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Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies

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EXAMINING ONCOLOGY NURSES' KNOWLEDGE
OF CHEMOTHERAPY ERRORS USING
TWO SELF-DIRECTED LEARNING STRATEGIES

A Dissertation

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirements for the Degree

Doctor of Philosophy

Anna N. Vioral

Indiana University of Pennsylvania

May 2014

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Medication errors have emerged as an increasing safety concern for hospitalized patients. Chemotherapy errors have topped the list of high-alert medications with errors occurring during administration, dispensing, and prescribing. Nurses are instrumental in the complex multidisciplinary high-risk process of chemotherapy administration.

This study sought to determine if oncology nurses' use of two different self-directed learning (SDL) strategies increased their knowledge of national chemotherapy safety standards over time. This study also explored if selected demographic variables influenced knowledge retention. Lewin's Planned Change Theory guided this study utilizing a three-stage model to "unfreeze," "change," and "refreeze" knowledge over time.

A quasi-experimental longitudinal repeated-measures design was used to assess oncology nurses' knowledge of national chemotherapy safety standards before, immediately following, and four weeks after participants completed the learning interventions. The sample included 48 chemotherapy competent registered nurses from six mid-Atlantic state healthcare facilities. Descriptive statistics and mixed between-within subject's analysis of variance were conducted to examine the research variables. Both absolute and adjusted measures of knowledge were investigated.

Findings revealed a significant main effect for absolute knowledge (Wilks' Lambda = .76, $F(2,32) = 4.95$, $p = .01$, partial eta squared = .24) and adjusted knowledge (Wilks' Lambda = .79, $F(2,32) = 4.58$, $p = .01$, partial eta squared = .22) in the identification of errors over three time points. However, there was no significant main effect ($F(1,33) = 2.04$, $p = .16$, partial eta squared = .058) between the educational absolute or the adjusted knowledge groups ($F(1,33) = 21.35$, $p = .25$, partial eta squared = .039). Knowledge was also retained despite generational learning preferences, oncology certification, and years of administering chemotherapy. Results also revealed the commonly omitted errors by oncology nurses administering chemotherapy.

These findings provide implications for oncology nurses, educators, and administrators on how SDL strategies impact knowledge over time and chemotherapy errors. Results should be used to standardize chemotherapy processes and to develop or redesign educational programs. Future studies should measure knowledge using multiple types of SDL methods, explore transfer of knowledge to practice, and examine knowledge in other disciplines.

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LIST OF ABBREVIATIONS

ASCO	American Society of Clinical Oncology
CTFC	Chemotherapy Task Force Council
CPOE	Computerized Physician Order Entry
EL	Electronic Learning
FMEA	Failure Mode Effect Analysis
KR	Knowledge Retention
LMS	Learning Management System
MAE	Medication Administration Errors
ONS	Oncology Nursing Society
QOC	Quality Oncology Coordinator
SDL	Self-Directed Learning
SELV	Simulated Electronic Learning Vignette
SLP	Self-Learning Packet
SOP	Standard of Practice
STAR	Simulation Training Academic Research Center

CHAPTER ONE

INTRODUCTION

The Institute of Medicine (IOM) (2006) has estimated that on average hospitalized patients receive at least one medication error per day. The IOM landmark report, *Preventing Medication Errors*, stated that “medication errors harm at least 1.5 million patients every year in hospitals, long-term care facilities, and out-patient clinics” (Institute of Medicine, 2006, p. 1). Literature reports few reliable estimates on the cost of these errors to patients, families, hospitals, health-care providers, and insurance companies. The IOM (2006) estimates \$8,750.00 added costs to a hospital stay for each medication error. With an estimated 400,000 medication errors and complications occurring annually, the total annual cost would be approximately 3.5 billion dollars (Institute of Medicine, 2006). Medications of greatest concern for errors include the high-alert medications identified by the Institute for Safe Medication Practices (ISMP) (2012). High-alert medications have the highest risk of causing significant patient harm or death when prescribed or administered in error (ISMP, 2012). Chemotherapy tops the list of high-alert medications outranking intravenous (IV) potassium chloride and insulin as a potential threat to patient safety (ISMP, 2012).

Several factors contribute to the increased potential for chemotherapy errors. Chemotherapy involves complex multi-drug regimens. Chemotherapeutic agents also have a lower therapeutic index and narrower safety margins than other drug classifications (Sheridan-Leos, 2007). Even small errors may result in major harm because chemotherapy dosing involves patient-specific not standardized dosing based on body size or renal function (Sheridan-Leos, 2007). The complex high-risk process of chemotherapy administration increases the risk for nurses to make errors at multiple points across the treatment course (Vioral, 2014).

Furthermore, many variations in prescribing, dispensing, and administration related to these agents leads to an increased potential for errors that may result in lethal negative outcomes. Research on chemotherapy medication administration errors has identified three classifications of errors: prescribing, dispensing, and administration (Ford, Killebrew, Fugitt, Jacobsen, & Prystas, 2006; Markert, Thierry, Kleber, Behrens, & Engelhardt, 2009; Rinke, Shore, Morlock, Hicks, & Miller, 2007). Literature revealed that 41%-50% of chemotherapy related errors occur during administration, followed by 23%-38% during dispensing, and 4%-21% when ordering or prescribing the agents (Ford et al., 2006; Markert et al., 2009; Rinke et al., 2007). Research also reported that 85% of the errors reach a patient and 15.6% require additional patient monitoring and therapeutic interventions (Rinke et al., 2007). Ranchon et al. (2011) reported in a prospective study that if 13 chemotherapy errors that reached patients were not intercepted, an additional 216 hospitalized days would have resulted in an estimated total cost of (F)92,907 (\$120,000).

Therefore, minimizing errors and increasing safety has risen to the forefront of oncology practices. The complex high-risk process of administering chemotherapeutic agents creates a challenge for stakeholders to develop a framework of best practices to reduce errors and increase knowledge for individuals involved in both direct and indirect care (Vioral, 2014). The IOM (2006) recommended that healthcare facilities using chemotherapy to care for patients with cancer should implement the following: a) structured error-avoidance plans; b) resources to promote accurate prescribing, dispensing, and administration of chemotherapy; and c) analytical processes to continuously evaluate ways to decrease chemotherapy errors. Nurses are instrumental in the chemotherapy process, yet the literature lacks sufficient evidence that

assesses oncology nurses' knowledge of chemotherapy administration. Lack of knowledge in the administration process may contribute to an increase in chemotherapy errors.

This chapter introduces a study that investigated the effects of standardizing chemotherapy practice according to the American Society of Clinical Oncology (ASCO) and the Oncology Nursing Society (ONS) chemotherapy safety standards; determined if pedagogical approaches increase oncology nurses' knowledge retention (KR) of the standards; and explored if selected demographic variables influenced KR. Effective pedagogical approaches for oncology nurses may increase their knowledge about chemotherapy errors that may occur during the administration process. Oncology nurses with increased clinical knowledge may decrease errors and improve patient outcomes. The results of this study generated findings to provide evidence-based recommendations for educators on how to develop or redesign educational programs.

This chapter presents the background outlining the literature on chemotherapy errors, national standards addressing chemotherapy, and KR in oncology nurses receiving education. This chapter also discusses the problem and purpose of the study, the research questions, and theoretical framework that guided the study. Theoretical and operational definitions of the variables are included. The chapter concludes with assumptions for consideration, delimitations, and the study's significance.

Background of Problem

Despite the risks involved in chemotherapy administration and recommendations made by the IOM, few national standards have existed for safe administration of chemotherapeutic agents. In 2008, the ASCO and the ONS initiated a collaborative project to develop standards for safe chemotherapy administration to adult patients with cancer. The project included patient safety with chemotherapy regimens across the treatment plan (Jacobson et al., 2009). These two

organizations in collaboration with other professional associations developed the *ASCO/ONS Chemotherapy Standards for Safe Chemotherapy Administration* to improve quality and safety of chemotherapy administration in a variety of settings (Jacobson et al., 2009). The final version of the ASCO/ONS standards included 31 standards encompassing seven domains: a) review of clinical information and selection of treatment regimen; b) treatment planning and informed consent; c) ordering of treatment; d) drug preparation; e) assessment of treatment compliance; f) administration and monitoring; and g) assessment of response and toxicity monitoring (Jacobson et al., 2009; Vioral & Kennihan, 2012). Both ASCO and ONS recommended adherence to these standards as a goal for all providers involved in the administration of chemotherapy. However, no evidence was located supporting the use of the standards or recommendations on how to educate nurses about the standards.

The literature identified concerns about the knowledge and skills of healthcare providers administering chemotherapy (Batty, White, & Miller, 2011; Carrington, Stone, Koczwara, & Searle, 2010; Jacobson et al., 2009; Sheridan-Leos, 2007), yet there was no evidence on how healthcare agencies should address the new standards in regards to knowledge, education, and implementation. If policies do not address safe administration of chemotherapy, and if staff are not provided the knowledge and skills to safely administer and handle these agents, patient outcomes may be impacted (Vioral & Kennihan, 2012). Therefore, the Oncology Quality Coordinator (OQC) of a large urban healthcare system consisting of five hospitals and 15 out-patient oncology offices established a multidisciplinary inter-facility Chemotherapy Task Force Council (CTFC) in response to the ASCO and ONS proposed standards for the administration of chemotherapy (Vioral & Kennihan, 2012).

The CTFC organized a multidisciplinary team from across the healthcare system to develop, implement, and evaluate the chemotherapy administration standards (Vioral & Kennihan, 2012). The participants for the CTFC included representatives from pharmacy, oncology nursing staff experts, oncology management and educators, nursing administration, and physicians from the oncology practices within the system (Vioral & Kennihan, 2012). Additional disciplines including human resources, employee health, materials management, and employee safety were recruited to address selected standards (Vioral & Kennihan, 2012). This standardization process evolved over three years. From 2009-2012, the CTFC met monthly to examine current practices, develop new standards, and implement new best practices. By the end of 2009, the CTFC had identified over 40 different forms and 30 different policies and procedures from across the system (Vioral & Kennihan, 2012). Although each facility shared some commonalities, no consistent standards or processes related to prescribing, ordering, mixing, dispensing, handling, and/or administering chemotherapeutic agents existed (Vioral & Kennihan, 2012). Over the course of 2010, the CTFC worked diligently to create universal language, standards, and forms for the system (Vioral & Kennihan, 2012). In 2011, the CTFC finalized the development of the new standards and forms along with establishing an implementation plan (Vioral & Kennihan, 2012). The CTFC condensed 31 standards, 40 forms, and 30 policies and procedures into 16 standards of practice (SOP), 11 new forms, four revised forms, and four new reference sheets (Vioral & Kennihan, 2012). The newly developed standards and forms represented the ASCO/ONS chemotherapy safety standards.

Once the standards were developed and approved through the appropriate councils and disciplines at each facility within the system, the CTFC discussed methodologies for implementation and evaluation (Vioral & Kennihan, 2012). However, the healthcare system in

this study had not developed or implemented a prior program with this level of complexity. The education required disseminating the SOPs across five hospitals and 15 out-patient facilities (Vioral & Kennihan, 2012). The complexity of these standards created concerns among the members of the CTFC on how to best educate the employees in an effective manner. The CTFC also voiced concerns on how to evaluate the outcomes of the education (Vioral & Kennihan, 2012).

Therefore, the members of the CTFC conducted a review of literature on current healthcare educational strategies. According to Billings and Halstead (2012), nurse educators faced challenges such as cost-effectiveness and lack of time when providing staff development education. These issues challenged nurse educator's creativity when providing new learning for staff development (Clifford, Goldschmidt, & O'Connor, 2007). The literature stressed the importance of providing education in a flexible, convenient, and accessible manner in today's healthcare environment. Based on these recommendations, the CTFC discussed the potential options to effectively and efficiently deliver consistent standardized education to the employees (Vioral & Kennihan, 2012). Ideas were generated to use self-learning packets (SLP), PowerPoint (PPT) presentations, or online learning modules. The literature referred to these strategies as self-directed learning (SDL).

In SDL, the learner takes the initiative for the learning process and allows individuals to study at their own pace and direction (Clifford et al., 2007). SDL accommodates diverse learning needs and backgrounds of nurses (Clifford et al., 2007). SLPs emerged as the most common example of SDL. Despite the increased use of this type of education in healthcare, minimal empirical evidence supported or refuted this methodology as effective. The use of the

Internet and computer technology for training has also become common practice as an SDL method of teaching and training in the recent years (Ochoa & Wludyka, 2008).

According to Braet (2009), electronic learning (EL) in healthcare training has become the norm for 21st century education. Many healthcare agencies increased the use of EL to meet the increasing demands in professional fields. EL has several advantages over traditional pencil and paper education formats. For example, EL provides greater accessibility, more efficiency in updating than printed material, standardized content and delivery, accountability, outcome measurement with automated tracking, and allowing participants a choice on the time, place, and pace of learning (Ochoa & Wludyka, 2008; Ryan et al., 2007). While organizations have used EL in employee training, minimal evidence existed on the outcomes of this approach compared to other educational methods. Even less empirical evidence existed in nursing that measured the KR after using different SDL educational approaches. Assessing the learning outcomes after educational interventions demonstrates what learners achieved. In other words, the outcomes provide the evidence or effectiveness of what was learned.

KR involves maintaining knowledge gained from an experience over time (Kirsch, 2008), and is a critical factor for sustainable performance (Nelson & McCann, 2010). Unfortunately, the majority of course evaluations measure satisfaction rather than learning (Kirkpatrick & Kirkpatrick, 2006), and few studies measure KR immediately or longitudinally. Polit and Beck (2012) describe longitudinal studies as a collection of data at more than one point in time. However, literature does not provide a definitive time frame that constitutes “longitudinal.” The longitudinal literature in Chapter Two of this study averages from four to six weeks. An assumption exists that studies conducted past this time frame may introduce extraneous variables

into a study. Based on the averages in the literature, the researcher of this study chose four weeks as the longitudinal time frame to measure KR.

Additional concerns arose that no studies emerged investigating how demographic variables such as generational learning preferences, oncology certification, or years of experience administering chemotherapy influenced KR using these educational methods. Consequently, nurse educators and administrators need more understanding of how educational approaches impact KR. Systematic research may provide evidence on what knowledge learners have acquired and retained. This study investigated KR outcomes of the ASCO/ONS chemotherapy safety standards using SLP and EL approaches in oncology nurses administering chemotherapy.

Statement of the Problem

Prior research provided empirical evidence that chemotherapy errors occur during prescribing, dispensing, and administration (Ford et al., 2006; Markert et al., 2009, Rinke et al., 2007). The majority of the literature supported that computerized physician order entry (CPOE) positively impacts outcomes by decreasing errors during prescribing and dispensing. However, the registered nurse (RN) verifies the last safety check prior to administration of the chemotherapy. Yet, research has not examined ways to decrease administration errors that reach the patients or assessed oncology nurses' knowledge of the chemotherapy administration process.

Ensuring that oncology nurses have a sound understanding of the ASCO/ONS chemotherapy safety standards is imperative to increase safe administration of chemotherapy. Investigating oncology nurses' knowledge of the entire administration process, developing standards of practice, providing education of the standards, and re-evaluating the nurses'

knowledge may contribute significant findings to address error reduction in chemotherapy administration. With current economic challenges in the United States, many healthcare agencies seek ways to reduce costs when educating employees. Healthcare agencies often opt to move education electronically as part of the solutions to the financial challenges. Although healthcare agencies increasingly provide education using SDL, minimal empirical evidence exists on the outcomes of these approaches.

According to Kirkpatrick and Kirkpatrick (2006), the majority of healthcare agencies measure learner satisfaction immediately following the education. However, literature provided minimal evidence measuring knowledge and change in practice beyond the immediate education. Additionally, no evidence was located examining if demographic variables such as generational learning preferences, oncology certification, or years of experience administering chemotherapy influenced KR when using SDL methods. Healthcare providers must develop a deeper understanding of how these educational approaches impact KR. Despite the evidence of increased chemotherapy errors, the literature did not address knowledge of oncology nurses' understanding of the errors. Furthermore, the literature provided no evidence of oncology nurses' KR after using these SDL approaches.

Purpose

The purpose of this study was to determine if oncology nurses' use of SLPs versus video-taped simulated electronic learning vignettes (SELVs) increased their KR of the ASCO/ONS chemotherapy safety standards. This study also explored if selected demographic variables influenced KR between the pedagogical approaches. The results of this study may generate findings that will aid nurses in identifying how to avoid errors during chemotherapy administration. The findings may also assist educators to develop programs using evidenced-based pedagogical approaches.

A quasi-experimental longitudinal repeated-measures design was used to assess oncology nurses' knowledge of the ASCO/ONS chemotherapy safety standards at three separate times: a) before; b) immediately following; and c) four weeks after all participants completed the learning either via the SLPs versus SELVs. The research consisted of a pre-test and post-test administered at completion of the education and four weeks later. A control group and a quasi-experimental group facilitated comparisons. The control group received the SLP education, while the quasi-experimental group received the video-taped SELV. Using the SELVs may provide improved retention compared to other SDL educational strategies. Participants in the quasi-experimental group received the education using seven SELVs, while the control group reviewed the material via a SLP to read and complete the post-assessments. A between-within group comparison was conducted, with the type of instruction (SLP versus SELV) defined as the independent variable, and an error identification score as the dependent variable.

Research Questions and Hypotheses

This study answered the following questions regarding oncology nurses' KR using SLP and EL educational approaches. How do SLPs and SELVs education differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy?

The knowledge was measured in two ways, thus investigating two sets of hypotheses:

1. Using an absolute measure of knowledge (number of correct answers)
 - i. H_0 - SLPs and SELVs education do not differ in terms of their effectiveness in increasing oncology nurses' short-term (post-

intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.

- ii. H_1 - SLPs and SELVs education do differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.

- 2. Using an adjusted measure of knowledge (number of correct answers adjusted for certainty in the answer):

- i. H_0 - SLPs and SELVs education do not differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.
- ii. H_1 - SLPs and SELVs education do differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling

for generational learning preferences, oncology certification, and years of administering chemotherapy.

This study investigated oncology nurses' knowledge of errors that occur during the chemotherapy administration process, educated them on the ASCO/ONS chemotherapy safety standards of practice, and re-evaluated their knowledge of chemotherapy errors after the interventions.

Conceptual Framework

Kurt Lewin's *Planned Change Theory* (1947a) guided the study. Lewin's theory utilizes a three-stage model of change known as the unfreezing-change-refreeze model that requires prior learning to change (Lewin, 1947b). The first stage called "unfreezing" involves dismantling the existing "mind-set" whereby the defense mechanism must be bypassed (Lewin, 1947b). The second stage is where the change occurs, and typically involves a period of confusion and transition. Often an awareness exists that the old ways are being challenged, but there is not a clear picture as to why the ways are being replaced (Lewin, 1947b). The third and final stage referred to as "re-freezing" crystallizes a new mindset and the comfort levels return to previous levels (Lewin, 1947b). This theory supports the framework of this study because the current policies and procedures were dismantled (unfreezing) to challenge the concept of "this is how we have always done it" (change), to recreating, implementing, and evaluating new standards for best practice (refreezing).

The literature lacked evidence on errors made by nurses administering chemotherapeutic agents and their level of knowledge concerning errors throughout the administration process. This study addressed oncology nurses' understanding of chemotherapy errors during the administration process, educated nurses on the ASCO/ONS chemotherapy safety standards using SDL interventions, and

measured KR longitudinally. Lewin's three-step model links with each variable in the study by facilitating "planned change" through learning. Lewin's Planned Change Theory guided this study by: a) integrating field theory and group dynamics to assess and "unfreeze" the current practices and oncology nurses' knowledge of chemotherapy errors; b) facilitating "change" to adopt the ASCO/ONS chemotherapy safety standards using selected SDL interventions; and c) measuring the sustainability or "refreezing" of oncology nurses' knowledge of chemotherapy errors.

Definition of Terms

The following key terms are pertinent to this study and are conceptually and operationally defined below.

Certification. Certification signifies that a nurse develops specialty knowledge beyond the entry level in his/her specialty (Oncology Nursing Certification Corporation, 2012). For this study, certification applies to oncology nurses who have obtained any of the Oncology Nursing Certification Corporation (ONCC) certifications: Oncology Certified Nurse (OCN[®]); Certified Breast Care Nurse (CBCN[®]); Certified Pediatric Hematology Oncology Nurse (CPHON[®]); Advanced Oncology Certified Nurse Practitioner (AOCNP[®]); and Advanced Oncology Clinical Nurse Specialist Practitioner (AOCNS[®]). This information is self-reported by the participants.

Chemotherapy. Chemicals that have a specific toxic effect upon a disease-producing microorganism or that selectively destroy cancerous tissue refers to chemotherapy (Polovich, Whitford, & Olsen, 2009). Chemotherapy in this study refers to cytotoxic agents that involve detailed dosing schemes without causing overwhelming systemic organ damage. These agents involve a variety of administration routes including intravenous, oral, intrathecal, intraperitoneal, subcutaneous, intramuscular, and intrahepatic. Chemotherapy requires a multidisciplinary

process of physicians, pharmacists, and nurses. This study focuses on measuring oncology nurses' knowledge of administering chemotherapy using an SELV.

Chemotherapy error vignette. Literature did not provide a theoretical definition for chemotherapy error vignettes. The researcher theoretically defines a chemotherapy error vignette as a one-minute video-taped scenario of expert oncology clinicians visually and verbally enacting incorrect administration of chemotherapy. The participants analyze the administration of chemotherapy by viewing the simulated vignettes. After viewing the vignettes, the oncology nurses report up to 10 chemotherapy administration errors as identified in the literature. The oncology nurses view the video and enter the errors identified into a learning management system (LMS). The researcher then reviews the reported errors applying a score from 0 (no errors) to 10 (maximum errors) correctly identified.

Electronic-learning (EL). Literature defines EL as any use of computers and/or networks for the purposes of online administration, course information, and/or communications that require participants to review the material on their own time (Batty et al., 2011). EL involves a subset of teaching and learning activities offered through webinars, interactive multimedia via the Internet, video conferencing, simulations, and other interactive teaching and learning methods (Zerwekh, 2011). This study operationalizes EL as instructional content delivered through a LMS via the Internet. The EL education is self-paced and asynchronous.

Knowledge retention (KR). Kirsch (2008) defined KR as critical learning outcomes that are lost over time. In other words, individuals have certain critical knowledge that when lost may involve negative outcomes. KR involves prioritizing what is at the greatest risk of loss so that the knowledge is maintained (Kirsch, 2008). Furthermore, action plans must be developed so that individuals retain the vital knowledge to avoid negative outcomes. KR has been

identified as one of the critical factors for maintaining sustainable performance (Nelson & McCann, 2010). The researcher in this study defined KR as the mean scores on chemotherapy errors identified in the error vignette. The greater number of errors identified by the participant indicated higher levels of KR.

Learning Management System (LMS). Literature defined LMSs as virtual systems that help in the creation and management of course material in EL (Kumbhar, 2009). Examples include Blackboard, Moodle, and Desire-2-Learn. The LMS provides the infrastructure that supports the online classroom (Gautreau, 2011). The LMS in this study became the primary mode of learner-to-educator interactions.

Self-directed learning (SDL). Literature defined SDL as a process of learning based on adult learning principles whereby the learner takes some personal control over the planning and management of the learning (Levett-Jones, 2005; O'Shea, 2003). Participants in this study engage in learning at their own pace using either using a SLP or SELV.

Self-learning packets (SLPs). Xu, Martin, and Gribbins (2010) described a SLP as a self-contained packet containing necessary information that allows the individual to learn a particular subject or topic. A SLP contains all necessary information that allows students to learn a particular activity at their own pace. The control group in this study is provided education using a SLP on the ASCO/ONS chemotherapy safety standards for the participants to learn at their own pace. The material is written in printed format in booklets. There are seven learning modules that provide the ASCO/ONS chemotherapy safety standards. Participants read the SLP and then answer questions at the end of each section as a self-guided review.

Simulation. Activities that mimic the reality of a clinical environment and that are designed to demonstrate procedures, decision-making, and clinical reasoning through techniques such as role-

playing, interactive videos, or mannequins is referred to as simulation (Jeffries, 2005). Simulation in this study involved CTFC members who used role playing to demonstrate the new ASCO/ONS chemotherapy safety standards of practice.

Vignette. The Webster-Merriman dictionary (n.d.) defines vignette as a short descriptive literary sketch, brief incident, or scene. Vignettes have been described as short stories about individuals in specified situations (Finch, 1987); short written or pictorial scenarios intended to elicit responses (Brauer et al., 2009); and auditory and visual transmissions of images used to facilitate behavior changes (Ramsay, Holyoke, Branen, & Fletcher, 2012). Vignettes have also been defined as simulations of real events and used in research studies to describe particular situations to elicit participant's knowledge (Lanza, 1990). Social scientists and anthropologists have used vignettes since the 1950s to study concepts related to health and illness, attitudes, and beliefs (Gould, 1996). A vignette in this study refers to a short video whereby staff members simulate the ASCO/ONS chemotherapy safety standards of practice. The Simulation, Teaching, and Academic Research (STAR) Center in conjunction with the CTFC developed the simulated vignettes. Seven educational vignettes address the 31 standards for chemotherapy safety set forth by ASCO and ONS.

Simulated electronic learning vignettes (SELVs). Literature did not provide a theoretical definition for SELVs. The researcher theoretically defined SELVs as expert oncology clinicians visually and verbally enacting each of the ASCO/ONS chemotherapy safety standards of practice scenarios. Each SELV also includes a post-assessment, evaluation, and automated employee completion verification. Using a LMS, the SELVs provide education by means of textual information, pictures, flowcharts, and videos. This type of educational method provides the learner with access whenever and wherever they want, and the ability to view them

repeatedly as needed. SELVs allow individuals to view actual objects in realistic scenes in motion along with narration (Zhang, Zhou, Briggs, & Nunamaker, 2006). SELVs provide a multi-sensory learning environment that may improve learners' ability to retain information. This study operationalizes the term SELV as short online videos uploaded to a LMS with staff members simulating the ASCO/ONS chemotherapy safety standards of practice. The SELV is used as an interventional tool to educate oncology nurses on the ASCO/ONS chemotherapy safety standards. Additionally, the SELV intended to assess oncology nurses' knowledge of chemotherapy errors.

Assumptions

The following assumptions were held by the researcher for this study:

1. Chemotherapy errors occur more often than they are reported.
2. Increasing knowledge will decrease chemotherapy errors and improve nursing practice and patient outcomes.
3. Participants will provide accurate identification of chemotherapy administration errors in the completion of the study.
4. Participants may not receive their preferred method of learning.

Additional assumptions involve the study's demographic variables: generational learning preferences, oncology certification, or years of experience administering chemotherapy of the participants. These variables are of particular interest because: various generations may retain knowledge based on their learning preferences, oncology nurses assume certified nurses have increased knowledge of chemotherapy, and nurses with more years of experience administering chemotherapy may have greater knowledge than novices. Therefore, this study examined these variables based on the following assumptions:

1. Generational learning preferences may increase or decrease knowledge and retention.
2. Certified nurses may have increased knowledge related to chemotherapy administration.
3. Non-certified nurses may have decreased knowledge related to chemotherapy administration.
4. Experienced oncology nurses may have increased knowledge related to chemotherapy administration.
5. Inexperienced oncology nurses may have decreased knowledge related to chemotherapy administration.

