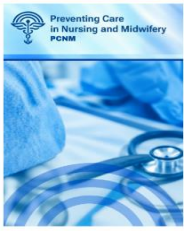
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Review Articles

Barriers to Personal Protective Equipment (PPE) Compliance Among Oncology Nurses: A Systematic Review

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Abstract

Background: Oncology nurses are routinely exposed to cytotoxic drugs, making appropriate use of personal protective equipment (PPE) an essential component of occupational safety. Despite established safety recommendations, adherence to PPE precautions remains inconsistent, potentially increasing the risk of occupational exposure and related health consequences.

Objectives: This systematic review aimed to identify, categorize, and synthesize the barriers to consistent PPE use among oncology nurses.

Methods: A systematic search was conducted in PubMed, Scopus, Web of Science, SID, Magiran, IranDoc, and IranMedex for studies published from January 2011 to December 2024. The review was conducted in accordance with the PRISMA 2020 statement. Methodological quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools. Findings from 17 eligible studies were synthesized using thematic analysis based on Braun and Clarke's framework.

Results: Barriers to PPE use were grouped into three main domains: individual and psychosocial factors, including inadequate knowledge and low self-efficacy; organizational factors, including insufficient training, high workload, and limited managerial support; and environmental and structural factors, including inadequate workplace design and limited availability of PPE. Overall, the included studies demonstrated moderate to high methodological quality, although reliance on self-reported measures was a common limitation.

Conclusion: PPE non-adherence among oncology nurses reflects the interaction of individual, organizational, and environmental barriers rather than a single behavioral deficit. Strategies to improve PPE adherence should therefore extend beyond education alone and address workplace conditions, ongoing competency-based training, PPE accessibility, and organizational and managerial support.

Implications for Nursing and Midwifery Preventive Care

- Strengthen preventive nursing care by implementing continuous, competency-based PPE training and early identification of occupational exposure risks.
- Promote safe nursing workflows, accessible PPE, and managerial support to prevent occupational exposure and protect nurses' health.

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Introduction

Cancer remains a major global public health challenge, with a growing number of patients requiring anticancer treatment [1, 2]. The increasing use of cytotoxic chemotherapy has also increased the potential for occupational exposure to hazardous drugs (HDs) among healthcare workers. Although these treatments have improved outcomes for many patients, their preparation, administration, and disposal can expose healthcare personnel to occupational hazards [3].

Chemotherapy agents are classified as HDs because of their genotoxic, carcinogenic, teratogenic, and reproductive toxicity. Occupational exposure can occur through dermal contact, inhalation of contaminated aerosols or particles, and accidental ingestion. Cytotoxic drug residues have also been detected on surfaces in oncology care areas, including medication preparation and administration areas, indicating that exposure may occur beyond direct handling of these agents [4]. Oncology nurses are of particular concern because they provide direct patient care and may routinely prepare, administer, and dispose of cytotoxic drugs [5].

Exposure to cytotoxic drugs has been associated with dermatologic, respiratory, hematologic, and reproductive health effects [6]. Despite these risks, oncology nurses do not always follow recommended safety precautions, particularly when using personal protective equipment (PPE) [7-9]. Inadequate PPE use can increase the likelihood of occupational exposure and is therefore an important area for preventive nursing practice.

Professional organizations and regulatory bodies, including the American Society of Clinical Oncology (ASCO), the Oncology Nursing Society (ONS), and the United States Pharmacopeia (USP), provide recommendations for the safe handling of HDs [10]. Depending on the task and level of exposure, these recommendations include appropriate gloves, protective gowns, eye protection, and respiratory protection. However, adherence varies across PPE types. Gloves are generally used more consistently, whereas eye protection, respiratory protection, and protective gowns are less consistently used [11, 12].

Several factors may affect whether oncology nurses use PPE as recommended, including knowledge and beliefs, workload, access to protective equipment, workplace conditions, training, and managerial support. However, findings across studies remain scattered, and the relative contribution of these factors is not always clear. An updated synthesis is also needed because research on HD safety continues to expand and recommendations for safe handling have evolved. Previous reviews have considered occupational safety among healthcare workers more broadly or have focused on particular settings or regions. A review focused specifically on oncology nurses can provide a clearer account of the barriers encountered in their day-to-day practice and help distinguish individual factors from barriers arising from the organization and work environment. Identifying these barriers can inform preventive strategies to reduce occupational exposure to cytotoxic drugs.

