European Journal of Oncology Nursing 41 (2019) 24–32

Contents lists available at ScienceDirect

European Journal of Oncology Nursing

journal homepage: www.elsevier.com/locate/ejon

Current evidence of education and safety requirements for the nursing administration of chemotherapy: An integrative review

Elisabeth Coyne[a,*], Sarah Northfield[b], Kylie Ash[c], Leisa Brown-West[d]

[a] Menzies Health Institute, Griffith University, Australia
[b] Cancer Care Services, Royal Brisbane and Women's Hospital, Herston, QLD, 4029, Australia
[c] School of Nursing, Queensland University of Technology, Kelvin Grove, QLD, 4059, Australia
[d] Cancer Care Division (Australia), ICON Integrated Cancer Centre, QLD, 4509, Australia

ARTICLE INFO

Keywords:
safety
Education
Chemotherapy
Integrative review
Nursing

ABSTRACT

Purpose: The administration of chemotherapy is a complex task which has many safety issues. Safe administration of chemotherapy by nurses should be evidence-based. The aim of this integrative review was to synthesise the evidence about education and practice requirements for safe administration of chemotherapy by nurses.

Method: A systematic search of four databases identified 17 studies for inclusion in this review. Key words: Nurse, chemotherapy, cytotoxic drug, administration, safety, education. Data extracted from the studies included author, year, aims, design, sample, outcome measures and findings. After screening the articles, extracting study data and completing a summary table, critical appraisal of the studies was completed using the Mixed Methods Appraisal Tool (MMAT).

Results: All the studies focused on strategies to promote patient and nurse safety during nursing administration of chemotherapy. Content analysis identified five themes: governance, process safeguards, communication, interdisciplinary collaboration and education. Key strategies or interventions that increased patient and/or nurse safety identified were standardised computer-generated chemotherapy orders, barcodes, medication safety procedures, education and simulated learning.

Conclusions: This review found low-level evidence exists about the education and safety requirements for nursing administration of chemotherapy. High-level research is needed to assist healthcare services to select evidence-based educational and safety strategies and provide appropriately resourced work environments to support the safe nursing administration of chemotherapy and deliver the best possible patient outcomes.

1. Introduction

Both patients and health professionals are at risk of adverse health outcomes if chemotherapy is not administered safely. Chemotherapy medication errors can cause significant patient morbidity, mortality and financial burden (Louvrier et al., 2015). Adherence to guidelines and effective communication between health professionals can prevent most medication errors (Lennes et al., 2016; Schleisman and Mahon, 2015). Medication errors will occur at several key points during the administration of chemotherapy, from the time of prescription through to preparation and administration to the patient (Ranchon et al., 2011). Health professionals need to be aware of their responsibility in the process to ensure safe administration of medication (González et al., 2017).

Exposure to chemotherapy during preparation and administration is a known occupational risk (Polovich and Martin, 2011). Continued exposure to low doses of chemotherapy in the workplace has been shown to increase nurses risk of adverse health outcomes; including headache, vertigo, hair loss, skin rashes and burning eyes (Hanafi et al., 2016). Research has explored the practices of nurses and their reported exposure highlighting the inherent risk in the delivery of chemotherapy. An American study of 402 nurses working in ambulant cancer settings indicated that 16.9% of nurses in their survey self-reported skin or eye exposure to cytotoxic drugs in the past year (Friese et al., 2012). Another American study of 2069 cancer nurses found that 12% reported a cytotoxic spill within the past week due to technical problems in attaching/detaching the IV administration set to the chemotherapy bag or chemotherapy preparation (Boiano et al., 2014).

* Corresponding author. Logan Campus, School of Nursing and Midwifery, Griffith University, Australia.
E-mail addresses: e.coyne@griffith.edu.au (E. Coyne), sarah.northfield@health.qld.gov.au (S. Northfield), k.ash@qut.edu.au (K. Ash), leisa.brown-west@icon.team (L. Brown-West).

https://doi.org/10.1016/j.ejon.2019.05.001
Received 19 December 2018; Received in revised form 29 April 2019; Accepted 3 May 2019

Furthermore, 10% of respondents reported that the cytotoxic spill was not cleaned up (Boiano et al., 2014). There was no current research identifying long-term effects of occupational exposure (Hanafi et al., 2016). Cancer nurse education, cytotoxic safety training and the provision of appropriate personal protective equipment is essential to ensure nurse safety during chemotherapy administration in the workplace (Neuss et al., 2016).

There is increased administration of chemotherapy in outpatient and community settings, which adds to the likelihood of adverse outcomes from unsafe practices due to decreased opportunity for standardised health system controls (Turner and Stephenson, 2015). A qualitative study explored the perspectives of cancer nurses when working with patients across inpatient and outpatient settings highlighting the concerns related to education in a home setting (Shea et al., 2016). Nurses generally identified that they face challenges related to patient education when administering oral chemotherapy or chemotherapy in the patient's home (Divakaruni et al., 2018; Shea et al., 2016). Whilst the convenience of the patient receiving chemotherapy in their own home provides significant benefits, nurses found that patients in non-hospital settings do not receive adequate education or support regarding home chemotherapy administration (Divakaruni et al., 2018). Current guidelines did not provide clear evidence related to the administration and delivery of patient education on chemotherapy in non-hospital settings. As a consequence, patients had increased rates of emergency hospital visits because they had either stopped taking their chemotherapy medication or did not report adverse side effects (Divakaruni et al., 2018; Shea et al., 2016). Clear practice guidelines informing nurse education and training could positively influence such outcomes.

Health care professionals should work within guidelines which are based on current evidence to ensure best practice is set as a standard for optimum patient outcomes (Australian Commission on Safety and Quality in Health Care, 2018). In cancer care, guidelines address both patient and nurse safety related to the administration of chemotherapy however the level of evidence is missing (Neuss et al., 2016). For the purpose of this review nurse administration of chemotherapy is defined as the process of checking, administering and disposing of chemotherapy and waste (Clinical Oncology Society of Australia, 2008). The nurse is responsible for ensuring the protocol and prescription is reviewed, the patient has received appropriate information and patient assessments are performed throughout the administration of therapy (Carrington et al., 2010). The aim of this integrative review was to synthesise the evidence about education and safety practice requirements for safe nursing administration of chemotherapy.

2. Methods

An integrative review design was used as a framework for ensuring a comprehensive review of qualitative, quantitative and mixed method studies (Hopia et al., 2016).