Delimitations

The sample was delimited to a convenience sample of oncology nurses using healthcare systems in a specific geographical area. The convenience sample also limited the ability to generalize findings to all oncology nurses. The study involved only oncology nurses, but delimitations include that the subjects were randomly assigned to the educational strategy. All instruction in these courses was delivered through a universal LMS. The study was also delimited to only oncology nurses who actively administer chemotherapy. The study did not include those nurses who administer chemotherapy to non-oncology patients in non-oncology settings.

Significance of Study

Literature provides a plethora of discussions about quality and safety in healthcare. In a position statement, the National League for Nursing (NLN), called for reform of nursing education to “promote quality education that prepares a work force capable of practicing in a

healthcare environment” (NLN, 2008, p. 2). The NLN position statement reflects the impetus to provide and improve quality and safety to patients in healthcare settings. The Quality and Safety Education for Nurses (QSEN) project also fosters the development of nurses’ knowledge and skills to improve quality and safety in healthcare settings (QSEN, 2009).

Nurses must continuously deal with multiple clinical issues in the oncology setting. As the cancer population expands to an estimated 1.6 million new diagnoses in 2013 (American Cancer Society, 2013), the need for more oncology nurses also increases. Nursing expectations also continue to increase requiring nurses to often do more with fewer resources. These challenges create an environment whereby nurses may experience increased errors when caring for their patients. Educational strategies are often advocated as one method of reducing drug errors (IOM, 2006). Unfortunately, minimal education opportunities are offered and attended within oncology healthcare settings because of lack of resources and increased time constraints with additional job responsibilities. Required educational components are reviewed annually, but ongoing professional development often occurs outside the workplace and is the responsibility of the oncology nurse (Dennison, 2011). This study provided oncology nurses with comprehensive education on the ASCO/ONS chemotherapy safety standards. Healthcare providers must understand the importance of these standards to potentially decrease errors and increase safety of chemotherapy administration.

Although chemotherapy errors often involve several disciplines, the RN verifies the last safety check prior to administration of the chemotherapy. Research suggests that nurses may underreport chemotherapy errors for fear of retribution, thus the amount of errors that reach patients may be higher than reported in the literature (Ford et al., 2006; Markert et al., 2009; Rinke et al., 2007). Ensuring that oncology nurses have a sound understanding of the

ASCO/ONS chemotherapy safety standards is imperative to increase safe administration of chemotherapy. However, research has not examined ways to decrease administration errors that reach the patients or oncology nurses' knowledge of the chemotherapy administration process. A need exists to examine how a set of standardized guidelines with a proactive approach across the entire course of chemotherapy prescribing, dispensing, and administration process impacts outcomes on errors and safety. Therefore, this research study investigated oncology nurses' understanding of chemotherapy errors during the administration process, educated the nurses on the ASCO/ONS chemotherapy safety standards using SDL interventions, and measured KR longitudinally.

Standardizing processes for chemotherapy administration creates a framework for best practice that defines roles and responsibilities and facilitates accountability with a goal to reduce errors and increase safety. Healthcare providers must understand the importance of the standards for chemotherapy administration to decrease errors and increase safety with these medications. Developing mechanisms to educate healthcare providers with the amount of material to disseminate across multiple disciplines requires an effective and efficient strategy.

Offering nurses education balanced with employer-related constraints is an ongoing challenge in healthcare facilities. Literature cites SDL as the most common method used by healthcare agencies to educate the healthcare professionals (Murad, Coto-Yglesias, Varkey, Prokop, & Murad, 2010). Literature interchanges multiple synonymous terms as examples of SDL such as: informal discussions; independent studies; guided studies; computer-assisted learning (CAI); teleconferencing; SLPs; self-learning modules (SLM); distance education; EL; online modules; video learning; problem-based learning (PBL); and teleconferencing (O'Shea, 2003). However, the common SDL educational methods used in healthcare settings specifically

include SLP and computer-based learning (Durmaz, Dicle, Emre, & Cakir, 2012). Although literature cites SLPs and EL as the two most commonly accepted methods of educational approaches used in healthcare organizations, minimal empirical evidence exists supporting or refuting the significance of these interventions. This study investigated how SLPs and SELVs impact oncology nurses' KR of the ASCO/ONS chemotherapy safety standards.

Healthcare incorporates more web-based technology (Ochoa & Wludyka, 2008) and develops more programs using SLPs and EL as potential efficient and effective alternatives to classroom education (Sung, Kwon, & Ryu, 2008). Although health care agencies continue to use these methods to educate employees, literature has provided minimal empirical evidence supporting or refuting the effectiveness. Furthermore, literature provides minimal evidence regarding KR using these methods. The majority of empirical evidence assesses KR at the end of the education and assumes that the short-term gains are retained (Kerfoot, DeWolf, Masser, Church, & Ferderman, 2007). The SDL strategies must strive to generate a deeper approach to learning with retention of the material. Literature suggests that SDL may influence KR, yet remains inconclusive. The influence of demographic variables such as generational learning preferences, oncology certification, or years of experience administering chemotherapy has also not been reported in the literature. Furthermore, the literature lacks evidence addressing education or KR in oncology nurses using these SDL methods. This study examined how SLPs and SELVs impact oncology nurses KR immediately and longitudinally.

Formats of instructional delivery need to be ongoing to evaluate and make improvements based on the evaluations. With healthcare agencies spending approximately \$135 billion on employee training using various types of SDL (Ubell, 2010), measuring KR of nurses using SDL is imperative. Healthcare agencies must demonstrate positive outcomes (Berge, 2007). Therefore, the majority of agencies have migrated to faster, more efficient SDL education methods. However, faster educational

training may result in negative KR outcomes if the SDL methodology is ineffective. This study provided a source of information that can be used to plan and deliver educational materials that best promote knowledge retention. The findings may also provide evidence on SDL pedagogical approaches that educators can use to develop more robust educational programs with KR. Therefore, investigating oncology nurses' knowledge of the entire administration process, developing standards of practice, providing education of the standards using SDL, and re-evaluating the nurses' knowledge contributed significant findings to address error reduction in chemotherapy administration.

Summary

Developing and implementing standardized processes in prescribing, dispensing, and administering chemotherapy among a multidisciplinary team of physicians, pharmacists, and nurses promotes excellence, minimizes potential for errors, and improves efficacy and efficiency (Carrington et al., 2010; Jacobson et al., 2009). This study specifically addressed oncology nurses administering chemotherapy. Research lacked evidence related to oncology nurses' KR of chemotherapy administration errors. This research investigated the effects of standardizing chemotherapy practice according to the ASCO/ONS chemotherapy safety standards. Developing and implementing standards of this magnitude requires an innovative, convenient, and effective teaching strategy with outcome measurements. Using a quasi-experimental longitudinal design, this study determined if oncology nurses' use of SELVs versus traditional SLPs increased knowledge of the ASCO/ONS chemotherapy safety standards. This study investigated if selected demographic variables influenced KR using these two different pedagogical approaches. The results of this study may generate findings to address KR and develop educational programs using evidenced pedagogical approaches. The Chapter Two reviews the research studies that have investigated chemotherapy errors and examined KR in healthcare using SDL

pedagogical approaches. Chapter Two also analyzes research studies that explore factors influencing KR.

CHAPTER TWO

LITERATURE REVIEW

This chapter provides a review of literature relevant to how selected SDL strategies used to educate oncology nurses on the ASCO/ONS chemotherapy safety standards impacts oncology nurses' KR of chemotherapy errors. The chapter begins by describing the theoretical framework that guides the study. Next, the chapter discusses the types and incidences of chemotherapy errors along with potential solutions. Examples of selected SDL strategies used in this study and how they impact KR are also discussed. The use of SELVs as the study's tool is also explored. The chapter concludes briefly with literature related to selected participant demographic variables (generational learning preferences, oncology certification, or years of experience administering chemotherapy) that may potentially influence KR.

An extensive review of the literature on the study's theoretical framework and concepts was conducted using the Academic Search Complete; Applied Science & Technology Source; Cumulative Index to Nursing and Allied Health Literature (CINAHL); Communication & Mass Media Complete; Computers & Applied Sciences Complete; Education Full Text (H. W. Wilson); Education Research Complete; Education Resources Information Center (ERIC); Humanities Full Text (H.W. Wilson); Library Literature & Information Science Index (H. W. Wilson); Library, Information Science & Technology Abstracts; MEDLINE; Psychology and Behavioral Sciences Collection; Social Sciences Full Text (H. W. Wilson); and Sociological Collection databases from 1990-2013.

The review specifically focused on nursing, healthcare, and educational literature published in English language. The search strategy consisted of MeSH terms related to "chemotherapy/antineoplastic agents" combined with: "errors," "medication errors," "patient

safety,” “quality improvement,” “best practice,” “administration,” and like terms provided in the databases. An additional search strategy consisted of MeSH terms related to “e-learning/web-based learning/computer assisted instruction (CAI)” and “SDL/SLP/self-learning modules (SLM)” combined with: “hospital education,” “nursing education,” “oncology,” “oncology nursing,” “vignettes,” “continuing education,” “online continuing medical education (CME),” “virtual learning,” “chemotherapy,” “KR,” “generational learning preferences,” “oncology certification,” “experiential learning,” and like terms provided in the databases. The reference sections of all the retrieved literature connected to the concepts were scanned for further relevant material. Literature was chosen based on relevance related to the theoretical framework and the concepts of chemotherapy errors, SDL, SLP, EL, vignettes, KR, oncology certification, experience, and generational learning preferences. The next section provides a discussion of the theoretical framework that guides this proposed study.

Conceptual Framework: Lewin’s Planned Change Theory

Kurt Lewin’s Planned Change Theory (1947b) guided this study. Lewin has used this theory to study the nature of societal, group and organizational change, organizational development, and planned approach to change. This study investigated oncology nurses’ knowledge of errors that occur during the chemotherapy administration process, educates them on the ASCO/ONS chemotherapy safety standards of practice, and re-evaluates their knowledge of chemotherapy errors after the interventions using Lewin’s planned approach. The following section provides an overview of the Lewin’s Planned Change Theory, the application of the theory to this study, and the research conducted using this theory.

Overview of Lewin's Planned Change Theory

Lewin's Planned Change Theory focused on group and organizational change (Cummings & Worley, 2001) using a humanistic and democratic approach to change the espoused values (Burnes, 2004a). Change often evokes conflicts of interest among individuals. Therefore, change involves a planned process not a revolutionary one-time event. Lewin (1948) believed the key to resolving these conflicts was to facilitate "planned change through learning." Lewin's planned approach to change comprised four concepts: a) field theory, b) group dynamics, c) action research, and d) a 3-step model of change (Burnes, 2004b).

Field theory. Lewin (1947a) described field theory as an approach to understand complex group and organizational behaviors. Lewin (1947a) maintained that group and organizational behaviors were developed by surrounding conditions or forces. If one could identify the forces by understanding why groups and organizations reacted as they did, forces could be restructured to bring about change (Burnes, 2004a). Consequently, any changes in behavior stemmed from changes in the forces within the field (Lewin, 1947a).

Group dynamics. According to Burnes (2004a), Lewin stressed that the group rather than the individual behaviors drove change. Therefore, trying to merely change individual behavior would not occur if they were constrained by group pressures. Consequently, Lewin (1947b) maintained that the focus of change should concentrate on group norms, roles, and interactions. However, understanding the internal field and group dynamics was not enough to bring about change. Group members in the field needed to understand the necessity of change before engaging and committing to the changes (Burnes, 2004a). This led to the development of action research and the 3-step model of change (Burnes, 2004a).

Action research. Action Research emphasized that change required action by the group in the field. When the groups developed an understanding of the reasons to change through their own analysis of the situations, change was more successful (Burnes, 2004a). In other words, the groups in the field must take ownership of the issues before change could occur effectively. Involving the group in the process would result in more successful changes (Lewin, 1947b).

3-step model. Lewin theorized a 3-Step model of change that has evolved as the “unfreeze-change-refreeze” model for organizational development. The first stage called “unfreezing” involved dismantling the existing “mind-set” whereby the defense mechanism must be bypassed (Lewin, 1947b). The second stage was where the “change” occurred, but typically involved a period of confusion and transition as to why the old ways were being replaced (Lewin, 1947b). The third and final stage referred to as “re-freezing” crystallized a new mindset and the comfort levels returned to previous levels (Lewin, 1947b).

Although Lewin’s Theory has been acknowledged as significant to organizational change, critics have argued that the theory was static, simplistic, and a mechanical linear process to change organizational processes (Pettigrew, 1990a; 1990b). Figure 1 illustrates how critics viewed Lewin’s Theory.

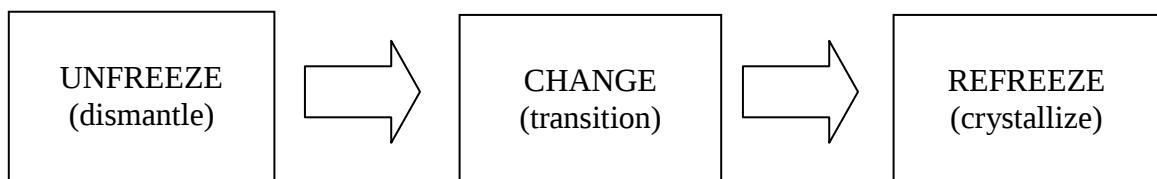


Figure 1. Critics perception of Lewin’s planned change theory.

Lewin (1947b) argued that organizations are in a state of constant change that involves a complex and iterative nonlinear learning process. Schein (1996) described Lewin’s insight to change as a profound dynamic process that involved painful unlearning and difficult relearning.

The arguments of whether the process is linear or non-linear should not supersede the importance of achieving change. Individuals must develop an understanding and restructure their perceptions of the world around them before change can successfully occur (Lewin, 1947b). Therefore, integrating field dynamics, group dynamics, and action research within the 3-Step model facilitates movement from one step to the other. Figure 2 illustrates a nonlinear change that integrates the components of Lewin's theory. This study was guided by the 3-Step model with an integration of the field theory, group dynamics, and action research.

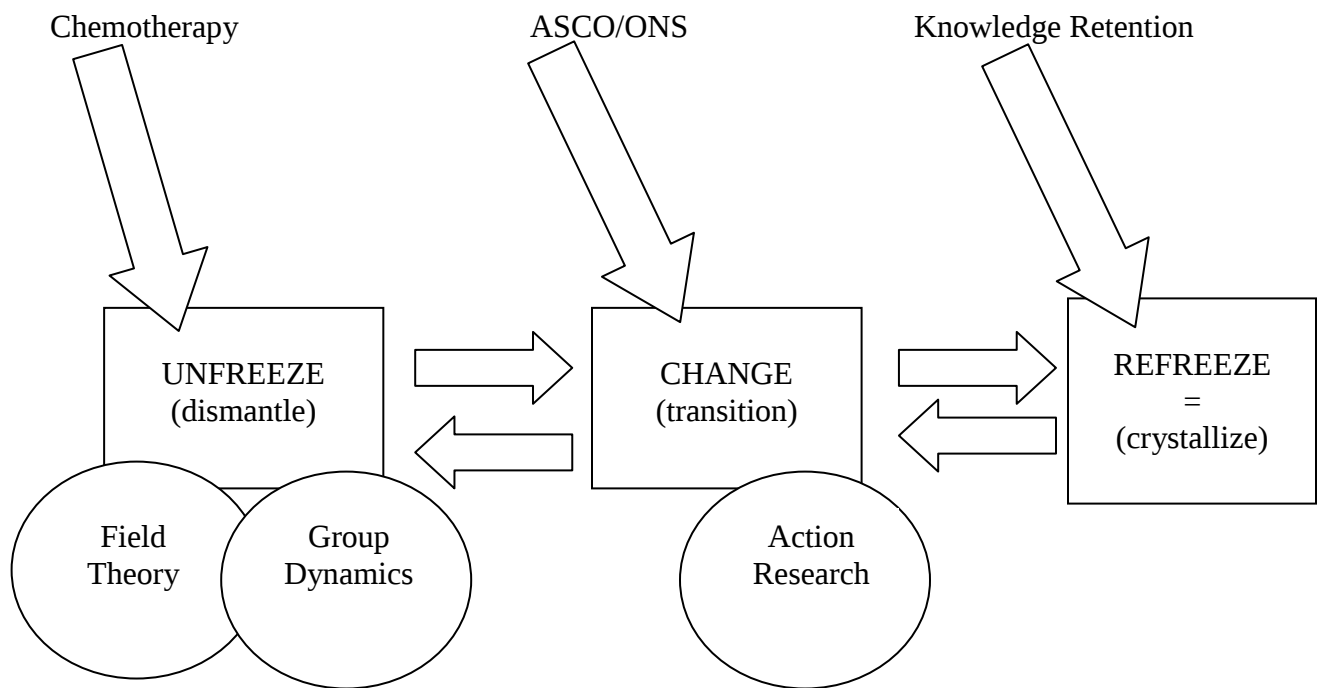


Figure 2. Lewin's planned change theory.

Linking Lewin to Chemotherapy Errors, Interventions, and Knowledge Retention

Chemotherapy medications are highly potent agents that involve a multidisciplinary process for administration. Multiple errors can occur during the prescribing, dispensing, and administration process. As part of the chemotherapy administration procedures, the nurse must also verify the prescribing and dispensing steps of the process. One medication administration

error (MAE) may lead to potentially fatal and lethal outcomes and the nurse administering the agent is the last to verify the process. However, literature lacked evidence on errors made by nurses administering chemotherapeutic agents and their level of knowledge concerning errors throughout the administration process. This study addressed oncology nurses' understanding of chemotherapy errors during the administration process, educated nurses on the ASCO/ONS standards using SDL interventions, and measured KR longitudinally. Lewin's 3-Step model links with each variable in the study by facilitating "planned change" through learning. The following section describes the steps in Lewin's model.

Unfreezing. Stage one of Lewin's theory involves becoming motivated to change and "unfreezing" the current state. Lewin (1939) believed that behavior was based on a "quasi-stationary equilibrium" supported by a complex field of forces. In other words, behavior remained stationary or frozen and was supported in this frozen state by the surrounding complex environment. Lewin (1939) argued that the equilibrium needed to be "unfrozen" before old behavior could be discarded and new behavior adopted. The equilibrium or current behaviors would also change more easily if restraining forces such as personal defenses, group norms, or organizational culture were unfrozen (Weick & Quinn, 1999). Once "unfrozen," structured organizational review or process changes may occur. However, unfreezing behaviors and current practices often involve conflict and resistance. Thus, applying Lewin's field theory and group dynamics may facilitate this "unfreezing" process necessary for change.

Lewin's stage of "unfreezing" using field theory and group dynamics links to this study by investigating oncology nurses' knowledge of chemotherapy errors. According to Lewin (1939), "unfreezing" and changing behavior successfully occurs only by gaining commitment and full involvement of everyone involved. Anyone can initiate change, but without active and

equal participation from everyone involved, the outcomes would be unsuccessful. This stage involves a change agent to recognize the problem, mobilize the group to see the need for change, and create a shared vision (Shirey, 2013). The most effective way to gain full involvement involves the use of both field theory and group dynamics.

To “unfreeze” the current state of the organization in this study, the researcher developed an understanding of the field. The field in this study refers to the healthcare organization and the nurses administering chemotherapy while working in the healthcare organization. Prior to initiating change, the researcher developed an understanding of the organizational field including the current processes, policies, procedures, potential challenges and barriers to change, and the organizational culture. This information provided the researcher with a sense of the field environment and enabled the researcher to engage in the group dynamics.

The group dynamics involved in the complex chemotherapy administration process included physicians, pharmacists, and nurses. Although all these disciplines were involved in the administration process, this study focused specifically on the smaller group dynamics of the oncology nurses administering the chemotherapy. The researcher of this study developed a large multidisciplinary CTFC to influence the group dynamics. According to Lewin (1947b), the researcher needed to understand the group norms, roles, and interactions. By bringing together the CTFC, the researcher hoped to engage the larger CTFC group to develop an understanding of the current practices and concerns surrounding the administration of chemotherapy in the organization. The group members in the field needed to understand the necessity of change before they could engage and commit to change.

The researcher facilitated the CTFC using quality improvement efforts, examining retrospective errors, and reviewing current standards of practice to promote a culture of safety.

The CTFC then identified the current state of the chemotherapy administration process. This process applied Lewin's concept of group dynamics because the CTFC could understand the current state of chemotherapy administration across the organizations. Although the CTFC changed practice for all disciplines across the system, this study focused on the oncology nurses' ability to identify errors throughout the administration process. Therefore, assessment of oncology nurses' knowledge of chemotherapy administration errors was completed.

Although critics cite Lewin's theory as simplistic, this process of gaining commitment and full involvement is not an easy task. Facilitating groups to examine the current culture of an organization, actions of all the disciplines, and to understand why the current practice must change, was a daunting task. Thus, Lewin's 3-Step model involved a complex not a simplistic process of breaking down the field of current practices and gaining group commitment before changes could be introduced.

Changing. During the second step of Lewin's model, all the forces (the organization, physicians, pharmacists, and nurses) must work to identify and evaluate all the available options for change (Lewin, 1947b). This involves an action research-based learning approach that enables groups and individuals to move toward different more acceptable behaviors. Pettigrew (1990a) described the process of change as a complex analytical, political, and cultural challenging process that involves changing core beliefs, structure, and strategy of an organization. Pettigrew (1990b) criticized that Lewin's 3-Step model approach was too prescriptive and lacked attention to analyzing and conceptualizing organizational change. However, Lewin repeatedly wrote that successful change relied on identifying the existing group norms and patterns of routines so that problems could be uncovered, analyzed, and rationalized (Lewin, 1939, 1947, 1948). The process of change also required cognitive restructuring,

interpretation of concepts, and development of new standards to evaluate (Weick & Quinn, 1999). This process could not occur without attention to analyzing and conceptualizing organizational change.

During this step, the CTFC group identified exactly what needed to be changed and why. Evaluating the quality improvement outcomes, retrospective errors, and current standards of practice identified by the group during the “unfreezing” step provided specific details of what needed to be changed. Although practice must change for the multidisciplinary CTFC group, this study focused on the oncology nurses ability to identify errors throughout the administration process. Therefore, the oncology nurses were then presented with the ASCO/ONS chemotherapy safety standards using two different SDL interventions. The CTFC also received the education on the ASCO/ONS standards, but were not included in the scope of this study. During this step, it is common for the groups to develop fear and question why the change is necessary (Lewin, 1947b). Learning new concepts, meanings, and standards impacts the level of change and often produces anxiety within groups (Schein, 1996). The leader at times may need to refer back to the “unfreezing” step to review the field and group dynamics. This reminds the group of the importance of the change they identified in step one of the process. Facilitating the group between steps supports the complexity and non-linear process of Lewin’s theory. Although “change” creates motivation to learn, it does not necessarily control or predict the direction (Schein, 1996). Therefore, assessment of the outcomes must occur.

Refreezing. The final step in this 3-Step model seeks to make the change permanent and stabilize the environment. “Refreezing” seeks to stabilize the group at a new stationary balance to ensure the new behaviors are relatively safe from regression (Burnes, 2004a). Lewin (1947b) saw successful changes as a group activity because changes in individual behavior did not ensure

the group norms and routines were changed. Refreezing often requires changes to organizational culture, policies, and practices (Lewin, 1947b). This stage should stabilize the environment to ensure sustainability over time. Therefore, this study measured the success of “refreezing” a group of oncology nurses knowledge on chemotherapy administration. Oncology nurses knowledge of chemotherapy administration errors were measured immediately following the educational interventions and four weeks later. The findings may indicate that “refreezing” has emerged, or that additional educational interventions must occur. Lewin’s theory has been used in similar studies supporting the dynamic complex process involved with group and organizational change. The following section discusses identified studies using change theory.

Research Supporting Lewin’s Planned Change Theory

The literature review demonstrated that Lewin’s theory has been used extensively in clinical nursing practice, nursing education, educational administration, nursing research, and healthcare care operations (Shirey, 2013). However, this literature offered anecdotal evidence using Lewin’s theory as a framework to guide change in practices, structures, and processes. The literature lacked empirical research to provide healthcare leaders with sufficient evidenced based outcomes to support change in practice. The following four studies from various disciplines supported Lewin’s change theory.

Zand and Sorensen (1975) used Lewin’s framework to investigate successful and unsuccessful application of management science. Management scientists were individuals who sought to improve the effectiveness of an organization in the 1970s. Questionnaires were sent to 390 members of a large management scientist chapter. Data from the 154 participants described the “unfreezing” step as complex and potentially unstable. The management scientists who were disengaged, resentful, and resistant had more negative outcomes when implementing change ($p <$

.01). Conversely, those management scientists who proceeded in supportive and engaged manners experienced more positive change outcomes ($p < .01$). When the group had congruent perceptions the change process contributed to the group developing more improvement solutions. Participant's responses indicated that change was far from complete in "refreezing" when based only on management scientist's agreement. Careful attention to testing the solutions and evaluating the results must occur. Findings revealed that "refreezing" did not indicate the level of success. Rather, "refreezing" and levels of success depended on "unfreezing" and "changing" steps to introduce new behavior. The study provided specific examples of favorable forces, yet limited examples of unfavorable forces and unsuccessful changes. The study's findings suggested that the balance between favorable and unfavorable forces may predict the probability of successful sustainable change.

Action research by Adams and McNicholas (2007) used Lewin's theory in a case study to examine the corporate processes for developing a sustainability report, the hurdles faced by organizations, how organizational accountability change occurred, and what changes led to sustainability performance at a company in Melbourne, Australia. Through the use of Lewin's theory, the study provided immediate feedback to the participants to enhance reporting practices and to incorporate sustainability issues into decision making. Contrary to Zand and Sorensen (1975), the findings by Adams and McNicholas (2007) cited that although the managers were able to produce a Sustainability Report, they lacked engagement in the process. Adams and McNicholas (2007) contended that more robust stakeholder engagement and team leaders would have facilitated the "unfreezing" step. Adams and McNicholas' (2007) findings contradicted Zand and Sorensen (1975) that more positive outcomes occurred with the engaged employees than with disinterested negative employees. The participants were less engaged, yet

demonstrated improved reports. Although this study provided additional findings regarding Lewin's theory, the study lacked a discussion on the most important "refreezing" step of the model.

