devices could inadvertently result in less wearing of personal protective equipment.
- To whom will the research have an impact?
 - Cancer nurses and health and safety policy.

McDiarmid et al. 2010; Hanafi et al. 2015; Eisenberg 2016; Field, Hughes, and Rowland 2017; Simons and Toland 2017).

The short and longer-term effects of occupational exposure can increase the risk of cancer, reproductive hazards, skin irritation and sensitisation, and respiratory effects. Reported adverse effects, including carcinogenicity, teratogenicity, and mutagenicity, including chromosomal aberrations that mirror those of cancer patients (Polovich 2004; Connor and McDiarmid 2006; McDiarmid et al. 2010; Hanafi et al. 2015; Eisenberg 2016; Field, Hughes, and Rowland 2017; Simons and Toland 2017; Hu et al. 2023). The design of cytotoxic drugs is to kill or inhibit the growth of cancer cells; they also harm the healthy cells of those cancer nurses delivering treatment if not appropriately handled (Meade, Simons, and Toland 2017; Eisenberg and Klein 2021).

To mitigate these safety issues, healthcare facilities and cancer nurses should follow established standardised education (Coyne et al. 2019), nursing and health and safety guidelines and protocols for the safe handling, preparation, administration, and disposal of cytotoxic drugs (Meade 2014; Coyne et al. 2019; Mathias et al. 2019; Oncology Nursing Society 2019). This hierarchy of control includes wearing appropriate personal protective equipment (PPE), implementing engineering controls (e.g., closed systems devices), using proper techniques for drug preparation and administration, and following proper waste management procedures (Yu 2020; Eisenberg and Klein 2021; Meade, Simons, and Toland 2017). Regular monitoring, evaluation, and education are essential to maintaining a safe working environment for healthcare workers handling cytotoxic drugs but are rarely adhered to (Mathias et al. 2019).

Closed systems are one solution to reducing risk in numerous countries; however, these are currently optional (Yu 2020), and the evidence base for their use needs to be more conclusive (Gurusamy et al. 2018; Health Improvement Scotland 2019). Connor and McDiarmid (2006) and Eisenberg and Klein (2021) highlight the need to explore this potential occupational exposure in the cancer nursing population further.

Other reviews in this field of inquiry have focused on factors influencing safe handling precautions and education (Lin et al. 2019) and patient and staff safety requirements (Coyne et al. 2019). Conducting this systematic review to understand cancer nurses' experiences and perceptions of potential occupational exposure to cytotoxic drugs worldwide gives another contextual lens on this topic, helping to understand the safety and wellbeing of this workforce.

Due to the often-emotive nature of this topic, a known theoretical framework for synthesis was applied (Carroll et al. 2013). This approach aids in categorising existing concepts to the priori framework and considers potential new emerging concepts within the existing literature. The framework from Polovich and Clark (2012) (Figure 1) was selected as the priori framework to provide an inductive and deductive synthesis of the evidence base for this review. The theoretical framework has been the only one developed for handling hazardous drugs. This framework provided a complementary approach to the research question posed by allowing the tenets of influencing factors, hypothetically associated with perception and experience of the potential of occupational exposure to cytotoxic drugs, to be integral to the process of the deductive thematic analysis, allowing for themes to emerge direct from using inductive coding (Fereday and Muir-Cochrane 2006).

The proposed model considers the interaction between the individual and the environment, influencing their behaviour (Polovich and Clark 2012). In Figure 1, knowledge of the hazard is related to perceived risk and self-efficacy. Higher self-efficacy in using PPE and positive organisational influences is expected to decrease perceived barriers. Perceived risk, self-efficacy, perceived barriers, organisational influences, and interpersonal influences are all expected to impact safe handling precautions. Conflict of interest was added as this may be associated with patient needs rather than individual control.

1.1 | Aim

The study aims to understand cancer nurses' experiences and perceptions of potential occupational exposure to cytotoxic drugs.

2 | Methodology

2.1 | Search Methods

For this study, we adhered to the Joanna Briggs Institute (JBI) methodology for systematic reviews and reviewed the cancer nurses' experiences and perceptions of potential exposure to cytotoxic drugs. For a complete set of database searches and results, see *data base searches and results*, Appendix S1. Restricted publication dates were from 2000 until early 2022, and results were limited to the English language only where the database allowed.

The following databases and platforms were searched between the 18th and 24th of February 2022: CINAHL with Full

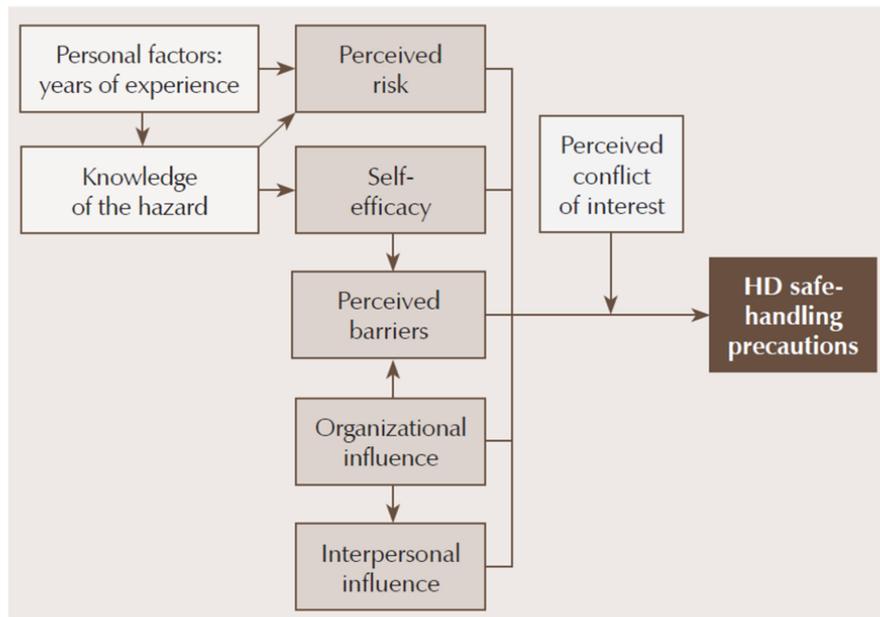


FIGURE 1 | Theoretical framework: factors predicting use of hazardous drug (HD) safe-handling precautions (Polovich and Clark 2012). From “Predictors of Hearing Protection Use for Hispanic and Non-Hispanic White Factory Workers,” by D.M. Raymond 3rd, O. Hong, S.L. Lusk, & D.L. Ronis, 2006, *Research and Theory for Nursing Practice: An International Journal*, 20, p. 129. Copyright 2006 by Springer Publishing Company, LLC. Adapted with permission. [Colour figure can be viewed at wileyonlinelibrary.com]

text (EBSCO), PubMed (including Medline and PMC), Web of Science, Ovid Nursing, PsycINFO (EBSCO) using the search terms ‘cancer nurs*’, ‘perception’, ‘experiences’ ‘cytotoxic drugs’, and ‘occupational exposure’. See Appendix S1 for a fuller search strategy. A hand-search was conducted online in a University Library catalogue, Library Search, and Google Scholar, as well as in cancer and oncology nursing journals, available via subscriptions with full text not indexed in any searched databases. These include the *European Journal of Oncology Nursing*, *Seminars in Oncology Nursing*, and *Cancer Nursing Practice*.

Grey literature searching was undertaken using Google, and the specific organisational websites of the European Oncology Nursing Society, Oncology Nursing Society, and UK Oncology Nursing Society were looked at. In addition, forward and backward citation searches were conducted from the included articles.

The guidelines of The PRISMA 2020 (*Guidelines for reporting systematic reviews* Appendix S2) statement, an updated guideline for reporting systematic reviews, will report the review results (Page et al. 2021). The review protocol is registered (ID CRD42022289276) on The International Prospective Register of Systematic Reviews (PROSPERO).

2.2 | Inclusion and Exclusion Study Selection

Articles were managed in Endnote, including the removal of duplicates. They were then exported onto Rayyan QCRI for screening. Three reviewers independently screened the titles and abstracts against pre-defined eligibility criteria. A fourth reviewer resolved disagreements between the reviewers. Where abstracts were unavailable, full-text articles were obtained, and this review identified 38 studies under the inclusion criteria (Table 1).

2.3 | Data Evaluation

2.3.1 | Quality Assurance

Two reviewers independently assessed included studies using quality scoring for methodological content (adapted from Hawker et al. 2002). The assessment included relevance to the research question, the data source, and the study type. Subsequently, each paper was assigned a score ranking, noted in the findings table (*Study characteristics* Appendix S3), with any specific factors, acknowledging the heterogeneity of the studies and possible methodological limitations, including where some of the quality criteria were not applicable. The completed quality appraisal did not impact the study's eligibility to be included and aimed to generate an overall quality assessment.

2.4 | Data Extraction and Synthesis of the Included Studies

A framework synthesis (Gale et al. 2013) was completed to categorise the studies by coding, indexing, and theming against the priori framework (Polovich and Clark 2012) with factors: knowledge of the hazard, perceived risk, self-efficacy, perceived barriers, organisational influence, interpersonal influence, personal factors, and conflict of interest (Figure 2).