2.1. Problem identification

The research question was 'What are the current practices and minimal standards of education and safety requirements for nurse administration of chemotherapy?' The literature review protocol has been published (Coyne et al., 2017b)

2.2. Search terms

A range of key words were identified during the scoping and preliminary literature search phase. A table of key words was developed by the research team using the Population; Interest; Outcome (PIO process framework). Key words were refined during the completion of the literature review searches to ensure a comprehensive review of literature exploring the education and safety requirements for nurses to administer chemotherapy drugs. Searches were conducted between July to Nov 2017 by two authors (MK, EC) across CINAHL with Full Text EBSCO Nursing and Allied Health; PubMed (which includes Medline and Pre-Medline) Health Sciences; The Cochrane Library and Embase using a combination of key words and MeSH terms. Reference lists of included articles and supporting references from international and Australian Cancer Nursing Administration Chemotherapy Guidelines were hand searched. With the assistance of a health librarian, specific search terms were developed for each database to enable a conclusive search; PubMed: MeSH terms across Title/Abstract; EMBASE and PsycINFO: Subject Heading and Keyword; CINAHL as Subject Heading and Title/Abstract, in CENTRAL as MeSH and Title/Abstract/Keyword, and in Web of Science as Topic. A spreadsheet was developed to document the article retrieval process and references were directly uploaded into an online EndNote Library© to maintain an up-to-date reference list. Table 1 presents the search terms.

Table 1
PIO search terms – integrative review.

Question Component	Key Term	Final Search Synonyms
Population	Registered/enrolled nurse	Nurses "Nurs*"
Interest	Nursing administration of cytotoxic drugs	Administration "chemotherapy administration" Cytotoxic drugs Chemotherapy "cancer treatment"
Outcome measures	Safety and education	Safety "safe practice" "safe handling" Education "educat*" training "skill*"

2.3. Inclusion & exclusion criteria

The inclusion criteria were primary research papers, published in English, available in full text, using quantitative, qualitative or mixed methods, across any health care setting. The dates were 2006–2017 to ensure research was related to current administration practices for chemotherapy. Exclusion criteria were articles focused on the administration of targeted therapies, such as biotherapy agents and monoclonal antibodies; clinical guidelines and legislative requirements.

2.4. Study selection

The initial search generated 3037 titles, which were downloaded into EndNote Online©, 450 duplicates were removed. Additional relevant records identified from Australian Drug Administration Course [ADAC] were included (Cancer Institute NSW, 2018). The titles and abstracts were searched within EndNote using the terms *nurse, chemotherapy*, and *safety* as these were identified as the best keywords to find studies which related to nursing administration of chemotherapy. Within EndNote, 650 included articles were screened within the title and abstract against the inclusion criteria by EC and MK. Full text review using inclusion/exclusion criteria was completed by the research team on 104 articles to select the final articles for inclusion. Each article was reviewed and scored [0–2] for inclusion by two team members. Challenging decisions regarding the inclusion of an article were resolved through discussion within the research team. This occurred with six articles, an audit trail was kept for the full review process. The research team consisted of five clinicians and two researchers who were all members of the Cancer Nurses Society of Australia Education Standing Committee. The Preferred Reporting Items for Systematic Reviews and Meta-analyses: the PRISMA statement was used to guide

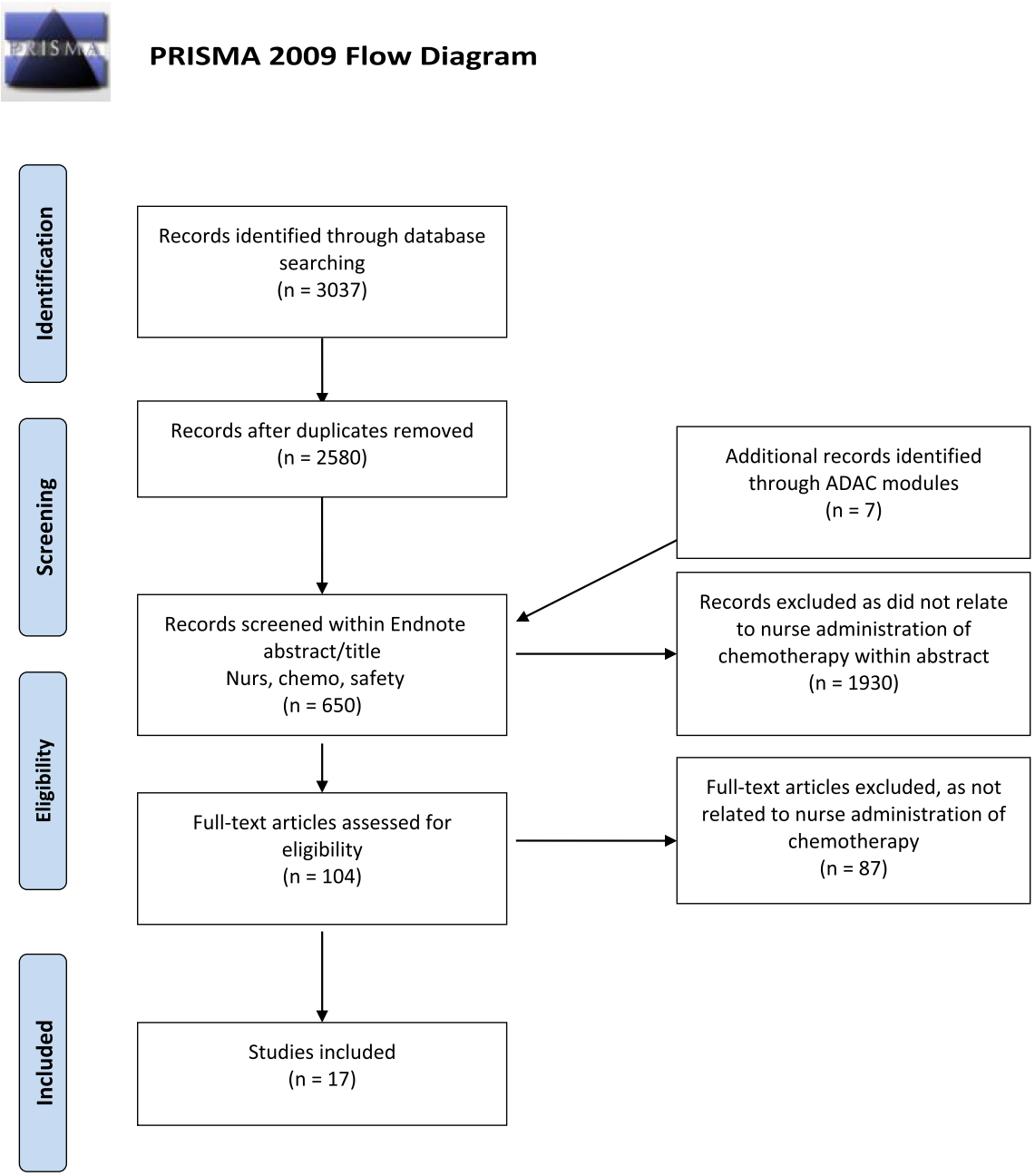

Fig. 1. Prisma flowchart of study identification.

study selection (Liberati et al., 2009), Fig. 1 – PRISMA flowchart highlighting how relevant studies were identified.