Medley and Akan (2008) explored an application of Lewin's model to an assessment and re-visioning process by a community-based non-profit organization. Using a case study approach, the researchers examined actions embarked on by the organization to address decreased funding and client losses through the Job Assistance Services. For two years prior to this study, the organization was experiencing a decline in services and funding. A public survey was used to "unfreeze" the perceptions of the public. The 506 responses provided factors on the organizations role in the community along with suggestions for new roles. The "unfreezing" step of identifying the community's perceptions heightened the awareness of the management staff to change the focus of the organization. Innovative ideas from the survey responses encouraged the organization to make changes to meet the public's requests. New strategic planning and re-visioning of the organization occurred during step two of the model. "Refreezing" was evident in the strategic planning outcomes and increased financial independence. The findings suggested that Lewin's model reflected a process of organizational assessment, development, change, and outcomes. Unlike Zand and Sorensen (1975) and Adams and McNicholas (2007), Medley and Akan (2008) reported measurable outcomes indicating the sustainability or "refreezing" step had occurred.

The only recent healthcare related research study using Lewin's theory was conducted by Wells, Manuel, and Cuning (2011) who examined nurses' perceptions following a change from team to a total patient care delivery model. Wells et al. (2011) used a mixed-method longitudinal descriptive design to determine the impact of the change in the care delivery model. During the

“unfreezing” phase, nurses identified components of an ideal model of care delivery to the organizational steering committee. During the “change” phase infrastructure changes were completed and nurses were actively engaged in the process and decision making. Of the 118 eligible nurses, only 32% ($n = 38$) of the self-report surveys were returned at pre-implementation, 31% ($n = 36$) at 3 months post-implementation, and 27% ($n = 21$) at 12 months later. Although consistent with Lewin’s theory that nurses were given the opportunity to participate in the “unfreezing” and “change” phases, the findings revealed more satisfaction during the “unfreezing” and “change” phases than at 3 and 12 months post-implementation. Nurses reported a lack of administrative support during the post-implementation time frame. Contrary to the previous study’s findings by Zand and Sorensen (1975), Wells et al. (2011) findings lacked stabilization in the “refreezing” stage despite nurse involvement during the “unfreezing” and “change” phases. These findings suggested that nurses’ dissatisfaction may have contributed to a negative impact on the “refreezing” or stabilization of the environment. These findings also refute the simplicity of Lewin’s model and underscore the importance of understanding the field and group dynamics to effectively “unfreeze,” “change” and “refreeze” the environment.

Summary and Gaps in Literature

This section describes Lewin’s Planned Change Theory, linked the theory to this proposed study, and discussed research using Lewin’s theory. Lewin’s work stemmed from his concern to find an effective approach to resolving conflict through changing behavior. Lewin also promoted an ethical and humanistic approach to change and saw learning and involvement as key processes for change. Although Lewin’s theory has existed for decades, the lack of relevant research was disappointing. The majority of the literature used Lewin’s theory as a

framework to guide organizational change, yet lacked empirical evidence supporting or refuting the theory as an effective model for creating change. Furthermore, the studies in this section provided inconclusive evidence regarding the effectiveness of Lewin's theory to create change.

Zand and Sorensen (1975) suggested that successful "refreezing" occurred when the group was actively engaged during the "unfreezing" and "change" phases. However, Wells et al. (2011) reported that even when nurses were involved in "unfreezing" and "change," they were dissatisfied in the "refreezing" phase. Adams and McNicholas (2007) indicated that even when the group lacked engagement they successfully changed. Additionally, all of the studies focused primarily on the "unfreezing" and "change" steps of Lewin's theory. Lewin (1947) stressed the importance of ensuring the new behaviors were relatively safe from regression. Only two studies provided minimal discussions about the "refreezing" phase. Medley and Akan (2008) reported increased financial independence and Wells et al. (2011) addressed "refreezing" at 3 and 12 months post-implementation.

The inconclusiveness of these research findings with limited significant empirical evidence supported the need for future research using Lewin's theory. Unfortunately, the majority of the healthcare literature provided anecdotal applications of Lewin's theory to guide change. With the rapid changes in healthcare, research should examine the effectiveness of change using Lewin's theory. The studies in this section used descriptive, action research, and case study designs to investigate change. Future studies should use quasi-experimental designs to examine change between groups. More longitudinal designs should examine organizational change over time to address the sustainability of the outcomes. Additionally, sampling concerns in these studies included: lack of power analysis, limited discussion of participant characteristics, and inability to generalize or transfer findings based on the study designs. Future

studies should investigate potential variables that may contribute to organizational change using Lewin's theory.

Lewin's critics argued that the planned approach to change is simplistic and outmoded. Unfortunately, the studies reviewed in this section support the critic's accusations. However, these studies only addressed Lewin's 3-Step model and failed to integrate how Field Theory, Group Dynamics, and Action Research impact the 3-Step model. Lewin (1947b) viewed these concepts as a unified whole supporting and reinforcing each other to bring about change. Using the integrated model heightens the complexity of Lewin's theory. Lewin's Planned Change Theory guided this proposed study by: a) integrating field theory and group dynamics to assess and "unfreeze" the current practices and oncology nurses' knowledge of chemotherapy errors; b) facilitating "change" to adopt the ASCO/ONS chemotherapy safety standards using selected SDL interventions; and c) measuring the sustainability or "refreezing" of oncology nurses' knowledge of chemotherapy errors. The next section provides a brief definition of chemotherapy, discusses chemotherapy medication types and incidences of errors with potential solutions, and synthesizes the findings from the literature.

Definition of Chemotherapy

Polovich et al. (2009) described chemotherapy as chemicals that have a specific toxic effect upon a disease-producing microorganism or that selectively destroy cancerous tissue. Chemotherapy administration involves the use of protocols ranging from one agent to multi-agent regimens given as repeated cycles. The chemotherapy agents are potent and potentially toxic. Systemic administration routes include intravenous, intramuscular, subcutaneous, intravascular, intradermal, intrahepatic, intraperitoneal, intrapleural, and oral. The ASCO/ONS chemotherapy safety standards apply to all routes of administration. The dosages are calculated

based on the patient's body surface area and/or renal function using standardized calculation formulas. Chemotherapy in this study refers to cytotoxic agents that involve detailed dosing schemes without causing overwhelming systemic organ damage with fatal outcomes. Deviations from the standard of practice increase the potential for chemotherapy errors.

The chemotherapy administration process involves a multidisciplinary team of physicians ordering the agents, pharmacists mixing and dispensing the agents, and nurses administering the agents. Given the complexity of the protocols, extensive routes of administration, and the multidisciplinary team, multiple errors can occur during the prescribing, dispensing, and administration process. One overdosing error may lead to potentially fatal and lethal outcomes, while one under-dosing error may compromise successful outcomes. Although the physician orders the agents and pharmacy dispenses the agents, the nurse must verify these steps in the process prior to administration to recognize potential errors by all of the disciplines. Therefore, prior to administering the chemotherapeutic agents, the oncology nurse has the responsibility and accountability to verify all the steps in the process, including prescribing and dispensing. Yet, no studies have examined oncology nurses' knowledge of the errors that can occur throughout the chemotherapy administration process.

Medication Errors

Medication errors made by healthcare providers are among the most serious class of errors and cause considerable harm (IOM, 2006). Unfortunately, chemotherapy agents rank among the most common causes of medication-error related deaths (ISMP, 2012; Phillips et al., 2001). Chemotherapy presents additional dangers because many of the drugs have a narrow therapeutic index, possess toxicities in therapeutic doses, and consist of complex regimens. Medication administration requires several steps involving a multidisciplinary team. Errors may

occur due to procedural, technical, or behavioral reasons. Furthermore, errors can occur when human and system factors interact with the complex phases of prescribing, dispensing, and administration to produce unintended and potentially harmful outcomes (Carrington et al., 2010).

The literature interchanges a variety of terms when discussing medication errors including: systemic adverse event (SAE); adverse drug event (ADE); adverse drug reaction (ADR); medication error (ME); and medication administration error (MAE). For the purposes of this literature review, research that used any of these terms was examined and included in the review if the errors: a) were intercepted before reaching the patient; b) caused harm or did not harm the patient; c) were procedural, technical, or behavioral; and d) occurred during the prescribing, dispensing, or administration phases. For the ease of reading this review of literature the term “medication administration error (MAE)” is used to describe any type of mistake due to errors in prescribing, ordering, dispensing, monitoring, and administration that may or may not have resulted in any change of patient care. The term MAE also refers to a failure in the treatment process which has led to or had the potential to lead to the patient undergoing harm. The following literature addresses the chemotherapy types and incidences of errors identified in the literature.

Chemotherapy Errors

The highly publicized sentinel event at the Dana Farber Cancer Institute in 1994 contributed to the national patient safety movement. The unfortunate incident resulted in two patients receiving four times the intended dose of chemotherapy within two days of each other by the same medical team. Death resulted in one patient and the other patient suffered permanent heart damage. The errors were overlooked by a half dozen physicians, pharmacists, and nurses and repeatedly documented in the medical record. The media publicized these errors

repeatedly over the next three years. In that time the organization underwent massive upheaval of their chemotherapy processes which lead to the national chemotherapy patient safety efforts and processes.

Chemotherapy MAEs have been studied by classifying the types of errors involved according to ordering, dispensing, and administration. The majority of these studies flourished 10 years after the Dana Farber events. Gandhi et al. (2005) conducted a prospective cohort study of two adult and one pediatric out-patient chemotherapy infusion units at Dana Farber. Chemotherapy orders and charts were reviewed from March-December of 2000 by trained oncology nurses and pharmacists. Of the 10,112 medication orders reviewed from 1606 patients, 92 (37%) were chemotherapy related errors. Errors occurred most commonly when ordering (50%) chemotherapy, followed by administering (45%), and dispensing (44%). Although all of the errors were intercepted prior to reaching the patient, 63% of the errors had the potential to cause lethal outcomes. Despite the horrifying outcomes 10 years earlier at this same institution, the error rates had not significantly dropped. Furthermore, the study did not examine whether prescribed treatments matched the designated protocols which may have led to an underestimation of the true errors rate. Gandhi et al. (2005) recommended standardizing chemotherapy order templates and drug dosages to address the high incidence of ordering errors. Clearly these findings suggested that future studies needed to further examine types and incidences of chemotherapy errors along with potential solutions.

Ford et al. (2006) reported the frequency and types of MAEs in a large community hospital oncology ward. During a two-year prospective study conducted by Ford et al., nurses reported 141 errors. The errors (21%) occurred during the ordering process either in writing or transcription, 38% were pharmacy or registered nurse dispensing errors, and 41% were

administration errors. The highest incidence of errors reported by Ford et al. (2006) occurred during administration which conflicted with Gandhi et al. (2005) findings which reported the highest incidence of errors (50%) occurring during ordering. The findings suggested that to formulate prevention strategies, institutions should first determine the origination of the errors. Using MAEs as an end point provided consistent analysis in an atmosphere aimed at system improvement. A significant limitation of the study included the self-reporting system of MAEs. Self-reporting may not have captured all MAEs due to reluctance of reporting for fear of retribution, forgetting to report, not reporting late administrations, or failing to recognize an error. The researchers recommended future studies addressing ways to reduce errors in prescribing, dispensing, and administration.

In another chemotherapy error study, Rinke et al. (2007) examined patterns in pediatric chemotherapy errors through a query of the United States Pharmacopeia MEDMARX voluntary database reports from 1999-2004. Of the 310 reported errors, 85% reached a patient and 15.6% required additional patient monitoring and therapeutic interventions. Using chi-square statistical analyses, the researchers also examined inpatient (171) and outpatient (31) errors. The inpatient errors were 11.7% in prescribing, 23.4% in dispensing, and 50% in administration, compared with 22.6%, 32.3%, and 42%, respectively, in the outpatient errors. This study also examined the causes of the errors whereby 41.3% were attributed to performance deficits. However, the researchers did not clearly delineate what constituted performance deficits. Although this was a pediatric study, the common themes were congruent with the Ford et al. (2006) study revealing that the lowest errors occurred during prescribing, followed by dispensing and administration errors. Rinke et al. (2007) cited the voluntary reporting as a limitation to the study for similar reasons as Ford et al. (2006). The researchers concluded that further examination in patient

safety, nurse experience, and developing targeted interventions to safeguard against chemotherapy errors demanded further investigation.

One of the largest studies of chemotherapy errors was conducted by Walsh et al. (2008) to determine the rates and types of medication errors associated with both adults and pediatrics in out-patient oncology treatment areas. Walsh et al. (2008) used a diverse population including four oncology sites geographically dispersed throughout the United States over a nine-month time frame. Trained abstractors reviewed 11,908 medication orders for errors. The abstractors found 3,171 (27%) were chemotherapeutic medications, and 112 (8%) of the errors were related to chemotherapy. Unfortunately, 15 of these 112 errors resulted in patient injury: 11 involved the adult population and four involved pediatric patients. Over half of the total errors (56%) identified occurred during administration, followed by prescribing errors (36%). These findings concurred with previous studies by Ford et al. (2006) and Rinke et al. (2007). Walsh et al. (2008) contributed additional findings related to chemotherapy errors. They found that many of the chemotherapy orders were written for the patient's entire regimen over a span of several months at the initiation of treatment. Doses were then adjusted as needed at each visit, thus, increasing administration errors. In concordance with other studies, if errors were not reported, they were not identified. Recommendations were made to develop computerized order entry, interview staff about errors, and to directly observe chemotherapy administration for errors in future studies.

Chemotherapy errors and adverse events were monitored using two error-management systems in a study by Markert et al. (2009). The researchers conducted a prospective investigation of ordering, dispensing, and administration of chemotherapy and SAEs occurring in both inpatient and outpatient oncology wards of an institution. The PERMIT error-management

system monitored errors in chemotherapy ordering and dispensing, and the MERKE system monitored severe adverse reactions over a period of 24 months. Descriptive data analysis using median results and ranges analyzed 22,216 chemotherapy orders. The PERMIT system reported 17.1% errors with 3.8% in the chemotherapy order, 4.5% in patient data, and 8.7% in missing consents. The MERKE system identified 3,792 SAEs and three administration errors reached the patient. The only errors captured were those entered into the PERMIT or MERKE system, which once again relied on voluntary reporting. The researchers recommended the use of computerized chemotherapy ordering systems, standardizing chemotherapy templates, and adding additional teams to review chemotherapy orders before medications reach any patient.

Despite the research to raise awareness about chemotherapy errors and the potential consequences, only one study addressed the cost related to these potential errors. In a one year prospective study by Ranchon et al. (2011), chemotherapeutic medication errors in actual and intercepted cases were examined in terms of cost. The study was conducted in a 1,200 bed teaching hospital in France where 21,000 doses of chemotherapy were administered over 12 months. Of these, 449 resulted in errors with 436 of those errors intercepted by physicians, pharmacists, or nurses prior to administration. Unfortunately, 13 errors reached the patients and two required enhanced monitoring. The study findings underscored that if the intercepted errors had not occurred, patients would have had an additional 216 hospitalized days. Interestingly, Ranchon et al. (2011) reported that 91% of the errors occurred when prescribing. These findings contradicted previous studies (Ford et al., 2006; Markert et al., 2009; Rinke et al., 2007; Walsh et al., 2008) who reported the highest incidence of errors occurred during administration. Ranchon et al. (2011) did not describe specific examples related to the identified errors. However, the

researchers highlighted the need for developing systematic preventative actions to reduce errors and improve quality outcomes which align with the previous studies to date.

Summary and gaps in literature. Literature reveals that the majority of errors occur during administration (49%), then dispensing (32%), and finally ordering (31%) (Ford et al., 2006; Gandhi et al. 2005; Markert et al., 2009; Ranchon et al., 2011; Rinke et al., 2007; Walsh et al., 2008). These findings report that the errors involve multiple root causes across the trajectory of the chemotherapy administration process. This highlights the complexity of the process and underscores the importance of identifying solutions to reduce errors. The prescribing and dispensing errors identified in these studies were captured by trained experts reviewing chemotherapy orders for errors. Limitations to all of these studies include that the errors were voluntarily reported using a form of self-reporting for nurses to identify administration errors. According to Blegen et al. (2004), voluntary reporting of medication errors by nurses captured only an estimated 47%-60% of actual errors. Nurses were found to underreport errors, failed to recognize errors, forgot to report errors, or were reluctant to report errors for fear of retribution (Blegen et al., 2004; Ford et al., 2006). Additionally, these studies did not examine factors contributing to errors such as: distractions in the workplace; years of experience; oncology certification status; employee workloads; or staffing ratios. These variables may affect chemotherapy administration outcomes. Furthermore, the studies did not address oncology nurses' knowledge of chemotherapy errors that occur throughout the administration process including verification of prescribing and dispensing. To optimize the quality of care, research must investigate how to potentially reduce the number of chemotherapy errors that reach the patient during the administration process. Recommendations included further studies on methods to reduce errors such as, developing targeted interventions, standardizing chemotherapy

ordering templates, implementing computerized physician order entry (CPOE), and developing standards of practice (SOP), and policies and procedures (Ford et al., 2006; Gandhi et al. 2005; Markert et al., 2009; Ranchon et al., 2011; Rinke et al., 2007; Walsh et al., 2008).

Chemotherapy Error Solutions

Despite the recommendations to investigate multiple solutions for error reduction in ordering, dispensing, and administration of chemotherapy, research has primarily focused on standardizing chemotherapy ordering templates and implementing CPOE (Dumasia, Harris, & Drelichman, 2006; Kim et al., 2006; Serrano-Fabiá, Albert-Marí, Almenar-Cubell, & Jiménez-Torres, 2010; Voeffray et al., 2006). Although administration errors were reported as the highest incidence, the literature has overwhelmingly recommended CPOE as solutions to chemotherapy errors. The oncology nurse administering the chemotherapy must understand that CPOE does not prevent errors. Additionally, the nurse must identify the potential errors that may occur when verifying the prescribing process using CPOE. The following review of literature highlights the chemotherapy errors and incidences using CPOE.

Computerized physician order entry. One of the earliest studies examining chemotherapy error reduction following implementation of CPOE was conducted by Kim et al. (2006) in pediatric oncology. Prior to CPOE deployment, data were collected for 241 days using a paper-based survey tool to audit 1,259 chemotherapy orders. Post implementation, 1,116 chemotherapy orders were audited over 296 days using a web-based direct-entry tool. Despite the use of different data collection tools, both captured the same data: correct treatment plan, correct order dosing, matching order to treatment plan, cumulative drug dosages, correct calculations, and presence of nursing checklist. Findings revealed that the daily chemotherapy orders had decreased errors in all areas, but there was an increase in the number of orders not

matching the correct treatment plan. Reasons for this increase were not accounted for in the study. This raises significant concerns in the administration process because patients receiving chemotherapeutic agents not matching the prescribed plan may result in lethal outcomes. The study also did not address nurses knowledge of the potential errors associated with CPOE. Recommendations included continued surveillance for persistence of old errors as well as implementing an automated linkage of order sets to specific protocols. Although Kim et al. (2006) found an overall decrease in chemotherapy errors; CPOE did not completely eliminate the errors and introduced potentially new challenges in the process such as the chemotherapy order templates not matching the recommended standardized dosages.

Similarly, Voeffray et al. (2006) assessed the effect of a CPOE system on the number of prescribed orders with errors that were recorded by the pharmacy in a large European University hospital. Chemotherapy protocols were standardized and transferred to the computerized order entry system. Prescription errors were recorded by the centralized pharmacy 15 months before and 21 months after the introduction of CPOE. Before CPOE, 141 of the 940 prescribed chemotherapy regimens (15%) had errors. After CPOE, 75 of the 1505 prescribed chemotherapy regimens (5%) had errors. Prescribed orders not using CPOE attributed to 69 of the 75 errors (92%) after CPOE implementation. Additional findings reported that CPOE decreased improper dosing and incorrect dosing calculations. However, CPOE increased the errors because the ordered drug regimens did not match the prescribed treatment plan with the recommended evidence-based dosages. These findings concurred with Kim et al's. (2006) study results. Chemotherapy errors persisted even with the implementation of CPOE. Limitations to both Voeffray et al. (2006) and Kim et al. (2006) studies included using only one center to examine errors. Although, Voeffray et al. (2006) also did not address nurses knowledge of the potential

errors associated with CPOE, they did recommend extending the scope to encompass the entire chemotherapy drug administration process. This recommendation supports the necessity of investigating nurses' understanding of chemotherapy errors during the administration process.

Dumasia et al. (2006) determined whether standardized chemotherapy order forms would lead to improvement in completeness of chemotherapy orders in a community teaching hospital. These researchers retrospectively evaluated 473 traditional non-standardized patient chemotherapy orders over 12 months and found 45% with completed orders. Standardized chemotherapy written order forms were then implemented and over the next two years, 81% of the 546 orders were correctly completed. The hospital then implemented CPOE and over the next 12 months, and 93% of the 570 orders were completed correctly. The electronic medication ordering system allowed for more accurate conveyance of information and required physicians to complete all ordering fields necessary for chemotherapy error reduction: diagnosis, regimen, height, weight, body surface area (BSA), route, frequency, duration, and dosage calculations. Unfortunately, the researchers did not report why 7% of the orders were not accurately completed after computerized forms were implemented. They also did not report if the CPOE were mandatory fields. Recommendations from the study included populating the computerized order fields with standardized regimens and automatic drug calculations. However, even with standard regimens and automatic drug calculations, errors may occur from inaccurate data entry of height and weight. This further supports necessity of investigating nurses' knowledge of errors that may occur during the entire administration process.

In a prospective audit of an out-patient oncology setting, Small, Barrett, & Price (2008) investigated the recommendations proposed by Dumasia et al. (2006). Small et al. (2008) examined six months of chemotherapy orders for errors. Of the 1653 chemotherapy orders, 314

were logged on an excel spreadsheet and 1339 were computerized. CPOE reduced some of the errors such as a reduction in dose calculation rates from 6.2% using spreadsheets to 1.9% in CPOE. Transcription errors from handwritten orders were also prevented. However, CPOE failed to identify 47% of errors involved with inaccurate dosage or regimen modifications and incorrect cycle numbers. The ordering physician often modifies dosages or the standard regimen based on changes in the patient's condition. CPOE failed to capture those modifications, thus the patients may have received an unintended dose or regimen. Furthermore, chemotherapy regimens are ordered using cycles, and errors may occur if the incorrect cycle is entered using CPOE. Body surface area was also found to be incorrectly entered into the CPOE. These findings concurred with Dumasia et al. (2006) that CPOE did not completely eliminate errors and presented potentially new errors. Failure to recognize these errors may result in serious lethal outcomes. These findings underscore the importance of oncology nurses' understanding and identifying errors that may occur during the chemotherapy administration process. Although Small et al. (2008) did not investigate nurses administering chemotherapy, they did recommend having an experienced staff in chemotherapy to potentially prevent more serious MAEs.

A follow-up study by Serrano-Fabiá et al. (2010) addressed recommendations made by Voeffray et al. (2006) to extend the scope of a study investigating the entire chemotherapy drug administration process. Serrano-Fabiá et al. (2010) conducted a longitudinal prospective two-year cohort study analyzing medication errors in a multidisciplinary university hospital with a computerized pharmacy process. The study aimed to quantify the effectiveness in the detection of chemotherapy medication errors during prescribing, dispensing, administration, and follow-up stages using a computerized pharmacotherapy process. There were 16,473 chemotherapy preparations for 225 patients over the two years. A total of 276 medication errors were identified

with 75.7% attributed to prescribing errors, 21% in preparation errors, and 1.1% in administration errors. The errors (20%) that reached the patient included incompatible fluids and under dosing of chemotherapy. The other 80% of errors involved inaccurate dosing and incorrect medication orders. The researchers concluded that CPOE reduced, but did not eliminate MAEs. Serrano-Fabiá et al. (2010) reinforced that a key element to improving quality outcomes and patient safety is incorporating a multidisciplinary process addressing prescribing, dispensing, and administration. The findings also support the need to investigate oncology nurses' knowledge of the errors that can occur throughout the administration process.

Summary and gaps in literature. Research has identified that CPOE resulted in a significant decrease of chemotherapy errors (Dumasia et al., 2006; Serrano-Fabiá et al., 2010; Voeffray et al., 2006). However, 7% of the orders were not completed properly (Dumasia et al., 2006), 5% of prescribed regimens had errors (Voeffray et al., 2006), and 20% of errors reached patients (Serrano-Fabiá et al., 2010). Serrano-Fabiá et al. (2010) concluded that CPOE improved quality and patient safety in prescribing, dispensing, and administration thereby significantly reducing errors. However, CPOE introduced new challenges in the chemotherapy administration process. For example, the prescribed treatment plans did not match the protocols (Kim et al., 2006) and CPOE did not intercept dose modification, cycle number errors, and incorrect body surface area data entry (Small et al., 2008). Unfortunately, CPOE may create a false security among healthcare providers and oncology nurses that CPOE eliminates errors. Rather, the empirical evidence suggested that although CPOE decreased chemotherapy errors, 20% still reached the patients. Although the oncology nurse administers the chemotherapy, the administration process for the nurse involves reviewing for potential errors by the physicians when ordering and the pharmacists when dispensing the chemotherapy. The literature has

focused a plethora of studies on CPOE as a solution to decrease chemotherapy errors. However, the literature does not report on the knowledge of oncology nurses throughout the administration process. This supports the necessity to investigate oncology nurses' knowledge of chemotherapy errors.

Researchers provided recommendations for future studies such as extending research to encompass the entire chemotherapy drug administration process instead of focusing on one aspect of the prescribing, dispensing, and administration (Voeffray et al., 2006). The aforementioned studies also underscored that chemotherapy errors do not occur in isolation; rather, they involve physicians, pharmacists, and nurses. As a result, all staff that prescribes, dispenses, and administers chemotherapy has a role in addressing ways to potentially reduce errors that may occur despite the CPOE solution. Although CPOE has decreased chemotherapy errors, additional challenges in the administration process have been identified. CPOE may introduce a false sense of security that computers decrease errors. Therefore, the complexity involved with the administration of chemotherapy demands a rigorous multidisciplinary process. Although each step in the process involves a specific discipline (physicians, pharmacists, nurses), the oncology nurse has the responsibility and accountability to verify the previous steps in the process prior to the chemotherapy administration. The oncology nurse administering the chemotherapy must understand and identify the potential errors that may have occurred by the physicians and/or pharmacists in the process. Additionally, the oncology nurse must understand his/her role and that potential error can occur in the administration process. However, the studies did not investigate oncology nurses' knowledge of errors that occurred during the chemotherapy administration process. Rather, the studies focused on CPOE as a solution.

Furthermore, the studies did not examine if variables such as years of experience or oncology certification impacted error reduction during the administration process. An assumption exists that oncology nurses with greater years of experience or those nurses who maintain certification may have increased knowledge of the errors in the administration process. However, these variables were not addressed in the literature. Several of the researchers did make similar recommendations to investigate error reduction after developing SOPs for policies and procedures (Markert et al., 2009; Rinke et al., 2007; Serrano-Fabiá et al., 2010).