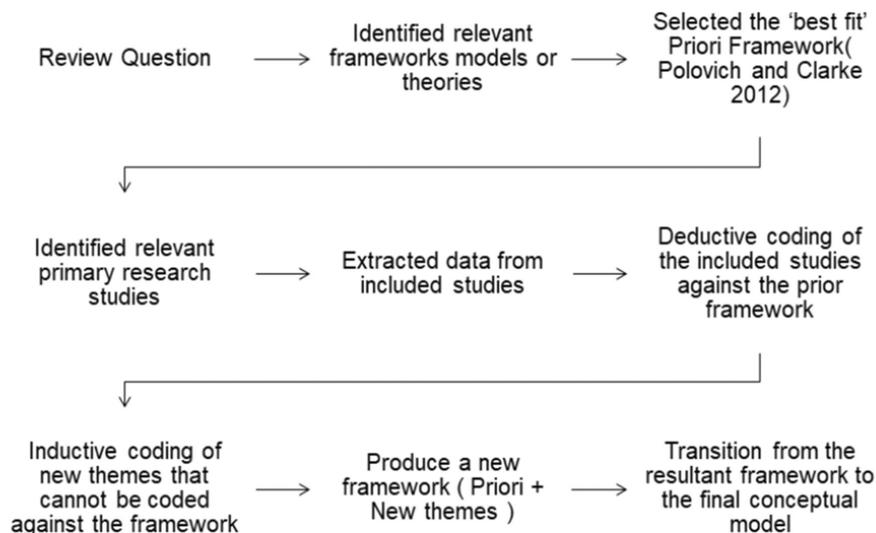
2.5 | Findings

The initial search provided 179 studies, of which 34 were duplicates. One hundred and seven records were excluded at the title and abstract review stage. This review includes 38 studies reported in 41 journal articles, with Graeve, McGovern, Alexander, et al. (2017), Graeve, McGovern, Arnold, et al. (2017),

TABLE 1 | Inclusion and exclusion criteria.

	Inclusion	Exclusion
Study type	An empirical article: qualitative, quantitative, or mixed methods or nonexperimental (cohort studies)	Systematic reviews and literature reviews
Setting	All care settings in which cytotoxic drugs are administered	No administration or handling of cytotoxic drugs
Population	Cancer nurses handling cytotoxic drugs during preparation, administration, disposal, and handling patient excreta	Other health care professionals than nursing, for example, pharmacy and nursing assistants. Also, studies that showed nurses comprise less than 20% of the population
Context	Potential occupational exposure when handling cytotoxic drugs	Not handling cytotoxic drugs. Handling of antibiotics, immunotherapy, and /or antibody therapy
Concept	Reporting factors associated with perception and experience	Not reporting factors influencing associated with perception and experience
Publication type	Primary research studies published in peer-reviewed journals	Conference abstracts, book chapters, reviews, commentaries, editorials, and study protocols
Language	Published in English	Published in other languages other than English
Date	Published since 2000, just before and after the control of substances hazardous to health	Published before 2001

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A mixed studies review with a Framework Synthesis**

**FIGURE 2** | Framework synthesis process (Granikov et al. 2022).

Soheili, Jokar, et al. (2021), Soheili et al. (2021a), and Soheili et al. (2021b) covering the same study population but different publications (Figure 3).

2.6 | Study Characteristics

Twenty-six studies were quantitative, five were qualitative, and seven were mixed methods. The articles were then organised into a data extraction sheet (*Study characteristics* Appendix S3).

2.7 | Country of Origin

Eight studies were from the USA (Callahan et al. 2016; Colvin, Karius, and Albert 2016; DeJoy et al. 2017; Graeve, McGovern, Alexander, et al. 2017; Graeve, McGovern, Arnold, et al. 2017; He et al. 2017; Polovich and Clark 2012; Silver, Steege, and Boiano 2016); Seven studies were conducted in Turkey (Baykal, Seren, and Sokmen 2009; Çınar and Karadakovan 2022; Kosgeroglu et al. 2006; Kutlutürkan and Kırca 2022; Topçu and Beşer 2017; Tuna and Baykal 2017; Turk et al. 2004); five studies were from Iran (Alehashem and Baniasadi 2018; Hanafi et al. 2015;

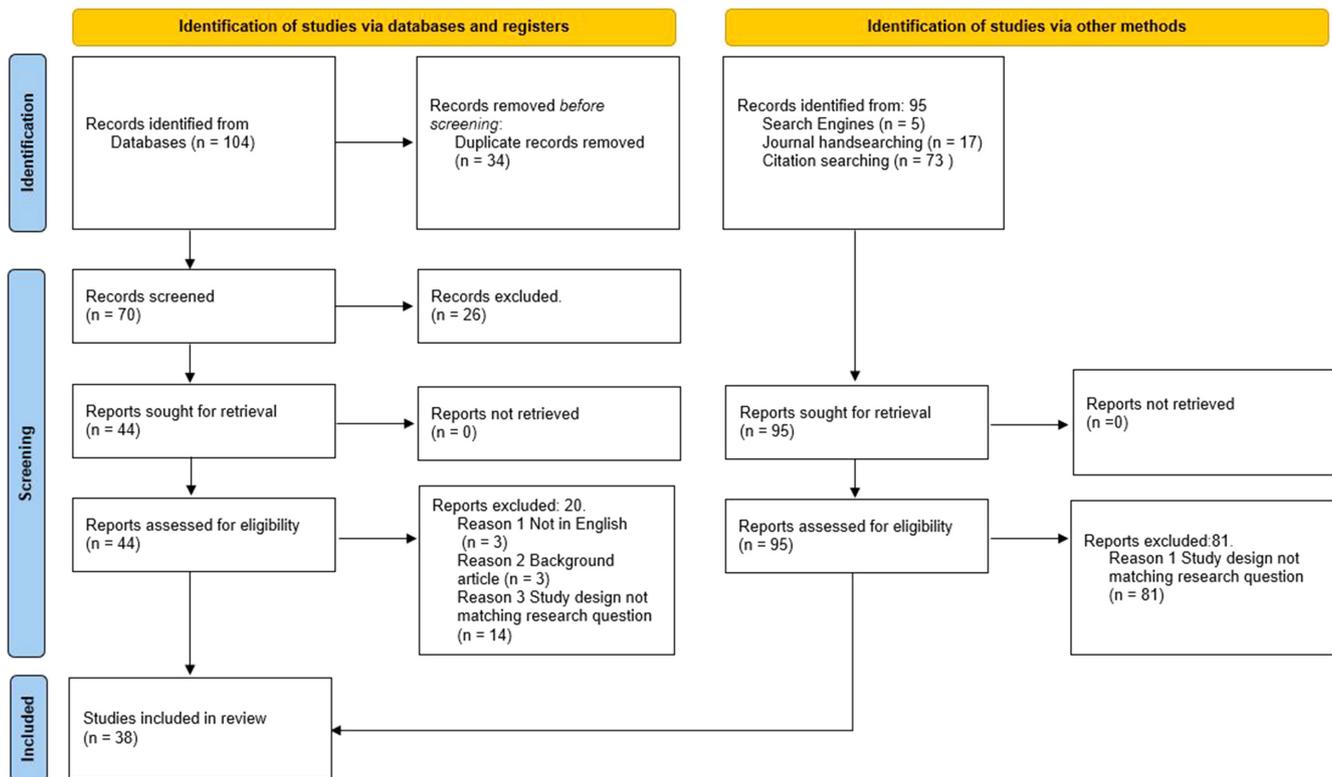


FIGURE 3 | PRISMA 2020 diagram (Page et al. 2021). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

Orujlu et al. 2016; Shahrabi et al. 2014; Soheili, Jokar, et al. 2021; Soheili et al. 2021a; Soheili et al. 2021b); three studies are from the UK (Simons and Toland 2017, 2019; Verity et al. 2008) and two studies in Brazil (Batista et al. 2022; Borges, Silvino, and dos Santos 2015). The other studies were from Ethiopia (Asefa et al. 2021), Egypt (Mahdy, Rahman, and Hassan 2017), Greece (Constantinidis et al. 2011), Israel (Ben-Ami et al. 2001), France (Benoist et al. 2022), Taiwan (Chen, Lu, and Lee 2016), Nigeria (Nwagbo et al. 2017), Canada (Hon, Teschke, and Shen 2015), South Korea (Kim et al. 2019), Jordan (Abu Sharour et al. 2021), Pakistan (Khan, Khowaja, and Ali 2012), Thailand (Srisintorn et al. 2021), Spain (Bernabeu-Martínez et al. 2021), and Cyprus (Kyprianou et al. 2010), with one study from each country.

2.8 | Theoretical Frameworks

Seven studies utilised the theoretical framework—Factors Predicting the Use of Hazardous Drugs (HD) Safe Handling Precautions (Abu Sharour et al. 2021; Callahan et al. 2016; Graeve, McGovern, Alexander, et al. 2017; Graeve, McGovern, Arnold, et al. 2017; He et al. 2017; Mahdy, Rahman, and Hassan 2017; Polovich and Clark 2012; Srisintorn et al. 2021). Topçu and Beşer (2017) utilised the Health Belief Model: perceived sensitivity, perceived seriousness, perceived benefits, perceived barriers, and “cues to actions.” Ben-Ami et al. (2001) and Nwagbo et al. (2017) studies utilised the Health Belief Model and its extended form of Protection Motivation Theory (PMT). The PMT model assumes that engaging in specific health behaviours is a direct function of a person’s motivation to protect oneself: perceived susceptibility, severity, perceived benefits, perceived barriers, and self-efficacy.

2.9 | Study Measurement Tools

Thirty-three studies used surveys with 22 being adapted questionnaire (Abu Sharour et al. 2021; Ben-Ami et al. 2001; Benoist et al. 2022; Borges, Silvino, and dos Santos 2015; Callahan et al. 2016; Colvin, Karius, and Albert 2016; Graeve, McGovern, Alexander, et al. 2017; Graeve, McGovern, Arnold, et al. 2017; He et al. 2017; Hon, Teschke, and Shen 2015; Khan, Khowaja, and Ali 2012; Kim et al. 2019; Kosgeroglu et al. 2005; Kutlutürkan and Kırca 2022; Kyprianou et al. 2010; Mahdy, Rahman, and Hassan 2017; Orujlu et al. 2016; Polovich and Clark 2012; Shahrabi et al. 2014; Silver, Steege, and Boiano 2016; Srisintorn et al. 2021; Turk et al. 2004; Verity et al. 2008) or a newly developed questionnaire (Alehashem and Baniyasi 2018; Baykal, Seren, and Sokmen 2009; Bernabeu-Martínez et al. 2021; Çınar and Karadakovan 2022; Constantinidis et al. 2011; DeJoy et al. 2017; Hanafi et al. 2017; Nwagbo et al. 2017; Simons and Toland 2017, 2019).