2.5. Data evaluation

The retrieved articles were evaluated by EC and MK and a quality assessment was undertaken using the Mixed Methods Appraisal Tool (MMAT). This critical appraisal tool was chosen due to the heterogeneity of included studies and the content validity, reliability and efficiency of the MMAT tool for quality appraisal has been noted in previously published works (Pluye and Hong, 2014). Two researchers [EC, MK] independently scored articles, and scores were compared to identify differences, which were resolved through discussion with the research team. All articles were retained irrespective of their MMAT scores to ensure a comprehensive integrative review. The studies were accessed for 'level of evidence' using the NHMRC Evidence Hierarchy scale (Merlin et al., 2018). Table 2 presents the full article summary including MMAT scores and Level of Evidence.

2.6. Data analysis & synthesis

Data extraction was completed by using the Matrix Method© to enhance the rigor of this stage of the review (Garrad, 2016). This data extraction method provides a clear framework to systematically extract relevant data from each of the included studies and populate each section of the review matrix. The included studies were summarised on an excel spreadsheet to allow data comparison and synthesis. The data was extracted and documented using the following headings - author, year, country, title, research aims, sample, study design, outcome measures, findings, recommendations, MMAT scores, level of evidence and key points. A content analysis of the studies was also conducted to identify recurring topics and develop themes. The stepped process

Table 2
Summary of studies.

Author year Country	Aims	Sample	Study design	Outcome measures	Findings	Recommendations	MMAT	LE
Ashley et al., 2011 UK	Evaluation of failure mode and effect analysis of chemotherapy administration	One adult inpatient & outpatient unit 40 staff including nursing and medical	Quality audit; Failure mode and effect analysis	Error rate during administration	Failure in clear communication led to errors	Manager walk around improves communications and identification of potential problems.	100%	V
Beaver and Magnan, 2015 USA	Change to closed system	One outpatient unit nursing staff	Case study	Error rate during administration	Using a structured process with the team, prepared staff and enabled safe change	Closed System Drug Transfer Device (CSTD) safer for patient and staff	100%	V
Boiano et al., 2014 USA	Describe chemotherapy drug administration practices by health care workers	2069 health care workers who completed antineoplastic modules 98% nurses	Quant online survey	Health professionals behaviours	Survey found of the 2069 participants: 95% completed training, 73% were familiar with guidelines, 62% primed line with saline or used appropriate PPE; 85% wore chemotherapy gloves, 58% wore non-absorbent gowns, 12% wore eye protection, 70% reported spills when attaching the IV line, 19% completed medical surveillance	Better reporting and communication with healthcare workers is needed to highlight risk factors	75% no response rate identified	III-3
Bonnabry, et al., 2005 Switzerland	To perform a risk analysis of the cancer chemotherapy process	Five health care organisations Analysis of risk	Prospective risk analysis; Failure mode, effect and critical analysis	.Medication errors	Centralisation of pharmacy and medication ordering process reduced errors	Re-engineering cancer chemotherapy process by centralisation of pharmacy and the implementation of information technologies had significant and cost effect reduction in errors reported	100%	IV
Coyle et al., 2014 USA	Describe clinical practice change	One Cancer unit review of charts	Practice change evaluation	Medication errors	Planned policy change including education, assessment tool, documentation, and patient education led to sustained change and reduction in errors.	90% reduction in the administration of vesicant agents peripherally, with no occurrence of extravasations in the first 6 months of implementation	50% no data analysis or researcher influence	V
Gonzalez, 2013 USA	Explore management of extravasations	N/A	Case study; Literature review	Not measured	Education of the patient and nurse to increase understanding of medications and recognition of extravasations improves patient safety	Yearly education, algorithms for drug administration helped enable best patient outcomes	N/A	V
Huertas-Fernandez et al., 2017 Spain	Evaluate administration of cytostatic agents	One hospital, 500 cancer patients chart audit	Cohort study, quantitative non-randomized	Medication errors	There was a reduction of medication errors that reached the patient after safeguard implementation. Safeguards prevented medications errors which caused patient harm.	Implementing safeguards such as computerised prescription, pharmacist validation and barcode system facilitates error detection before it reaches the patient; errors were reduced by 36.4%.	100%	III-2
Hydzik, C. 2009 USA	Present rationale for IP chemotherapy	N/A	Case study Literature review from one oncology unit	Not measured	Education of patient and nurse on patient assessment and documentation improves patient outcomes.	Better patient outcomes if clear steps were followed for administration of chemotherapy.	N/A	V
Looper, et al., 2016 USA	Development of best practice guidelines for paediatric administration of chemotherapy	One oncology unit chart audit	Quality audit	Risk identification	Standardised process for line priming, staff training, SBAR communication. Workplace champions improved change over process.	Planned process of change of practice included medication barcodes, priming of lines, documentation audits, and communication tools.	50% no data analysis or researcher influence	V
Markert et al., 2009 Germany	Investigate underlying reasons for medication errors	One oncology unit: 22,216 chemotherapy orders	Chart audit with quantitative analysis	Medication errors	Chart checking across all areas of administration reduced medication errors.	Computerised medication orders, standard treatment orders and additional checking of medication orders reduced errors.	100%	III-3
		N/A		Exposure risk			N/A	V

(*continued on next page*)

Table 2 (*continued*)