Multidisciplinary chemotherapy processes for error reduction. Another recommendation for reducing potential errors involves the use of a multidisciplinary process. Thus far the findings have demonstrated that the chemotherapy administration process is complex and involves a multidisciplinary effort of physicians, pharmacists, and nurses. Literature suggests standardizing processes, developing multidisciplinary approaches, implementing interdisciplinary oncology programs, and analyzing processes to address chemotherapy errors. The most common quality improvement effort used by healthcare organizations is the failure mode and effect analysis (FMEA) approach. This approach assumes that humans have the potential to err beyond an individual's control (Woodhouse, Burney, & Coste, 2004). FMEA promotes a culture of safety by creating a philosophical shift from retrospective error measurement using root-cause analysis to a proactive assessment of potential harm to prevent errors (Ashley et al., 2011; Sheridan-Leos, Schulmeister, & Hartranft, 2006; Spath, 2003). The FMEA approach requires that organizations examine errors in conjunction with current processes to identify where the breakdown occurred, thus causing an actual or potential chemotherapy MAE. This approach incorporates Lewin's framework by examining the

field and group dynamics prior to making change. Reviewing errors enables the organization and disciplines to understand the processes and how the errors occurred.

Sheridan-Leos et al. (2006) reviewed the process of conducting FMEA and provided suggestions on how to apply FMEA to chemotherapy administration processes. The FMEA team should consist of a leader and facilitator along with expert staff members representing each discipline in the process (Sheridan-Leos et al., 2006). Organizational processes, policies, and procedures that apply to chemotherapy must be reviewed. Sheridan-Leos et al. (2006) recommended using flow charts as the preferred methodology to best illustrate the processes. Next, a hazard analysis identifies potential failure modes, determines potential effects on patients, ranks severity, and identifies areas of greatest concern. Based on the FMEA findings, new processes may be designed and piloted to measure outcomes. Sheridan-Leos et al. (2006) supported FMEA as a proactive process to promote chemotherapy safety as an ongoing quality improvement process.

Despite the popularity of FMEA in healthcare, minimal literature specific to chemotherapy failure modes were found. Ashley et al. (2011) used FMEA to assess and improve the safety of chemotherapy administration. The study was conducted from May 2009 to September 2009 on a 21-bed inpatient and 10-seat outpatient adult oncology unit in the United Kingdom. The FMEA team consisted of one manager, one educator, four expert oncology staff nurses, and two postdoctoral patient safety research fellows. The FMEA process described by Sheridan-Leos et al. (2006) was used in this study to identify 30 failure modes. Of the 30 failure modes, 12 were deemed as high priorities warranting remedial attention such as: delayed administrations, drugs administered that were not prescribed, incorrect dosages administered, omission of agents from the protocol, and incorrectly programmed infusion pumps. These

failures involved errors in prescribing, dispensing, and administration that the nurse is responsible for verifying prior to administering. This underscores the importance of identifying the oncology nurses' knowledge of errors during the administration process.

Actions by the FMEA team were undertaken to address each of these high priorities such as decreasing distractions and interruptions when administering chemotherapy regimens, instituting double-check policies, and developing algorithms to standardize processes (Sheridan-Leos et al., 2006). Although the use of FMEA increased staff awareness and changed some processes, the outcomes were not clearly reported by the researchers. Another limitation to the study was that pharmacists and physicians were not involved in the FMEA multidisciplinary process. Future studies should investigate the effectiveness of a multidisciplinary FMEA to prospectively decrease errors in the chemotherapy administration process. Furthermore, studies should examine potential causes of errors specific to administration. The findings of this study not only underscored the importance of identifying the errors, but also the necessity to investigate oncology nurses' knowledge of errors involved with the administration of chemotherapy.

Another quality improvement effort to potentially reduce errors was conducted by Womer et al. (2002). The division of oncology at a 303-bed acute-care institution consisted of trained clinical pharmacists and technicians who mixed and dispensed the chemotherapy for both inpatient and outpatient clinical areas. The quality improvement effort used flow charts to illustrate 20 pages of the entire chemotherapy process. The team used a series of "rapid cycle changes" to address the highest error prone areas identified from the flow charts: a) drive out fear using non-punitive reporting procedures; b) trap and learn from actual and intercepted errors; c) focus on output rather than input with orders; d) simplify and standardize protocols; e)

use constraints (policies) and force functions (mandatory order entry fields) for chemotherapy processes; f) reduce handoffs; and g) pay attention to human factors to decrease distractions.

Womer et al. (2002) reported that chemotherapy errors dropped from 6.2/1000 inpatient to 1.0/1000 after implementing a multidisciplinary systems approach to chemotherapy safety processes. Although Womer et al. (2002) cited challenges with CPOE, clinical trials, and staffing, they attributed their success of decreased errors over five years to the sustained system changes and constant vigilance to the chemotherapy processes. The researcher's reported that establishing a culture of safety with sustained improvement required a long-term commitment (Womer et al., 2002).

More recent studies and literature recommendations included the integration of FMEA and implementing interdisciplinary oncology programs with standardization of processes. Chung, Collins, and Cui (2011) developed and implemented an interdisciplinary oncology program in a community hospital. Prior to the implementation, the hospital lacked a defined structure and practice model for chemotherapy administration. Program development occurred in three phases: a) establishing chemotherapy guidelines, forms, and protocols; b) integrating clinical and operational best-practices for chemotherapy administration by pharmacy and nurses; and c) developing relationships with the physicians to establish CPOE communication with all disciplines. Prior to implementation 96 chemotherapy orders were reviewed for errors and 75 orders were reviewed post-implementation. Although not statistically significant, a 45% reduction ($p < 0.0625$) in overall chemotherapy-related errors was reported. The researchers recommended that future studies should also investigate the cost-effectiveness of standardization and error reduction. The findings of this study suggested the importance of developing a

multidisciplinary team to examine the current state of the organization related to chemotherapy processes prior to implementing change.

Chemotherapy administration safety standards. Despite the incidences, risks, and errors, few national standards existed for safe administration of chemotherapy until 2008. The two largest governing organizations for chemotherapy standards of practice in the United States, the ASCO for physicians and the ONS for nurses initiated a collaborative project in 2008 to develop standards for safe chemotherapy administration in the out-patient setting to adult patients with cancer. These recommendations were similar to guidelines published by the Clinical Oncological Society of Australia (COSA) published in 2008 based on prescribing, mixing, and administration of cancer therapy (Carrington et al., 2010).

The scope of the ASCO/ONS project included patient safety with chemotherapy regimens across the treatment trajectory (Jacobson et al., 2009). These two organizations in collaboration with other professional associations developed guidelines to improve quality and safety of chemotherapy administration in a variety of settings (Jacobson et al., 2009). The final version included 31 standards encompassing seven domains: a) review of clinical information and selection of treatment regimen; b) treatment planning and informed consent; c) ordering of treatment; d) drug preparation; e) assessment of treatment compliance; f) administration and monitoring; and g) assessment of response and toxicity monitoring (Jacobson et al., 2009). Both ASCO and ONS recommended adherence to these standards as a goal to all providers involved in the administration of chemotherapy. Both organizations continued to meet and in 2011, the standards were updated to include all healthcare areas that administer chemotherapy (Jacobson et al., 2012). The standards also evolved to highlight oral chemotherapeutic agents. Although the standards addressed mixing and prescribing, a significant limitation was exclusion of the

American Society of Health System Pharmacists (ASHP) during development of these national standards. Conversely, the COSA development included the Cancer Pharmacist Group (CPG).

The ASCO/ONS standards take an integrated proactive approach across the entire process of chemotherapy ordering/prescribing, mixing/dispensing, and administration process. The standards provide guidelines that apply to multiple clinical settings. For this reason, these standards have had a growing influence on regulators, payers, and patient advocacy groups as the expectation for standards of care in the chemotherapy administration process. Implementing these chemotherapy safety standards will require organizations to examine current administration processes for potential changes, implement those identified changes, and re-evaluate the effectiveness/outcomes of those changes.

Summary and gaps in literature. The complex high-risk process of chemotherapy administration increases the risk for nurses to make errors at multiple points across the treatment course. The numerous variations in prescribing, dispensing, and administration related to these agents leads to an increased potential for errors that may result in lethal negative outcomes. Research also reported that 85% of the errors reached a patient and 15.6% required additional patient monitoring and therapeutic interventions (Rinke et al., 2007). Therefore, minimizing errors and increasing safety has risen to the forefront of oncology practices.

Prior research has suggested multiple solutions for chemotherapeutic error reduction including implementation of CPOE, multidisciplinary processes, and safety standards. Although CPOE resulted in decreased errors, they were not eliminated and actually created new challenges and errors. Unfortunately, CPOE lacked the sophistication to identify the correct cycles of the complex regimens. Furthermore, the prescribed treatment regimens often did not match the national standards for dosing. Although the CPOE solution decreased the prescribing and

dispensing errors, researchers reported continued administration errors. However, the findings did not cite the specific reasons for the administration errors that reached the patients (Dumasia et al., 2006; Voefray et al., 2006). This ongoing high percentage of chemotherapy errors reaching patients demands further investigation and potential recommendations.

Multidisciplinary processes such as FMEA were also recommended as a proactive assessment to potentially prevent errors. However, literature provided limited information on the effect of FMEA on chemotherapy errors. Sheridan-Leos et al. (2006) found that FMEA increased awareness, but did not impact errors. Womer et al. (2002) and Chung et al. (2011) reported error reduction, yet failed to cite reasons for the remaining errors. The researchers in all the studies acknowledged that the complex high-risk process of administering chemotherapeutic agents created challenges for stakeholders. Other than Chung et al. (2011) the literature provided no evidence of organizations developing frameworks of best practices to reduce errors. Furthermore, the literature provided no evidence addressing the knowledge of healthcare providers administering chemotherapy. The literature on the multidisciplinary standardization of the chemotherapy administration process also lacked evidence on nurses' knowledge of errors that occur during the administration process.

The RN verifies the last safety check prior to administration of the chemotherapy. Research has suggested that nurses may underreport errors for fear of retribution, thus the amount of errors that reach patients may be higher than reported in the literature. Therefore, the RN must have baseline knowledge of the entire administration process including prescribing and dispensing. Yet, research has not examined ways to decrease administration errors that reach patients or assessed oncology nurses' baseline knowledge of the chemotherapy administration process.

A need exists for a set of standardized guidelines with a proactive approach for chemotherapy prescribing, dispensing, and administration processes that focus on error reduction and increased safety. Standardizing processes for chemotherapy administration creates a framework for best practice that defines roles and responsibilities. This framework also facilitates accountability with a goal to reduce errors and increase safety. Although prior studies suggested that a proactive approach integrating FMEA with innovative models of care and standardization of processes may reduce errors in the chemotherapy administration process, the studies lacked evidence identifying specific chemotherapy administration errors. ASCO/ONS developed national chemotherapy safety standards in 2008, yet no literature was located on the effects of chemotherapy error reduction after implementing the standards. Furthermore, the studies did not examine if variables such as years of experience or oncology certification influenced nurses making chemotherapy errors during the administration process. Empirical studies may support or refute the assumption that oncology nurses with more years of experience or those who maintain certification have knowledge of errors that occur during chemotherapy administration. Healthcare providers must understand the importance of the standards for chemotherapy administration to potentially decrease errors and increase safety with these medications (Vioral, 2014). Furthermore, a need exists to understand nurses' knowledge of chemotherapy errors. The findings of such a study may potentially identify specific examples of errors that continue to occur despite previously discussed interventions.

This study investigated oncology nurses' understanding of chemotherapy errors during the administration process, educated nurses on the ASCO/ONS standards using SDL interventions, and measured KR longitudinally. This study was built on Lewin's theoretical framework. Therefore, the study integrated field theory and group dynamics to "unfreeze" the

current practices related to chemotherapy administration in the healthcare organization. The study used quality improvement efforts such as FMEA, examining retrospective errors, and reviewing current standards of practice to develop an understanding of the current practices and concerns surrounding the administration of chemotherapy in an organization. Although practice must change for the multidisciplinary group, this study focused on oncology nurses' ability to identify errors throughout the administration process. Once the current state of the organization and group were identified, the next step involved developing and implementing interventional educational strategies.

The second aim of this study was to examine educational approaches used in the healthcare setting to educate nurses. The following sections provide a review of literature on the common educational strategies used in healthcare organizations.

Definition of Self-Directed Learning

The origins of SDL traced back to Socrates (Candy, 1991). However, initial studies of SDL were attributed to Houle (1961), Knowles (1975), and Tough (1979). Research on SDL stemmed from the seminal work of Tough (1979) who reported about 90% of adults engaged in some type of SDL activity. As the pace of technological and social change accelerated, SDL became popular among educators as a way to endorse lifelong learning (Levett-Jones, 2005). Despite the popularity to the concept of SDL, the term remained weakly conceptualized and inadequately studied in the literature.

The definition of SDL varied throughout the literature as an ambiguous concept that means different things to different individuals. The most common definition in the majority of the literature was that of Knowles (1975), "A process in which individuals take the initiative, with or without the help of others, to diagnose their learning needs, formulate learning goals,

identify resources for learning, implement appropriate learning strategies, and evaluate learning outcomes” (p. 18). According to the American Nurses Association (ANA) (1978), “SDL involves activity for which the learner takes the initiative and the responsibility for the learning process” (p. 2). In SDL the educator designs the learning activity, and then assumes the role of a facilitator (Knowles, 1975). This instructional method has gained a growing popularity in healthcare organizations.

Literature has reported a steady decline of traditional classroom-based hospital educational programs with an increase in various types of SDL (Braet, 2009). In a systematic review, Murad et al. (2010) found SDL was used as the most common method for healthcare professionals to stay current and knowledgeable. This surge occurred due to increasing demands by staff for flexible schedules, limited budgets, resource shortages, increased travel costs for employees, greater staff turnover, and role changes for nurses requiring broader professional competencies (Atack, 2003; Bloomfield, While, & Roberts, 2008; Schneiderman, Corbridge, & Zerwic, 2009). Caring for multiple patients with highly specialized needs, working varying shifts in the hospital, having different responsibilities on each shift to care for patients, meeting mandatory agency requirements, and completing hospital committee work also contributed to challenges for nurses in healthcare organizations to access education and continuing education (CE) programs (Schneiderman et al., 2009; Sung et al., 2008).

Traditional classroom-based education as well as formal in-services and programs only serviced a portion of the staff based on the shifts that staff members were scheduled. Offering SDL accommodated the needs of all staff on the unit as the material was readily available 24 hours a day (Wolbrink & Burns, 2012). Even part-time staff working non-daylight hours were ensured efficient standardized educational delivery (Jeffries, 2001) that promoted individualized

learning (Bloomfield et al., 2008; Clifford et al., 2007). SDL became a method to deliver a consistent message to all employees in a designated time frame. Therefore, SDL emerged as a flexible educational strategy for providing information and knowledge to nurses in the complex healthcare environment (Braet, 2009; Strother, 2002; Ubell, 2010).

Although numerous advantages to SDL emerged in the literature, potential disadvantages to SDL were also cited including the lack of: social presence (Oztok & Brett, 2011), technological support (Brinkerhoff & Koroghlanian, 2007), and self-discipline (Atack, 2003). Another concern with SDL was the inconsistent use of the term. The literature indicated that SDL occurred in multiple formats such as: informal discussions, independent studies, guided studies, computer-assisted learning (CAI), teleconferencing, SLPs, self-learning modules (SLM), distance education, EL, online modules, video learning, problem-based learning (PBL), and teleconferencing (O'Shea, 2003). These synonymous terms contributed to further ambiguity of the SDL concept. Education and training is fundamental to every aspect of chemotherapy safety. Therefore, if the educational research lacks a clear definition of SDL, confusion may hinder the application of the results to practice (Ainoda, Onishi, & Yasuda, 2005). Research examining specific examples of SDL may assist educators to develop programs using evidence-based pedagogical approaches.

In the 21st century, the common educational methods used in healthcare settings involve SDL specifically SLP and computer-based learning (Durmaz et al., 2012). The experiences of the researcher conducting this study concur with the literature. The most commonly observed methods of SDL in healthcare included written SLPs and uploading PPT slides to an online platform for participants to review. A significant concern arose that these methods only engaged the learner in the cognitive domain through reading. Literature suggested that adding an audio

component to the SDL activity would enhance the learning. For example, Ridgeway et al. (2007) compared test scores in surgical care following either a web-based PPT presentation or a voice over PPT presentation. Of the 88 randomly allocated medical students to each group, those in the aural group had significantly higher test scores ($p < 0.012$). Although the results suggested that engaging the learner aurally and visually with interactive multimedia may impact knowledge outcomes, the study lacked outcomes addressing KR (Ridgeway et al., 2007).

Kirsch (2008) defined KR as a focus on critical knowledge that is at-risk of loss. In other words, KR involved maintaining knowledge gained from an experience over time. Key elements associated with KR included prioritizing what is at-risk based on potential knowledge, assessing the impact on organizational performance, and developing action plans to retain knowledge (Kirsch, 2008). KR was identified as one of the critical factors for maintaining sustainable performance (Nelson & McCann, 2010). However, the majority of empirical evidence addressed KR immediately following the educational intervention (Considine, Botti, & Thomas, 2005; Lee, Fernandez, Staff, & Mah, 2013; Rufo, 1985; Schwid, Rooke, Ross, & Sivarajan, 1999; Subbarao, Bond, Johnson, Hsu, & Wasser, 2006; Zhang et al., 2006). Few studies examined KR beyond the immediate activity to support or refute KR over time (Comer et al., 2011; Durmaz et al., 2012; Tantrarungroj & Lai, 2011; Wu, 2012). Studies investigated KR in healthcare (Rufo, 1985; Comer et al., 2011; Considine, Botti, & Thomas, 2005; Durmaz et al., 2012; Lee, Fernandez, Staff, & Mah, 2013; Schwid et al., 1999; Subbarao et al., 2006; Tantrarungroj & Lai, 2011; Wu, 2012). However, no studies examined oncology nurses' KR with chemotherapy administration errors or safety standards for administration. Although SDL has emerged as the accepted educational format in healthcare, minimal evidence was located supporting or refuting the effectiveness of SDL on KR.

For the purposes of this literature review, research that used any of the synonymous SDL terms was examined and included in the review if the SDL: a) involved the use of SLP or SLM; b) investigated types of EL using video simulation, audio-visual technology, simulated videos, or video vignettes; and c) compared different types of SDL. Research comparing SDL to traditional classroom programs or examining learning styles was excluded from this review as these variables were beyond the scope of this study. This section specifically focused on a review of literature on the KR of healthcare professionals who use SLPs and SELVs as SDL instructional methods in healthcare organizations.

Self-Learning Packets

The literature uses the terms SLP and SLM interchangeably. For the purposes of this review, the term SLP was used to encompass both of these terms. Marzahl (2001) defined SLPs as self-contained packages with all the necessary information that allows the learner to participate in a learning activity at his/her own pace. Typically SLPs provide written information to the learner on specific topics that include introductions, objectives, expectations, procedures, allotted time, related readings, and evaluation measures (Herrick, Jenkins, & Carlson, 1998; Marzahl, 2001). The majority of literature related to SLPs occurred from 1970-1990 on topics such as SLP effectiveness, how to develop learning packets, characteristics of learners, cognitive retention, and cost-effectiveness (Marzahl, 2001). However, only two empirically published studies addressed KR and met the components of SDL identified by Knowles (1975).

Self-learning packets and knowledge retention. Written SLPs have been used for general and specialty education as an instructional method for healthcare professionals. Many healthcare facilities choose written SLPs as a preferred educational strategy because they are

easily circulated in the workplace at a relatively low cost (Ubell, 2010). Rufo (1985) concurred with Ubell (2010) that developing effective learning methods for healthcare professionals was necessary along with evaluating the KR achieved with this type of educational strategy. In a quasi-experimental post-test design, the use of SLPs was evaluated in the orientation of licensed nurses of a large tertiary care hospital (Rufo, 1985). A total of 170 nurses were randomized to the experimental (SLP) and control (traditional orientation) group of new employees. Nurses were required to complete 10 different orientation learning modules. Findings indicated the mean post-tests scores immediately following the completion of the modules were 18.39 for the SLP group compared to 15.50 for the traditional group. Of the 10 modules offered, half were statistically significant ($p < .01$) for KR. The SLP participants demonstrated an increase in the post-test scores. No reliability or validity was reported in the study on the SLP. Furthermore, no plausible explanation was provided for the five SLPs lacking statistical significance on KR. The researchers did not report the amount of time participants were allotted or actual time spent to complete the SLP. The study also did not indicate how much material was included in the SLP.

Similarly, Considine et al. (2005) also used a pre-test/post-test, controlled, quasi-experimental design to examine the effect of SLP on emergency department (ED) nurses' knowledge of assessment of oxygenation and the use of supplemental oxygen. A total of 88 ED nurses from four different ED sites in Melbourne participated in the study. Of the 88 participants, 37 were from two control ED sites and 51 participants from another two ED sites. Unlike Rufo (1985), the SLP was developed by and reviewed for content validity by five expert ED nurses. The content was divided into five sections with six activity sheets to complete. Reliability was not reported on the activity sheets. The control group did not receive any intervention. The experimental group completed the activity sheets. The mean pre-test scores

between the control ($M = 12.59$) and the experimental ($M = 13.98$) group did not significantly differ ($p = 0.091$). This suggested that both groups had similar baseline knowledge. The experimental group mean post-test scores ($M = 19.31$) were significantly higher ($p = .01$) than the control group's mean ($M = 13.05$). These findings suggested that using SLPs increased the ED nurses' knowledge relating to the assessment of oxygenation and use of supplemental oxygen. The researchers did not mention if the pre-test and post-test were the same. Furthermore, participants may have potentially guessed on the post-tests or completed the post-tests without reading the SLPs. These limitations may have biased the study outcomes. The researchers suggested conducting future studies to evaluate the effect of SLPs on clinical decisions and practice, but did not address measuring KR over time.

Summary and Gaps in Literature

SLPs have become one of the commonly accepted methods used for education in healthcare organizations across the country. The review of literature suggested that studies have evaluated the effects of SLP on KR (Herrick et al., 1998; Lipe et al., 1994). However, upon extensive review of the literature, only anecdotal findings that were not empirically based were located. Both Rufo (1985) and Considine et al. (2005) found that SLPs increased KR among nurses and that they may provide a viable alternative to traditional education. However, neither study addressed KR beyond the immediate post-test results or evaluated translation into practice. Although Considine et al. (2005) reported validity of the SLPs, neither study reported reliability or mentioned if the pre-tests and post-tests were the same. Neither study discussed how the SLPs were administered or if the pre-tests and post-tests were proctored. This raises concern that participants may not have completely read the packets and potentially skimmed over the material to complete the pre-test and post-test. Furthermore, neither study described the length of the

packet nor how long the participants took to complete the SLP activity. Additionally, neither study examined factors contributing to KR such as years of experience or learning preferences. Although the studies showed promise, the findings from both studies limit the ability to derive significant conclusions about the outcomes related to the use of SLPs. Future studies should be considered to gather additional evidence and more longitudinal studies should investigate KR using SLPs and other SDL interventions. Further research should also investigate if selected demographic variables influence KR when using SLPs and other SDL interventions.

Simulated Electronic Learning Vignettes

In addition to SLPs, this study used SELVs as both an educational intervention and measurement tool for KR. To assist the readers understanding of this type of SDL, this section briefly reviews the terms simulation, EL, vignettes, and SELVs that were defined in Chapter One. These definitions will help guide the reader to an understanding of SELVs. This section also provides a review of literature related to audio-visual vignettes and KR as both an intervention and measurement tool.

Jeffries (2005) described simulation as activities that mimic the reality of a clinical environment. Simulation has been used to demonstrate procedures, decision-making, and clinical reasoning through techniques such as role-playing, interactive videos, or manikins (Jeffries, 2005). EL uses computers to offer activities through webinars, interactive multimedia via the Internet, video conferencing, simulations, and other interactive teaching and learning methods (Zerwekh, 2011). EL requires participants to review the material on their own time (Batty et al., 2011). Vignettes use short stories or scenarios to elicit responses (Brauer et al., 2009; Finch, 1987). Vignettes also use auditory and visual transmissions of images used to facilitate behavior changes (Ramsay, Holyoke, Branen, & Fletcher, 2012). SELVs integrate simulation, EL, and vignettes to provide a multi-sensory learning environment that may improve learners' ability to retain information. SELVs allow individuals to view scenarios in

a realistic scene. Narration is included and they can be viewed repeatedly (Zhang et al., 2006).

Although the literature did not provide studies specifically addressing SELVs and KR, several studies used variations of simulated, audio-video, EL vignettes as an educational intervention to measure KR.

Audio-visual vignettes as an intervention and knowledge retention. Schwid et al. (1999) conducted one of the earliest and only studies to examine whether a computer simulation improved knowledge more effectively than a SLP. Using a randomized controlled study in a large academic medical center, 45 anesthesia residents were randomly assigned to either a simulation online module or a SLP to review the Advanced Cardiac Life Support (ACLS) Guidelines. After the review in this post-test only design, the participants completed a mock mega code. The simulation group ($n = 23$) had a mean score of 34.9 compared to the SLP group ($n = 22$) mean score of 29.2. Additionally, 84% of the simulator group passed the code, whereas only 53% of the SLP group successfully passed the code. Only means and percentages were reported in the study findings. No statistically significant findings were reported. Although the two evaluators were trained experts in ACLS who used strict grading criteria, no inter-rater reliability or validity was reported. This study also did not investigate KR, only a post-test design. However, the study did suggest that simulated online modules were more effective than SLPs to learn the ACLS guidelines. Future studies should use pre-test/post-test designs with larger samples to investigate KR using these educational methodologies.

Zhang et al. (2006) examined the influence of EL videos on learning outcomes in four different settings: a) EL with audio-video vignettes; b) EL without audio-video vignettes; c) EL without audio-video using only PPT slides; and d) traditional classroom. A total of 138 undergraduate participants from seven different disciplines in a large Southern university were randomly assigned to one of the four groups. The intervention included the same material for all

groups, but was delivered based on their assigned group. All groups received the same content, but the method of delivery was different. Each group completed a closed book written pre-test and immediate post-test. The questions were the same in the pre-test and post-test and used in all groups. However, the researchers reported no reliability or validity of the pre-test, post-test, or SLP. The ANOVA results indicated a significant difference among the group means ($F(3,134) = 9.916, p < 0.001$). The Tukey post-hoc results also showed a post-gain in the EL audio-video vignette group suggesting increased KR. Unfortunately, the researchers used a poor study design and data collection by only investigating one class session and not examining KR longitudinally. Although the researchers collected demographic data, they did not report if the variables impacted KR among the groups. The researchers recommended conducting future studies to examine effects throughout an entire course and at selected time frames upon course completion.

Using a similar design, Durmaz et al. (2012) examined the effect of screen-based computer simulations (SBCS) on knowledge, skills, and clinical decision making processes to teach pre- and post-operative care management to second-year undergraduate nursing students in Turkey. Of the 82 participants, 41 were randomly assigned to the experimental (SBCS) and 41 to the control (skills lab) group. Only 30 students completed both the pre-test and post-test. Similar to Zhang et al. (2006), participants in this study also completed a closed book written pretest and posttest. The same material was in both the pre-test and post-test. However, Durmaz et al. (2012) performed the post-test two weeks after the educational intervention was completed. Unlike Zhang et al. (2006), there was no significant difference between the group's post-education knowledge levels ($p < .421$), but several limitations existed in this study. For example, the attrition rate may have impacted the statistical analyses with only 30 participants. The researchers did not provide any reliability or validity on the SBCS. Furthermore, the participants

were in the same academic year with frequent contact in their courses and clinical settings. The potential for participant interaction was high and not reported in the findings. Durmaz et al. (2012) reported demographic findings, but they did not investigate if the participant variables influenced KR. Recommendations were made to replicate similar studies using larger samples on nurses and healthcare professionals to examine the effectiveness of SBCS.