Six studies conducted face-to-face or telephone interviews (Asefa et al. 2021; Benoist et al. 2022; Chen, Lu, and Lee 2016; Polovich and Clark 2012; Soheili, Jokar, et al. 2021; Soheili et al. 2021a; Soheili et al. 2021b; Topçu and Beşer 2017). Six observation studies were conducted after surveys to monitor the practice of safe handling of cytotoxic drugs (Ben-Ami et al. 2001; Chen, Lu, and Lee 2016; Colvin, Karius, and Albert 2016; Hanafi et al. 2017; Kosgeroglu et al. 2006; Shahrabi et al. 2014).

The mapping of all included articles in the review to the priori framework aligned with the methodology approach of framework synthesis (Table 2). The mapping visually represents

TABLE 2 | Mapping to the original priori framework.

Authors study	Research Interest of variables of perception and experience in decreasing order											
	Safe handling precautions	Perceived solutions	Knowledge of hazard	Organisational influence	Personal factors	Side effects	Perceived risks	Perceived barriers	Self-efficacy	Perceived conflict of interest	Risky behaviour	Interpersonal factors
Abu Sharour et al. (2021) Jordan	X		X	X	X		X	X	X	X		X
Alehashem and Baniasadi (2018) Iran	X	X	X		X							
Asefa et al. (2021) Ethiopia	X	X	X	X	X			X				
Batista et al. (2021) Brazil	X		X			X						
Baykal, Seren, and Sokmen (2009) Turkey	X	X	X	X		X	X				X	
Ben-Ami et al. (2001) Israel	X	X	X			X	X	X	X		X	
Benoist et al. (2022) France	X	X	X	X	X	X	X					
Bernabeu-Martínez et al. (2021) Spain							X					
Borges, Silvino, and dos Santos (2015) Brazil	X		X			X						
Callahan et al. (2016) USA	X	X	X	X	X		X	X	X	X		X
Chen, Lu, and Lee (2016) Taiwan	X	X		X	X		X	X	X	X		
Çınar and Karadakovan (2022) Turkey	X	X						X				
Colvin, Karius, and Albert (2016) USA	X	X							X			
Constantinidis et al. (2011) Greece	X	X				X		X				
DeJoy et al. (2017) USA	X	X		X	X		X					

(Continues)

TABLE 2 | (Continued)

Authors study	Research Interest of variables of perception and experience in decreasing order											
	Safe handling precautions	Perceived solutions	Knowledge of hazard	Organisational influence	Personal factors	Side effects	Perceived risks	Perceived barriers	Self-efficacy	Perceived conflict of interest	Risky behaviour	Interpersonal factors
Graeve, McGovern, Alexander, et al. (2017), Graeve, McGovern, Arnold, et al. (2017) USA	X	X	X		X		X	X	X	X	X	X
Hanafi et al. (2017) Iran	X	X	X		X	X					X	
He et al. (2017) USA	X			X	X							X
Hon, Teschke, and Shen (2015) Canada	X		X			X		X				
Khan, Khowaja, and Ali (2012) Pakistan		X	X			X			X			
Kim et al. (2019) South Korea	X			X	X		X	X				
Kosgeroglu et al. (2006) Turkey	X	X	X	X	X			X	X		X	
Kutlutürkan and Kirca (2022) Turkey				X		X			X			
Kyprianou et al. (2010) Cyprus	X	X	X	X	X	X	X					
Mahdy, Rahman, and Hassan (2017) Egypt	X	X		X		X		X				
Nwagbo et al. (2017) Nigeria	X	X	X		X							
Orujlu et al. (2016) Iran	X	X	X	X	X	X		X				
Polovich and Clark (2012) USA	X	X	X	X	X		X	X	X	X		X
Shahrasbi et al. (2014) Iran	X	X	X	X		X						
Silver, Steege, and Boiano (2016) USA	X	X		X								

(Continues)

TABLE 2 | (Continued)

Authors study	Research Interest of variables of perception and experience in decreasing order												
	Safe handling precautions	Perceived solutions	Knowledge of hazard	Organisational influence	Personal factors	Side effects	Perceived risks	Perceived barriers	Self-efficacy	Perceived conflict of interest	Risky behaviour	Interpersonal factors	
Simons and Toland (2017) UK	X					X							
Simons and Toland (2019) UK	X	X	X		X	X							
Soheili, Jokar, et al. (2021), Soheili et al. (2021a), Soheili et al. (2021b) Iran	X			X		X			X				
Srisintorn et al. (2021) Thailand	X	X	X		X	X		X	X	X			X
Topçu and Beşer (2017) Turkey	X	X		X		X		X					
Tuna and Baykal (2017) Turkey	X	X		X		X							
Turk et al. (2004) Turkey	X	X	X		X	X					X		
Verity et al. (2008) UK		X	X		X		X						
Total	34	28	23	20	19	19	18	14	13	7	6	6	6

where each paper aligns with the framework. In addition, it briefly highlights the research priority under investigation, reporting a decrease in focus from left to right.

3 | Narrative Summary of the Mapping to Priori Framework

3.1 | Personal Factors

Personal factors were associated with the demography of the population and the level of nursing chemotherapy experience. Seven studies reported significant correlations when comparing the demographical factors such as education, age, and work experience (Alehashem and Baniyasi [2018](#); Asefa et al. [2021](#); Chen, Lu, and Lee [2016](#); DeJoy et al. [2017](#); Kim et al. [2019](#); Srisintorn et al. [2021](#); Abu Sharour et al. [2021](#)). Eight studies compared the demography with other variables that reported no significant differences (Benoist et al. [2022](#); Graeve, McGovern, Alexander, et al. [2017](#); Graeve, McGovern, Arnold, et al. [2017](#); Hanafi et al. [2015](#); Kosgeroglu et al. [2006](#); Kyprianou et al. [2010](#); Polovich and Clark [2012](#); Turk et al. [2004](#); Verity et al. [2008](#)).

3.2 | Level of Knowledge of Hazards

Seven studies reported a high level of knowledge of occupational exposure among their participants (Ben-Ami et al. [2001](#); Borges et al. [2015](#); Callahan et al. [2016](#); Graeve, McGovern, Alexander, et al. [2017](#); Graeve, McGovern, Arnold, et al. [2017](#); Hon, Teschke, and Shen [2015](#); Nwagbo et al. [2017](#); Orujlu et al. [2016](#); Srisintorn et al. [2021](#)). Seven studies reported an adequate level of knowledge of occupational exposure amongst their participants (Alehashem and Baniyasi [2018](#); Batista et al. [2021](#); Benoist et al. [2022](#); Hanafi et al. [2017](#); Kyprianou et al. [2010](#); Polovich and Clark [2012](#); Shahrasbi et al. [2014](#)). Seven studies reported a lack of knowledge of occupational exposure amongst their participants (Abu Sharour et al. [2021](#); Asefa et al. [2021](#); Baykal, Seren, and Sokmen [2009](#); Khan, Khowaja, and Ali [2012](#); Simons and Toland [2019](#); Turk et al. [2004](#); Verity et al. [2008](#)). Kosgeroglu et al. ([2006](#)) was the only study that referred to nurses being aware but then needing to apply the knowledge to practice.

3.3 | Perceived Risks

In measuring perceived risk, nine studies reported that their participants had a high perceived risk (Abu Sharour et al. [2021](#); Callahan et al. [2016](#); DeJoy et al. [2017](#); Kyprianou et al. [2010](#); Polovich and Clark [2012](#); Simons and Toland [2019](#); Soheili et al. [2021a](#); Srisintorn et al. [2021](#); Verity et al. [2008](#)) and conversely five studies reported a low perceived risk from their participants (Benoist et al. [2022](#); Ben-Ami et al. [2001](#); Chen, Lu, and Lee [2016](#); Khan, Khowaja, and Ali [2012](#); and Topçu and Beşer [2017](#)). Chen, Lu, and Lee ([2016](#)) further reported the perceived risk of toxicity as ‘encapsulated’ and ‘well-diluted’ by the pharmacist before reaching them for administration. Topçu and Beşer ([2017](#)) noted that low perceived risk was associated with ‘contamination is impossible’ when using closed systems.

Hon, Teschke, and Shen ([2015](#)) reported a statistically significant ($p=0.002$) difference in perception of the risk when pharmacists downplayed preparing the drugs compared to nurses administering the drugs. Graeve, McGovern, Alexander, et al. ([2017](#)) and Graeve, McGovern, Arnold, et al. ([2017](#)) showed a statistically significant increase in self-perceived risk using pre and post-survey after training and contamination swabbing result intervention study.

There were various consequences of having a high perceived risk. Baykal, Seren, and Sokmen ([2009](#)) reported that a perception of high risk made the nurses *not* want to work in the oncology department due to perceived health concerns. Conversely, Polovich and Clark ([2012](#)) correlated higher perceived risks to a better safety climate in the nurses' unit.

Bernabeu-Martínez et al. ([2021](#)) examined the perceived risk of their participants by asking about each practical stage of the administration process. The perceived risk of the participants was lowest for transporting the CD to the place of administration. The highest risk was associated with accidental exposure during connection and disconnection of infusion lines and areas around the spike, where there is the risk of exposure by drops and spills, tears, or inadequate connection. Bernabeu-Martínez et al. ([2021](#)) stated that administration followed by waste management was perceived as the highest activity in the potential for occupational exposure. The intravesical installation presented the most significant risk, followed by premade bolus / intermuscular, with infusional and ocular administration being identified as the least potential for occupational exposure. The nurse reported the risk of exposure to be higher and associated with the administration phase of the process.

3.4 | Self-Efficacy

Self-efficacy was perceived to be linked to the ability to perform self-measures over time, contributing to their health (Ben-Ami et al. [2001](#)). Callahan et al. ([2016](#)) stated a high level of self-efficacy in their study, whereas Abu Sharour et al. ([2021](#)) and Polovich and Clark ([2012](#)) noted a medium level of self-efficacy. A perceived influencing factor in self-efficacy was clinical knowledge and skill reported by Hon, Teschke, and Shen ([2015](#)), Kutlutürkan and Kırca ([2022](#)), and Soheili et al. ([2021a](#)). Five studies reported self-efficacy and adherence to PPE guidance in reducing exposure to CDs (Chen, Lu, and Lee [2016](#); Graeve, McGovern, Alexander, et al. [2017](#); Graeve, McGovern, Arnold, et al. [2017](#); Kim et al. [2019](#); Kosgeroglu et al. [2006](#); Srisintorn et al. [2021](#)). Double gloving during the disconnection of the IV line and washing hands after the administration of chemotherapy were described as safety measures to reduce exposure by Colvin, Karius, and Albert ([2016](#)).