Author year Country	Aims	Sample	Study design	Outcome measures	Findings	Recommendations	MMAT	LE
Menonna-Quinn, 2013 USA	Highlight risks of chemotherapy administration in different areas		Case study Literature review		Highlighting risks and educating health professionals' increases safe handling practices.	Nurse exposure during preparation, transport, administration and care of patient.		
Muehlbauer et al., 2013 USA	Maintain competency in areas low chemotherapy administration	One oncology unit; 15 nurses	Case report		Simulation provided a way to enable medical surgical areas to evaluate competency and educate staff in relation to chemotherapy administration.	Simulation enabled assessment of common chemotherapy protocols, maintaining safe environment, debrief.	50% no data analysis or researcher influence	V
Prakash et al., 2014 Canada	Assess the effects of interruptions	37 nurses	Mixed method 3 phase, descriptive	Medication errors	Interruptions during medication administration increased errors.	Medication errors were reduced by implementing strategies such as a timer for administration, quiet zones for preparation and speak out-loud processes for drug checks.	75% no response rate identified	III-3
Sheridan-Leos, 2006 USA	Review of process of FMEA for promoting safety	N/A	Quality audit; Failure mode and effect analysis	Medication errors	Nurses need to promote a culture of safety.	Nurses play a vital role in error prevention and ongoing process of quality audits.	50% no data analysis or researcher influence	IV
Sheridan-Leos, 2007 USA	Describe how chemotherapy education was redesigned using a proactive approach to help novice oncology nurses	One unit; 24 nursing staff; 12 experienced 12 novice	Mixed method	Exposure risks	Number of near misses reported: (by experienced staff) = 2, (by novice nurses) = 5; Average score on chemotherapy exam: (experienced staff) = 89, (novice staff) = 95.5; number of process issues identified: (experienced staff) = 3, (novice staff) = 6	Potential for error exists at every step of the chemotherapy process. A proactive approach to chemotherapy education, combined with ongoing formal and informal evaluations, can be used to help novice oncology nurses prevent errors and thereby improve chemotherapy safety.	50% no RR sample data, no clear results	IV
Turner and Stephenson, 2015 Australia	Evaluate process change to improve documentation	200 chart audits	Case study audit	Administration practices	.Baseline audit showed areas for improvement across all areas of chemotherapy administration	Medication prompts, clear criteria for administration and patient education improved documentation of chemotherapy administration	100%	IV
Villarini et al., 2011 Italy	Evaluate work environment contamination by antineoplastic drugs in a hospital in Central Italy and to assess the genotoxic risks associated with antineoplastic drug handling	52 exposed and 52 controls health care workers	.Cohort study	Measurement of surface equipment and clothing contamination. Staff urine and blood examined for DNA damage	Day oncology nurses showed highest extent of DNA damage. Gender age and smoking habits were not associated with any increase in the extent of DNA migration, either in the exposed or reference group. Wearing PPE has been associated with a statistically significant decrease in the extent of primary DNA damage.	Wearing appropriate PPE during chemotherapy administration does safeguard nurses as exposure from inhaled and dermal contamination of some health professionals led to DNA damage.	100%	III-2

Note: DNA = DeoxyriboNucleic Acid; LE = Level of Evidence range from V lowest level to 1 highest level; MMAT = Mixed Methods Appraisal Tool 0–100%; SBAR = Situation, Background, Assessment, Recommendation, used to facilitate prompt and appropriate communication; PPE = Personal Protective Equipment; FMECA = Failure Mode, Effect and Critical Analysis; FMEA = Failure Mode and Effect Analysis; IP = Intraperitoneal; ME = Medication Error; IV = Intravenous; NA = not applicable.

involved reading all full text articles and development of an online spreadsheet of themes by the research team. The research team then met face-to-face to discuss and finalise the themes (Pluye and Hong, 2014).

3. Results

Seventeen studies were included in the review. Qualitative methodologies were used in twelve studies, of which most were case study presentations. Quantitative methodologies were employed in three studies and mixed methodologies in two studies. Ten of the studies were conducted in United States. The other studies were from United Kingdom, Spain, Italy, Switzerland, Germany, Canada and Australia. Fifteen studies were able to be scored using the MMAT. Two case study style reviews had no clear research question or sample. The level of evidence was identified to ascertain the quality of the research in an attempt to justify the evidence supporting current practices (Merlin et al., 2018). The highest level of evidence was level III-2 a cohort study, which was a quantitative non-randomized sample (Huertas-Fernández et al., 2017). Most of the studies were level V being descriptive case studies.

The selected studies do provide information relevant to the current research question. However the case studies were mainly the presentation of a small practice changes within a cancer care area (Ashley et al., 2011; Beaver and Magnan, 2015; Coyle et al., 2014; Gonzalez, 2013; Hydzik, 2009; Looper et al., 2015; Menonna-Quinn, 2013; Muehlbauer et al., 2013; Sheridan-Leos, 2007; Sheridan-Leos et al., 2006; Turner and Stephenson, 2015). The studies all had a focus on patient and nurse safety and presented recommendations from their work which was helpful in informing the current understanding of the range of strategies to enable safe administration of chemotherapy. There was a strong focus on governance and organisational requirements which facilitate the nurses' ability to follow a structured process of safe administration. See Table 2 for a summary of studies.

4. Themes

The studies were critiqued and five themes developed. These were governance, process safeguards, communication, interdisciplinary collaboration and education. See Table 3 which presents the themes and study with that theme.

4.1. Governance

This theme was derived from the underlying point from the studies that organisational safety and quality practices are critical for safe administration. Organisations' need to have a process for risk assessment and identification to direct the development of guidelines and policies to guide practice. Institutional practices such as audits, the use of closed systems, standardised assessment and flow tools help ensure safe practices are adhered to during all aspects of chemotherapy administration (Beaver and Magnan, 2015; Coyle et al., 2014; Gonzalez, 2013). Further studies highlight that if risk assessments are completed and evaluated it allows for comparison of acceptable and non-acceptable risks to be identified (Ashley et al., 2011; Bonnabry et al., 2006; Hydzik, 2009; Markert et al., 2009). Several studies measured the risks for nurses, identifying that there are levels of hazards in relation to the complexity of the medications being administered (Boiano et al., 2014; Menonna-Quinn, 2013; Sheridan-Leos, 2007; Villarini et al., 2011). Adherence to safe handling practices was measured in a survey of 2069 US healthcare workers [98% nurses], which found 85% wore chemotherapy gloves, 58% wore nonabsorbent gowns, 70% had cytotoxic spills while attaching the IV line and eight out of ten spills were less than 5 mm (Boiano et al., 2014). Only 19% reported completing any medical surveillance while working with chemotherapy (Boiano et al., 2014). The Boiano et al. (2014) study highlights issues with health professional compliance with safety and quality practices and the need for strategies to mitigate this risk.

4.2. Process safeguards

The next theme was about the process of chemotherapy administration and how particular points in administration have risk. Process safeguards can interrupt the sequence of events, prevent errors from occurring and help maintain a safe environment for patients, family and health professionals. Examination of the progression of medication errors from the chemotherapy order to administering the medication to the patient highlights the need to focus on standard processes and repeated checking to ensure the correct medication is administered correctly and safely (Ashley et al., 2011). Three studies found standardised computer generated orders (checked with a barcode) reduced errors substantially (Bonnabry et al., 2006; Huertas-Fernández et al., 2017; Markert et al., 2009). Clear drug protocols and audits to ensure the correct process was followed were found to reduce medication errors in

Table 3
Table of themes from literature synthesis.