Objectives

The primary objective of this systematic review was to identify, categorize, and synthesize the barriers to consistent and appropriate PPE use among oncology nurses. PPE adherence was defined as the reported or observed use of recommended protective equipment during activities involving cytotoxic or other hazardous drugs, as assessed in the included studies.

By examining the barriers to PPE adherence, this review addresses an important aspect of preventive nursing practice. Identifying modifiable barriers may help guide interventions to reduce occupational exposure and protect the reproductive and overall health of oncology nurses.

Methods

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The review protocol was not prospectively registered in PROSPERO.

Search Strategy

A comprehensive search strategy was developed in consultation with a medical librarian to maximize the retrieval of relevant literature. The following electronic databases were searched: PubMed (MEDLINE), Scopus, Web of Science, ProQuest, and Embase (international databases), and the Scientific Information Database (SID), Magiran, IranDoc, and IranMedex (regional Persian databases). Google Scholar was also searched as a supplementary source to identify potentially relevant studies that might not have been retrieved through the electronic database searches.

The search strategy combined controlled vocabulary, including Medical Subject Headings (MeSH), with relevant free-text keywords related to personal protective equipment, oncology nursing, cytotoxic or hazardous drugs, occupational exposure, adherence, compliance, and barriers.

The PubMed search strategy was as follows: ("Personal Protective Equipment"[Mesh] OR "PPE" OR "gloves" OR "gowns" OR "respirator" OR "eye protection") AND ("Oncology Nursing"[Mesh] OR "oncology nurses" OR "chemotherapy nurses" OR "cancer nurses") AND ("Occupational Exposure"[Mesh] OR "barriers" OR "compliance" OR "adherence" OR "factors" OR "knowledge" OR "attitudes" OR "practices").

The search was restricted to studies published between January 1, 2011, and December 31, 2024. The final database search was conducted on December 15, 2024.

Inclusion/Exclusion Criteria

Studies were eligible if they were peer-reviewed original research articles using quantitative, qualitative, or mixed-method designs and included registered nurses working in oncology settings, including inpatient, outpatient, or chemotherapy units. Eligible studies had to examine barriers, factors, or correlates influencing PPE use or adherence to safety precautions during the handling or administration of cytotoxic or other hazardous drugs.

Studies published in English or Persian were considered eligible, provided that the full text was available for detailed assessment and data extraction.

Studies were excluded if they were non-peer-reviewed publications, including editorials, commentaries, letters, or conference abstracts without full text; theoretical or opinion papers; studies focusing exclusively on pharmacists, physicians, or other healthcare professionals without reporting nurse-specific findings; or studies that did not assess PPE use, adherence, or barriers to safe handling practices.

Studies published before 2011 or after 2024 were also excluded.

Data Extraction

A standardized data extraction form was developed and piloted using three studies to ensure consistency. Two reviewers (L.K. and N.T.) independently extracted data, and discrepancies were resolved through discussion or consultation with a third reviewer (M.J.).

Extracted information included study characteristics such as author(s), publication year, country, study design, and sample size; participant characteristics, including age, sex, professional experience, and work setting when reported; and specific barriers affecting PPE use or adherence. Information on the use of individual PPE components, including gloves, gowns, masks or respiratory protection, and eye protection, was also extracted when reported. Contextual factors and interventions were extracted when they contributed to understanding barriers to PPE adherence.

Quality/Risk of Bias Assessment Tools

The methodological quality of the included studies was independently assessed by two reviewers (L.K. and N.T.) using the appropriate Joanna Briggs Institute (JBI) critical appraisal tools for each study design.

The JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used for cross-sectional studies, whereas qualitative studies were assessed using the JBI Critical Appraisal Checklist for Qualitative Research. Inter-rater agreement was evaluated using Cohen's kappa ($\kappa = 0.82$), indicating strong agreement.