3.5 | Perceived Barriers

Orujlu et al. ([2008](#)) reported that using PPE during waste disposal and cleaning spills was less than other activities in the study. Six studies stated that a lack of wearing PPE was due to discomfort, work pressures, or availability (Ben-Ami et al. [2001](#); Callahan et al. [2016](#); Graeve, McGovern, Alexander, et al. [2017](#); Graeve, McGovern, Arnold, et al. [2017](#); Kim et al. [2019](#); Mahdy,

Rahman, and Hassan 2017; Srisintorn et al. 2021). Asefa et al. (2021) stated that PPE was not required, and Chen, Lu, and Lee (2016) said it was due to a barrier due to cost implications. Constantinidis et al. (2011) and Topçu and Beşer (2017) cited a lack of training as a barrier. The number of nurses, lack of payments, extra leave, and psychological support were perceived barriers by Çınar and Karadakovan (2022). Polovich and Clark (2012) study reported the low perceived barriers associated with higher safe handling.

3.6 | Organisational Influence

Four studies stated that a lack of training for administering cytotoxic drugs has been identified as influencing work safety climate in several studies (Asefa et al. 2021; Benoist et al. 2022; Kutlutürkan and Kırca 2022; Shahrasbi et al. 2014). Chen, Lu, and Lee (2016), Kim et al. (2019), and Tuna and Baykal (2017) all cited that cost-cutting measures and insufficient PPE availability make the environment unsafe. Six studies highlighted that the perceived safe climate in the workplace improved the usage of PPE (Abu Sharour et al. 2021; Callahan et al. 2016; DeJoy et al. 2017; Kim et al. 2019; Polovich and Clark 2012; Srisintorn et al. 2021).

Six studies described the nurses' perception of working conditions and environment as longer working hours (Kosgeroglu et al. 2006; Orujluo et al. 2008; Baykal, Seren, and Sokmen 2009; Topçu and Beşer 2017; Tuna and Baykal 2017; Kutlutürkan and Kırca 2022), whereas Kyprianou et al. (2010) and Mahdy, Rahman, and Hassan (2017) described high workloads. Four studies suggested that lower pay and lack of overtime payments lead to burnout and emotional disturbances among nurses linked to a variety of adverse outcomes in healthcare, including worker errors and injuries (DeJoy et al. 2017; Silver, Steege, and Boiano 2016; Orujluo et al. 2008; Soheili, Jocar, et al. 2021; Soheili et al. 2021a; Soheili et al. 2021b).

Soheili et al. (2021a) identified organisational influences that could include inadequate ventilation, lighting, and noise reduction. Chen, Lu, and Lee's (2016) study perceived that the higher role status in the organisation's pay created resistance to being transferred, even if pregnant.

Chen, Lu, and Lee (2016) reported a cultural difference when observing nurses administering CDs where the patients' needs came first, and PPE was time-consuming and interrupted their schedule. The nurses stated in this study that their expertise in administering CDs meant that they would not be exposed to PPE when opting out.

3.7 | Interpersonal Influences

Callahan et al. (2016) and Polovich and Clark (2012) reported strong interpersonal influence by nurses, which resulted in using precautions while handling CDs. Graeve, McGovern, Arnold, et al. (2017) reported that interpersonal influence was significantly associated with PPE use after implementing a quality improvement intervention. The participants of Abu

Sharour et al. (2021) and Srisintorn et al. (2021) had moderate interpersonal influence. He et al. (2017) reported a negative interpersonal influence.

3.8 | Perceived Conflict of Interest

Perceived conflict of interest is defined by Gershon et al. as a conflict "between workers' need to protect themselves and their need to provide medical care to patients" (1995, 225). Khan, Khowaja, and Ali (2012) report that 58% of nurse participants felt that "chemotherapy causes more harm than good," making them feel guilty. Chen, Lu, and Lee (2016) noted that nurses perceived PPE usage as harming patients psychologically and possibly refusing treatment, specifically with children. The participants believed it was appropriate to avoid using PPE because they were more experienced and always knew how to reduce contamination. Chen, Lu, and Lee (2016) found that pregnancy posed a perceived conflict between a social and professional role in administering chemotherapy and the balance between foetal safety and job protection.

Graeve, McGovern, Alexander, et al. (2017) and Graeve, McGovern, Arnold, et al. (2017) found that perceived conflict of interest was insignificant against all other variables. Callahan et al. (2016) showed that lower conflict of interest was associated with higher knowledge, higher self-efficacy, low perceived barriers, and better workplace safety. Abu Sharour et al. (2021) reported that conflict of interest negatively predicted safe handling precautions along with perceived risk and age. Srisintorn et al. (2021) showed a small magnitude but statistically significant association with PPE usage. Polovich and Clark (2012) noted that a high conflict of interest was statistically significantly associated with low workplace safety, low interpersonal influences, and low PPE usage.

3.9 | HD Safe Handling Precautions

Safe handling precautions were the focus of most papers with the exclusion of four studies (Bernabeu-Martínez et al. 2021; Khan, Khowaja, and Ali 2012; Kutlutürkan and Kırca 2022; and Verity et al. 2008). Recommended safe handling practices were reported as not followed by Abu Sharour et al. (2021), Hon, Teschke, and Shen (2015), He et al. (2017), Kosgeroglu et al. (2006), and Topçu and Beşer (2017).

4 | Inductive Synthesis

4.1 | Perceived Solutions

4.1.1 | Education and Guidelines

Eleven Studies described that their participants had received formal education training (Alehashem and Baniyasi 2018; DeJoy et al. 2017; Callahan et al. 2016; Constantinidis et al. 2011; Kyprianou et al. 2010; Mahdy, Rahman, and Hassan 2017; Polovich and Clark 2012; Silver, Steege, and Boiano 2016; Simons and Toland 2019; Srisintorn et al. 2021; Verity et al. 2008). Four studies reported that their participant had received in-service

training as education (Alehashem and Baniasadi 2018; Hanafi et al. 2015; Shahrasbi et al. 2014; Tuna and Baykal 2017). Six studies identified that there was a lack of available education (Asefa et al. 2021; Baykal, Seren, and Sokmen 2009; Benoist et al. 2022; Çınar and Karadakovan 2022; Khan, Khowaja, and Ali 2012; Topçu and Beşer 2017). Three studies narrated the education coming from textbooks, internet content, and often unreliable sources (Kyprianou et al. 2010; Shahrasbi et al. 2014; Turk et al. 2004). Graeve, McGovern, Alexander, et al. (2017) and Graeve, McGovern, Arnold, et al. (2017) were the only study to report training and the use of contamination swabbing in clinical areas and pre-and post-knowledge tests as an education intervention.

Alehashem and Baniasadi (2018) reported limited association with professional bodies concerning guideline use. DeJoy et al. (2017) reported the most familiarity with the Oncology Nursing Society (ONS) (USA) guidelines, and 81% were familiar with one of the four guidance documents. Three studies reported that guideline knowledge was translated into good practice (Alehashem and Baniasadi 2018; Nwagbo et al. 2017; Silver, Steege, and Boiano 2016). Two studies stated that the information level must be seen in practice (Constantinidis et al. 2011; Kosgeroglu et al. 2006). In the Graeve, McGovern, Alexander, et al. (2017) and Graeve, McGovern, Arnold, et al. (2017) study, despite using ONS recommendations integrated into the study design, high contamination levels were still present, indicating areas for improvement.

4.1.2 | Surveillance

Graeve, McGovern, Alexander, et al. (2017) and Graeve, McGovern, Arnold, et al. (2017) reported surveillance as swabbing for environmental contamination to give a targeted intervention to help create awareness amongst the healthcare team in the workplace. In two studies, participants stated that they felt more physiological surveillance should be available (Baykal, Seren, and Sokmen 2009; Constantinidis et al. 2011). In the Chen, Lu, and Lee (2016) study, the participants identified their personal experiences of no side effects following repeated exposure as a justification for their behaviour and overall safety without monitoring.

4.1.3 | Hierarchy of Controls Excluding the Use of PPE

The hierarchy of controls has five levels of actions to reduce or remove hazards and lower worker exposure. Based on general effectiveness, the preferred order of action is elimination, substitution, engineering controls, administrative controls, and PPE.

Four studies used biosafety cabinets and isolators to prepare drugs in the preparation phase (Baykal, Seren, and Sokmen 2009; Ben-Ami et al. 2001; Orujlu et al. 2008; Shahrasbi et al. 2014).

Eight studies indicated the usage of engineering controls to reduce exposure to CDS; Shahrasbi et al. (2014) reported the usage

of biosafety cabinets to prepare the CDs, and surface sampling was done to monitor any spillages of the CDs. Baykal et al. (2008), Ben-Ami et al. (2001), and Orujlu et al. (2008) reported the usage of biosafety cabinets; Chen, Lu, and Lee (2016) reported centralised oncology pharmacy with professional equipment where all the drugs were prepared and sent for administration.

Recent studies by Asefa et al. (2021), DeJoy et al. (2017), Silver, Steege, and Boiano (2016), Simons and Toland (2017, 2019), and Topçu and Beşer (2017) reported the usage of closed system transfer devices (CSTDs) for the preparation and administration of CD.

When referring to the engineering controls of closed system devices and administration of CDs, Asefa et al. (2021) stated that 37 (48.1%) of the respondents used disposable syringes without Luer-lock fittings during cytotoxic drug administration. DeJoy et al. (2017) reported that 94% of the nurses indicated that they “always” used luer-lock fittings for needleless systems and 91% claimed that they “always” used needleless systems. Silver, Steege, and Boiano (2016) study found statistically significant reductions in spills when using two types of devices designed to prevent exposure: CTSDs and luer-lock fittings. Bernabeu-Martinez et al. (2021) study highlighted that the risk was reduced if associated with a luer-lock system, with a perception of risk of exposure less for valve systems versus three tree systems.