Theme	Processes for improving safety	References
Governance	Risk assessment policy Closed system preparation and administration system Standardised assessment and flow tools	(Ashley et al., 2011; Beaver and Magnan, 2015; Boiano et al., 2014; Bonnabry et al., 2006; Coyle et al., 2014; Gonzalez, 2013; Hydzik, 2009; Markert et al., 2009; Sheridan-Leos, 2007; Villarini et al., 2011)
Process safeguards	Standardised orders, electronic orders, barcode Protocols, guidelines and audits Quiet zone, time out, speak out-loud checks between nurses Patient and family education	(Ashley et al., 2011; Bonnabry et al., 2006; Huertas-Fernández et al., 2017; Menonna-Quinn, 2013; Prakash et al., 2014; Sheridan-Leos, 2007; Sheridan-Leos et al., 2006; Turner and Stephenson, 2015)
Communication	Handover - identification of high risk periods Speak out-loud with patient clarification Standard documentation Patient education	(Ashley et al., 2011; Coyle et al., 2014; Huertas-Fernández et al., 2017; Looper et al., 2015; Markert et al., 2009; Prakash et al., 2014)
Interdisciplinary collaboration	Understanding roles, ability to escalate problems Clear documentation and accountability	(Ashley et al., 2011; Coyle et al., 2014; Turner and Stephenson, 2015)
Education	Simulation and blended learning modules Patient and family education Patient navigation	(Gonzalez, 2013; Muehlbauer et al., 2013; Sheridan-Leos, 2007; Turner and Stephenson, 2015)

several studies (Menonna-Quinn, 2013; Sheridan-Leos, 2007; Sheridan-Leos et al., 2006; Turner and Stephenson, 2015). Other recommendations were the use of a quiet zone for preparation, time out and speak-out loud checks for administration to ensure the nurse was focused and checked all components of the preparation and administration process (Prakash et al., 2014).

4.3. Communication

The communication theme was about identifying high risk times within chemotherapy administration and making sure clear communication of information was established (Ashley et al., 2011). This theme also included the importance of providing a standard process for handover, documentation and medication checking (Coyle et al., 2014; Huertas-Fernández et al., 2017; Looper et al., 2015; Markert et al., 2009; Turner and Stephenson, 2015). The speak-out loud checks and patient education were instrumental in ensuring the nurse and the patient had the right medication, route and understood treatment effects (Prakash et al., 2014).

4.4. Interdisciplinary collaboration

Understanding the individual and collaborative roles within the health professional team and being able to escalate concerns was a theme which highlights the multidisciplinary aspect of administration of chemotherapy. Accountability of members of the health team was noted as important if safe administration of chemotherapy was to be achieved; including reporting of errors and audit of practices (Ashley et al., 2011; Coyle et al., 2014; Turner and Stephenson, 2015).

4.5. Education

The theme of education of the nurse and patient was across all the other themes, however the review highlighted a need for a distinct program of learning, based on a nationally standardised position statement recommendations and demonstration of capability by nurses before they can safely administer chemotherapy (Sheridan-Leos, 2007). Simulation of adverse situations was evaluated and recommended as best practice, particularly in smaller units or non-specialist units where high risk situations do not occur regularly (Gonzalez, 2013; Muehlbauer et al., 2013). Patient and family education was also noted to improve patient outcomes and reduce medication errors (Turner and Stephenson, 2015).

5. Discussion

The aim of this literature review was to identify and critique the current evidence and practices in relation to the minimal standards of education and safety requirements for nurse administration of chemotherapy. The review highlighted that there was a lack of strong evidence to inform current practices of chemotherapy administration. However the studies critiqued did provide valuable insight into what has worked well and not so well in particular clinical areas. The review process identified six case study reports which provided information related to a particular practice change within one clinical area (Turner and Stephenson, 2015). The larger quantitative studies provided information about health professional practices in relation to chemotherapy administration by nurses (Boiano et al., 2014; Huertas-Fernández et al., 2017; Markert et al., 2009; Prakash et al., 2014; Villarini et al., 2011). All the studies focused on patient and nurse safety to promote improved patient outcomes, which enabled the completion of a content analysis, identifying five common themes.

The theme related to ‘governance’ explored how the organisation was a fundamental part of enabling safe practices for both patients and family. The health care setting is required to provide an environment which recognises associated risks and works to provide a safe environment for the health professional to administer chemotherapy (Australian Commission on Safety and Quality in Health Care, 2018; Neuss et al., 2016). Within this theme is the suggestion that organisations provide equipment, which is considered best practice, such as a closed system to enable minimal drug exposure for both patients, health professionals and the surrounding environment. Standardised protocols for administration aim to reduce medication errors for both the nurses and patient (Kane-Gill et al., 2017).

Computer generated orders and barcodes provide a greater degree of accuracy to medication orders (Kelly et al., 2016). Yearly audits of chemotherapy practices and medication errors provide an evaluation which highlights areas for change and improvement. Research highlighted the importance of clinical practice evaluations such as audits and manager reviews to provide staff with feedback and direction for improving clinical practice (al Tehewy, Fahim, Gad, El Gafary, & Rahman, 2016).

The theme ‘process safeguards’ related to the process of administration and understanding the sequence of events that can lead to medication errors. Process safeguards can prevent an error from reaching the patient, consequently promoting safe practice for the patient and the heath professional. The studies within the review focused on standardised orders and protocols to reduce errors. Previous research has identified that human factors such as complexity and lack of clarity of the drug order increased medication errors across the whole process (Di Simone et al., 2016; Durham et al., 2016).

Interruptions and lack of awareness were also noted as influencing factors during the process of medication administration for health professionals (Durham et al., 2016). Quiet zones, time out and speak out-loud processes have been techniques used to reduce errors and increase clarity of checking orders. These techniques have reduced medication errors across clinical areas (Corso et al., 2014; Verweij et al., 2014).

The importance of effective communication is embedded within all the other themes. However to accentuate the importance of communication as an influencing factor for safe chemotherapy administration it is presented as a stand-alone theme. Clear communication and clarification of information from all parties involved, including the patient and family and health professional, reduces the risk of errors (Australian Commission on Safety and Quality in Health Care, 2018; Marmor and Li, 2017). This is an important aspect related to the provision of patient education. The patient and family should be encouraged to identify their educational needs and understanding as current evidence shows patient-mediated education improves patient outcomes (Coyne et al., 2017a; Schooley et al., 2015). Effective patient education about medications increases the patient's understanding of the right medication, route and side effects (De La Maza et al., 2016). Specific communication strategies reported to improve patient safety included the identification of high risk periods and engaging in speak out-loud patient and medication checks at the bedside (Garfield et al., 2016; Marmor and Li, 2017).

The theme ‘interdisciplinary collaboration’ explored the benefits of understanding the roles within the team and how to challenge and escalate concerns. Individual accountability was highlighted as key to improving patient safety. Each health professional must be accountable for their role, including clear documentation, answering questions or escalating concerns (O'Connor and Carlson, 2016). The reporting of near misses is an important part of evaluating current practice and identifying need for change (González et al., 2017; O'Connor and Carlson, 2016). The challenge for nurses is to possess enough confidence to challenge unsafe practices and act as an agent of change to promote best practice. It is by challenging practice that a culture of safety is developed (Bagenal et al., 2016; Kerfoot, 2016).