Disagreements were resolved through discussion or consultation with a third reviewer (M.J.).

Studies were not excluded solely based on methodological quality; instead, appraisal findings were considered when interpreting the synthesized evidence.

Synthesis Methods

Given the substantial heterogeneity in study designs, populations, measures of PPE adherence, and reported barriers, statistical pooling was not considered appropriate. The findings were therefore synthesized narratively and thematically. Thematic analysis was conducted using the six-phase approach described by Braun and Clarke, comprising familiarization with the data, generation of initial codes, identification of potential themes, review of themes, definition and naming of themes, and production of the report.

The coding process and theme development were iterative, with all three reviewers contributing to the interpretation and refinement of the final themes. NVivo 12 was used to organize and code the extracted qualitative data, while EndNote 20 was used for reference management and duplicate record removal.

Result

Study Selection

The database search identified 138 records, including 38 from PubMed, 29 from Scopus, 24 from Web of Science, and 47 from other databases. After removing 47 duplicate records in EndNote 20, 91 records remained for title and abstract screening. Of these, 44 records were excluded because they did not meet the eligibility criteria, primarily due to inappropriate populations, study designs, or topics. Full-text reports were sought for the remaining 47 records.

Three reports could not be retrieved because their full texts were unavailable, and 44 reports were assessed for eligibility. Of these, 27 were excluded because of an inappropriate population (n = 12), absence of relevant PPE-related outcomes or barrier data (n = 10), or an ineligible study design (n = 5). Ultimately, 17 studies met the inclusion criteria and were included in the qualitative synthesis. The study selection process is presented in the PRISMA 2020 flow diagram [Figure 1].

Characteristics of Included Studies

Seventeen studies were included in the final synthesis.

The included studies varied in design and were conducted across several countries, including the United States, Jordan, Iran, Turkey, and Egypt. The studies examined PPE use and adherence to hazardous drug-handling precautions from multiple perspectives, including nurses' knowledge, attitudes, and practices; perceived barriers; organizational factors; and workplace conditions. Some studies also evaluated factors associated with adherence or interventions intended to improve safe-handling practices. Detailed characteristics of the included studies are presented in [Table 1].

Quality Assessment Results

The methodological quality of the primary empirical studies was generally moderate to high.

The cross-sectional studies assessed using the JBI Analytical Cross-Sectional Checklist scored 6/9-9/9, while the included randomized controlled trial scored 9/10 on the corresponding JBI appraisal tool. The integrative reviews were assessed separately using the JBI Text and Opinion Checklist and were not assigned quantitative quality grades. No study was excluded solely on the basis of methodological quality.

The appraisal findings were considered when interpreting the synthesized evidence, particularly when assessing the consistency and strength of the reported barriers.

Detailed results of the quality appraisal are presented in [Table 2].

Identified Barriers to PPE Compliance

The thematic analysis identified three overarching categories of barriers to PPE adherence: individual psychological and behavioral factors, organizational and managerial factors, and environmental and structural factors.

These categories encompassed barriers related to knowledge and awareness, health beliefs and self-efficacy, workload and training, resource availability, managerial support, workplace design, and interpersonal influences. Table 3 presents the identified themes, subthemes, and supporting evidence from the included studies.

To summarize how frequently specific barriers were reported across the included primary studies, we counted the number of studies reporting each barrier and calculated the proportion. Table 4 presents the frequency of the identified barriers.