Tantrarungroj and Lai (2011) investigated the effectiveness of embedded neuroscience streaming video in five different undergraduate courses. Of the 92 eligible undergraduate participants, 46 were randomly assigned to the experimental (OTSGV video group) and 46 to the control (OTSGO written text only) group. A post-test only design was used immediately following the lesson and four weeks later to investigate KR. Although the mean was slightly higher for the OTSGV ($M = 15.72$, $SD = 4.51$) compared to the OTSGO group ($M = 14.24$, $SD = 4.16$), no significant difference was found on KR between the groups ($p = .0525$) on the immediate post-test. The immediate post-test findings concurred with similar studies by Durmaz et al. (2012) and Zhang et al. (2006). However, Tantrarungroj and Lai (2011) examined KR four weeks later. The mean was significantly ($p = .03$) higher for the OTSGV ($M = 13.12$, $SD = 4.09$) compared to the OTSGO group ($M = 11.49$, $SD = 3.52$) suggesting increased KR. Although the quasi-experimental design with a random sample increased the study's rigor, the researchers did not provide reliability or validity on the streaming videos. Like previous studies, Tantrarungroj and Lai (2011) reported demographic data, but did not examine if the variables influenced KR. However, this was one of the few studies that investigated KR using video educational interventions longitudinally.

In a similar study, Comer et al. (2011) used a web-based training course with embedded video clips on how to reduce central line-associated bloodstream infections. There were 177

respondents from five different hospitals across the United States. There was no control group, all participants completed a pre-test, viewed the video, completed a post-test immediately following the intervention, and a follow-up post-test three-four months later. Unlike Tantrarungroj and Lai (2011), the immediate post-test scores were statistically significant ($p < .001$) indicating an increase in KR from pre-test scores. Although KR scores three-four months later decreased by 12.2% from the immediate post-test, the scores remained statistically higher ($p < .001$) suggesting KR occurred. The survey used by Comer et al. lacked reliability and validity concurring with other studies. Although the sample was diverse in terms of healthcare disciplines and geographically dispersed, the researchers did not examine if demographic variables influenced KR. Future studies should stratify results by disciplines. Additional studies using quasi-experimental design with a control group or comparing web-based videos to other types of SDL may increase rigor.

Wu (2012) used data from a large heart and lung clinical trial (PULSE) to examine nurses KR of ECG monitoring one to two years after completing an online ECG course. The sample consisted of 17 hospitals of varying sizes and types from the United States, Canada, and China. Participants included 504 registered nurses who completed a pre-test, four online ECG modules, and an immediate post-test. The same post-test was administered one to two years after completion of the study. Results indicated a significant ($p < 0.0001$) decrease in retention from post-test ($M = 70.48$, $SD = 15.20$) to follow-up ($M = 61.87$, $SD = 15.98$). However, the retention was significantly ($p < .0001$) better than baseline knowledge ($M = 51.10$, $SD = 13.39$). Although Wu (2012) investigated KR longitudinally, numerous limitations impacted the study findings. For example, the broad span of one to two years to measure KR introduces numerous variables that may have impacted the outcomes such as: work experience, additional education, and

environment. The researcher also failed to mention if the participants had the ability to view the online modules during that one to two year time frame which may have biased the results. Furthermore, Wu reported no reliability or validity on the online modules. Wu also did not investigate if potential demographic variables influenced KR.

A web-based teaching module was developed by Lee et al. (2013) to educate new residents and students on the insertion technique and complications of inserting nasogastric feeding tubes. In a retrospective chart review, 86 of the 184 feeding tubes were placed incorrectly. Based on this data, the researchers recruited 43 students and practitioners to complete a pre-test, web-based module, and post-test on feeding tube insertion. Prospectively, 32 of the 43 participants were observed by the researchers to successfully insert feeding tubes correctly on their first attempt ($p < .005$). Furthermore, knowledge significantly improved ($p < .001$) from pre-test 50.9% to posttest 72.3%. No reliability or validity was reported on the web-based module. The researchers were unable to control for practitioner experience using a one-group pre-test/post-test design. Future studies should use a control group with a larger sample. Additionally, more studies should investigate whether experience influences KR. This section discussed the literature findings that used various types of audio-video vignettes as educational interventions. Vignettes may also be used as a data collection tool.

Audio-visual vignettes (measurement tool) and knowledge retention. Critics of vignettes report concerns about reliability and internal validity: a) that each question pertaining to the situation measures the same phenomenon and, b) the need to ensure the depicted situation in the vignette genuinely portrays the phenomenon of interest (Flaskerud, 1979). Lanza and Carifio (1992) reported concerns that participant responses to vignettes cannot be assumed to be identical to the responses in an actual event. Furthermore, vignettes use an artificial stimulus, yet

participants are expected to imagine how they would respond in a particular situation (Lanza & Carifio, 1992). Therefore, participants may respond differently when faced in a real-life situation.

However, Eskelinen and Caswell (2006) argued that video-vignettes provided more rich and motivating material than text. The researchers aimed to explore whether the video-vignette method was appropriate to describe how professional social worker teams made judgments about their clients. A video vignette case was presented to four social worker teams in focus group sessions to compare the teams' assessment of the client. The findings accentuated how teams interpreted the same client in different ways. Using the vignette, the researchers were able to gain access to a sensitive area of inquiry and the participants were able to grasp the situation and identify themselves within the experience. Despite the critics, vignettes have demonstrated an expedited method of collecting data from large samples, contentious issues, or where observation would be particularly time consuming (Gould, 1996). Advantages associated with vignettes as research tools include the ability to: collect information simultaneously from large samples, manipulate a number of variables at once, and standardize the situation under investigation so that participants can respond to the same stimulus (Gould, 1996; Lanza & Carifio, 1992).

Despite the advantages to vignettes, nursing and healthcare have only sporadically used them as a data collection tool. Furthermore, when vignettes have been used to gather data, the studies only used vignettes in the written format to assess emotions (Muhlenkamp, Walker, & Bourne, 1983; Taylor, Skelton, & Butcher, 1984) and knowledge (Fothergill-Bourbonnais & Wilson-Barnett, 1992; Gould, 1994). After extensive review of the literature, only one study and one pilot study emerged using audio-video vignettes or simulated vignettes as a data collection tool.

Subbarao et al. (2006) used 12 simulated clinical video vignettes to portray incorrect resuscitation scenarios. Each simulation was beta-tested prior to the study, but no other reliability or validity was reported. A 43-question pre-test/post-test design was used to determine first responders' knowledge of how to manage chemical, biological, radiological, nuclear, and explosive disasters. A total of 54 physicians, nurses, and paramedics completed the course. The findings indicated an increase from the pre-test mean score of 53.5 to a post-test mean score of 78.3. Although the researchers used a diverse sample, they did not report how many years' experience the participants had in healthcare or how many disasters they had responded. Furthermore, no additional demographic variables were discussed or reported. The findings did suggest that using simulated video vignettes were effective in transmitting core knowledge with immediate retention. However, the researchers did not examine longitudinal KR. Future studies should examine how simulated video vignettes compare to SLPs on KR both immediately and longitudinally after the educational intervention.

In a previous pilot study by Vioral (2014), a quasi-experimental longitudinal, one-group pre-test-post-test design was used to assess oncology nurses' knowledge of the ASCO/ONS chemotherapy safety standards before, immediately after, and four weeks after participants viewed SELVs. The pilot study was comprised of 66 RNs who administered chemotherapy in both in- and out- patient settings in a mid-Atlantic state nonprofit multi-hospital system. Vioral (2014) investigated if oncology nurses' use of SELVs increased their knowledge of the ASCO/ONS chemotherapy safety standards. The study also described the oncology nurses' satisfaction with the SELVs.

Using a repeated-measures analysis of variance (RM-ANOVA) to explore knowledge retention over time, results showed the mean number of error scores differed significantly across time points

($F[2,130] = 6.184, p = .003, \eta^2 = .087$). A statistically significant increase of .75 errors was identified from pre- to post-test. The one month follow-up was also statistically significant. Unfortunately, the number of errors identified returned to the pre-test level. The majority of the oncology nurses learned the new standards and retained the knowledge from pre- to post-test indicating that EL with simulated vignettes was an effective method for increasing knowledge. However, the return to baseline knowledge from post-test to one month follow-up was discouraging.

Content, system, delivery, and overall satisfaction were also measured using descriptive statistics from the participant's responses on a 16-item EL Satisfaction Tool. The nurses expressed greater satisfaction with the content ($M = 8.1, SD = 2.99$) and overall satisfaction ($M = 36.4, SD = 13.79$) than with the delivery ($M = 10.1, SD = 4.19$) and system ($M = 18.1, SD = 7.31$) methods. Although the study by Vioral (2014) investigated knowledge retention and EL satisfaction, the study did not determine how generation learning preferences, oncology certification, or years of experience may have potentially impacted KR.

Summary and Gaps in Literature

Given the lack of reliability, validity, and questionable study approaches, minimal conclusions can be drawn from these studies. The designs lacked rigor, the samples were underpowered small convenience samples, data collection methods were inconsistent, and data analysis lacked consistent statistical significance. Although SELVs provide convenient, standardized delivery, self-paced learning, and a wider range of pedagogical stimuli (Strother, 2002), the literature findings provided mixed results on the effect of SELV and KR. With the exception of Schwid et al. (1999), all of the studies used a pre-test/post-test design to investigate KR using variations of simulated videos. However, only four of the studies examined KR beyond the immediate post-test. Zhang et al. (2006), Comer et al. (2011), Lee et al. (2013), and

Vioral (2014) reported an increase in immediate post-test KR whereas Durmaz et al. (2012) and Tantrarungroj and Lai (2011) cited no significant differences in immediate post-test KR. However, Comer et al. (2011) and Lee et al. (2013) did not use a control group which may have compromised the validity. Conversely, Wu (2012), Tantrarungroj and Lai (2011), and Comer et al. (2011) did report significant increases in KR in their longitudinal findings. Although the previous studies suggested that the teaching methodology may have influenced KR, the heterogeneity of the studies' tools limited the conclusions. Furthermore, the researchers reported no reliability or validity on the tools. Another concern with these studies involved the lack of research using SELV's in healthcare settings to measure KR. The increasing popularity of online web-based types of learning in healthcare settings requires researchers to investigate the effectiveness of the teaching strategy. Other than Schwid et al. (1999), no studies have compared simulated EL videos to SLPs on KR longitudinally. Additional research evaluating KR outcomes using variations in SELVs compared to SLPs must occur to contribute to the literature. Finally, the research thus far has collected selected demographic variables. However, the findings lacked evidence investigating if the variables influenced KR. Further research should investigate if selected demographic variables influence KR when using SELVs and other SDL interventions.

Demographic Variables Influencing Knowledge Retention

Chapter One of this study presented assumptions related to selected variables that may influence KR including: a) generational preferences, b) oncology certified nurses have increased knowledge retention related to chemotherapy, and c) experienced oncology nurses have greater knowledge about chemotherapy than nurses with less experience. This section briefly describes

the literature related to selected participant demographic variables that may potentially influence KR.

Generational Preferences

The generational differences among nurses encountered today involve more than likes, dislikes, and perspectives (Paterson, 2010). The values developed in one's youth form the foundation for learning preferences as adults (Paterson, 2010). The assumption exists that those whose ages cluster together will exhibit similar preferences for learning (Paterson, 2010). From these assumptions, scholars have clustered these individuals into four generational groups: a) traditionalists, born between 1920-1939; b) baby boomers, born between 1940-1960; c) generation Xers, born between 1961-1980; and d) Y generation/millennials, born after 1981 (Paterson, 2010; Notarianni, Curry-Lourenco, Barham, & Palmer 2009; Walker et al. 2006).

Assumptions have been made that younger Millennial and Generation X nurses prefer SELV types of SDL education compared to the Baby Boomers. Despite these assumptions, minimal empirical studies have been published supporting or refuting how the generations prefer to learn. The majority of the traditionalists have retired, thus literature has not provided learning assumptions for this generation. Anecdotal published literature report that baby boomers prefer readily available training materials that they can examine in more detail on their own (Paterson, 2010). Generation Xers prefer visual learning with clear simple images to illustrate the point (Paterson, 2010). Millennials prefer digital education with up to date technology, but they also like print and online references to read (Paterson, 2010). Based on these anecdotal assumptions, educators may assume that all the generations may prefer SDL activities including SLPs and SELVs. However, studies by Hu, Herrick, and Hodgins (2004) and Walker et al. (2006) have found conflicting evidence.

In a descriptive study, Hu et al. (2004) examined generational profiles and differences in a medical surgical and critical care department of a Southeastern hospital. The convenience sample included 42 registered nurses, 16 technicians, and 4 secretaries. Of the 62 respondents, 6.5% were Traditionalists, 42% were Baby Boomers, 50% were Generation Xers, and 1.6% were Millennials. The survey findings describing characteristics of the generations indicated that 40% of the Baby Boomers and 34% of the Generation Xers and Millennials found online learning frightening and complicated. Unfortunately, the researchers did not report the generations preferred methods of learning. Future studies should use larger samples to explore the preferred learning methods of all generations in healthcare.

In another study, Walker et al. (2006) used a descriptive survey design to compare generational differences among nursing students. The sample included 25 Generation X and 105 Millennial junior and senior baccalaureate students. The students were taught both by traditional lecture and online instruction. Of the 134 participants, both groups preferred lecture (83%) over computerized learning. Furthermore, 90% of the participants overwhelmingly did not prefer web-based methods of learning. The findings suggested that although Millennials were perceived as technologically savvy, they enjoyed the benefits of classroom based educational experiences. The study was conducted only in one school of nursing and not in a healthcare setting. The sample also did not include all generations. Future studies should examine all generational learning preferences in healthcare settings.

Unfortunately, only two empirical studies have reported evidence on generational learning preferences. Both Hu et al. (2004) and Walker et al. (2006) concurred that web-based learning was not the preferred method of learning for undergraduates or healthcare providers. However, the samples were small and used descriptive designs. The findings suggested that

web-based learning was not preferred across the generations. However, no other types of SDL methods were investigated. Despite this minimal evidence, the majority of healthcare settings continue to use various methods of SDL including SLPs, and SELVs. However, minimal evidence existed regarding healthcare providers preferences. Furthermore, the literature provided no studies that examined if generations had differences in KR when provided various types of SDL for learning in healthcare settings. Future studies should examine if learning preferences influence KR in healthcare settings.

Professional Certifications

Certification was another variable of interest in this study. Assumptions exist that oncology certified nurses may have increased knowledge and retention related to chemotherapy administration. Certification signifies that a nurse develops specialty knowledge beyond the entry level in their specialty (ONCC, 2012). Coleman et al. (2009) cited certification in oncology nursing as a formal recognition of clinical expertise. Leak and Spruill (2008) maintained that certification validates oncology nurses' commitment to and knowledge about care of patients with cancer. Brown, Miller-Murphy, Norton, Donahue-Baldwin, and Ponto (2010) reported that oncology nursing certification reflects a professional achievement that indicates a nurse has the knowledge and expertise to competently care for patients with cancer. Despite these acclamations, the evidence supporting the value of certification involves descriptive studies of perceptions and opinions about the rewards and benefits. Few studies addressed if or how certification may impact knowledge, and ultimately practice and patient outcomes.

Stromborg et al. (2005) collected 139 surveys from 35 different states and countries at an American Board of Nursing Specialties (ABNS) conference. The findings indicated that certification was more than a title that offers a connotation of knowledge and experience as a registered nurse. Of

the 139 respondents, 58% reported seeing a difference in the performance of certified nurses. Unfortunately, certification remains complex with over 50 specialties. This complexity suggests that future studies should explore specific certification and how potential increased knowledge impacts outcomes. However, minimal research has validated that certification ensures competency or impacts KR.

Coleman et al. (2009) compared certified to noncertified oncology nurses for knowledge related to symptom management of pain and chemotherapy induced nausea and vomiting. The prospective descriptive design used a large academic health center in the southern United States. Of the 93 oncology registered nurses, 35 (38%) were certified in oncology. Findings showed that certified nurses scored significantly higher on the knowledge of pain ($p < .02$) and nausea/vomiting ($p < .02$) surveys. Although the results indicated that oncology certification may improve patient care, the sample was only representative of one institution. Furthermore, the researchers did not report the years of experience of the participants or if they had additional recent education on these topics. Additionally, the study did not compare pre-test/post-test knowledge or KR of nurses on pain and nausea/vomiting. Future studies should involve multisite comparative studies to explore knowledge and retention of certified oncology nurses. As organizations aspire to achieve Magnet designations, certification takes on greater significance (Schmal & Derrevere, 2012; Stromberg et al., 2005). Unfortunately, literature lacked evidence on the influence of certification on KR. Future research examining relationships between certification and KR may support the role of certification.

Experiences

Another potential variable influencing KR includes experience. The longer nurses have been administering chemotherapy, the more experience and knowledge they may develop and

retain as experts (Benner, 1984). Although Benner (1984) suggested that experts retain more knowledge, studies have reported a decrease in knowledge with increasing years of practice (Choudhry, Fletcher, & Soumerai, 2005). Choudhry et al. (2005) completed a large systematic review of studies from 1966-2004 relating medical knowledge and healthcare quality to years in practice and physician age. A total of 59 empirically based studies were included in the final analysis. As physician experience increased, the physician performance decreased in 52% of the studies. Several studies ($n = 19$) assessed the influence of physician years in practice on adherence of standards of therapy. Of the 19 studies, 14 (74%) found a consistent negative association between adherence and appropriate use of standards. The findings were paradoxical since assumptions exist that clinical experience enhances knowledge. Although this review addressed physicians experience and knowledge, these findings indicate the necessity for additional studies in other disciplines including nursing. Furthermore, healthcare advances occur frequently, and without ongoing education, knowledge may become out of date. Based on these findings, future studies with larger samples investigating differences in years of experience and knowledge retention are recommended.

Summary and Gaps in Literature

Several concerns emerged in the literature on generational preferences, oncology certification, and years of experience. The empirical evidence was inconclusive and limited in sample sizes, designs, and findings. The majority of literature on generational preferences was anecdotal or descriptive. The findings by Hu et al. (2004) and Walker et al. (2006) suggested that the generations do not prefer SDL methods of learning. However, the commonly used educational methods in healthcare settings include SDL. The literature on oncology certification described findings from surveys reporting perceptions and opinions. There was minimal

evidence on how certification may influence knowledge or KR. Stromborg et al. (2005) and Coleman et al. (2009) suggested the oncology certification influenced knowledge. However, the sample sizes were small which limited the findings and neither study addressed KR. Significant concerns also arose with experiential assumptions on knowledge. Benner (1984) suggested that expert nurses retained more knowledge. However, Choudhry et al. (2005) found that as experience increased, knowledge decreased. Although the literature discussed these variables, none of the studies investigated how these variables may potentially influence knowledge and KR. Future studies should investigate the potential impact of generational differences, oncology certification, and years of experience on KR.

Summary

The ASCO/ONS chemotherapy safety standards of practice were developed to promote safety and potentially decrease errors during the chemotherapy administration process. Yet, no studies have examined chemotherapy errors, organizations using the ASCO/ONS chemotherapy safety standards, nurses' knowledge of errors, or outcomes. Although the literature reported ongoing chemotherapy administration errors, this evidence was obtained using voluntary self-reporting. No studies have examined oncology nurses' knowledge of the chemotherapy administration process. Educating oncology nurses on these comprehensive guidelines may potentially decrease errors during chemotherapy administration. Providing this invaluable information requires robust educational teaching strategies to engender a deeper approach to learning whereby the knowledge transforms (Biggs & Tang, 2007).

This chapter also examined types of educational strategies most commonly used to educate nurses in healthcare organizations. The literature reported that healthcare organizations are increasingly providing education using SDL such as SLP and types of SELV, yet the

effectiveness of these interventions remains inconclusive. The literature suggested that audio-visual vignettes facilitate behavioral changes, depict difficult situations, provide comprehensive material to large samples in a consistent manner, and delivers the same stimulus. Despite the increasing popularity of SDL using SLP and EL in the healthcare setting, the lack of reliability, validity, and questionable study methods provided minimal conclusions on the use of these educational approaches. With United States organizations spending approximately \$135 billion on employee training using various types of SDL (Ubell, 2010), measuring KR of employees using SDL is imperative. Berge (2007) emphasized that healthcare organizations undergo increasing pressure to demonstrate that training and development contribute to positive outcomes. Faster educational training may result in negative KR outcomes if the SDL methodology is ineffective. Literature discussed the advantages to SDL, but the evidence supporting improvement in KR using SLPs or SELVs remained inconclusive. Despite the increased use of SDL over the past decade, literature lacked robust evidence supporting the effectiveness. The majority of literature assessed knowledge at the end of the module or training using a pre-test/post-test design. However, an assumption existed that the short term gains were retained. In addition to the lack of published research on SDL, the studies often involved small sample sizes, in limited geographical areas with no reported reliability and validity of the instruments. Furthermore, the studies did not investigate if demographic variables influenced KR. Future studies must investigate the reliability and validity of SDL instruments, explore variations of SDL as educational interventions, measure outcomes, investigate if demographic variables influence KR, and evaluate the translation of knowledge into practice.

To address the ambiguity of the SDL concept described in the literature, this study used SLPs and SELVs as interventions to educate oncology nurses on the ASCO/ONS chemotherapy

safety standards of practice. This study educated nurses on the ASCO/ONS standards using SDL interventions and measure KR longitudinally. Lewin's Planned Change Theory guided this study during the planned interventional phase of the study. SLPs and SELVs were used as SDL educational methodologies. This integrated Lewin's concept of action-research to implement change. Investigating how long the nurses retain the knowledge regarding identification of chemotherapy errors demands further research. Therefore, this study also determined the impact of the education on KR both immediately and longitudinally. This measurement aligns with Lewin's theory assessing for "refreezing" or sustainability. Finally this study investigated if selected demographic variables influence KR. The findings of this study provide empirical evidence on oncology nurses' knowledge of chemotherapy errors over time and outcomes on how different SDL methodologies affect KR. Chapter Three describes the methodology used for this current study.

CHAPTER THREE

METHODOLOGY

This chapter describes the study design, ethical issues for the study of human participants, sampling plan, setting, data collection procedures, and data analysis. The instruments including the validity and reliability are also described in this section.

Study Design

A quasi-experimental longitudinal repeated-measures design was used to assess oncology nurses' knowledge of the ASCO/ONS chemotherapy safety standards before, immediately following, and four weeks after all participants completed the learning either via the SLPs or SELVs. The study investigated if oncology nurses' use of SLPs versus SELVs increased their knowledge retention of the ASCO/ONS chemotherapy safety standards over time.

The research consisted of a pre-test and post-tests administered at completion of the education and four weeks later. A control group and a quasi-experimental group facilitated comparisons. The control group received the SLP education, while the quasi-experimental group received the video-taped SELV. The study intended to investigate if using the SELVs provided improved retention compared to other SDL educational strategies. Participants in the quasi-experimental group received the education using seven SELVs, while the control group reviewed the seven sections of a SLP. A between-within group comparison was conducted, with the type of instruction (SLP versus SELV) defined as the independent variable, and an error identification score as the dependent variable.

Advantages to this design include minimizing external validity threats, allowing for generalizations, and increasing efficiency for longitudinal research. A longitudinal study assesses changes over time (Polit & Beck, 2012) and provides evidence of retention of

knowledge. Literature did not provide a definitive time frame around what constitutes “longitudinal.” According to Polit and Beck (2012), a longitudinal design is any study where researchers collect data at more than one point in time over an extended period. This study measured the oncology nurses’ KR of the ASCO/ONS standards immediately following the intervention and at four weeks after the educational intervention.

A significant disadvantage to quasi-experimental designs includes increased threats to the internal validity. Unfortunately, the participants have increased exposure to confounding variables which may hinder the ability to draw casual inferences in the study (Polit & Beck, 2012). One way to limit this potential bias includes using regression analyses to control for the potential confounding variables. Therefore, this study also examined how selected demographic variables may have influenced the participant’s KR of chemotherapy administration errors.

Ethical Considerations

Prior to conducting the study, approval from the Institutional Review Board (IRB) at Indiana University of Pennsylvania (IUP) was obtained. After approval from the IRB at IUP, additional approval was obtained from the participating hospitals in the study. No vulnerable populations were used in this study. There were no known risks to the participants in this study. All participants were informed that their participation was voluntary and confidential. Full disclosure of the study’s purpose and potential outcomes was presented to the participants prior to participation in the study. No major ethical issues existed related to this study. There were no negative ramifications if they chose not to participate or if they chose to withdraw from the study. Participation in the study and their error scores did not affect employment status. Only the researcher had access to the participant data. The director and/or other designated administrator did not know who consented to the study or access to the data.

All individual responses were coded with unique identifiers through the learning management system (LMS) for aggregate analysis and to maintain confidentiality. The demographic data and the pre- and post-tests were stored on both the external password protected LMS and a password protected computer. All data that were extracted were maintained on computer discs or flash drives. The flash drives and discs were stored in a locked filing cabinet. To be in compliance with federal regulations, all data will be retained for at least three years.

Setting

Oncology nurses administering chemotherapy from Mid-Atlantic state nonprofit healthcare facilities that had designed chemotherapy infusion centers and/or inpatient oncology units were notified by email about this study. The researcher of this study pre-selected healthcare facilities based on the inclusion and exclusion criteria to seek interest in participation. Emails and phone inquiries were also used to seek potential interest. Only six of the 20 healthcare facilities responded with interest.

Sample

The convenience sample for the study was selected from a population of RNs who were currently chemotherapy competent to administer these medications according to system healthcare facility guidelines. Inclusion criteria for recruited participants included:

1. male or female age 18 or older;
2. with an active registered nurse license;
4. employed in one of the healthcare facilities in a designated oncology area authorized to administer chemotherapy; and
5. chemotherapy/targeted therapy competent RN according to the system guidelines.

Exclusion criteria included participants:

1. not currently chemotherapy competent per healthcare facility guidelines;
2. involved in the development of the system ASCO and ONS standard development on the CTFC; and
3. who participated in the pilot study.

This study investigated both within and between subject variables. The study intended to investigate the impact of either SLPs or SELVs on the participants KR (within subject variable). Additionally, how selected demographic variables (generational learning preferences, oncology certification, years of experience) impacted KR (between subject variables) were examined. According to Pallant (2010) and Tabachnick and Fidell (2007), this type of methodology involves a repeated-measures analysis of variance (RM-ANOVA) using a mixed between-within subjects ANOVA. This statistical analyses was used to compare oncology chemotherapy competent RN scores on the chemotherapy error vignette prior to the intervention, following the intervention, and one-month later.