4.2 | Side Effects and Risky Behaviours (Inductive)

Sixteen studies reported side effects as health problems due to handling CDs. These adverse effects include weakness, fatigue, sleepiness, loss of hair, headache, nervousness, respiratory problems, nausea, eye irritation, and decreased blood count leading to problems with immunity and anaemia (Batista et al. 2021; Baykal, Seren, and Sokmen 2009; Borges, Silvino, and dos Santos 2015; Constantinidis et al. 2011; Hanafi et al. 2017; He et al. 2017; Kyprianou et al. 2010; Mahdy, Rahman, and Hassan 2017; Orujlu et al. 2016; Shahrasbi et al. 2014; Simons and Toland 2017, 2019; Soheili et al. 2021a; Topçu and Beşer 2017; Tuna and Baykal 2017; Turk et al. 2004). Benoist et al. (2022) reported cutaneous, primarily in burns or tingling sensations, and Tuna and Baykal (2017) reported lip blisters. Kutlutürkan and Kırca (2022) reported psychosocial problems such as burnout syndrome, compassion, and emotional exhaustion. Menstrual cycle irregularities and reproductive issues were reported in seven studies (Borges, Silvino, and dos Santos 2015; Constantinidis et al. 2011; Kyprianou et al. 2010; Mahdy, Rahman, and Hassan 2017; Orujlu et al. 2016; Simons and Toland 2017; Turk et al. 2004). Ben-Ami et al. (2001) reported that their participants perceived susceptibility increased as much as the body damage potential was tangible and visible, for example, eye splashes, compared to other actions that cannot be monitored or measured.

Three studies reported risky behaviours of nurses in the working areas, such as eating, storing food and beverages, drinking beverages, smoking, and using cosmetics (Baykal, Seren, and Sokmen 2009; Ben-Ami et al. 2001; Turk et al. 2004).

Ben-Ami et al. (2001) described that older nurses were less likely to perform risky behaviours. They noted a significant correlation between health beliefs and the usage of safety measures, perceived susceptibility, and perceived benefit. They found no connection between the perceived severity of side effects and safe behaviour.

Kosgeroglu et al. (2006) did not find a significant correlation between protection of the environment or self-associated with experience in the chemotherapy unit, the participant's age, or the education received.

Kosgeroglu et al. (2006) and Ben-Ami et al. (2001) observed that nurses were more likely to be cautious about preparation rather than administering CD to the patient. Hanafi et al. (2015) attributed the preparation of CDs to the adverse effects suffered by the nurses but were unable to identify the CD responsible.

High contamination levels were observed by Graeve, McGovern, Alexander, et al. (2017) and Graeve, McGovern, Arnold, et al. (2017), indicating risky behaviour in CD checking areas and a lack of double gloving.

5 | Discussion

This systematic review is the first to utilise a deductive and inductive framework synthesis to understand the perceptions and experiences of cancer nurses of potential occupational exposure when handling CDs worldwide. The deductive synthesis utilising the Theoretical Framework: Factors Predicting the Use of Hazardous Drug (HD) Safe-Handling Precautions (Figure 3) gave the framework a unique picture of perceived influencing factors, with most studies aimed to explore the outcome of safe handling precautions.

Framework, deductive synthesis revealed 38 global heterogeneous studies from 17 countries with different methodologies, populations, clinical settings, underpinning education and guidance, environmental safety and surveillance practices, and safe handling precautions applied. Like Lin et al. (2019) and Bernabeu-Martínez et al. (2018), it was deemed challenging to conduct a meta-analysis. Even the most consistent validated measurement by Polovich and Clark (2012), which was utilised across six studies, revealed the global contextual diversity underscoring the prevalence of complexity arising in this area of research (Abu Sharour et al. 2021; Callahan et al. 2016; Graeve, McGovern, Alexander, et al. 2017; Graeve, McGovern, Arnold, et al. 2017; He et al. 2017; Mahdy, Rahman, and Hassan 2017; and Srisintorn et al. 2021).

This review describes the cancer nursing perception as 'situational' inductively. The participants in the 38 studies described individual, shared, and cultural perceptions embodied in different healthcare systems and workplace safety, the use of different clinical guidelines, a variation on the requirement for education, and the ensuing application to their clinical practice. Thirty-two studies utilised self-reported, subjective methodology. Therefore, this review raises the point that the responses from cancer nurses are espoused perceptions of what should occur daily.

Supporting this interpretation further are the seven mixed methods (Asefa et al. 2014; Benoist et al. 2022; Chen, Lu, and Lee 2016; Graeve, McGovern, Alexander, et al. 2017; Graeve, McGovern, Arnold, et al. 2017; Polovich and Clark 2012; Soheili et al. 2021a; Topçu and Beşer, 2017) and five observational studies (Chen, Lu, and Lee 2016; Colvin, Karius, and Albert 2016; Hanafi et al. 2017; Kosgeroglu et al. 2006; Shahrabi et al. 2014) where the attitudes and beliefs and perception of practice changed, when delivering care within a complex environment in different countries. One study by Hanafi et al. (2015) stated that the complexity of the environment resulted in the potential to achieve less than 50% adherence to PPE for preparation and administration. Therefore, it is proposed that perception is espoused because the practice experience differs depending on an individual's daily environmental circumstances.

By being solely reliant on the perceived solutions of education, environmental surveillance, and hierarchy of controls in creating the work safety climate, there is no consideration of the multiple unforeseen clinical tasks requiring priority decision-making about 'in-the-moment' safe handling precautions (Fazel et al. 2022), also described as 'optimising violations' to get the job done quickly (Reason 1990). Despite the availability of guidelines in most countries (Bernabeu-Martínez et al. 2018; Coyne et al. 2019; Quispe Condor et al. 2021), in their deliberative process of contextualising policy, literature, and expert opinion, Fazel et al. (2022) uncovered that the most common barriers within the clinical practice were poor training (46%), poor safety culture (41%), and inconsistent policies (36%). All of these factors affect the perception and experience of cancer nurses of potential occupational exposure to CDs. Lin et al. (2017) state three defining characteristics common to the safety climate in healthcare providers: the creation of a safe working environment by senior management (cultural perception) in healthcare organisations, the shared perception of healthcare providers about the safety of their work environment, and the effective dissemination of safety information. In addition, Lin et al. (2017) suggest that organisational influence must provide a positive attitude to improving work safety climate and should monitor environmental equipment and safety management operations. Consideration should be given to the perception of safety climate in the workplace. Compliance with safe work practices and sharing perceptions of work safety with colleagues should serve as a basis for jointly creating a safe working environment.

In this global review, the experience of providing workplace safety and the exploration of working conditions of nurses highlights that cancer nurses are feeling overburdened with the number of patients and workload, resulting in a perceived increase in potential occupational exposure from CDs. The extension of the inclusion criteria in this review generated more nuanced data about working practices that influence the cancer nurse's experience and perception of safe handling practices (Coyne et al. 2019; Lin et al. 2019). The qualitative interview studies indicated that many nurses want a secure environment and better working conditions. Limited, global representative qualitative studies have been conducted from 2015 until 2017 (Chen, Lu, and Lee 2016; Topçu and Beşer 2017; Tuna & Baykal 2017; Verity et al. 2008). There is growing evidence of exploring oncology nurses' broader contextual perceptions regarding occupational

needs, work-related stressors, and health work environment (Arıkan Dönmez et al. 2023; Soheili, Jokar, et al. 2021; Soheili et al. 2021a; Soheili et al. 2021b) and, in addition, the work safety modelling (Lin et al. 2022) and health behaviours determinants scale (Abu-Alhaja et al. 2022, 2023).

When considering creating a workplace safety solution to enhance the perceptions and experience of cancer nurses, the study by Graeve, McGovern, Alexander, et al. (2017) and Graeve, McGovern, Arnold, et al. (2017) used a two-armed approach: training and a contamination swabbing exercise. The results were then shared with the administration units to determine a change in practice. The results showed statistical significance in increasing perceived risk on pre and post-survey questions, resulting in higher use of PPE, but the swab retesting did not support an overall workflow change, with continued contamination. Since 2019, The United States Pharmacopoeia (USP) Chapter < 800 > guidelines (2017) are set to be adopted in the US and Canada, requiring regular surface sampling for antineoplastic drug (AD) surface contamination as a means of environmental surveillance. More contamination studies are being conducted and published, qualifying local variance. Arnold and Kaup (2019) analysis revealed that statistically significant differences were found between cancer nurse chemotherapy clinics in the frequency of contact among nursing staff in patient administration areas for five of the six surfaces. The duration of contact was not significantly different except for the duration of touching the IV pump.

In further support of safe handling practices and potential occupational exposure, Bernabeu-Martínez et al. (2021) indicate that cancer nurses perceive the specific actions that are out of their control in the process of administration and disposal as riskier. The highest risk is associated with accidental exposure during connection and disconnection of infusion lines, areas around the spike, where there is the risk of exposure by drops and spills, by tares in the infusion bags or inadequate connection. This study only questions the specifics of administration practice and needs to consider the layers of complexity when adding patient and family (human) factors into the process.

This review also spotlights that there may be a counter-effect to safe handling precautions. Chen, Lu, and Lee's (2016) study shows that experiencing annual surveillance reduces practising safe handling precautions, as the perception is that surveillance will diagnose an individual's occupational exposure to CDs. Furthermore, Topçu and Beşer (2017) identified closed system transfer devices that were perceived as reducing exposure to 'not possible', resulting in decreased usage of PPE, with Chen, Lu, and Lee (2016) reporting closed systems 'encapsulated toxicity'.

Similarly, both Baykal, Seren, and Sokmen (2009) and Turk et al. (2004) reported risky behaviours of nurses in hazardous working areas, such as eating, storing food and beverages, drinking beverages, smoking, and using cosmetics. One interpretation may be that they felt that they were conducting appropriate safe handling precautions, and, therefore, the risky behaviour was not perceived as dangerous but rather a lack of education.