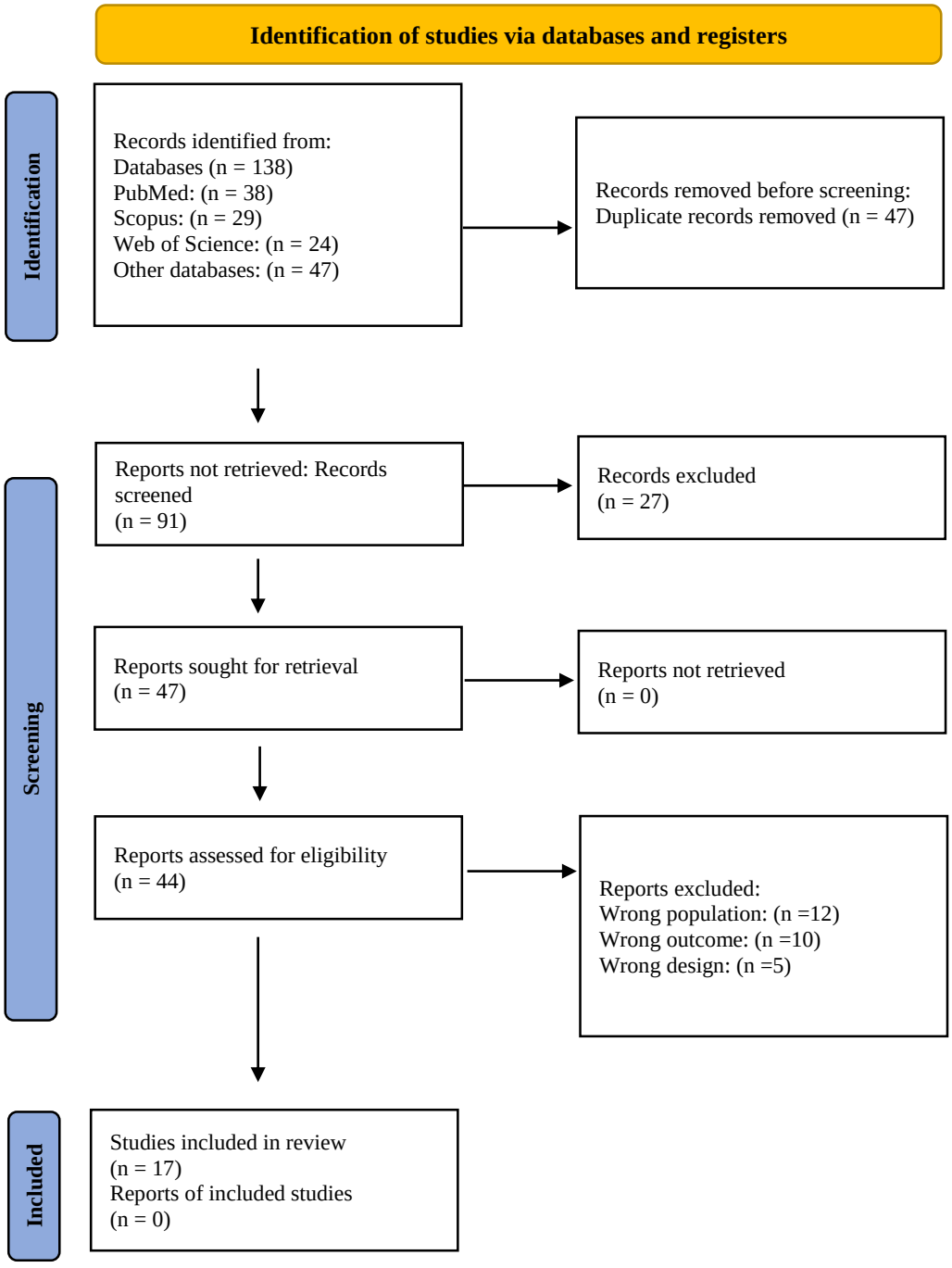


Figure 1. PRISMA 2020 Flow Chart for Study Selection

Table 1. Characteristics of the Included Studies

Author (Year)	Country	Study design	Sample size, n	Focus
Boiano et al. (2015)	USA	Cross-sectional	450	Health effects and adherence
Polovich and Martin (2011)	USA	Descriptive	312	PPE use patterns
Friese et al. (2019)	USA	Randomized controlled trial	120	Web-based intervention
Lawson et al. (2019)	USA and Canada	Web-based	500	Glove and gown use
Menonna-Quinn et al. (2019)	USA	Cross-sectional	215	Inpatient and outpatient PPE use
Loai et al. (2023)	Jordan	Cross-sectional	180	Knowledge of safe handling
Cinar and Karadakovan (2022)	Turkey	Cross-sectional	145	Occupational safety practices
Zayed et al. (2019)	Egypt	Cross-sectional	110	Knowledge, attitudes, and practices regarding safe handling
Callahan et al. (2016)	USA	Cross-sectional	230	Factors influencing PPE use
He et al. (2017)	USA	Cross-sectional	340	PPE use patterns and organizational correlates
Polovich and Clark (2012)	USA	Integrative review	—	Factors associated with hazardous drug handling
Reeves et al. (2013)	USA	Integrative review	—	Factors influencing PPE use
Abu Alhaija and Gillespie (2023)	Jordan	Retrospective cross-sectional	160	Adherence and attitudes
Graeve et al. (2017)	USA	Cross-sectional	205	Workplace and environmental factors
Najafi and Kahangi (2021)	Iran	Cross-sectional	130	Factors associated with non-compliance
Abu Sharour et al. (2021)	Jordan	Cross-sectional	175	Knowledge of safe-handling precautions
VerStrate (2015)	USA	Integrative review	—	Nursing practice perceptions

Note. PPE = personal protective equipment; KAP = knowledge, attitudes, and practices; HD = hazardous drug. An em dash indicates that a sample size was not applicable because the study was a review.

Table 2. Methodological Quality of the Included Studies Using Joanna Briggs Institute Critical Appraisal Tools

Study	Design	JBI appraisal tool	Score	Overall appraisal
Boiano et al. (2015)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
Polovich and Martin (2011)	Cross-sectional	Analytical Cross-Sectional Checklist	7/9	Moderate
Friese et al. (2019)	Randomized controlled trial	Randomized Controlled Trial Checklist	9/10	High
Lawson et al. (2019)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
Menonna-Quinn et al. (2019)	Cross-sectional	Analytical Cross-Sectional Checklist	7/9	Moderate
Loai et al. (2023)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
Cinar and Karadakovan (2022)	Cross-sectional	Analytical Cross-Sectional Checklist	7/9	Moderate
Zayed et al. (2019)	Cross-sectional	Analytical Cross-Sectional Checklist	6/9	Moderate
Callahan et al. (2016)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
He et al. (2017)	Cross-sectional	Analytical Cross-Sectional Checklist	9/9	High