Education was an overarching theme across communication and collaboration. In this theme the approach was to embrace new technology to engage and improve patient and nurse safety (Bott and Bransdon, 2015). Education strategies such as simulation, annual

updates and emergency procedures such as extravasation were noted as useful for non-cancer areas. Simulation enabled higher level learning while maintaining safe practice (Coyne et al., 2018; Schneidereith, 2015). Clinical areas also found benefit in blended learning approaches to improving health professional knowledge and attitudes (Henderson et al., 2016). There was also a need for a consistent approach to patient and family education which is known to improve patient outcomes (Hagan and Medberry, 2016; Riese et al., 2017).

Overall, higher level research is required for the development of strong evidence to support clinical practices focusing on patient and nurse education and safety during chemotherapy administration. This finding is similar to other specialty areas where a focus on safety is paramount for both patient and heath professional outcomes (Cho et al., 2018; Coster et al., 2017). Standardised education curriculum and competency-based assessment approaches are a gap in both research and clinical practice. To enable translation of research to practice, an exploration of patient and consumer engagement is required to understand the challenges in relation to engaging with patients and family during cancer treatment (Dieperink et al., 2017).

6. Implications to practice

Nurses are in a key position to influence clinical practices to enable safe administration of chemotherapy. Nurses need to become advocates for patient safety at all levels, including organisational and health service delivery levels. To improve safety for the patient, nurse and environment in regards to administration of chemotherapy, a closed system was considered best practice (Beaver and Magnan, 2015). Standardised orders and barcodes also reduced medication errors and should be implemented within clinical practice where possible. To enable a patient and consumer focus on safety, strategies such as speak out-loud for medication checks from drug to patient, patient education and simulated practice were highlighted as best practice.

7. Limitations

The limitations for the current review process were a lack of clarity in relation to terminology for chemotherapy drugs, this led to the use of both “chemotherapy” and “cytotoxic drug” as key terms. However, during the process of the review, the term “chemotherapy” was the most commonly used term and has been used in the presentation of these findings. The lack of higher level research evidence related to nurse administration of chemotherapy is a limitation when developing recommendations for practice. The authors’ decision to include low level research evidence should be noted when using the current literature review.

8. Conclusion

This review highlighted key activities which have been associated with safe nurse administration of chemotherapy and support positive patient outcomes. The analysis of the literature revealed similarities across cancer and other clinical areas where a focus on patient and staff safety should underpin individual and organisational activities. This literature review identified a lack of high level research methodologies. A recommendation would be longitudinal quantitative research exploring medication errors and patient outcomes across time to identify if practices changes are sustained and influence patient outcomes (Geerligs et al., 2018).

Conflicts of interest

None declared.

Acknowledgments

This project was funded by the Cancer Nurses Society of Australia and was completed by a project team within the CNSA Education Committee: Elisabeth Coyne, Sarah Northfield, Leisa Brown-West, Kylie Ash, Corrie Miles, Karen Munton, Catherine Barratt, Meghan Konda

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejon.2019.05.001.

References

al Tehewy, M., Fahim, H., Gad, N.I., El Gafary, M., Rahman, S.A., 2016. Medication administration errors in a university hospital. J. Patient Saf. 12 (1), 34–39. https://doi.org/10.1097/pts.0000000000000196.

Ashley, L., Dexter, R., Marshall, F., McKenzie, B., Ryan, M., Armitage, G., 2011. Improving the safety of chemotherapy administration: an oncology nurse-led failure mode and effects analysis. Oncol. Nurs. Forum 38 (6), E436–E444. https://doi.org/10.1188/11.onf.e436-e444.

Australian Commission on Safety and Quality in Health Care, 2018. National safety and quality health service standards. ACSQHC 2. Retrieved from. https://www.safetyandquality.gov.au/our-work/clinical-communications/.

Bagenal, J., Sahnan, K., Shantikumar, S., 2016. Comparing the attitudes and knowledge toward incident reporting in junior physicians and nurses in a district general hospital. J. Patient Saf. 12 (1), 51–53. https://doi.org/10.1097/pts.0000000000000103.

Beaver, C.C., Magnan, M.A., 2015. Minimizing staff exposure to antineoplastic agents during intravesical therapy. Clin. J. Oncol. Nurs. 19 (4), 393–395. https://doi.org/10.1188/15.cjon.393-395.

Boiano, J.M., Steege, A.L., Sweeney, M.H., 2014. Adherence to safe handling guidelines by health care workers who administer antineoplastic drugs. J. Occup. Environ. Hyg. 11 (11), 728–740. https://doi.org/10.1080/15459624.2014.916809.

Bonnabry, P., Cingria, L., Ackermann, M., Sadeghipour, F., Bigler, L., Mach, N., 2006. Use of a prospective risk analysis method to improve the safety of the cancer chemotherapy process. Int. J. Qual. Health Care 18 (1), 9–16. https://doi.org/10.1093/intqhc/mzi082.

Bott, E., Bransdon, M., 2015. Diminishing disparities with an online blended-learning approach. Asia Pac. J. Clin. Oncol. 11, 136. https://doi.org/10.1111/ajco.12432-2.

Cancer Institute NSW, 2018. eviQ Education. Retrieved from. https://education.eviq.org.au/courses?categoryid=36.

Carrington, C., Stone, L., Koczwara, B., Searle, C., 2010. Development of guidelines for the safe prescribing, dispensing and administration of cancer chemotherapy. Asia Pac. J. Clin. Oncol. 6 (3), 213–219. https://doi.org/10.1111/j.1743-7563.2010.01313.x.

Cho, E., Park, J., Choi, M., Lee, H.S., Kim, E.Y., 2018. Associations of nurse staffing and education with the length of stay of surgical patients. J. Nurs. Scholarsh. 50 (2), 210–218. https://doi.org/10.1111/jnu.12366.

Clinical Oncology Society of Australia, 2008. Guidelines for the Safe Prescribing, Dispensing and Administration of Cancer Chemotherapy. Clinical Oncology Society of Australia.

Corso, R., Vacirca, F., Patelli, C., Leni, D., 2014. Use of "Time-Out" checklist in interventional radiology procedures as a tool to enhance patient safety. Radiol. Med. 119 (11), 828–834. https://doi.org/10.1007/s11547-014-0397-9.

Coster, S., Watkins, M., Norman, I.J., 2017. What is the impact of professional nursing on patients' outcomes globally? An overview of research evidence. Int. J. Nurs. Stud. https://doi.org/10.1016/j.ijnurstu.2017.10.009.