A power analysis determined the required sample size for RM-ANOVA. Literature did not provide prior effect size evidence. According to statisticians Bausell and Li (2006), using a medium effect size ($ES = .05$), a power of .80, an alpha level of significance ($p = .05$), and a conservative correlation coefficient ($r = .4$), a sample size of 44 chemotherapy competent RNs needed to be recruited (22 per group). Polit and Beck (2012) recommended accounting for attrition rates between 30%-50%, particularly in longitudinal studies. To account for possible attrition by administering the vignette four weeks after the post-test, the researcher increased the sample size by 30% to recruit a total sample size of 58 participants. The total number of participants recruited for this study was $N = 66$. Of the 66 participants (73%), 48 completed the

entire study, 24 completed the SLPs, and 24 completed the SELVs. There was a 27% attrition rate with 12 SLP and six SELV participants withdrawing prior to completion of the study.

Recruitment Process

This section discusses the participant recruitment process used in this current study. The selection of participants, consent process, and incentives is described.

Selection of Participants

The population selected for the study included selected healthcare facilities in Western Pennsylvania that had designated chemotherapy infusion centers and/or in-patient oncology units. Only oncology nurses who had been deemed competent in chemotherapy administration by their facility and who actively administered chemotherapy were included in the selection process. Chemotherapy competency was established by attending either an institutional or nationally recognized chemotherapy course and by maintaining chemotherapy administration competencies per institutional guidelines.

The researcher of this study pre-selected healthcare facilities based on the inclusion and exclusion criteria to seek interest in participation. Emails and phone inquiries were also used to seek potential interest. Only six of the pre-selected healthcare facilities responded with interest. These facilities did not have a formal IRB process. Therefore, the facilities reviewed the research protocol, letters of proposed consent, and granted permission to conduct the study after approval of the IRB from IUP (see Appendices A-G). After IRB approval from IUP (see Appendix H), the director or other designated administrator of the eligible facilities were contacted via an electronic invitational mailing (see Appendix I) to confirm interest in participating in the study.

If the facilities were still interested in participating in the study, the director or other designated administrator was requested to forward the invitational email (see Appendix J) to all eligible chemotherapy competent RNs employed in the healthcare facilities. An educational recruitment flyer was also electronically sent to the director or other designated administrator to post in their designated area(s) (see Appendix K). In order to participate in this study, the participants needed to meet the inclusion criteria, agree to participate, and sign the Informed Consent Form (see Appendix L) printed on IUP letterhead. Staff meetings were set up by the director or other designated administrator for the researcher of this study to attend. The researcher described the intent of the study and obtained the Informed Consent Form from interested participants at the staff meeting.

Consent Process

The informed consent was printed on IUP institutional letterhead and provided to each eligible participant. The purpose as well as the voluntary nature of the study was explained to the participant. The researcher informed the participant that only the researcher had access to their responses and that all data would remain confidential. Furthermore, the participant was informed that there were no negative ramifications if he/she chose not to participate, the responses remained confidential, and he/she may withdraw from the study at any time.

There were two opportunities to obtain consent. First, consents were obtained from the participants during site visits. After the intent of the study was reviewed with the potential participants, the director or other designated administrator were asked to leave the room. The researcher distributed consents to the eligible participants. They could either sign or not sign the consent. A manila envelope was passed around the room to collect all consents forms (whether signed or unsigned). Second, if participants chose to participate after the site visits prior to the

initiation of the study, they could have contacted the researcher by phone, email, or text to obtain the informed consent. A signed copy of the consent was provided to each participant.

Incentives

Those participants who completed the study in entirety (completed the pre-, post-, and four-week follow-up chemotherapy error SELV along with the seven SLPs or SELVs on the ASCO/ONS chemotherapy safety standards) were entered into a random drawing for a \$50.00 gift card. There were four 50.00 gift cards incentives offered: two for the SLP group and two for the SELV group. Application was made to the Pennsylvania State Nurses Association, an accredited approver by the American Nurses Credentialing Center's (AACN) Commission on Accreditation, for approval of contact hours for this activity. Those participants were emailed CEs (either 13 for the SELVs or 13.1 for the SLPs) for completion of all steps of the study. Participants from the SLP intervention group had the opportunity to view the SELVs at any time after the completion of the study if they chose. Participants from the SELV intervention group had the opportunity to receive a SLP after the completion of the study if they chose. After the study closed, the participants also had the opportunity to contact the researcher to review their identified errors from the pre-, post-, and follow-up SELVs.

Instruments

This study collected demographic data as well as used a SELV instrument to measure oncology nurses' knowledge of chemotherapy administration errors. The study also used two educational interventions: a) SLP; and b) SELV of the ASCO/ONS standards. The following section describes each intervention and instrument in detail.

American Society of Clinical Oncology/Oncology Nursing Society Educational Intervention Self-Learning Packets and Simulated Electronic Learning Vignettes

The seven educational SLPs and SELVs addressed the 31 standards for chemotherapy safety set forth by the ASCO and ONS. The SLPs and SELVs provided an overview of the changes in practice, the new standards of practice, visual pictures or handouts of the new resources, final summaries recapping the major changes, and post-assessments to measure learning outcomes. The SLPs were provided in a written format. The SELVs portrayed simulated scenarios that demonstrated the new standards with audible discussions, computer access to retrieve resources, and interactive hyperlinks (Vioral & Kennihan, 2012).

Chemotherapy Administration Error Simulated Electronic Learning Vignette

Created by Vioral (2014), the Chemotherapy Administration Error SELV was an audio-visual three-minute video-taped vignette of an RN administering chemotherapy with 10 administration process errors. The vignettes also had screen shots of forms necessary in the administration process. The chemotherapy administration error SELV was created to illustrate the 10 most common ordering, dispensing, and administration errors identified in the literature review (Jacobson et al., 2009; Jacobson et al., 2012; Schulmeister, 2005). The nurse administering the chemotherapy was responsible to verify that these 10 processes occur during administration. Omission of any of these steps may contribute to a potentially lethal negative chemotherapy MAE and outcome. The errors portrayed in the SELV included verifying that there were no:

1. incomplete orders;
2. inadequate consents;
3. estimation of the height and weight;

4. exclusion of drug calculations and lab verifications;
5. elimination of double check processes;
6. omission of the final verification components at the patient bedside;
7. exclusion of wearing proper personal protective equipment;
8. errors when connecting the chemotherapy directly to the patient;
9. omission of patient teaching; and
10. incorrect disposal of waste in inappropriate containers.

The participants were asked to view the video, write down the identified errors as they were viewing the vignette, and then enter their responses into the LMS. Each correct error identified received one point for a total possible score of 10. The higher scores indicated increased knowledge of chemotherapy errors. The lower scores indicated decreased knowledge of chemotherapy errors.

Instrument development. In a previous pilot study, Vioral (2014) used a quasi-experimental, longitudinal, one-group pre-test-post-test design to assess oncology nurses' knowledge of the ASCO/ONS chemotherapy safety standards before, immediately after, and four weeks after all the participants viewed the SELVs. Under direction by Vioral (2014), the CTFC in the study standardized, implemented, and evaluated the ASCO and ONS national safety standards for chemotherapy administration using an innovative educational strategy. The CTFC condensed the ASCO/ONS 31 standards, 40 forms, and 30 policies and procedures to 16 new standards of practice (SOPs), 11 new forms, four revised forms, and three new reference sheets (Vioral, 2014). Appendix M provides a summary of the new SOPs, SLPs, and SELVs. The chemotherapy administration error SELV as well as the seven educational SELVs were developed in conjunction with the Simulation Training Academic Research (STAR) Center.

Members of the CTFC participated in the development of the SLPs as well as in the taping of the SELVs. Upon completion of the SLPs and the SELVs, the STAR Center edited the footage for the CTFC to establish validity and determine reliability (Vioral, 2014).

Validity. As previously discussed in Chapter Two, critics cite concerns with internal validity of SELVs: a) ensuring the depicted situation genuinely portrays the phenomenon of interest; and b) ensuring each question pertaining to the situation measures the same phenomenon (Flaskerud, 1979). A three pronged approach was suggested by Flaskerud (1979) to increase internal validity: a) developing vignettes from existing literature; b) submitting vignettes to a panel of experts; and c) pre-testing to eliminate ambiguous questions. The educational intervention SELVs and the chemotherapy administration error SELV followed the suggested criteria cited in the literature in the development of both the educational SELV and chemotherapy error SELV. The SELVs were developed from existing literature, submitted to a panel of experts, and pre-tested to eliminate ambiguous questions (Flaskerud, 1979).

After the educational and chemotherapy error SELVs along with the SLPs were developed, content validity was established. Content validity ensured that the educational interventions provided accurate representation of the standards. The content validity of the instrument ensured that the tool measured what it was intended to measure. Three expert members of the CTFC used a content validity index (CVI) four-point ordinal rating scale to determine the representativeness of the content, clarity, and overall errors of the SELV, and the educational SLPs and SELVs (Vioral, 2014).

Of the 10 errors in the chemotherapy SELV, all had a CVI of 100%. No modifications to the SELV were necessary. The seven interventional SLPs and SELVs underwent the same process and had a CVI of 100%. The chemotherapy administration error SELV and the

educational interventions (SLPs and SELVs) were then reviewed by an expert panel of 10 CTFC members with greater than 15 years chemotherapy and oncology experience. The expert reviewers evaluated the items in the error SELV as highly reflective of the chemotherapy errors identified in the literature. The reviewers also evaluated the educational interventional SLPs and SELVs as reflective of the 16 new SOPs with the 11 new forms, four revised forms, and three new reference sheets (Vioral, 2014). No further changes were recommended, the instrument and interventions were then used in the pilot study to establish reliability.

Reliability. Prior to the pilot, the 10 expert panel members of the CTFC completed the chemotherapy administration error SELV and documented the errors. The panel also completed inter-rater reliability to determine if the SELV measured the chemotherapy administration errors. The panel achieved consensus and exact agreement that the errors portrayed in the vignette matched the errors identified in the literature. The 10 expert panel members were able to identify the 10 errors in the vignette. No changes were made to the SELV prior to using the tool in the pilot study (Vioral, 2014). The chemotherapy administration error SELV was pilot tested using a convenience sample of 66 oncology RNs who administered chemotherapy in both in- and out-patient settings in a mid-Atlantic state nonprofit multi-hospital system (Vioral, 2014). No changes on the error SELV were made for this study.

Reliability was also established on the educational SLPs and SELVs. The CTFC expert review panel completed the SLPs to estimate the time for completion. The expert panel averaged 12-16 hours to complete the SLPs and 8-12 hours to complete the SELVs. The panel also completed inter-rater reliability and concurred that the SLPs and the SELVs reflected the ASCO/ONS standards in the 16 new SOPs. No changes were made to the SELV and were then used in the pilot study. The same educational SLPs and SELVs were used in this current study.

Demographic Instrument

In addition to the instrument presented above, participants completed a demographic questionnaire created by the researcher. The items were forced choice responses in a multiple choice format. Following completion of the pre-assessment chemotherapy SELV, the participants were asked to provide information on the following items: age, gender, educational level, years in nursing, years as oncology nurse, years administering chemotherapy, oncology certification, nursing position, specialty area within oncology, and learning preference. The demographic data were used in data analysis to describe the sample, investigate the effects on the dependent variable (KR), and examine potential bias and variance within the groups. Appendix N provides the intended demographic instrument.

Procedures

The researcher visited each site prior to the research and education opportunity. During the visits, the researcher discussed the history and rationale of the ASCO/ONS chemotherapy safety standards. The researcher also explained that the information gained from this study may help to develop improved educational opportunities, and potentially decrease errors and increase chemotherapy safety. During the site visits, the participants had an opportunity to ask questions and address any concerns with the researcher. The researcher was also available for questions by phone, emails, and text messaging at any time during the study and education.

After explaining the intent of the study, the researcher asked the director or other designated administrator to leave the room. Consents were provided to all the eligible participants in attendance. Participation in the study was voluntary. Therefore, the eligible participants either signed the consent to participate or left the consent blank. All consents were collected by the researcher and placed in a sealed manila envelope. The consents were

maintained in a secure locked cabinet only available to the researcher. After the staff meetings, the researcher only communicated directly with the participants (via email, phone, or text) who consented to the study, not the director or other designated administrator.

A learning management system (LMS) was used by the participants to view the chemotherapy error SELV, enter their answers, and complete the SELV educational interventions. The LMS vendor set up a password protected course for only the researcher to access. The STAR Center provided the 100 licenses in the LMS at no charge. The STAR Center will be acknowledged in publication and presentations related to this study for their LMS technological support in the study. The course was password protected and only the researcher had access to the course materials and data in the LMS. Appendix O provides a detailed email correspondence related to the 100 licenses. The procedures for data collection involved four steps.

Step One

In step one of this current study, each consented participant was required to view the chemotherapy error SELV. The error SELV was available through an email link that could be accessed from any computer at work or home at any time. Each participant received an individual email from the researcher with the link to access the SELV (see Appendix P). Each participant was asked to log into the LMS with their employee number, view the video, write down the identified errors as they were viewing the vignette, type their responses into the LMS, and complete the demographic questionnaire. Each participant was informed that there were exactly 10 errors related only to the chemotherapy administration process. The participant was reminded to only focus on chemotherapy process errors when viewing the SELV. The participant was only able to access the error vignette once, and needed 30 minutes to complete

the components of step one. The participant had two weeks to complete step one of the study. Every 48 hours an email reminder was automatically generated by the LMS up to five times to remind the participant to complete the initial SELV.

The error SELV demonstrated an RN administering chemotherapy with 10 errors in the vignette. The vignette provided an assessment of the nurses' knowledge of the chemotherapy administration process based on the number of errors they identified while watching the video. While viewing the video, the participant was asked to write down the errors identified in the chemotherapy administration process. After viewing the SELV, the participant entered the 10 responses into the LMS. Each correctly identified error received one point for a total of 10 possible points. To further measure knowledge, after each error entry, the participant rated their level of knowledge certainty of each error they identified. Using a scale of 1-5 (1 = not certain at all) to (5 = very certain) the participant selected the level of knowledge certainty after each error identified (see Appendix Q). The findings further identified specific gaps in knowledge of chemotherapy errors. Completion time to complete the error SELV and demographic questionnaire was approximately 30 minutes. After two weeks, that error SELV vignette was no longer accessible. The aggregate data were then extracted from the LMS by the researcher. A code book in Statistical Package for the Social Sciences (SPSS) was developed and the data were manually entered. Each participant was re-assigned a new identification number in SPSS starting at number one to further maintain confidentiality.

Step Two

During step two of the current study, the seven SLPs were compiled by the researcher and the seven SELVs were uploaded to a LMS using audio-video technology for participants to view. The participants were randomly assigned to either receive the ASCO/ONS education via a SLP or SELV. A coin-toss was used to assign the first participant. If the coin flipped as “heads” that participant was assigned to the SLP group. If the coin is flipped as “tails” that participant was assigned to the SELV group. The next participant was assigned to the opposite group of the first. For example, if the first participant flipped “heads” he/she was assigned to the SLP group. The next consented participant was automatically then assigned to the SELV group. The next participant was assigned to the SLP group. Then every other assignment occurred until an adequate sample size was obtained.

The participants then had six weeks to complete either the seven SLPs or seven SELVs of the ASCO/ONS chemotherapy safety standards at their own pace. The SLPs were distributed in person to the participants by the researcher. Participants completing the SLP filled in their employee number inside the front cover of the SLP. The SELVs were available for access at any computer at work or home at any time of day. Participants assigned to the SELV group logged into the LMS with their employee number. An email was sent to the participants by the researcher with a link to access the LMS. Based on the previous pilot study by Vioral (2014), the estimated time required to complete the chemotherapy administration error SELV module was 10-12 hours. The estimated time to complete the seven SLPs was 12-16 hours. The educational interventions provided the participants with the ASCO/ONS chemotherapy safety standards and a review of current best practice. After each SLP section or SELV, a summary of the content for that section was provided and the participants completed the post-assessment

questions via the LMS or in the SLP. These were not graded. Email reminders to complete the SLPs or SELVs were automatically generated by the LMS and sent weekly for the six weeks to remind participants to complete the assigned education. At the end of the sixth week, the modules were closed for access. The researcher collected the SLPs in person ensuring all the content was returned to the researcher. The aggregate data in the LMS were archived by the researcher to a computer disc and maintained in a locked cabinet.

Step Three

The third step during data collection required the participant to view the same chemotherapy error SELV used in the pre-test intervention. The participant had 10 days to log into the LMS using their employee number to view the same chemotherapy administration error SELV. The SELV was available on any computer at work or home at any time. An email was sent by the researcher to each participant with a link to access the LMS. The participant was asked to log into the LMS with the employee number, view the video, write down the identified errors while viewing the vignette, type the responses into the LMS, and complete the demographic questionnaire. The participant was informed that there were exactly 10 errors related only to the chemotherapy administration process.

The participants were reminded to only focus on chemotherapy process errors when viewing the SELV. The participants were only able to access the error vignette once. After viewing the SELV, the participants entered their 10 responses into the LMS. Each correctly identified error received one point for a total of 10 possible points. To further measure knowledge, after each error entry, the participants rated their level of knowledge certainty of each error they identified. Using a scale of 1-5 (1 = not certain at all) to (5 = very certain) the participants selected their level of knowledge certainty to reply after each error identified. They

needed 30 minutes to complete the components of step three. The participants had 10 days to complete step three of the study. Follow-up reminders by email were automatically sent from the LMS to the participants every 48 hours up to five times as a reminder to complete the post-SELV assessment. Access to the vignette was closed after 10 days. The aggregate data were extracted by the researcher from the LMS, matched to the pre-error participant through their employee and de-identified assigned number and manually entered into the SPSS code book.

Step Four

In the final step of the current study, the participants that consented to the research were sent an email and called by phone as a reminder by the researcher to complete the post-error SELV four weeks after the completion of the educational intervention closed. The participants once again viewed the same chemotherapy administration error SELV to identify administration errors. The SELV was available on any computer at home or work at any time. An email with the link to the LMS was sent by the researcher to the participants. The participants had 10 days to log into the LMS to view the same error SELV that was used in the pre- and post-test and enter the identified errors. Follow-up reminders to complete the SELV were automatically sent via the LMS every 48 hours up to five times to the participants who did not complete the final assessment to potentially increase sample completion.

The participants were asked to log into the LMS with their employee number, view the video, write down the identified errors as they are viewing the vignette, type their responses into the LMS, and complete two additional demographic questions about their educational learning preference (SLP or SELV) and the week they completed the educational intervention. The participants were informed that there were exactly 10 errors related only to the chemotherapy administration process. The participants were reminded to only focus on chemotherapy process

errors when viewing the SELV. The participants were only able to access the error vignette once. After viewing the SELV, the participants entered their 10 responses into the LMS. The correctly identified errors received one point for a total of 10 possible points. To further measure knowledge, after each error entry, the participants rated their level of knowledge certainty of each error they identified. Using a scale of 1-5 (1 = not certain at all) to (5 = very certain) the participants selected their level of knowledge certainty to reply after each error identified. They needed to have 30 minutes to complete the components of step four. The participants had 10 days to complete step four of the study. After completion of the four-week follow-up error SELV, the participants were provided demographic information to select their preferred educational intervention (SLP or SELV). The participants also selected the week they completed the SLP or SELV educational intervention.

The researcher determined the employees who completed all the components of the study including the pre-test error SELV, either the SLP or SELV educational intervention, the immediate post-test error SELV, demographic questionnaire, and the four-week follow-up error SELV in entirety. Those participants were entered into a random drawing for a \$50.00 gift card. Two gift cards were given to the SLP group participants and two gift cards were given to the SELV intervention group participants. Application to the Pennsylvania State Nurses Association, an accredited approver by the American Nurses Credentialing Center's (AACN) Commission on Accreditation, for approval of contact hours for this activity was submitted. Those participants were also emailed contact hour certificates for completion of the educational interventions. Personal information about the participants will be maintained in the researcher's password-protected computer and hard copies kept in a locked file in the researcher's office. The researcher extracted the employee numbers of the participants who completed the study in

entirety from the LMS and place their number in hat. A member of the CTFC pulled a participant SPSS assigned number from a hat at a designated council meeting. Two participants from the SLP and two from the SELV participant groups were chosen. The researcher cross referenced the SPSS assigned number to their employee number in the data base to identify the winners. The winners were notified by the researcher via email once identified. The gift cards were mailed to the participants. After the study closed, the participants had the opportunity to contact the researcher to review their identified scores from the pre-, post-, and follow-up SELVs. Answers were withheld until completion of the study to avoid introducing bias to the study by providing the answers.

Data Analysis

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 21.0 for Windows. Only sets of data from participants who completed the pre-test, immediate post-test and four-week follow-up chemotherapy error SELV were used in the data analysis. A codebook was developed for the data analysis by the study researcher. For quality control the researcher rechecked all received data for completeness, coding of data was conducted and reviewed by the researcher. The researcher independently conducted random checks every 10th survey to ensure accuracy.

After data were entered from the initial SELV testing, the data were extracted from the LMS. Each of the participant's replies were extracted from the LMS, reviewed for completeness, and scored by hand. The researcher matched the participants' responses of errors to the list of 10 errors identified in the literature. Any answer that included the same terms or similar replies to match the answer key was scored as one point. To decrease the subjectivity of the researcher scoring the errors, two expert data assistants from the pilot study (Vioral, 2014)

also reviewed the replies to verify error identification. The two data assistants also participated in the 10 panel expert review of the reliability and validity of the instruments. The expert data assistants were only given the answers. No participant numbers or identities were available to the data assistants. The participant's employee number, name, assigned unique identifier, score, and demographic data were entered into the SPSS codebook developed by the researcher.

An excel spreadsheet was also created to track the commonly missed errors identified by the participants in the pre-errors, post-errors, and retention time points. Errors identified by the participants that were not related to the 10 study errors, were also tracked for data collection purposes.

Prior to statistical analysis, the data set was statistically examined for errors using frequency and descriptive data. Missing data were examined and only completed data sets were used in the study. Normality of the data was explored using Histograms and Q-Q Plots. Additionally, the data were checked to verify that the assumptions associated with the statistical analyses were met. Preliminary analyses to ensure no violation of the assumptions of normality, linearity, and homoscedasticity were performed prior to each statistical analysis.

Demographics

The demographic data were analyzed using descriptive statistics to report frequencies and percentages to describe the study sample including age, gender, educational level, years in nursing, years as oncology nurses, years administering chemotherapy, oncology certification, nursing position, and specialty area in oncology. Demographic items related to the potential confounding variables identified in the literature previously described in Chapter Two: age, oncology certification; years administering chemotherapy; and participant educational

intervention preference (SLP or SELV) were examined using mixed between-within AVOVA controlling for the selected variables.

Research Question

How do SLPs and SELVs education differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy?

The knowledge was measured in two ways, thus investigating two sets of hypotheses:

1. Using an absolute measure of knowledge (number of correct answers).
2. Using an adjusted measure of knowledge (number of correct answers adjusted for certainty in the answer).

Statistical Analyses

The absolute measure of knowledge ranged from 0-10 points (0 = no errors identified correctly) to (10 = all errors identified correctly). A concern arose that since the participants were informed that there are only 10 errors, they may have guessed at the errors to be sure that they had 10 answers. Therefore, the absolute measure of knowledge may have been positively biased. To control for this, an adjusted measure of knowledge was also used. After each error response, the participants were asked to rate their certainty of their response on a scale where 1 = not certain at all to 5 = very certain. The formula to calculate the adjusted measure of knowledge was: $K = 0$ if an error was not identified or identified incorrectly. Otherwise $K = \text{certainty}/5$. Thus, on any error: $K = 0, .2, .4, .6, .8, \text{ or } 1$.

The mixed between-within ANOVA statistical analyses allowed the researcher to examine the mean scores on the same group of participants on three different occasions: prior to the vignette, immediately following the education interventions, and at the one month follow-up. This analysis also provided Wilks' Lambda, associated significance probability, and an effect size. A probability level of $\alpha = .05$ was used to determine if the null hypotheses should be accepted or rejected. The effect size calculation determined the strength of the change after the participants received the SLP or SELV.

A mixed between-within subjects' ANOVA was also used to control for the effects of the confounding variables. The study explored the between-subject and within-subject variability by investigating how SLPs or SELVs affect KR within each group and whether the impact was different between the independent variables. The data analysis tested whether there were main effects for each of the independent variables (generational learning preferences, oncology certification, and years of administering chemotherapy). The analysis also tested whether the interaction between the two variables was significant. For example, the analysis: a) showed whether there was a change in knowledge at three time points (main effect for time), b) compared how the two interventions (SLPs and SELVs) affected knowledge over time (main effect for group), and c) explained whether the change in knowledge over time was different for the two groups (interaction effect). The F test determined if the relationship could be generalized to the population represented by the sample. The Wilks' Lambda value assessed the interaction and main effects. The partial eta squared assessed the practical size of the main effects and the between subjects effect.

Summary

This chapter reviewed the methodology for the current proposed study including the study design, ethical issues, sampling plan, instrumentations, data collection procedures, and data analysis using descriptive and inferential statistical analysis. The Chapter Four presents the data and analysis for the demographic variables and research question, and provides a description of the sample, the research question, hypothesis, and quantitative results.

CHAPTER FOUR

RESULTS

This chapter presents the results of the statistical analyses of this study. A description of the sample demographics will start this chapter. This chapter also includes results pertaining to the research question and hypotheses.

Sample Description

The study subjects were eligible oncology chemotherapy competent registered nurses ($N = 105$) from six mid-Atlantic healthcare facilities with designated chemotherapy infusion centers. Of the 105 eligible participants, 66 enrolled in the study (63% response rate). Participants who did not complete all steps of the study were excluded. Of the 66 enrolled, 48 participants completed the study in its entirety (73% completion rate).

Participants were randomly assigned to either the SLP or SELV group. Table 1 presents a summary of selected demographics by assigned learning group. The overall sample was predominately female (97.9%). Of the participants in the total sample, 33.3% had an associate degree while 27.1% had a diploma and 27.1% had bachelor degrees. Participants worked more in outpatient settings (56.3%) and in medical oncology specialties (87.5%). Certified nurses (52.1%) represented a slightly higher percentage in the overall sample. The SLP and SELV groups were not statistically different compared to the overall sample in terms of gender, degrees, certifications, and specialty areas. However, those employed in outpatient settings represented significantly more of the SLP group (66.7%) than of the SELV group (45.8%).