Polovich and Clark (2012)	Integrative review	JBI Text and Opinion Checklist*	—	—
Reeves et al. (2013)	Integrative review	JBI Text and Opinion Checklist	—	—
Abu Alhaija and Gillespie (2023)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
Graeve et al. (2017)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
Najafi and Kahangi (2021)	Cross-sectional	Analytical Cross-Sectional Checklist	7/9	Moderate
Abu Sharour et al. (2021)	Cross-sectional	Analytical Cross-Sectional Checklist	8/9	High
VerStrate (2015)	Integrative review	JBI Text and Opinion Checklist	—	—

Note. JBI = Joanna Briggs Institute. An em dash (—) indicates that a quantitative appraisal score was not assigned because the JBI Text and Opinion Checklist does not yield a numerical score; these studies were assessed narratively

Table 3. Themes, Subthemes, and Supporting Evidence for Barriers to PPE Adherence

Theme	Subtheme	Description	Supporting studies
1. Individual psycho-behavioral factors	Knowledge and awareness	Limited knowledge of appropriate PPE selection and safe donning and doffing procedures, together with underestimation of occupational exposure risks.	[14, 15, 20]
	Health beliefs and self-efficacy	Low confidence in performing recommended protective practices and perceptions that PPE may be uncomfortable, inconvenient, or of limited benefit.	[16–18]
	Experience and age	Greater reliance on established routines or personal experience among some experienced nurses, potentially reducing adherence to recommended precautions.	[19, 20]
	Training and education	Inadequate or infrequent training and limited opportunities to reinforce correct PPE practices.	[18, 19, 23]
2. Organizational and managerial factors	Workload and time pressure	High workload, competing clinical demands, and time pressure that may make consistent adherence to safety precautions more difficult.	[19–21]
	Resource availability	Limited availability, accessibility, or suitability of required PPE, and concerns about its cost or comfort.	[20, 22]
	Managerial support and safety culture	Limited managerial supervision, enforcement of safety policies, and organizational emphasis on safe handling practices.	[21, 23]
3. Environmental and structural factors	Workplace design	Inconvenient placement of PPE supplies and workplace conditions that may hinder timely and appropriate use of protective equipment.	[22, 23]
	Interpersonal and social influences	Peer practices and workplace norms that may influence individual decisions regarding adherence to PPE precautions.	[21, 23]

Note. PPE = personal protective equipment. Supporting studies indicate which included studies reported each barrier or related factor. The descriptions summarize reported barriers and do not imply causal relationships unless explicitly demonstrated in the original studies.