Coyle, C.E., Griffie, J., Czaplewski, L.M., 2014. Eliminating extravasation events: a multidisciplinary approach. J. Infusion Nurs. 37 (3), 157–164. https://doi.org/10.1097/nan.0000000000000034.

Coyne, E., Dieperink, K.B., Østergaard, B., Creedy, D.K., 2017a. Strengths and resources used by Australian and Danish adult patients and their family caregivers during treatment for cancer. Eur. J. Oncol. Nurs. 29, 53–59. https://doi.org/10.1016/j.ejon.2017.05.005.

Coyne, E., Northfield, S., Ash, K., Brown-West, L., Miles, C., Munton, K., Barratt, C., 2017b. The minimum education and safety requirements for the nursing administration of cytotoxic drugs: an integrative review protocol. Aust. J. Cancer Nurs. 18 (2), 10–15.

Coyne, E., Rands, H., Frommolt, V., Kain, V., Plugge, M., Mitchell, M., 2018. Investigation of blended learning video resources to teach health students clinical skills: an integrative review. Nurse Educ. Today 63, 101–107. https://doi.org/10.1016/j.nedt.2018.01.021.

De La Maza, V., Torres, J.P., Fernandez, M., Castro, M., Manriquez, M., Vogel, E., ... Viveros, P., 2016. Education program to parents of children with cancer and their impact in the level of knowledge, perception of hospital care and occurrence of adverse events. Pediatr. Blood Canc. 63, S50. https://doi.org/10.1002/pbc.26233.

Di Simone, E., Tartaglini, D., Fiorini, S., Petriglieri, S., Plocco, C., Di Muzio, M., 2016. Medication errors in intensive care units: nurses' training needs. Emerg. Nurse 24 (4), 24–29. https://doi.org/10.7748/en.2016.11577.

Dieperink, K., Coyne, E., Creedy, D., Ostergaard, B., 2017. Family functioning and perceived support from nurses during cancer treatment among Danish and Australian