In this review, cancer nurses are perceiving and or experiencing side effects which they attribute to exposure to cytotoxic drugs (Borges, Silvino, and dos Santos 2015; Constantinidis et al. 2011; Hanafi et al. 2017; Kutlutürkan and Kırca 2022; Kyprianou et al. 2010; Mahdy, Rahman, and Hassan 2017; Nwagbo et al. 2017; Orujlu et al. 2016; Shahrabi et al. 2014; Simons and Toland 2017; Soheili, Jokar, et al. 2021; Soheili et al. 2021a; Soheili et al. 2021b; Topçu and Beşer 2017; Tuna and Baykal 2017; Turk et al. 2004). These are short- and longer-term effects, including reproductive issues and foetal abnormalities. These reported side effects are perceived globally, not confined to any country or workplace. Internationally, it remains challenging to attribute any of the side effects to specific actions or inactions concerning safe handling precautions.

This review adapted the priori framework (Polovich and Clark 2012) to consider cancer nurses' perceptions and experiences about potential occupational exposure to CDs; the framework represents the concept of the espoused perception of safe practice, which coexists and often conflicts with the experience of conducting safe practice when reducing the potential occupational exposure to CDs (Figure 4).

In this review, the framework was not being tested; we were using it to guide the synthesis of the included studies. The original priori framework (Polovich and Clark 2012) attributes direct links between its elements. This review has detracted from making direct associations between the elements in the model, as this could only be achieved with a robust meta-analysis. The inductive additions to the framework are lighter in colour than the original priori framework categories.

From left to right (Figure 4), going from espoused perception and experience, working towards hazardous drugs and safe handling precautions is seen at three levels.

The review sees the perception and experience of potential occupational exposure of cancer nurses as a complex intervention and challenge to homogenise within a global context when cancer nursing espoused perception and the expertise in workplace safety and safe handling practice played out differently depending on the country, the unit set, the organisation, and the individual cancer nurses involved. How this complex environment is affected will be determined by the cascade of events and if they result in an occupational exposure event, in short-term or long-term exposure for any individual cancer nurse.

5.1 | Implications for Practice

This review recommends that the theoretical model moves from the safe handling precautions being solely the individual's accountability, where the hierarchy of control is devised, education is delivered, guidance is given, and surveillance is applied, with the outstanding focus being on the 'why' individuals are not practising safe handling. This adapted model proposes understanding that individual cancer nurse perception is created from a shared and cultural perception in which the handling CDs is embedded, changing practice in perception and experience of safe handling precautions depending on the workplace safety of the clinical setting and the country.

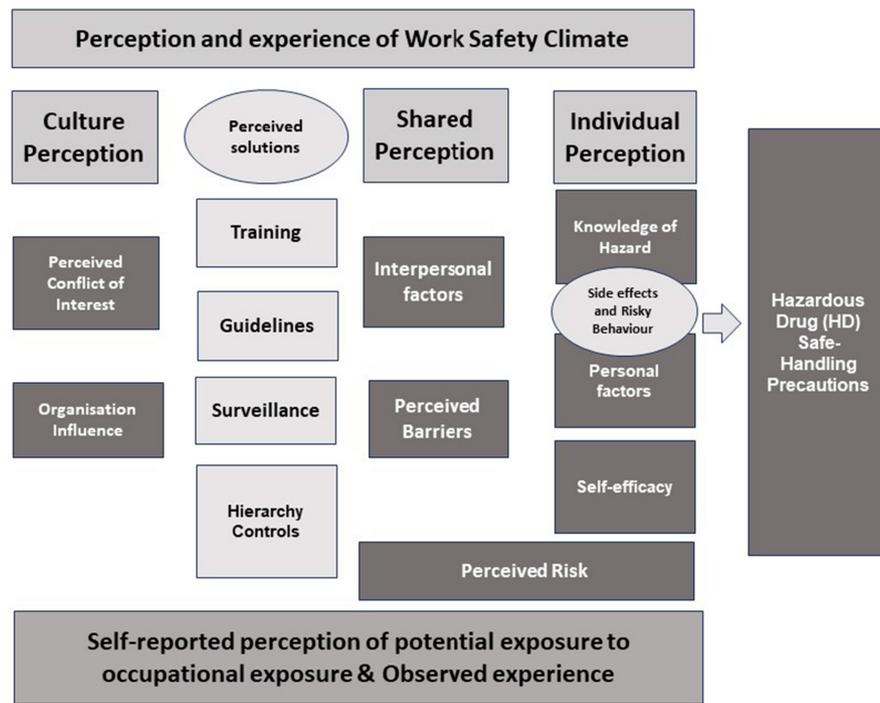


FIGURE 4 | Adapted theoretical framework. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.com)]

It is imperative, then, that due to the complexity and differing practices, local units must provide nationally agreed education, guidelines, and appropriate and safe working environments to enable the perception of the correct safety practices, acknowledging that the practical experience is often chaotic and exists in an unpredictable environment. The safe practice has to be monitored against national and international cancer nursing policies and directives. Practice must also be monitored to ensure that knowledge and competency are applied and embedded daily by regularly imposing risk assessment, observation, and simulated activity. Practice alone cannot rely on the perceived solutions of education and guidance, with the responsibility and accountability being on the cancer nurse. Practice experience must be monitored against the cultural and shared perception influencing practice.

Further testing of this theoretical model is necessary to understand the complexity of the working environment and more innovative educational approaches to embed safety practices in it. Furthermore, future research should focus on quality improvement contamination swapping activity and more inexpensive and immediate innovations to detect occupational exposure to cytotoxic drugs.

6 | Conclusions

Occupational cytotoxic exposure is a reality globally. We have gained new insights on this topic by conducting this framework synthesis review to understand cancer nurses' experiences and perceptions of potential occupational exposure to cytotoxic drugs worldwide. This review reflects the heterogeneous practice and how this is measured about safe handling precautions, including the diversity in perception and experience in knowledge, perceived barriers, perceived risk,

self-efficacy, organisational influence and interpersonal influence, and perceived conflict globally. The review identified further categories of education, guidance, surveillance, hierarchy of controls, risky behaviour, and side effects. This review continues to prove that there is a challenge to standardised international improvement and urges practice to guide safety and well-being when administering cytotoxic drugs, locally and nationally.

6.1 | Limitations

Using framework analysis benefited the review by providing a deductive and inductive approach, giving meaning relevant to the research topic under investigation. However, the framework approach is based upon one framework, and the resulting adaptation must still be tested in practice. Limitations were found in the nature of the studies as this was dominated by self-reported data, which again needs to be more generalisable in practice but gives a key indication for practice. The topic of perception and experience is subjective, and the findings would not be generalisable globally but would need to be repeated and interpreted locally. Another limitation was that all non-English-written papers were excluded from the review, which would have been applicable when reviewing the abstract. This limitation was most evident from the Asian research studies.

Author Contributions

K.C. lead author and design, development of protocol, review of articles for inclusion, data extraction, synthesis and write up. J.A. review of protocol and articles for inclusion. M.D. review of articles for inclusion, quality assurance, editing. M.K. designed search strategy and generated articles for review. D.D. review of articles for inclusion, data extraction, synthesis and write up.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supplementary material: Search Strategy

CINAHL with Full text (EBSCO), PubMed (including Medline and PMC), Web of Science, Ovid Nursing, PsycINFO.

Journal hand searching will also be done in key cancer and oncology journals that are not indexed in any of the above databases, as well as forwards and backwards citation searching.

Grey literature searching will also be undertaken to identify key research reports by relevant professional organisations e.g. European Oncology Nursing Society, Oncology Nursing Society. Any other grey literature sources in primary research format will be considered for inclusion, including theses, conference papers, and pre-prints.

Sources will be limited to those published in English and those published from 2001 onwards.

17. Search Strategy – keyword concepts

Main Concept	Cancer Nurses	Occupational Exposure	Cytotoxic drugs	Experiences
Subject Headings	Oncologic nursing (CINAHL) Oncology Nursing (Medline)	Occupational exposure	Cytotoxins Carcinogens Teratogens Antineoplastic agents (explode)	Perceptions Views Opinions Thoughts Perspectives
Free Text Search Terms	Oncology nurs* Cancer nurs*	Workplace exposure Potential exposure Occupational Hazard Occupational Risk Staff exposure Nurse safety Safe handling	Chemotherapy drugs Toxic drugs Chemotherapy Medication Antineoplastic drugs Antineoplastics Antineoplastic Agents Anticancer drugs Hazardous drugs Carcinogens Genotoxicity Teratogenicity Teratogens cytotoxins	Feelings Attitudes Knowledge

Search undertaken 11th Feb 2022

Cancer nursing	1	(MH "Oncologic Nursing+")	17,465
	2	TI oncolog* N2 nurs* OR AB oncolog* N2 nurs*	7,766
	3	TI cancer N2 nurs* OR AB cancer N2 nurs*	4,284
	4	S1 OR S2 OR S3	22,364
Occupational exposure	5	(MH "Occupational Exposure")	20,300
	6	TI work* N2 exposure OR AB work* N2 exposure	3,470
	7	TI potential exposure OR AB potential exposure	3,795
	8	TI occupation* N2 hazard* OR AB occupation* N2 hazard*	1,471
	9	TI occupation* N2 risk* OR AB occupation* N2 risk*	2,913
	10	TI staff* N2 exposure OR AB staff* N2 exposure	310
	11	TI nurs* N2 safety OR AB nurs* N2 safety	2,670
	12	TI safe handling OR AB safe handling	1,232
	13	S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12	31,857
Cytotoxic drugs	14	(MH "Cytotoxins") OR (MH "Carcinogens") OR (MH "Teratogens") OR (MH "Antineoplastic Agents+")	133,934
	15	TI chemotherapy drugs or toxic drugs or chemotherapy medication or antineoplastic drugs or antineoplastic agents or antineoplastics or anticancer drugs or hazardous drugs or carcinogens or genotoxicity or teratogenicity or teratogens or cytotoxic drugs or cytotoxins	2,680
	16	AB chemotherapy drugs or toxic drugs or chemotherapy medication or antineoplastic drugs or antineoplastic agents or antineoplastics or anticancer drugs or hazardous drugs or carcinogens or genotoxicity or teratogenicity or teratogens or cytotoxic drugs or cytotoxins	11,084
	17	S14 OR S15 OR S16	140,737
Experiences & Perception	18	TI experiences or Perceptions or Views or Opinions or Thoughts or Perspectives or Feelings or Attitudes or Knowledge	323,774
	19	AB experiences or Perceptions or Views or Opinions or Thoughts or Perspectives or Feelings or Attitudes or Knowledge	806,683
	20	S18 or S19	969,835
All terms combined	21	S4 AND S13 AND S17 AND S20	48
Language Limited to English	22	S4 AND S13 AND S17 AND S20	42
Date from 2000	23	S4 AND S13 AND S17 AND S20	41