Table 1

Frequency Distribution of Selected Demographic Variables

Variable	Category	SLP (<i>n</i> = 24)	SELV (<i>n</i> = 24)	Overall (<i>N</i> = 48)
		<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Gender	Male	0 (0.0)	1 (4.2)	1 (2.1)
	Female	24 (100.0)	23 (95.8)	47 (97.9)
Highest Degree	Diploma	6 (25.0)	7 (29.2)	13 (27.1)
	Associate	9 (37.5)	6 (25.0)	15 (31.3)
	RN-BSN	4 (16.7)	1 (4.2)	5 (10.4)
	Bachelor	5 (20.8)	8 (33.3)	13 (27.1)
	Master	0 (0.0)	2 (8.3)	2 (4.2)
Setting	In-Patient	8 (33.3)	13 (54.2)	21 (43.8)
	Out-Patient	16 (66.7)	11 (45.8)	27 (56.3)
Specialty	Medical Oncology	21 (87.5)	21 (87.5)	42 (87.5)
	Heme-Oncology	1 (4.2)	3 (12.5)	4 (8.3)
	Radiation Oncology	2 (8.3)	0 (0.0)	2 (4.2)
Oncology Certification	Certified	13 (54.2)	12 (50.0)	25 (52.1)
	Not Certified	11 (45.8)	12 (50.0)	23 (47.9)

Note. Total percentages may not equal 100 due to rounding.

Table 2 provides additional descriptive demographic statistics by assigned learning group on the participant's age, years in nursing, years as oncology nurses, and years administering chemotherapy. The participants' age ranged from 24-61 ($M = 42.7$, $SD = 9.90$) with the majority between the ages of 34-53 (62.5%). The mean number of years working as nurses was 15.4 ($SD = 10.42$), years as oncology nurses 10.6 ($SD = 9.37$), and years administering chemotherapy 9.5 ($SD = 9.44$). The majority of the participants had only been nurses in oncology (45.8%) and had administered chemotherapy (50%) for less than five years. The means of the SLP and SELV

groups did not differ statistically from the overall sample in terms of age, years of nursing, years as an oncology nurse, and years of administering chemotherapy.

Table 2

Descriptive Statistics on Selected Demographic Variables

Variable	SLP (<i>n</i> = 24)		SELV (<i>n</i> = 24)		Overall (<i>N</i> = 48)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age in Years	44.3	10.06	41.1	9.68	42.7	9.90
Years in Nursing	16.7	11.29	14.3	9.58	15.4	10.42
Years as Oncology Nurse	10.1	10.37	11.1	8.44	10.6	9.37
Years Administering Chemotherapy	9.3	10.70	9.8	8.20	9.5	9.44

Participants were randomly assigned to either the SLP or SELV group to increase the study rigor. At the conclusion of the study demographic data were collected to report on the participant's actual educational preference. This data is presented in Table 3. Of the 24 participants randomly assigned to the SLP education group, 83.3% preferred the SLP learning method whereas 16.6 % preferred the SELV group. Of the 24 participants randomly assigned to the SELV group, 50% preferred the SELV and 50% preferred the SLP. Table 4 presents the participants preference based on generational demographics. Of the nine Millennials, 66.7% (*n* = 6) preferred the SLP whereas only 33.3% (*n* = 3) preferred the SELV. The Generation Xers, representing the largest group in the sample, with 79.2% (*n* = 19) preferring the SLP and 20.8% (*n* = 11) preferring the SELV. The SLP was preferred by 77.8% (*n* = 7) of the Baby Boomers and only 22.2% (*n* = 2) preferred the SELV. No Veterans were represented in this study sample.

Thus, in the overall sample of 48 nurses, 66.7% ($n = 32$) preferred the SLP and 33.3% ($n = 16$) preferred the SELV educational interventions.

Table 3

Participants Educational Intervention Preference

	Preferred Educational Intervention	
	SLP	SELV
Educational Intervention	n (%)	n (%)
SLP Assigned ($n = 24$)	20 (83.3)	4 (16.6)
SELV Assigned ($n = 24$)	12 (50.0)	12 (50.0)
Overall Combined ($N = 48$)	32 (66.7)	16 (33.3)

Note. Total percentages may not equal 100 due to rounding.

Table 4

Generational Learning Preferences

Generation	Preferred Educational Intervention	
	SLP	SELV
	<i>n</i> (%)	<i>n</i> (%)
Millennials (<i>n</i> = 9)	6 (66.7)	3 (33.3)
Generation Xers (<i>n</i> = 30)	19 (79.2)	11 (20.8)
Baby Boomers (<i>n</i> = 9)	7 (77.8)	2 (22.3)
Overall Combined (<i>N</i> = 48)	32 (66.7)	16 (33.3)

Note. Total percentages may not equal 100 due to rounding.

Research Question

This study investigated oncology nurses' knowledge of errors that occur during the chemotherapy administration process. The purpose of this study was to determine if oncology nurses' use of SLPs versus SELVs increased their KR of the ASCO/ONS chemotherapy safety standards. The study also explored if selected demographic variables influenced KR between the pedagogical approaches. Using a quasi-experimental longitudinal repeated-measure mixed between-within ANOVA, the following question regarding oncology nurses' KR using SLP and SELV educational approaches was answered in the study.

Research Question

How do SLPs and SELVs education differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning

preferences, oncology certification, and years of administering chemotherapy? The knowledge was measured in two ways, thus resulting in two sets of hypotheses.

Set One

The absolute measure of knowledge ranged from 0-10 points (0 = no errors identified correctly) to (10 = all errors identified correctly). This set of hypotheses investigated an absolute measure of knowledge by examining the actual correct number of errors identified by the participants.

1. H_0 - SLPs and SELVs education do not differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.
2. H_1 - SLPs and SELVs education do differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.

Descriptive statistics on the absolute error scores across time points for the assigned learning groups are provided in Table 5. These statistics are unadjusted for the control variables. Neither learning group showed much change in errors scores from pre- to post- intervention. The mean number of errors identified by both learning groups increased from pre-intervention to retention slightly suggesting identification of one additional error. The model reports more accurate mean levels. Therefore, all of the figures show the mean values adjusted for all of the

control variables. Figure 3 illustrates the absolute errors identified by the SLP group as higher than the SELV group over time. Figures 4, 5, and 6 address the study variables of the participant's absolute means when controlling for preferred method of learning, oncology certification, and years of administering chemotherapy.

Table 5

Descriptive Statistics on Absolute Pre-, Post-, and Retention Error Scores

Time Period	SLP ($n = 24$)		SELV ($n = 24$)		Overall ($N = 48$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre-Score	6.2	1.21	5.8	1.25	6.0	1.24
Post-Score	6.2	1.02	5.9	1.51	6.0	1.29
Retention Scores	6.5	1.14	6.4	1.23	6.5	1.18

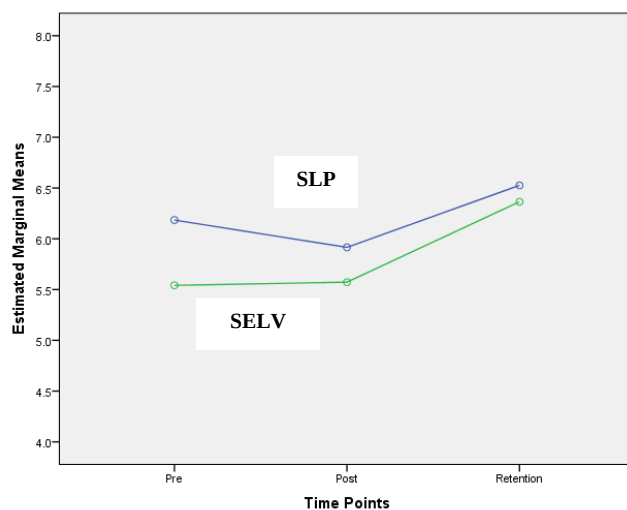


Figure 3. Estimated marginal absolute error means for assigned learning groups across three time points.

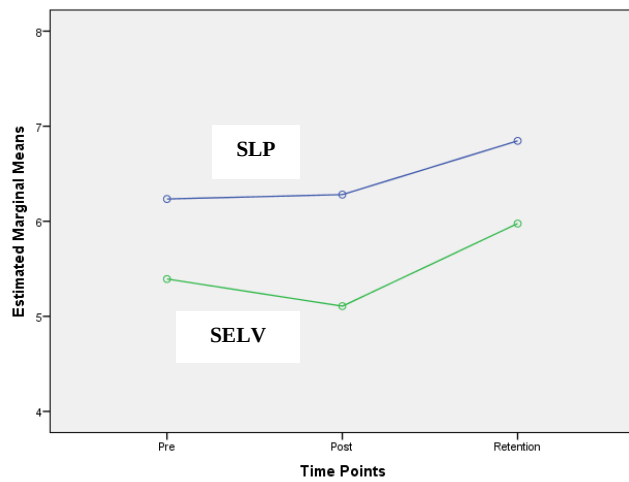


Figure 4. Estimated marginal absolute error means for preferred learning groups across three time points.

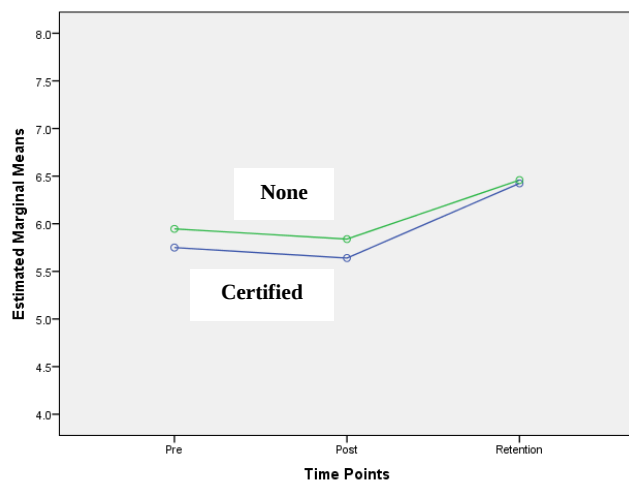


Figure 5. Estimated marginal absolute error means for oncology certification groups across three time points.

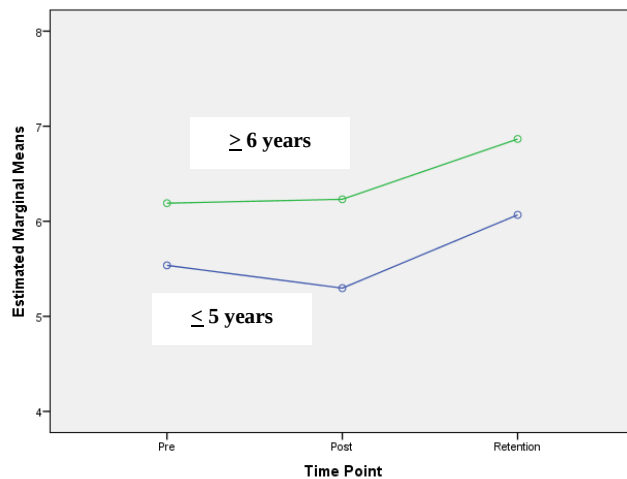


Figure 6. Estimated marginal absolute error means for years of administering chemotherapy groups across three time points.

Figure 4 illustrates the absolute means of the participants preferred method of instruction (SLP or SELV) when controlling for oncology certification and years of administering chemotherapy. Both groups' absolute mean scores increased from pre-, post-, to retention. The SLP group means were higher than the SELV group means by approximately one error. Both the certified and non-certified participants also had an increase in the absolute mean scores from pre/post to retention when controlling for learning preference and years of administering chemotherapy as shown in Figure 5. However, the non-certified participant means identified about one error more than the certified group. Figure 6 displays the absolute group means for those with five years or less experience and those with six years or more experience. When controlling for learning preference and oncology certification, the participants with six or more years of experience had higher error identification means than the group with five or less years of experience. Overall, improvement in scores was similar across time points for both learning groups.

The data analysis measured whether there were significant main effects for each of the independent variables (generational learning preferences, oncology certification, and years of administering chemotherapy). The analysis also determined whether the interaction between the two variables was significant. For example, the analysis: a) showed whether there was a change in knowledge at three time points (main effect for time), b) compared differences over time between the two interventions (SLPs and SELVs) affected knowledge when averaging (main effect for group), and c) explained whether the change in knowledge over time was different for the two groups (interaction effect). The Wilks' Lambda value assessed the interaction and main effects. The F test determined if the relationship could be generalized to the population represented by the sample. The partial eta squared assessed the magnitude of the effect sizes. A probability level of $\alpha = .05$ was used to determine if the null hypotheses should be accepted or rejected.

Several assumptions were necessary for this statistical analysis including level of measurement, random sampling, independence of observations, normality, and homogeneity. Preliminary analyses on the continuous variables were conducted to ensure there were no violations of these assumptions. Scatter plots indicated no violations, histograms were reasonably symmetrical with slight right-side skewness without large variations, skewness and kurtosis were calculated <3.0 , and p-p plots met normality.

Although a convenience sample was used, the participants were randomized to an assigned learning group. Normal distribution was met on the absolute pre-, post-, and retention scores. Levine's statistic was not significant for the absolute pre-error score ($p = .39$) and retention ($p = .16$). The absolute post-error score violated the homogeneity condition ($p = .01$).

However, the Box's test of equality of covariance matrices was not significant ($p = .55$) and did not violate homogeneity.

A mixed between-within subjects' ANOVA assessed the impact of two different interventions (SLP or SELV) on participants' absolute scores on chemotherapy errors across three time periods (pre-intervention, immediate post-interventions, and four-week follow-up). Table 6 presents the findings of the interaction effects between the SLP and SELV groups in identifying chemotherapy errors over time. There was no significant interaction effect between the assigned educational interventions and time, Wilks' Lambda = .98, $F(2, 32) = .40$, $p = .68$, partial eta squared = .024. Table 6 also shows that there was no significant interaction effect between the assigned educational interventions and time when controlling for generational learning preference, oncology certification, and years of administering chemotherapy. However, there was a substantial main effect for identifying chemotherapy errors over time, Wilks' Lambda = .76, $F(2,32) = 4.95$, $p = .01$, partial eta squared = .24. Both groups showed an increase in knowledge of chemotherapy errors at the retention.

Table 6

Multivariate Tests for Absolute Within Interaction and Main Effects

Effect	Wilks' Lambda	F	Model df	Error df	<i>p</i>	Partial Eta Squared
TP	.764	4.946	2	32	.013**	.236
TP * AI	.976	.398	2	32	.675	.024
TP * EP	.978	.354	2	32	.704	.022
TP * OC	.990	.159	2	32	.853	.010
TP * YAC	1.000	.001	2	32	.999	.000
TP * AI * EP	.959	.683	2	32	.513	.041
TP * AI * OC	.989	.172	2	32	.843	.011
TP * AI * YAC	.970	.502	2	32	.610	.030
TP * EP * OC	.989	.170	2	32	.844	.011
TP * EP * YAC	.943	.964	2	32	.392	.057
TP * OC * YAC	.973	.442	2	32	.647	.027
TP * AI * EP * OC	.970	.494	2	32	.615	.030
TP * AI * EP * YAC	.966	.562	2	32	.376	.034
TP * AI * OC * YAC	.978	.356	2	32	.703	.022
TP * EP * OC * YAC	.935	1.111	2	32	.341	.065

Note. Time point (TP); assigned intervention (AI); educational preference (EP); oncology certification (OC); years administering chemotherapy (YAC).

* $p < .05$. ** $p < .01$.

Table 7 shows that the main effect comparing the two types of educational interventions was not significant, $F(1,33) = 2.04$, $p = .16$, partial eta squared = .058. These findings suggest there was no difference in the overall knowledge level of the two educational interventions.

When controlling for oncology certification and years of administering chemotherapy, there was a significant main effect of the absolute measure of knowledge comparing SLP and SELV preferences $F(1,33) = 5.09$, $p = .03$, partial eta squared = .134. The main effect of the absolute measure of knowledge comparing years of experience was also significant ($F(1,33) = 8.37$, $p = .01$, partial eta squared = .202) when controlling for learning preference and oncology

certification. However, the main effect of the absolute measure of knowledge comparing oncology certification status was not significant ($F(1,33) = .62, p = .44$, partial eta squared = .018) when controlling for learning preference and years of administering chemotherapy.

Table 7

Absolute Between-Subjects Effects

Source	Type III Sum of Squares	F	<i>p</i>	Partial Eta Squared
AI	1.269	2.038	.163	.058
EP	3.170	5.091	.031*	.134
OC	.387	.621	.436	.018
YAC	5.211	8.369	.007**	.202
AI * EP	1.126	1.808	.188	.052
AI * OC	.362	.582	.451	.017
AI * YAC	.298	.478	.494	.014
EP * OC	.684	1.099	.302	.032
EP * YAC	.865	1.390	.247	.040
OC * YAC	.084	.135	.716	.004
AI * EP * OC	.495	.796	.379	.024
AI * EP * YAC	.001	.001	.975	.000
AI * OC * YAC	1.055	1.695	.202	.049
EP * OC * YAC	.384	.617	.438	.018

Note. Time point (TP); assigned intervention (AI); educational preference (EP); oncology certification (OC); years administering chemotherapy (YAC), Model df = 1 for every item.

* $p < .05$. ** $p < .01$

Set Two

This hypothesis investigated the adjusted measure of knowledge. A concern arose that the participants were informed that there were only 10 errors in the chemotherapy error SELV. Participants may have guessed at the errors to be sure that they had 10 answers. Therefore, the absolute measure of knowledge may have been positively biased. To control for this, an adjusted measure of knowledge was also used. After each error response, the participants were asked to

rate the certainty of their response from 1-5 where 1 = not certain at all and 5 = very certain. The formula to calculate the adjusted measure of knowledge for each error was:

$K = 0$ if an error is not identified or identified incorrectly. Otherwise $K = \text{certainty}/5$.

Thus, on any error: $K = 0, .2, .4, .6, .8$, or 1

The number of correct answers were adjusted for certainty in the answer.

1. H_0 - SLPs and SELVs education do not differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.
2. H_1 - SLPs and SELVs education do differ in terms of their effectiveness in increasing oncology nurses' short-term (post-intervention) knowledge and long-term (four-week follow-up) knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy.

Descriptive statistics on the adjusted error scores across time points for the assigned learning groups are provided in Table 8. These statistics are unadjusted for the control variables. Neither learning group showed much change in errors scores from pre- to post- intervention. The mean number of errors identified by both learning groups increased from pre-intervention to retention slightly suggesting identification of one additional error. The model reports more accurate mean levels. Therefore, all of the figures show the mean values adjusted for all of the control variables. Figure 7 illustrates the adjusted errors identified by the SLP group as higher than the SELV group over time. Figures 8, 9, and 10 shows the adjusted means of the study

variables of the participant's preferred method of learning, oncology certification, and years of administering chemotherapy. Figure 8 illustrates the adjusted means of the participants preferred method of instruction (SLP or SELV) when controlling for oncology certification and years of administering chemotherapy. Both groups adjusted mean scores increase from pre/post to retention. The SLP group adjusted means were higher than the SELV group means by approximately one error. Both the oncology certified and non-certified participants also had an increase in the adjusted mean scores from pre-, post-, to retention when controlling for learning preference and years of administering chemotherapy as shown in Figure 9. However, the non-certified participant means identified one error more than the certified group. Figure 10 displays the adjusted group means for those with five years or less experience and those with six or more years of experience. When controlling for learning preferences and oncology certification, the participants with six or more years of experience had higher error identification means than the group with five or less years of experience. Overall, improvement in scores was similar across time points for both learning groups.

Table 8

Descriptive Statistics on Adjusted Pre-, Post-, and Retention Error Scores

Variable	SLP (<i>n</i> = 24)		SELV (<i>n</i> = 24)		Overall (<i>N</i> = 48)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre-Score	5.9	1.20	5.3	1.45	5.6	1.35
Post-Score	6.1	1.39	5.9	2.03	6.0	1.72
Retention Scores	6.4	1.20	6.3	1.40	6.3	1.29

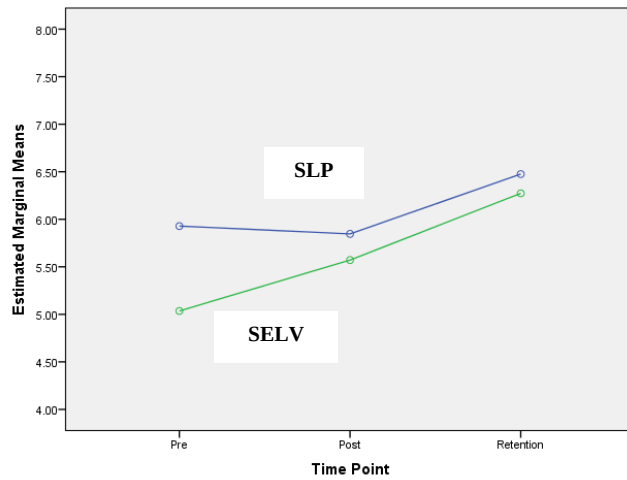


Figure 7. Estimated marginal adjusted error means for assigned learning groups across three time points.

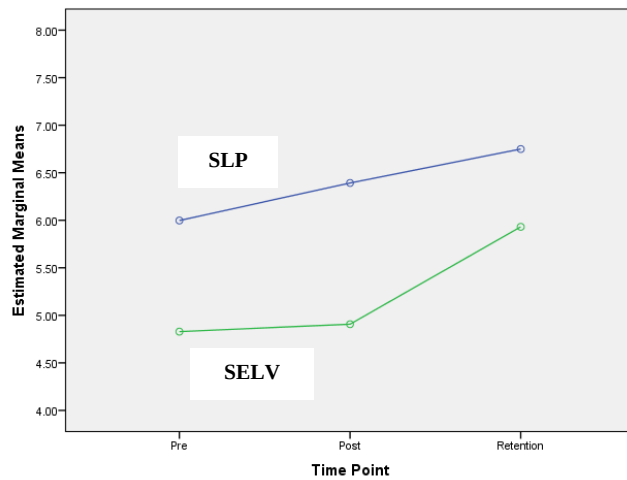


Figure 8. Estimated marginal adjusted means for preferred learning groups across three time points.

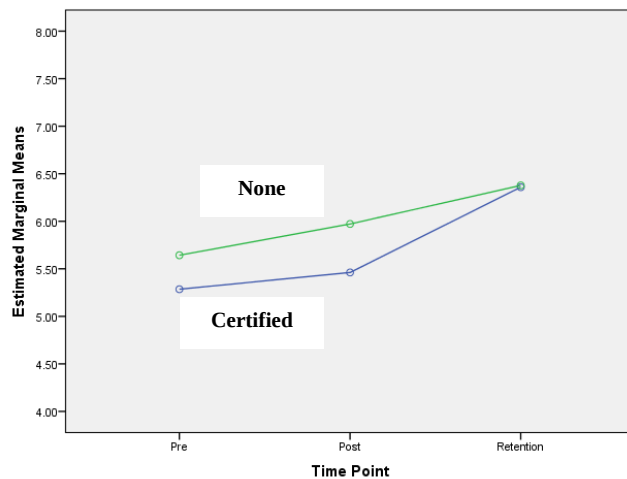


Figure 9. Estimated marginal adjusted means for oncology certification groups across three time points.

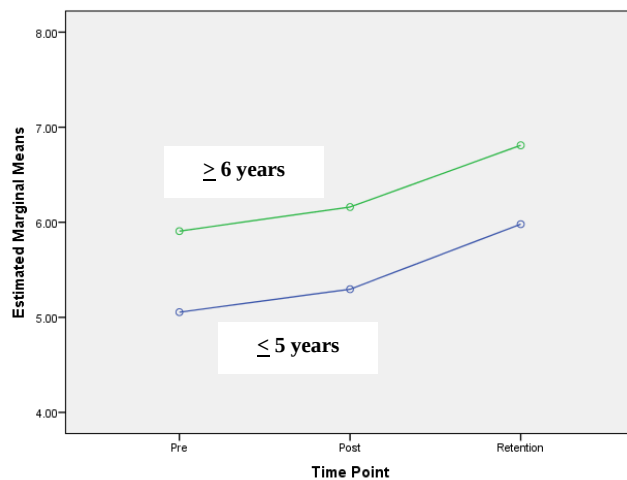


Figure 10. Estimated marginal adjusted means for years of administering chemotherapy groups across three time points.

The same preliminary analyses were conducted on the adjusted continuous variables to ensure there were no violations of the assumptions. Scatter plots indicated no violations, histograms were reasonably symmetrical with slight right-side skewness without large variations, skewness and kurtosis were calculated at <3.0 , and p-p plots appeared to meet normality.

Levine's statistic was not significant for the adjusted pre-error score ($p = .35$), post-error score ($p = .25$), and retention ($p = .09$). The Box's test of equality of covariance matrices was not significant ($p = .26$) and did not violate homogeneity.

A mixed between-within subjects' ANOVA assessed the impact of two different interventions (SLP or SELV) on participants' adjusted scores on chemotherapy errors across three time periods (pre-intervention, immediate post-interventions, and four-week follow-up). Table 9 presents the findings of the interaction effects between the SLP and SELV groups in identifying chemotherapy errors over time. There was no significant interaction effect between the assigned educational interventions and time, Wilks' Lambda = .96, $F(2, 32) = .61$, $p = .55$, partial eta squared = .037. Table 9 also shows that there was no significant interaction effect between the assigned educational interventions and time when controlling for generational learning preference, oncology certification, and years of administering chemotherapy. However, there was a substantial main effect for time, Wilks' Lambda = .78, $F(2,32) = 4.58$, $p = .012$ partial eta squared = .22. Both groups showed an increase in knowledge of chemotherapy errors at the retention.

Table 9

Multivariate Tests for Adjusted Within Interaction and Main Effects

Effect	Wilks' Lambda	F	Model df	Error df	<i>p</i>	Partial Eta Squared
TP	.778	4.576	2	32	.018*	.222
TP * AI	.963	.612	2	32	.549	.037
TP * EP	.965	.586	2	32	.563	.035
TP * OC	.986	.222	2	32	.802	.014
TP * YAC	.996	.061	2	32	.941	.004
TP * AI * EP	.966	.570	2	32	.571	.034
TP * AI * OC	.972	.461	2	32	.634	.028
TP * AI * YAC	.945	.936	2	32	.403	.055
TP * EP * OC	.996	.062	2	32	.940	.004
TP * EP * YAC	.984	.268	2	32	.767	.016
TP * OC * YAC	.956	.741	2	32	.484	.044
TP * AI * EP * OC	.994	.093	2	32	.911	.006
TP * AI * EP * YAC	.998	.035	2	32	.966	.002
TP * AI * OC * YAC	.988	.198	2	32	.821	.012
TP * EP * OC * YAC	.982	.291	2	32	.750	.018

Note. Time point (TP); assigned intervention (AI); educational preference (EP); oncology certification (OC); years administering chemotherapy (YAC).

* $p < .05$. ** $p < .01$.

Table 10 shows that the main effect comparing the two types of educational interventions was not significant, $F(1,33) = 1.36$, $p = .25$, partial eta squared = .039. These findings suggest there was no difference in the overall knowledge level of the two educational interventions. When controlling for oncology certification and years of administering chemotherapy, there was a significant main effect of the adjusted measure of knowledge comparing SLP and SELV preferences $F(1,33) = 5.20$, $p = .03$, partial eta squared = .136. The main effect of the adjusted measure of knowledge comparing years of experience was also significant ($F(1,33) = 5.50$, $p = .03$, partial eta squared = .143) when controlling for learning preference and oncology

certification. However, the main effect of the adjusted measure of knowledge comparing oncology certification status was not significant ($F(1,33) = .82, p = .38$, partial eta squared = .024) when controlling for learning preference and years of administering chemotherapy.