patients and their families. J. Clin. Nurs. https://doi.org/10.1111/jocn.13894.
Divakaruni, A., Saylor, E., Duffy, A.P., 2018. Assessing the need for improved strategies and medication-related education to increase adherence for oral anticancer medications in the young adult oncology population. J. Oncol. Pharm. Pract. 24 (5), 337–342. https://doi.org/10.1177/1078155217703790.
Durham, M.L., Suhayda, R., Normand, P., Jankiewicz, A., Fogg, L., 2016. Reducing medication administration errors in acute and critical care: multifaceted pilot program targeting RN awareness and behaviors. J. Nurs. Adm. 46 (2), 75–81. https://doi.org/10.1097/nna.0000000000000299.
Friese, C.R., Himes-Ferris, L., Frasier, M.N., McCullagh, M.C., Griggs, J.J., 2012. Structures and processes of care in ambulatory oncology settings and nurse-reported exposure to chemotherapy. BMJ Qual. Saf. 21 (9), 753–759. https://doi.org/10.1136/bmjqs-2011-000178.
Garfield, S., Jheeta, S., Husson, F., Lloyd, J., Taylor, A., Boucher, C., ... Franklin, B.D., 2016. The role of hospital inpatients in supporting medication safety: a qualitative study. PLoS One 11 (4). https://doi.org/10.1371/journal.pone.0153721. e0153721.
Garrad, J., 2016. fifth ed. Health Sciences Literature Review Made Easy: the Matrix Method, vol. 3 Ringgold Inc, Beaverton online access included).
Geerligs, L., Rankin, N.M., Shepherd, H.L., Butow, P., 2018. Hospital-based interventions: a systematic review of staff-reported barriers and facilitators to implementation processes. Implement. Sci. 13 (1), 36. https://doi.org/10.1186/s13012-018-0726-9.
González, J.A.E., Pujadas, E.N., Crespo, A.A., Pujol, X.B., Pascual, N.R., 2017. Medication errors due to wrong patient misidentification. Int. J. Clin. Pharm. 39 (1), 283–284. https://doi.org/10.1007/s11096-016-0404-4.
Gonzalez, T., 2013. Chemotherapy extravasations: prevention, identification, management, and documentation. Clin. J. Oncol. Nurs. 17 (1), 61–66. https://doi.org/10.1188/13.CJON.61-66.
Hagan, T.L., Medberry, E., 2016. Patient education vs. Patient experiences of self-advocacy: changing the discourse to support cancer survivors. J. Cancer Educ. 31 (2), 375. https://doi.org/10.1007/s13187-015-0828-x.
Hanafi, S., Torkamandi, H., Bagheri, S., Tavakoli, M., Hadav, N., Javadi, M., 2016. Safe handling of cytotoxic drugs and risks of occupational exposure to nursing staffs. J Pharm Care 3 (1), 11–15.
Henderson, S., Dalton, M., Cartmel, J., 2016. Using interprofessional learning for continuing education: development and evaluation of the graduate certificate program in health professional education for clinicians. J. Continuing Educ. Health Prof. 36 (3), 211–217. https://doi.org/10.1097/CEH.0000000000000093.
Hopia, H., Latvala, E., Liimatainen, L., 2016. Reviewing the methodology of an integrative review. Scand. J. Caring Sci. 30 (4), 662–669. https://doi.org/10.1111/scs.12327.
Huertas-Fernández, M.J., Martínez-Bautista, M.J., Rodríguez-Mateos, M.E., Zarzuela-Ramírez, M., Muñoz-Lucero, T., Baena-Cañada, J.M., 2017. Implementation of safeguards to improve patient safety in chemotherapy. Clin. Transl. Oncol. 19 (9), 1099–1106. https://doi.org/10.1007/s12094-017-1645-y.
Hydzik, C., 2009. Treatment of ovarian cancer with intraperitoneal chemotherapy. Oncol 23 (11), 15–20.
Kane-Gill, S.L., Dasta, J.F., Buckley, M.S., Devabhakthuni, S., Liu, M., Cohen, H., ... Smith, B.S., 2017. Clinical practice guideline: safe medication use in the ICU. Crit. Care Med. 45 (9), e877–e915. https://doi.org/10.1097/CCM.0000000000002533.
Kelly, K., Harrington, L., Matos, P., Turner, B., Johnson, C., 2016. Creating a culture of safety around bar-code medication administration: an evidence-based evaluation framework. J. Nurs. Adm. 46 (1), 30–37. https://doi.org/10.1097/nna.0000000000000290.
Kerfoot, K.M., 2016. Patient safety and leadership intentions: is there a match? Nurs. Econ. 34 (1), 44–45.
Lennes, I.T., Bohlen, N., Park, E.R., Mort, E., Burke, D., Ryan, D.P., 2016. Chemotherapy errors: a call for a standardized approach to measurement and reporting. J. Oncol. Pract. 12 (4), e495–501. https://doi.org/10.1200/jop.2015.008995.
Looper, K., Winchester, K., Robinson, D., Price, A., Langley, R., Martin, G., ... Flake, S., 2015. Best practices for chemotherapy administration in pediatric oncology: quality and safety process improvements. J. Pediatr. Oncol. Nurs. 33 (3), 165–172. https://doi.org/10.1177/1043454215610490.
Louvrier, M., Vigne, F., Decourcelle, C., Rouayroux, N., Dessaud, J., Christian, R., 2015. Chemotherapeutic agents in onco-haematology unit: how to learn from our mistakes? Int. J. Clin. Pharm. 37 (1), 235. https://doi.org/10.1007/s11096-014-0039-2.
Markert, A., Thierry, V., Kleber, M., Behrens, M., Engelhardt, M., 2009. Chemotherapy safety and severe adverse events in cancer patients: strategies to efficiently avoid chemotherapy errors in in- and outpatient treatment. Int. J. Cancer 124 (3), 722–728. https://doi.org/10.1002/ijc.23991.
Marmor, G.O., Li, M.Y., 2017. Improving emergency department medical clinical handover: barriers at the bedside. Emerg. Med. Australasia 29 (3), 297–302. https://doi.org/10.1111/1742-6723.12768.
Menonna-Quinn, D., 2013. Safe handling of chemotherapeutic agents in the treatment of nonmalignant diseases. J. Infusion Nurs. 36 (3), 198–204. https://doi.org/10.1097/NAN.0b013e318288a2e7.
Merlin, T., Weston, A., Tooher, R., 2018. National Health and Medical Research Council. *NHMRC additional levels of evidence and grades for recommendations for developers of guidelines*. Retrieved from. http://www.nhmrc.gov.au/.
Muehlbauer, P.M., Parr, M.B., Perkins, A.K., 2013. Using simulation to assess chemotherapy competency. Clin. J. Oncol. Nurs. 17 (4), 392–396. https://doi.org/10.1188/13.CJON.392-396.
Neuss, M.N., Gilmore, T.R., Belderson, K.M., Billett, A.L., Conti-Kalchik, T., Harvey, B.E., ... Polovich, M., 2016. 2016 updated American society of clinical oncology/oncology nursing society chemotherapy administration safety standards, including standards for pediatric oncology. J. Oncol. Pract. 12 (12), 1262–1271. https://doi.org/10.1200/JOP.2016.017905.
O'Connor, S., Carlson, E., 2016. Safety culture and senior leadership behavior: using negative safety ratings to align clinical staff and senior leadership. J. Nurs. Adm. 46 (4), 215–220. https://doi.org/10.1097/nna.0000000000000330.
Pluye, P., Hong, Q.N., 2014. Combining the power of stories and the power of numbers: mixed methods research and mixed studies reviews. Annu. Rev. Public Health 35 (1), 29–45. https://doi.org/10.1146/annurev-publhealth-032013-182440.
Polovich, M., Martin, S., 2011. Nurses' use of hazardous drug-handling precautions and awareness of national safety guidelines. Oncol. Nurs. Forum 38 (6), 718–726. https://doi.org/10.1188/11.onf.718-726.
Prakash, V., Koczmara, C., Savage, P., Trip, K., Stewart, J., McCurdie, T., ... Trbovich, P., 2014. Mitigating errors caused by interruptions during medication verification and administration: interventions in a simulated ambulatory chemotherapy setting. BMJ Qual. Saf. 23 (11), 884–892. https://doi.org/10.1136/bmjqs-2013-002484.
Ranchon, F., Salles, G., Späth, H.-M., Schwiertz, V., Vantard, N., Parat, S., ... Rioufol, C., 2011. Chemotherapeutic errors in hospitalised cancer patients: attributable damage and extra costs. BMC Canc. 11 (1). https://doi.org/10.1186/1471-2407-11-478.
Riese, C., Weiß, B., Borges, U., Beylich, A., Dengler, R., Hermes-Moll, K., ... Baumann, W., 2017. Effectiveness of a standardized patient education program on therapy-related side effects and unplanned therapy interruptions in oral cancer therapy: a cluster-randomized controlled trial. Support. Care Canc. 25 (11), 3475–3483. https://doi.org/10.1007/s00520-017-3770-0.
Schleisman, A.S., Mahon, S.M., 2015. Preventing chemotherapy errors with comprehensive medication assessment. Clin. J. Oncol. Nurs. 19 (5), 532–534. https://doi.org/10.1188/15.cjon.532-534.
Schneidereith, T., 2015. Seeing through google glass: using an innovative technology to improve medication safety behaviors in undergraduate nursing students. Nurs. Educ. Perspect. 36 (5), 337–339.
Schooley, B., San Nicolas-Rocca, T., Burkhard, R., 2015. Patient-provider communications in outpatient clinic settings: a clinic-based evaluation of mobile device and multimedia mediated communications for patient education. JMIR mHealth and uHealth 3 (1), e2. https://doi.org/10.2196/mhealth.3732.
Shea, M., Weinstein, N., Zerillo, J.A., 2016. Integrating nursing into oral chemotherapy education. J. Clin. Oncol. 34 (7_Suppl. l). https://doi.org/10.1200/jco.2016.34.7_suppl.81. 81-81.
Sheridan-Leos, N., 2007. A model of chemotherapy education for novice oncology nurses that supports a culture of safety. Clin. J. Oncol. Nurs. 11 (4), 545–551. https://doi.org/10.1188/07.cjon.545-551.
Sheridan-Leos, N., Schulmeister, L., Hartranft, S., 2006. Failure mode and effect analysis: a technique to prevent chemotherapy errors. Clin. J. Oncol. Nurs. 10 (3), 393–398. https://doi.org/10.1188/06.cjon.393-398.
Turner, A., Stephenson, M., 2015. Documentation of chemotherapy administration by nursing staff in inpatient and outpatient oncology/hematology settings: a best practice implementation project. JBI Database of Systematic Reviews and Implementation Reports 13 (10), 316–334. https://doi.org/10.11124/jbisrir-2015-2157.
Verweij, L., Smeulers, M., Maaskant, J.M., Vermeulen, H., 2014. Quiet please! Drug round tabards: are they effective and accepted? A mixed method study. J. Nurs. Scholarsh. 46 (5), 340–348. https://doi.org/10.1111/jnu.12092.
Villarini, M., Dominici, L., Piccinini, R., Fatigoni, C., Ambrogi, M., Curti, G., ... Moretti, M., 2011. Assessment of primary, oxidative and excision repaired DNA damage in hospital personnel handling antineoplastic drugs. Mutagenesis 26 (3), 359–369. https://doi.org/10.1093/mutage/geq102.