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title Page
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	YES
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Pg 2-4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Pg 4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Pg 5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Pg 4
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary material
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pg 4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Pg 4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Pg 2
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Pg 4
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Pg 5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Pg 5
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Supplementary Material
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NVivo
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Hawkers Quality Assurance tool
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 2 PRISMA Diagram
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	N/A
Study characteristics	17	Cite each included study and present its characteristics.	Pg 7-13
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	N/A
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N/A
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	N/A
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A studies were not excluded based on quality
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pg 19
	23b	Discuss any limitations of the evidence included in the review.	Pg 19
	23c	Discuss any limitations of the review processes used.	Pg 24
	23d	Discuss implications of the results for practice, policy, and future research.	Pg 23
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Pg 1 & 5 (ID CRD42022289276)
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	PROSPERO
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	UK Oncology Nursing Society Grant – No role in the review.



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Competing interests	26	Declare any competing interests of review authors.	None
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: <http://www.prisma-statement.org/>

Name of the Study	Sample of Nurses	Aim	Characteristics under the study	Methodology used	Theoretical model	Research setting	Tools	Hawker score (Max 27)
Abu-Sharour et al. (2021) Jordan	153	To examine knowledge of safe-handling precautions among a sample of oncology nurses	Knowledge, safe handling precautions	Quantitative Cross-sectional study	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	Nurses who were employed in two governmental hospitals in Jordan.	Factors Predicting Use of Hazardous Drug Safe-Handling Precautions (PHDP) model (Lusk et al., 1997); The Chemotherapy Handling Questionnaire, developed by Polovich and Clark (2012), was used to measure chemotherapy handling practices.	27
Ale Hashem & Baniasadi (2018) Iran	80	To evaluate the knowledge, attitude, and practice (KAP) of oncology nurses towards the safe handling of Anti-neoplastic drugs.	Knowledge, attitudes, and Safe handling practice	Cross sectional study - six university hospitals		Six University Hospitals, 80 Nurses participated	Developed Questionnaires: Demographic; Protocol knowledge & Standards; Attitudes towards working in oncology, concerns & feelings; direct handling practice.	26
Asefa et al. (2021) Ethiopia	77	To assess knowledge and practices of safe handling of CDs	Knowledge and Safe Handling precautions, PPE usage	Cross-sectional study		Nurses from one specialized hospital and one University Hospital	Adapted questionnaire. Variable: Knowledge; practice; Cytotoxic; Handling; Cytotoxic waste; Disposal waste; Personal Protective Equipment.	27
Batista et al. (2021) Brazil	35	To assess the knowledge of nursing professionals about the use of antineoplastic drugs in a general hospital.	Knowledge, perceived risks, experience of side effects in handling CDs	Descriptive and exploratory study with a qualitative approach		University Hospital	Semi-structured interview schedule	26
Baykal et al. (2009) Turkey	171	The purpose of determining the problems of nurses who work on oncology units and administer cytotoxic drugs, with their working conditions, personal rights and working life	Working conditions, Perception of PPE usage, and contamination	Analytic descriptive questionnaire.		Nine hospitals in Istanbul province nine (four private, two university and three public) hospitals	Local 47 -item: personal demographics (5); Working conditions (31 closed ended; 11 open; 12 classification). Expert validation only. Piloted in 15 nurses.	27
Ben-Ami et al. (2001) Israel	61	To examine the influence of the nurses' beliefs, attitudes, and knowledge concerning occupational exposure, on their behavior and proper use of recommended protective measures.	Framework – Psychological measures based on the Health Belief Model towards the Cytotoxic drugs and site observation of exposed and unexposed nurses.	Descriptive questionnaire	The Health Belief Model (HBM) and its extensive form	Two Central Hospitals in Israel and community nurses	Demographic data: age, sex, marital status, State of birth, military service, education, number of years as an RN and as an oncology nurse. 2. Lifestyle, smoking, and other habits. 3. Personal and family medical, occupational, and exposure history. 4. General health beliefs and the nurses' perceived personal health. 5. The nurses' knowledge of proper use of the protective measures during preparation and administration of CDs, and knowledge of potential risks of CDs. 6. Health behavior and safe behavior while dealing with the CDs. 7. Psychological measures: health beliefs and attitudes towards the CDs according to the HBM components: 1. perceived susceptibility 2. perceived severity 3. perceived benefits 4. perceived barriers 5. self-efficacy	21
Benoist et al. (2022) France	64	To assess the perception, knowledge, and handling practices of all occupation level categories	Knowledge and perceived risk of exposure to CDs	Descriptive questionnaire study, performed through face-to-face interviews		University Hospital	Adapted questionnaire from Hon et al 2015.	27
Bernabeu-Martinez. (2021) Spain	65	To assess the perception of risk of exposure in the management of hazardous drugs (HDs) through home hospitalization and hospital units	Knowledge, Perception of risk of exposure to HDs	Cross sectional study, Questionnaire based		National questionnaire disseminated via email with electronic link.	Adapted Questionnaire twenty-one specific questions	22
Borges et al. (2015) Brazil	26	To implement best practices guidelines for minimizing chemical exposure risk of nurses in a chemotherapy unit (CTU) using the knowledge, attitudes, and practices survey (KAP)	Adverse health effects, Knowledge, and perceived risk of exposure to CDs	Quantitative, descriptive KAP questionnaire based.		Two cancer units in the National cancer institute	Developed KAP questionnaire to identify the knowledge, attitudes, and practices with respect to a specific topic. The Likert scale was utilized with the questions.	23

Callahan et al. (2016) USA	115	To identify factors associated with oncology nurses' use of hazardous drug (HD) safe-handling precautions in inpatient clinical research units.	Exposure knowledge, self-efficacy, barriers to personal protective equipment use, perceived risk, conflict of interest	Descriptive, cross-sectional.	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	National Institutes of Health Clinical Centre in Bethesda, Maryland	The Hazardous Drug Handling Questionnaire (HDHQ) developed by Polovich and Clark (2012)	27
Chen et al. (2016) Taiwan	57	Aim of the study was to explore the concerns of nurses regarding their decision to use or not to use PPE in the cultural context of Taiwan.	Ethnographic, Site Observation PPE usage, barriers of PPE usage, perception of risk, self-efficacy.	Ethnographic Qualitative Study		Two Accredited medical centers with oncology team.	Interviews and observation. Ethnographic interviews were conducted using 3 levels of questions: descriptive, structural, and contrasting. Descriptive questions provided the general features of the research phenomenon.	24
Colvin et al. (2016) USA	33	The objective was to learn if current NIOSH PPE and hospital policy chemotherapy exposure controls were adhered to in actual clinical practice based on observation and nurses' self-assessment.	Site observation of safe handling measures and adherence to PPE	Micro-ethnography and questionnaire		Large Cancer Centre: Cleveland Clinic	Observation and self-assessment of adherence; 15 item checklists on skills (NIOSH & ONS Guidelines & Institutional policies).	26
Constantinidis et al. (2011) Greece	353	Aim of the study was to describe the existing knowledge and attitude of the healthcare workers regarding the risks concerning their work, as well as the adverse effects experienced by them in relation to their occupational exposure to chemotherapeutic agents	Knowledge, safe handling, safety climate, side effects	Questionnaire from twenty-four public and private hospitals covering the entire country between November 2006 and April 2007.		Questionnaire to twenty-four public and private hospitals covering the entire country	The first part contained a series of demographic characteristics, working position information and smoking habits. The second part contained three groups of specific questions according to the type of exposure to the chemotherapeutic agents, that is, the transportation and storage, or the preparation and reconstitution procedure and finally administration and patient care.	22
Çınar, & Karadakovan (2022). Turkey	117	To examine the risks faced by oncology nurses in the units they work in and occupational safety.	Safe handling, Knowledge, safety climate	Cross-sectional descriptive study		Questionnaire to cancer nurses actively registered to the Oncology Nurses Association in Turkey	Developed questionnaire.	26
Dejoy et al. (2017) USA	1814	This study examined the effects of pertinent organizational safety practices and perceived safety climate on the use of personal protective equipment, engineering controls, and adverse events (spill/leak or skin contact) involving liquid antineoplastic drugs.	Perceived risks, safe handling measures, and engineering controls for safe handling.	Cross-sectional survey		National Web-based survey	The survey included seven hazard modules and a core module in addition to a screening module. The data for this study came from the 2011 NIOSH Health and Safety Practices Survey of Healthcare Workers, an anonymous, multi-module, web-based survey. Details of survey is described in Steege et al, 2014	19
Graeve et al. (2017) ^{a & b} U S A	163	To develop and test a worksite intervention that protects healthcare workers who handle antineoplastic drugs from work-related exposures.	Framework model variables, PPE usage, Surface contamination and workplace safety climate	Intervention study.	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	A university hospital in a large midwestern metropolitan area and its outpatient chemotherapy infusion clinic.	The Hazardous Drug Handling Questionnaire (HDHQ) developed by Polovich and Clark (2012)	27
Hanafi et al. (2017) Iran	77	To examine all adverse effects associated with handling of antineoplastic drugs.	Knowledge, Safe Handling measures, adverse effects, monitoring	An observational cross-sectional survey Mixed method-using observations and cross-sectional survey		Three tertiary care teaching hospitals in Tehran, Iran	Questionnaire designed from recent guidelines.	25