Table 4. Frequency of Reported Barriers to PPE Adherence Across Included Primary Studies

Barrier category	Specific barrier	Studies reporting, n	%
Individual	Insufficient specific knowledge or underestimation of risk	12	70.6
	Low self-efficacy or perceived discomfort	10	58.8
	Reliance on experience or established routines	6	35.3
Organizational	High workload and time pressure	14	82.4
	Inadequate or infrequent training	13	76.5
	Limited managerial support or enforcement	11	64.7
	Limited availability or suitability of PPE	9	52.9
Environmental	Poor workplace design or inconvenient PPE location	8	47.1
	Peer influence or workplace social norms	7	41.2

Note. PPE = personal protective equipment. Percentages should be calculated using the number of eligible primary studies that contributed to the frequency analysis as the denominator. Studies may contribute to more than one barrier category; therefore, percentages do not sum to 100%.

Individual, Organizational, and Environmental Barriers to PPE Adherence

1. Individual Psycho-Behavioral Factors

Knowledge and Awareness

Limited knowledge was repeatedly identified as a barrier to appropriate PPE use. Although nurses generally recognized the hazards associated with chemotherapy drugs, several studies reported gaps in knowledge regarding PPE selection and safe donning and doffing procedures. For example, Crickman and Finnell (2017) reported that although nurses appropriately applied PPE during chemotherapy handling, only 11% removed PPE correctly, indicating a potential risk of self-contamination [13]. Other studies also reported underestimation of occupational exposure risks, particularly when exposure was perceived as brief or minimal [14]. These findings suggest that knowledge gaps may extend beyond which protective equipment should be used to include how it should be used safely.

Health Beliefs and Self-Efficacy

Individual perceptions of occupational risk and confidence in performing recommended safety practices were also associated with PPE adherence. Nurses who perceived greater risks from chemotherapy exposure and those with greater confidence in their ability to follow safety precautions tended to report better adherence [15]. Conversely, discomfort, inconvenience, and doubts

about the usefulness of PPE were reported as barriers to consistent use [15-17]. However, associations between demographic characteristics and PPE adherence were inconsistent across studies, suggesting that individual perceptions and perceived ability to perform protective practices may be more relevant than demographic characteristics alone.

Experience and Age

Differences in PPE adherence by age or professional experience have been reported in several studies, with younger or less experienced nurses sometimes demonstrating greater adherence to recommended precautions [18]. This pattern may reflect greater reliance among less experienced nurses on recent training and formal safety procedures, whereas more experienced nurses may rely more on established routines. However, this interpretation should be treated cautiously, as the relationship between professional experience and PPE adherence was inconsistent across studies.

2. Organizational and Managerial Factors

Training and Education

Inadequate or infrequent training was commonly identified as an organizational barrier. Some studies reported limited opportunities to reinforce safe handling practices and practical PPE procedures [18, 19]. The findings indicate that training should address the practical application of PPE precautions in addition to providing general information about hazardous drug exposure. However, the included evidence was insufficient to determine whether any specific training approach was superior to others.

Workload and Time Pressure

Workload and time pressure were among the most frequently reported barriers to PPE adherence. Nurses described competing clinical demands and the need to provide timely patient care as circumstances that could make consistent adherence to recommended precautions more difficult [19-21]. This finding indicates that PPE adherence is influenced not only by individual practices but also by the demands and organization of clinical work.

Resource Availability

The availability and suitability of PPE were also identified as important barriers. Some studies reported limited access to appropriate protective equipment, including specific types of gloves, gowns, and respiratory or eye protection [20]. Concerns regarding comfort, fit, and ease of use were also reported and may discourage consistent use. In some settings, cost and limited access to appropriate protective equipment further contributed to difficulties in maintaining recommended precautions.

Managerial Support and Safety Culture

Limited managerial support was another recurring organizational barrier. Inadequate supervision, inconsistent enforcement of safety procedures, and insufficient organizational emphasis on hazardous drug safety were reported as factors associated with poorer adherence [21]. Workplace expectations and the extent to which safe practices were routinely reinforced also appeared to influence nurses' PPE practices.

3. Environmental and Structural Factors

Workplace Design

Features of the physical work environment could affect access to and use of PPE. Studies reported problems such as inconvenient placement of PPE supplies and workplace conditions that made protective equipment more difficult to access or use appropriately [22, 23]. Ready availability of appropriate PPE at the point of care may therefore facilitate adherence, whereas poorly designed or inadequately equipped work areas may create additional barriers.

Interpersonal and Social Influences

Colleagues' practices were also identified as a factor influencing PPE adherence. In some settings, nurses' protective practices appeared to be shaped by their peers' behaviors and expectations [21, 23]. When adherence was not consistently observed within the team, safe practices may have been less strongly reinforced. This finding highlights the importance of the social work environment alongside individual and organizational factors.

Discussion

This systematic review identified a range of barriers to PPE compliance among oncology nurses, extending beyond individual knowledge or motivation. The findings point to the combined

influence of individual, organizational, and environmental factors. Although nurses' knowledge and perceptions of risk may affect their willingness to use PPE, compliance is also shaped by workload, access to appropriate protective equipment, managerial support, and the integration of safety procedures into everyday clinical practice. These findings suggest that PPE use should be considered in the context of the work environment rather than as an individual responsibility.

Previous reviews have examined factors associated with hazardous drug safe-handling practices among nurses, generally across broader healthcare settings. Reeves et al., for example, identified knowledge, organizational support, and other workplace factors as important influences on nurses' adherence to hazardous drug precautions [23]. The present review focuses specifically on oncology nurses and provides a broader perspective on the barriers to PPE use by considering factors at the individual, organizational, and environmental levels. The findings also suggest that organizational and environmental constraints may be at least as important as individual knowledge. Workload, limited resources, inadequate managerial support, and unfavorable working conditions can make consistent adherence difficult, even when nurses are aware of recommended precautions. This has implications for the design of interventions, as education alone is unlikely to address barriers that originate within the work environment.

Knowledge was not consistently associated with PPE compliance across the included studies. This finding is relevant to the Health Belief Model, which posits that health behavior is influenced by perceived susceptibility, perceived severity, perceived benefits and barriers, and self-efficacy [24]. In clinical practice, awareness of the hazards associated with chemotherapy exposure does not necessarily translate into consistent PPE use. Nurses may recognize the potential consequences of exposure but still omit or modify protective measures when they perceive the risk as low, are under time pressure, or find the required equipment inconvenient or uncomfortable. Improving compliance therefore requires attention to the practical and perceptual factors that influence behavior, rather than assuming that increasing knowledge will automatically change practice.

The observation that more experienced nurses may show lower compliance than less experienced nurses is also noteworthy. Clinical experience does not necessarily translate into greater adherence to safety procedures and, in some circumstances, may contribute to familiarity-based shortcuts or normalization of routine risks. Repeated performance of the same tasks may make certain precautions seem unnecessary, particularly when adverse consequences are rarely observed. Educational interventions should therefore be designed to reinforce safe practices among experienced staff and newer nurses. Practical training, simulation, skills-based demonstrations, and feedback on observed practice may be more useful for this purpose than repeated delivery of general information. Although evidence on technologies such as virtual reality was limited in the included studies, the reported limitations of passive educational approaches [18, 19] support further investigation of interactive training methods that allow nurses to practice hazardous-drug handling procedures in realistic situations.