He et al. (2017) USA	467	To examine patterns and organizational correlates of personal protective equipment (PPE) use and hazardous drug spills.	PPE use, safety climate and hazardous drug spills	Cross-sectional mailed survey.	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	Oncology Nursing Society members who administer hazardous drugs.	The Revised Hazardous Drug Handling Questionnaire measures frequency of using PPE Questionnaire.	25
Hon et al. (2015) Canada	120	To explore the degree of contact with antineoplastics, knowledge of risks associated with antineoplastics, perceptions of personal risk, previous training with respect to antineoplastics, and safe work practices.	Knowledge of risk, PPE usage, barriers, safe handling behavior	Cross-sectional		Six acute care facilities in Vancouver, British Columbia.	Self-administered questionnaire	24
Khan et al. (2012) Pakistan	35	To measure the levels of nurse's knowledge and attitude after the conduct of education session regarding chemotherapy administration and management.	Knowledge, attitudes, training	Single group pre-test post-test study design		Two oncology units of tertiary hospital, Pakistan	Knowledge-11 questions; Attitude-21 items. The face, content, construct and criterion validity and reliability of questionnaire were established	26
Kim et al. (2019) South Korea	872	To examine the safe handling practice of chemotherapeutic agents by Korean nurses working in inpatient units and to examine the relationship between Korean nurses' perceptions of the hospital safety climate and adherence to the safety guidelines for handling chemotherapeutic agents.	Perceived risks, safe handling measures, PPE	A descriptive, correlational design with a cross-sectional survey		Cross-sectional survey using data from the Korea Nurses' Health Study.	The KNHS adopted the protocols and survey questions of the United States of America (U.S.). Nurses' Health Study 3, with minor changes to reflect cultural and organizational differences	27
Kosgeroglu et al. (2005) Turkey	121	The aim of this study was to determine both the level of information that nurses possessed and the method of administration nurses used during chemotherapeutic drug preparation and administration.	Safe handling precautions, PPE usage, and site Observation	Descriptive study Mixed methods-Survey and site observations		The chemotherapy administration units of all hospitals in Eskisehir, west Turkey	Twenty-five questions in the questionnaire along with observation questions 11 for self-care and 14 for environmental -OSHA Directives (1986) and related literature.	27
Kutlutürkkan et al. (2022) Turkey	80	The aim of this study was to determine oncology nurses' views of the strengths, weaknesses, opportunities, and threats to oncology nurses.	Knowledge, risks, and safe handling of awareness of CDs. The working conditions and emotions of nurses were also described through the SWOT method.	Descriptive pilot study		The study population consisted of nurses who were members of the Oncology Nursing Association of Turkey	Developed questionnaire based on a literature review and a SWOT template.	27
Kyprianou et al. (2010) Cyprus	88	To evaluate the knowledge, attitudes, and beliefs of Cypriot nurses on their exposure to antineoplastic agents	Knowledge, perception of risks of exposure, PPE usage, and side effects from exposure.	A cross-sectional survey using a self-administered questionnaire		Nurses who work in three hospitals in Nicosia, Cyprus	The questionnaire was originally compiled by Turk et al., to evaluate the knowledge, attitudes and safe behaviors of nurses' handling cytotoxic drugs and was translated from Turkish to Greek by two bilingual volunteers.	26

Mahdy et al. (2017) Egypt	65	To evaluate the effect of cytotoxic drugs safety guidelines on knowledge, safe handling practices and attitude of oncology nurses	Knowledge, attitudes, Safe handling practices of CDs	A Quasi experimental design was utilized to conduct this study. A quasi-experimental research design with one group pre-test, post-test was used to conduct this study.	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	Cancer center affiliated to Ain Shams University Hospitals, Cairo, Egypt.	Questionnaire was developed by the researchers in an Arabic language based on the review of related literatures. The Hazardous Drug Handling Questionnaire (HDHQ) developed by Polovich and Clark (2012)	27
Nwagbo et al. (2017) Nigeria	100	To determine knowledge of chemotherapy and occupational safety measures of nurses in oncology units	Knowledge, Side effects, Occupational safety measures related to CDs	A cross sectional descriptive study	Protection Motivation theory	Cross-sectional study among nurses in the oncology unit of University College Hospital	Fifty-four item validated questionnaire; questionnaire was subjected to expert review to ensure content and face validity.	27
Orujlu et al. (2016) Iran	54	To evaluate knowledge, attitude, and performance of oncology nurses and to survey nurses' chemotherapy workload and the experienced side effects.	Knowledge, attitude, safe handling measures, working conditions, and the experienced side effects.	Quantitative Cross-sectional study		Four hospitals of Urmia University, Iran.	Developed Questionnaires including The Hazardous Drug Handling Questionnaire (HDHQ) developed by Polovich and Clark (2012)	23
Polovich and Clark (2012) USA	165	To examine relationships among factors affecting nurses' use of hazardous drug (HD) safe handling precautions, identify factors that promote or interfere with HD precaution use, and determine managers' perspectives on the use of HD safe-handling precautions.	Knowledge, attitude, and safe handling measures. Framework analysis of the theoretical predictor variables.	Cross-sectional, mixed methods	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	Mailed invitation to oncology centers across the United States.	The Hazardous Drug Handling Questionnaire (HDHQ) developed by Polovich and Clark (2012)	27
Shahrashi et al. (2014) Iran	225	To evaluate the attitude, knowledge and safe practices of nurses' handling cytotoxic drugs.	Evaluation of exposure and contamination	Quantitative Cross-sectional study and surface sampling and observation		Multiple sites, Nurses working in specialized cancer centers in Tehran	Based on International Guidelines: American Society of health System Pharmacists; occupational safety and Health Administration; health and Safety Executive. Two parts: understanding of hazard & Reported side effects.	21
Silver et al. (2016) USA	1094	To examine factors associated with adherence among 1094 hospital nurses who administered ADs.	Engineering controls, work practices, nurse perceptions, use of personal protective equipment PPE	Quantitative Cross-sectional study		National Survey- The study population primarily included members of professional practice organizations representing health care occupations which routinely use, or encounter selected chemical agents.	Adapted Questionnaire included seven hazard modules and a core module in addition to a screening module.	25
Simons & Toland (2017) UK	55	to explore the immediate adverse effects experienced by nurses during the administration of systemic anti-cancer therapy (SACT), specifically cytotoxic chemotherapy, and whether closed systems are being used to minimize exposure risk	Side effects, usage of closed systems	Cross sectional survey		Study population selected from local network of nurses and survey sent through social media of the nurses' network.	The questions were compiled by the authors based on available research and guidelines that list the potential adverse effects of occupational exposure to cytotoxic chemotherapy drugs	19
Simons & Toland (2019) UK	61	To explore awareness, knowledge, training, and use of protection measures by healthcare personnel working in areas where Systemic anti-cancer treatment is administered.	Knowledge of risks, PPE usage, and Engineering control	Quantitative Cross-sectional study		aimed at healthcare personnel working in SACT administration areas.	Certain Questions included in the survey were adherence to training and annual update from (Control of Substances Hazardous to Health (COSHH) 2002, HSE 2014, Santillo et al 2018)	24
Soheili et al. (2021^{a, b & c}) Iran	52	Exploring oncology nurses' perceptions regarding work-related stressors, health work environment & occupational needs.	Knowledge of risks, PPE usage, and Engineering control	Qualitative descriptive study.		eight cancer treatment centers in different cities of Iran	In-depth semi-structured interviews. Each interview started with a general question and continued with specific questions in line with the objectives of the study	27

Srisintorn et al. (2021) Thailand	884	aimed to evaluate the level of PPE usage and factors predicting PPE usage among nurses and nurse assistants in Thailand.	Knowledge, attitude, and safe handling measures. Framework analysis of the theoretical predictor variables.	Quantitative Cross-sectional study	Factors Predicting Use of Hazardous Drug (HD) Safe-Handling Precautions	survey was conducted in a university hospital and two general hospitals	The Hazardous Drug Handling Questionnaire (HDHQ) developed by Polovich and Clark (2012)	26
Topcu et al. (2017) Turkey	15	Aimed towards describing attitudes, opinions and experiences of nurses administering these drugs about safe handling precautions.	Evaluate factors that affect nurses using safe handling.	Qualitative study design.	Health Belief Model (HBM)	The study was conducted in two hospitals	A semi-structured interview including open-ended questions and based on HBM was used for data collection. Questions were based on the following constructs: perceived benefits of safe handling precautions, perceived barriers in taking safe handling precautions, perceived seriousness for safe handling precautions, perceived sensitivity for safe handling precautions, cues to action for safe handling precautions.	19
Tuna & Baykal (2017) Turkey	25	To determine the working conditions of the oncology nurses in terms of employee safety as well as their knowledge levels regarding the safe use of antineoplastic drugs.	Safe handling, side effects, working conditions, training, and knowledge.	Qualitative study with phenomenological design.		Oncology nurses who were working in an oncology center in the city of Istanbul	Qualitative study conducted in the phenomenological design.	26
Turk et al. (2004) Turkey	120	To evaluate the level of knowledge of nurses on the health effects and the routes of exposure to CDs, to clarify the protective measures while handling these agents and to determine the influence of this knowledge on clinical attitudes, behavior, and actual usage of safety measures.	Knowledge, perception of risk, safe handling precautions, and PPE usage.	Analytic cross sectional study Mixed methods- Direct observations and survey		Cancer nurses at university teaching hospital	Two self-reported questionnaires were used to collect the data of the study	24
Verity et al. (2008) UK	257	Aim of this study was to describe nurses' experiences, attitudes, and educational preparation for the chemotherapy administration process.	Experiences, attitudes towards and educational preparation for administrating chemotherapy and determine factors that influence their perceptions.	Postal survey		A postal survey was conducted across twenty-six London hospitals providing cancer services.	Developed Questionnaire: Education, Worries and Attitudes Questionnaire–Hospital Version.	27

Supplementary material: The main characteristics of the studies