Workload was one of the most frequently reported barriers, occurring in 82.4% of the included studies. When nurses are managing high patient volumes, time-sensitive treatments, and competing clinical demands, PPE procedures may be shortened, delayed, or omitted. Addressing this problem requires changes to the conditions under which chemotherapy care is delivered. Adequate staffing, realistic workload allocation, and workflows that allow sufficient time for PPE use may reduce the pressure to bypass safety procedures. PPE requirements should also be incorporated into routine chemotherapy workflows so that compliance does not depend on nurses finding additional time to complete them.

Managerial practices were another important influence on PPE use. Limited supervision, inconsistent enforcement of safety policies, and insufficient managerial support may signal that PPE compliance is a lower priority than completing

clinical tasks. In contrast, managers who routinely reinforce safety procedures, address non-compliance, ensure access to appropriate equipment, and provide feedback can make safe handling an expected part of clinical practice.

Leadership involvement is particularly important when staff perceive a tension between maintaining workflow efficiency and following safety procedures. Clear expectations and consistent implementation of safety policies can help reduce this ambiguity.

The physical work environment can also influence whether nurses can follow PPE recommendations. Poorly positioned PPE stations, inadequate workspace, insufficient ventilation, and uncomfortable protective equipment may create practical barriers to compliance. The association of PPE use with physical discomfort and unfavorable workspace conditions reported in previous studies [20, 22] supports the need for greater attention to the design of chemotherapy work areas. PPE should be readily accessible at the point of care, while workspace layouts should allow nurses to perform required protective procedures without disrupting patient care. Comfortable, appropriately sized equipment may also improve sustained use, particularly during prolonged clinical activities.

The evidence should be interpreted in light of several limitations of the included studies. Many relied on self-reported PPE use, which may overestimate actual compliance because participants may report behavior that conforms to expected safety standards. Direct observation, structured audits, or other objective measures would provide a more reliable assessment of actual practice. Considerable variation in study designs, populations, and definitions or measures of PPE compliance also prevented quantitative pooling of the findings. In addition, restricting the search to English- and Persian-language publications may have excluded relevant studies published in other languages. Finally, changes in hazardous-drug handling recommendations and PPE technology may affect the applicability of older findings to current oncology practice.

The findings have several practical implications for oncology nursing. Training should place greater emphasis on hands-on practice and decision-making in situations that resemble routine chemotherapy care rather than relying primarily on lectures or written materials. Staffing and workload should be reviewed where excessive clinical demands interfere with PPE use, and PPE should be consistently available in accessible locations. Organizations should also address ventilation, workspace layout, and the comfort and suitability of protective equipment. Regular monitoring of PPE practices, combined with constructive feedback, can help identify persistent problems and determine whether interventions are producing sustained changes in practice. Active involvement of nurse managers and clinical leaders is needed to ensure that these measures are consistently applied and that safe handling remains a routine expectation in oncology settings.

Conclusion

Individual, organizational, and environmental factors influence PPE adherence among oncology nurses. Improving adherence requires more than providing information about the risks of hazardous drug exposure. Preventive care strategies should address practical barriers to PPE use, including workload, access to appropriate protective equipment, training, managerial support, and the organization of the clinical environment. Integrating education and skills-based training with supportive organizational and environmental measures may provide a more sustainable approach to protecting oncology nurses from occupational exposure to hazardous drugs.

Ethical Considerations

As this systematic review used previously published data and did not involve direct interaction with human participants or collection of identifiable primary data, ethical approval was not required. The review adhered to principles of research integrity, transparency, and appropriate acknowledgment of the sources.

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Conflict of Interest

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Supervision: M. Jouzi
Writing – Original Draft: L. Kahangi
Writing – Review & Editing: N. Toghian Chaharsoughi, M. Jouzi
All authors read and approved the final manuscript.

Artificial Intelligence Utilization

The authors acknowledge using Qwen (an AI-powered language model) exclusively for language editing, manuscript structuring, reference formatting, and table design, in accordance with APA 7th edition guidelines. The AI tool was NOT used for: study conceptualization, literature screening, data extraction, quality assessment, thematic analysis, interpretation of findings, or drafting of the scientific content. All intellectual contributions, including the identification of barriers, synthesis of themes, and conclusions, were made entirely by the human authors. The authors take full responsibility for the accuracy, integrity, and completeness of the final manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this published article and its supplementary information files.

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