Table 10

Adjusted Between-Subjects Effects

Source	Type III Sum of Squares	F	p	Partial Eta Squared
AI	1.379	1.355	.253	.039
EP	5.292	5.200	.029*	.136
OC	.819	.805	.376	.024
YAC	5.598	5.501	.025*	.143
AI * EP	2.390	2.349	.135	.066
AI * OC	1.191	1.171	.287	.034
AI * YAC	.012	.012	.914	.000
EP * OC	.400	.393	.535	.012
EP * YAC	1.037	1.019	.320	.030
OC * YAC	.234	.230	.634	.007
AI * EP * OC	.238	.234	.632	.007
AI * EP * YAC	.195	.191	.665	.006
AI * OC * YAC	.493	.485	.491	.014
EP * OC * YAC	.001	.001	.970	.000

Note. Time point (TP); assigned intervention (AI); educational preference (EP); oncology certification (OC); years administering chemotherapy (YAC), Model df = 1 for every item.
* $p < .05$. ** $p < .01$.

Chemotherapy Errors

This study also investigated oncology nurses' knowledge of errors that occur during the chemotherapy administration process. Both the absolute and adjusted marginal mean scores indicated that oncology nurses only identified five - six baseline errors with only one additional error identified at retention points. Table 11 highlights the missed errors between groups across time. Results showed that the four most commonly missed errors across the three time points by

both groups and overall errors included omitting: a) verification of the height (82%), b) review of the order to the protocol (73%), c) verification of drug calculations and lab parameters (69%), and d) patient teaching (51%).

Table 11

Chemotherapy Administration Errors Identified Across Time

Error	SLP (<i>n</i> = 24) <i>n</i> (%)			SELV (<i>n</i> = 24) <i>n</i> (%)			Overall (<i>N</i> = 48) <i>n</i> (%)		
	Pre	Post	Retention	Pre	Post	Retention	Pre	Post	Retention
Incomplete Order	19 (79)	18 (75)	19 (79)	16 (67)	16 (67)	17 (71)	35 (73)	34 (71)	36 (70)
Consent	7 (29)	4 (17)	4 (17)	10 (42)	6 (25)	5 (21)	17 (35)	10 (21)	9 (19)
Height & Weight	19 (79)	9 (79)	21 (88)	21 (88)	20 (83)	19 (79)	40 (83)	39 (81)	40 (83)
Drug Calculations/ Labs	17 (71)	18 (75)	17 (71)	18 (75)	14 (58)	15 (63)	35 (73)	32 (67)	32 (67)
Initial Double Check	6 (25)	5 (21)	3 (13)	8 (33)	7 (29)	5 (21)	14 (29)	12 (25)	8 (17)
Bedside Patient ID	3 (13)	3 (13)	3 (13)	3 (13)	8 (33)	9 (38)	6 (13)	11 (23)	12 (25)
PPE	0 (0)	0 (0)	1 (0.4)	2 (0.8)	2 (0.8)	1 (0.4)	2 (0.4)	2 (0.4)	2 (0.4)
IV Verifications	6 (25)	7 (29)	6 (25)	7 (29)	7 (29)	4 (17)	13 (27)	14 (29)	10 (21)
Patient Teaching	12 (50)	12 (50)	10 (42)	15 (63)	15 (63)	9 (38)	27 (56)	27 (56)	19 (40)
Disposal/Waste	2 (0.8)	3 (13)	0 (0)	1 (0.4)	4 (17)	3 (13)	3 (0.6)	7 (15)	0 (0)

Summary

This chapter presented the data and analyses for the demographic variables and research questions. The descriptive statistics reported on the sample and the error scores across time. The mixed-between ANOVA presented findings on the differences in educational interventions between group and time points. Chapter Five presents a summary and discussion of the results, study limitations, implications for practice, and recommendations for future research.

CHAPTER FIVE

DISCUSSION AND IMPLICATIONS

This study used a quasi-experimental longitudinal mixed between-within ANOVA design to examine oncology nurses knowledge of chemotherapy errors and how two self-directed learning (SDL) educational strategies impacted their learning over time. This chapter begins with a discussion about the demographics, data analysis, and research question findings that were highlighted in Chapter Four. The discussion compares and contrasts the study findings to the literature as well as within the context of the theoretical framework. Limitations encountered within the study are presented. Additionally, implications and recommendations provide information for oncology nurses, nurse educators, and administrators. The chapter concludes with suggestions for future research on oncology nurses' knowledge of chemotherapy errors and SDL.

Discussion

Minimal research on oncology nurses' knowledge of chemotherapy administration errors has been reported. Furthermore, the inconclusive empirical evidence on the impact of SDL over time in oncology nurses warrants discussion of this study's findings. This section begins with a review of the demographic data. A discussion on the statistical outcomes for the research question is included. The effectiveness of how Lewin's Planned Change Theory impacts change over time is integrated in this section.

Demographic Variables

The demographic variables used to describe the sample included gender, highest degree, clinical setting, oncology specialty, years in nursing, and years as an oncology nurse. The male gender represented only 2.1% of this study sample ($N = 48$). Although not an exact match due to

the smaller sample size, this closely corresponded with national data from the American Nurses Association (ANA) (2011) that male nurses only account for 6.6% of 3.1 million nurses in the United States. The study demographics showed similar findings related to educational levels. The ANA (2011) reported that 45% of nurses have an associate degree, 34% a baccalaureate degree, and 20% a diploma degree in nursing. This study sample is similar to national trends with 31% having an associate degree, 27% a baccalaureate degree, and 27% a diploma degree.

Demographics also compared inpatient and outpatient settings. The majority of chemotherapy treatments have shifted with nurses administering more chemotherapy on a consistent basis in the outpatient setting (Jacobson, Earle, Price, & Newhouse 2010). This sample was more equitable with 44% inpatient and 56% outpatient. However, half of the healthcare facilities that participated in this study were inpatient and half were outpatient supporting the sample distribution.

Medical oncology nurses represented 88% of this sample. Although more than 1.6 million cancer diagnoses occur annually (American Cancer Society, 2013), only 9% involve hematological malignances (Leukemia & Lymphoma Society, 2013). Therefore, more medical oncology nurses are necessary in the workforce. The demographic distribution of this sample includes more medical oncology nurses supporting the national trends.

Overall years in nursing and as an oncology nurse were collected to describe the sample's work experience. Benner (1994) has suggested that years of experience contribute to expertise in a profession. The nurses in this study practiced on average for 15 years with 10 years of oncology experience. This suggested a higher level of expertise as nurses and oncology nurses.

Additional demographic variables were assessed including age, educational learning preferences, oncology certification, and years administering chemotherapy to control for

variances between subjects in the group samples. The ANA (2011) reported the average age of nurses as 45.5 years with 45% over the age of 50. The average age of this study's sample was 42.7 years, which closely correlated with the national data. Age was also broken into four generational categories: a) Millennial's were ages 24-33 (19%), b) Generation Xer's were ages 34-53 (63%), c) Baby Boomers were ages 54-74 (19%), and d) Veterans were ages 75-94 (0%). This sample was not congruent with national data as there were less Baby Boomers than suggested in the literature.

Demographics also assessed educational learning preferences. Of the nine Millennials, 66.7% ($n = 6$) preferred the self-learning packets (SLP) whereas only 33.3% ($n = 3$) preferred the simulated electronic learning vignettes (SELV). The Generation Xers represented the largest group in the sample with 79.2% ($n = 19$) preferring the SLP and 20.8% ($n = 11$) preferring the SELV. The SLP was preferred by 77.8% ($n = 7$) of the Baby Boomers and only 22.2% ($n = 2$) preferred the SELV. No Veterans were represented in this study sample. Of the 48 participants in this study, 66.7% preferred the SLP over the SELV educational intervention (33.3%). These findings concur with previous studies by Hu et al. (2004) and Walker et al. (2006) that web-based learning was not the preferred method of education across generations.

Oncology certification demographics showed that of the 48 participants, 50% were certified and 50% were not certified. Unfortunately, no national data were reported in the literature or by certification agencies indicating the number of nationally certified oncology nurses to compare to this study's findings. Thus, the findings in this study contribute to the literature and are discussed in the findings section of this chapter.

Although the participant's average number of years as an oncology nurse was 10, half of this study's sample was administering chemotherapy for less than five years. Benner (1984)

upheld that the more experience nurse gains, the more knowledge they retain. Conversely, Choudhry et al. (2005) found that performance decreased with increased years of experience. This will also be discussed more in the findings section of this chapter. The diversity of this sample supported the necessity to control the variables generational learning preferences, oncology certification, and years of administering chemotherapy in the study design.

Research Question Discussion

This study investigated oncology nurses' knowledge of chemotherapy administration errors and KR outcomes of the ASCO/ONS chemotherapy safety standards using SLP and SELV educational approaches. Lewin's Planned Change Theory (1947b) guided this study by suggesting that participants "unfreeze" their mind-set using field theory and group dynamics, "change" processes by applying action research, and "refreeze" a new mind-set regarding safe chemotherapy administration. To measure the outcomes, this study had one research question that measured knowledge in two ways: a) absolute, and b) adjusted.

Two sets of hypotheses were investigated for both measures of knowledge. The null hypothesis stated that the SLPs and SELVs did not differ in terms of their effectiveness in increasing oncology nurses' short term and long term knowledge of chemotherapy administration errors, after controlling for generational learning preferences, oncology certification, and years of administering chemotherapy. The alternative hypothesis stated that the groups differed in terms of knowledge. Both the absolute and adjusted measures of knowledge used the participants number of correct errors identified ranging from 0-10 (0 = no errors identified correctly) to (10 = all errors identified correctly). The following section discusses the analysis of the study findings.

Absolute measure of knowledge. The absolute measure of knowledge used the participants' exact number of correctly identified errors. Using the mixed between-within ANOVA, the null hypothesis was accepted. Although there was a significant increase of knowledge over time for both groups, there was no significant difference between the SLP and SELV groups in terms of learning when controlling for generational learning preferences, certification, and years of administering chemotherapy. Meaning, both groups had an increase in knowledge over time despite the educational group they were assigned.

As reported in Chapter Four, both groups had similar baseline mean scores: the SLP ($M = 6.2$, $SD = 1.21$), and the SELV ($M = 5.8$, $SD = 1.25$). The similarity in the participants' baseline knowledge decreases the variability between the groups. Meaning the similarity at baseline increases the reliability of the post and retention scores. Post-score results revealed a minimal increase in the means of both groups from baseline: the SLP ($M = 6.2$, $SD = 1.02$), and the SELV ($M = 5.9$, $SD = 1.51$). This study also found no increase in overall mean scores from pre- ($M = 6.0$, $SD = 1.24$) to post-test ($M = 6.0$, $SD = 1.29$). The data in this study supports previous research by Durmaz et al. (2012) who reported no significant differences in pre- to post-KR. However, this finding is inconsistent with prior research discussed in Chapter Two. Previous researchers concluded an overall increase in the pre/post means (Considine et al., 2005; Lee et al., 2013; Rufo, 1985; Subbarao et al., 2006; Zhang et al., 2006). Study design and sample may have contributed to the inconsistencies in the results of this study compared to previous research. This study used a mixed between-within ANOVA to examine knowledge over time between two groups. Participants were recruited from several healthcare facilities and randomized to either a SLP or SELV group. Previous research used convenience samples recruited from one facility, one-group designs (either SLP or SELV), and t-tests to measure

pre/post test scores. This study's sample and design decreased variability in the participants, thus providing more rigorous design. However, the differing results when compared with previous research support the need for further SDL studies using two-group rigorous designs.

Although important to examine the pre- post-test mean scores, the four-week follow mean scores indicated the KR outcomes of chemotherapy errors. The retention scores measured the participants KR. According to Lewin (1947b), "refreezing" or crystalizing the knowledge ensures new behaviors are relatively safe from regression. Therefore, the retention mean scores in this study have a greater implication of oncology nurses knowledge of chemotherapy administration errors.

This study found the greatest increase in both groups of mean scores occurring from baseline (SLP $M = 6.2$, $SD = 1.21$; SELV $M = 5.8$, $SD = 1.25$), to retention (SLP $M = 6.5$, $SD = 1.14$; SELV $M = 6.4$, $SD = 1.18$). The overall combined groups mean scores in this study also increased from baseline ($M = 6.0$, $SD = 1.24$) to retention ($M = 6.5$, $SD = 1.18$). This increase suggested an additional one-two errors were identified correctly four weeks following the post-assessment. There was also a substantial significant main effect (Wilks' Lambda = .76, $F(2,32) = 4.95$, $p = .01$, partial eta squared = .24) in the identification of errors over time. These results support Lewin's (1947b) theoretical framework that the participants retained or crystallized knowledge. Results of this study are similar to previous research findings. Tantrarungroj and Lai (2011) indicated no difference in post-test scores between groups, but found a significant increase in the four-week retention scores for two groups. Differing from this study, Tantrarungroj and Lai (2011) lacked baseline scores measuring only post- and retention scores.

Although there was a significant main effect for time points in this study, there was no significant main effect ($F(1,33) = 2.04$, $p = .16$, partial eta squared = .058) between the SLP and

SELV educational groups. Meaning, participants identified more errors over time despite the educational intervention group they were assigned. The results of this study refute previous research. As discussed in Chapter Two, Schwid et al. (1999) reported SELV participants retained more knowledge than the SLP participants. However, compared to this study, Schwid et al. (1999) used a post-test only design and did not measure KR over time.

Results of this study also oppose previous research by Comer et al. (2011) and a pilot study by Vioral (2014). Findings in this study indicated an increase of knowledge across three points in time, whereas Comer et al. (2011) and Vioral (2014) reported a decrease in knowledge over time. One plausible explanation to the contradictory findings is that this study used a more rigorous two-group randomized design with six healthcare facilities. Although Comer et al. (2011) had a large geographically dispersed sample with statistically significant findings, the researchers only examined SELV interventions. Vioral's (2014) pilot study also only measured KR using a SELV intervention with a small under-powered convenience sample from one facility. The variation in the samples and designs of previous research supports the need for further research. Although the results of this study support that oncology nurses retained knowledge across three time points, additional research comparing KR among different types of SDL over time is necessary.

Adjusted measure of knowledge. This study also measured the adjusted measure of knowledge. The adjusted measure of knowledge used the participants' number of correctly identified errors and adjusted for certainty. The concern arose that the participants may have guessed at the errors knowing that there were 10 errors to be identified. This may have positively biased the absolute measure of knowledge. To control for this potential bias, after each error response, the participants were asked to rate their level of certainty of their response

from 1-5 (1 = not certain at all) to (5 = very certain). A formula was used to calculate the adjusted measure of knowledge for statistical analyses. Using the mixed between-within ANOVA, the null hypothesis was also accepted for the adjusted measure of knowledge. There was a significant increase of knowledge over time, but there was no significant difference between the SLP and SELV groups in terms of learning when controlling for generational learning preferences, certification, and years of administering chemotherapy. Meaning, both groups had an increase in knowledge over time despite the educational group they were assigned.

The adjusted mean scores for identified chemotherapy errors were similar to the absolute score results in this study. Both groups had similar adjusted baseline mean scores: the SLP ($M = 5.9$, $SD = 1.20$), and the SELV ($M = 5.3$, $SD = 1.45$). Again, the similarity in the participants' baseline knowledge decreases the variability between the groups. Meaning increased reliability of the post and retention scores. Although both groups had similar baseline knowledge, the baseline adjusted identified errors were one less than the absolute identified errors. Meaning, when the scores were adjusted for certainty, the participants only identified five of the 10 possible errors correctly compared to the six errors identified by the absolute scores. The adjusted post-score results also revealed a minimal increase in the means of both groups from baseline: the SLP ($M = 6.1$, $SD = 1.39$), and the SELV ($M = 5.9$, $SD = 2.03$). The adjusted scores also found minimal increases in overall mean scores from pre- ($M = 5.6$, $SD = 1.35$) to post-test ($M = 6.0$, $SD = 1.72$). These findings corroborate to the previous literature findings discussed in the absolute measurement of knowledge.

The adjusted means like the absolute means also found the greatest increase in both groups of mean scores occurring from baseline (SLP $M = 5.9$, $SD = 1.20$; SELV $M = 5.3$, $SD = 1.45$), to retention (SLP $M = 6.4$, $SD = 1.20$; SELV $M = 6.3$, $SD = 1.40$). The overall combined

adjusted groups mean scores also increased from baseline ($M = 5.6$, $SD = 1.35$) to retention ($M = 6.3$, $SD = 1.29$). This increase suggested an additional one-two errors were identified correctly four weeks following the post assessment. There was also a substantial significant main effect (Wilks' Lambda = .79, $F(2,32) = 4.58$, $p = .01$, partial eta squared = .22) in the identification of errors over time. The adjusted score results also support Lewin's (1947b) theoretical framework that knowledge was crystalized and retained. Although there was a significant main effect for time points in this study, there was no significant main effect ($F(1,33) = 1.35$, $p = .25$, partial eta squared = .039) between the SLP and SELV educational groups. Meaning again that participants identified more errors over time despite the education intervention group they were assigned.

There were no additional findings noted between the absolute and adjusted results. No previously reported research adjusted scores to account for potential bias in responses. Even when the scores were adjusted for certainty, participants identified more errors over time despite the educational intervention group they were assigned. Perhaps scores increased because participants had time from pre-assessment to post- and retention assessments to discuss errors and apply knowledge to their daily practice. The results of this study suggest that both SLPs and SELVs contributed to KR supporting Lewin's theoretical framework that the participants retained or crystallized knowledge. However, oncology nurses were unable to identify all 10 errors. These results significantly contribute to literature and provide implications for oncology nurses, nurse educators, and administrators that are discussed in that section.

Controlling variables. To address variance in the study sample, decrease potential study error, and increase study rigor three independent variables were controlled for in this study: a) generational learning preferences, b) oncology certification, and c) years of administering chemotherapy. As discussed in Chapter One, these demographic variables were selected because

of the assumptions that generational learning preferences, oncology certification, and years of administering chemotherapy may have biased the results. The statistical analyses of these controlled variables are discussed in the following sections.

Generational learning preferences. As discussed in Chapter One, a concern existed that generational learning preferences may impact the study outcomes. Results of the study indicated that 66.7% of the overall participants ($N = 48$) preferred the SLP as the educational intervention. This data supports previous research (Hu et al., 2004; Walker et al., 2006), that web-based learning was not preferred across generations. However, the absolute and adjusted mixed between ANOVA results indicated that when oncology certification and years of administering chemotherapy were controlled, there was a substantial effect between the generational learning preference groups. The main effect of the absolute measure of knowledge comparing SLP and SELV preferences was significant ($F(1,33) = 5.09, p = .03$, partial eta squared = .134). The main effect of the adjusted measure of knowledge was also significant ($F(1,33) = 5.20, p = .03$, partial eta squared = .136). These findings suggested that the participants who preferred the SLP identified at least one-two more errors than the SELV group across time. Although the SLP participants identified more errors over time, the findings indicated that both groups did retain knowledge over time. No other study in the literature reported these findings. Perhaps offering education based on learning preference would improve KR and completion compliance of the learning activity. This has significant implications and recommendations for educators in healthcare facilities that are discussed in the next sections.

Oncology certification. Another assumption discussed in Chapter One was that oncology certification may impact KR. Of the 48 participants, 52.1% were oncology certified in this study. After controlling generational learning preference and years of administering

experience, there was no substantial effect for certification. The main effect of the absolute measure of knowledge comparing certification status was not significant ($F(1,33) = .62, p = .44$, partial eta squared = .018). The main effect of the adjusted measure of knowledge was also not significant ($F(1,33) = .82, p = .38$, partial eta squared = .024). Meaning, there was no statistical difference in the identification of errors despite the participant's certification status.

Certification status did not make a difference on knowledge. A plausible explanation to this finding is that the oncology certification exam validates specialized knowledge in multiple aspects of oncology, not only chemotherapy knowledge. Approximately 20% of the certification exam addresses chemotherapy knowledge (ONCC, 2014). Therefore, these results are not unreasonable. Minimal evidence was located in literature examining the impact of certification on KR. These results differ from previous research (Coleman et al., 2009) that reported significantly higher scores in oncology certified nurse's knowledge of pain. Differing from this study, Coleman et al. (2009) used a post-test only design with a small sample from one facility and only 38% certified nurses. Furthermore, Coleman et al. (2009) studied knowledge of pain not chemotherapy errors. Although this study contributes new findings to the literature, more research is necessary to examine the effect of certification on knowledge over time.

Years administering chemotherapy. An assumption that experiential learning impacts knowledge was also discussed in Chapter One. On average, the participants in this study were administering chemotherapy for 9.5 years and 50% had less than five years chemotherapy experience. The absolute and adjusted mixed between ANOVA results indicated that when generational learning preferences and oncology certification were controlled, there was a substantial effect in the participants with more than six years' experience. The main effect of the absolute measure of knowledge comparing years of experience was significant ($F(1,33) = 8.37, p$

= .01, partial eta squared = .202). The main effect of the adjusted measure of knowledge was also significant ($F(1,33) = 5.50, p = .03$, partial eta squared = .143). These findings suggested that the participants who had more than six years of experience identified at least one-two more errors than those with less than five years' experience. These results corroborate with Benner's (1984) theory that experts have greater knowledge than novices. Meaning that experiential and hands on chemotherapy administration may positively contribute to increased knowledge over time. However, the results of this study refute previous research. Choudhry et al. (2005) conducted a systematic literature review of 59 empirical studies and reported that physician performance decreased with increased experience. Compared to this study, Choudhry et al. (2005) measured performance not knowledge and did not measure KR over time. Therefore, the results of this study provide initial findings that KR may be impacted by years of experience. The need to conduct future research on this variable is warranted.

Chemotherapy discussion. As discussed in Chapter One, 41-50% of chemotherapy related errors occur during administration, followed by 23-38% during dispensing, and 4-21% when ordering or prescribing the agents (Ford et al., 2006; Markert et al., 2009; Rinke et al., 2007). Oncology nurses are instrumental in the chemotherapy administration process, yet literature lacks sufficient evidence of oncology nurses' knowledge of chemotherapy errors. Lewin's Planned Change Theory guided this study by investigating oncology nurses' knowledge of chemotherapy administration errors, educating nurses on the ASCO/ONS chemotherapy safety standards of practice, and re-evaluating their knowledge of errors over time. In step one of this study, the researcher applied Lewin's "unfreezing" stage of the theory by meeting with oncology nurses to discuss chemotherapy errors. Applying the concepts of Lewin's field theory and group dynamics, staff were encouraged to examine their facility policies, procedures,

standards, and errors related to the chemotherapy administration process. The pre-test scores also applied Lewin's theory through an assessment of oncology nurses' baseline knowledge of chemotherapy errors. Using Lewin's concept of action research to "change," participants were randomly assigned to the SLP or SELV educational intervention on the ASCO/ONS Standards in step two of the study. Steps three and four of this study examined the "refreezing" or KR over time by analyzing the post-test and retention scores.

The absolute mean scores of this study indicated that on average oncology nurses only identified 6.0 errors at baseline and post-test, and 6.5 errors four weeks later. The adjusted mean scores indicated that the participants only identified 5.6 errors at baseline, 6.0 errors at post-test, and 6.3 errors four weeks later. Although participant scores increased and retained knowledge over time, nurses were missing an average of four chemotherapy administration errors. These findings suggested that oncology nurses administering chemotherapy omitted four or more safety points in the administration process. Any error with chemotherapy may result in major harm. These results significantly contribute to the literature as the first evidence of oncology nurses' knowledge of chemotherapy errors.

Chapter Four provided the most commonly missed errors in the pre-, post-, and retention scores. Results showed that the four most commonly missed errors across the three points in time included omitting: a) verification of the height (82%), b) review of the order to the protocol (73%), c) verification of drug calculations and lab parameters (69%), and d) patient teaching (51%). Results in this study revealed that 73% of the participants omitted reviewing the order prior to administration. These results concur with previous research (Gandhi et al., 2005; Ranchon et al., 2011) that cited chemotherapy orders as one of the most common errors. Of greater concern, previous research found CPOE the number one solution to decreasing

chemotherapy order errors, yet even with CPOE 20% of errors continued to reach the patient (Serrano-Fabiá et al., 2010). Although this study did not collect data on the types of orders used in the facilities, research supports that if oncology nurses omit this step in the administration process, chemotherapy errors may occur. This may contribute to negative patient outcomes if omitted. With this study reporting that 73% of the nurses' omitted this step in the process, these findings have significant implications. This will be discussed in the next section.

Although 98% of the participants of this study correctly documented weight as an error, an overwhelming 98% did not identify verification of height. Both of these measurements are required to determine chemotherapy dosing. Previous research (Dumasia et al., 2006) reported height and weight as a key element in chemotherapy orders. One plausible explanation for not reporting height as an error may have been an assumption by oncology nurses. Common practice for oncology nurses includes assuming that when weight is completed height is also included. Another possible explanation for the missed height may have been related to the vignettes. Perhaps this was not clearly portrayed in the SELV. However, since this was not documented, the findings suggest that nurses' did not identify height as an error. To complete dosage calculations, both height and weight are necessary.

Omitting dose and lab verifications may also contribute to negative patient outcomes. Previous research (Kim et al., 2006, Voeffray et al., 2006, Small et al., 2008) concluded that omitting verification of the BSA and lab parameters contributed to missing dose modifications and changes in the planned treatment regimens. Findings in this study showed that 69% of the nurses did not report dosage calculations and verification of lab parameters as errors. This combined with 98% missing height measurements, presents alarming findings with significant implications.

The fourth most common omitted error in this study was patient teaching. Although 51% of the participants failed to identify patient teaching, no previous research directly supported or refuted this as contributory to errors. However, anecdotal literature supports that lack of patient teaching on the side effects and potential complications of chemotherapy may lead to negative outcomes (Jacobson et al., 2009; Jacobson et al., 2012; Schulmeister, 2005). Patients should be informed of when to notify providers with side effects and symptom management. These findings also have implications that will be discussed in the next section.

Summary of Results

This section described the sample demographic variables in comparison to national data. Additional demographic variables were described in detail to account for potential variation in the sample. The null hypotheses were accepted for both the absolute and adjusted measures of knowledge over time. Although there were significant increases in knowledge over time, there were no significant differences between the SLP and SELV groups in terms of learning outcomes. Knowledge was also retained despite generational learning preferences, certification, and years of administering chemotherapy. Lewin's theoretical framework guided this study supporting the "unfreezing" of knowledge using the pre-error scores, "change" in knowledge through the assigned educational intervention, and "refreezing" in the post- and retention error scores. The findings revealed four commonly omitted errors in the chemotherapy administration process. Limitations, implications, and recommendations will be discussed in the next sections.

Limitations

Several limitations existed in this study. This study used a mixed between-within repeated-measures ANOVA quasi-experimental design. Although the quasi-experimental design added rigor to the study, the design may have involved recall bias with the pre- and post-test

timing and measurement tool. The SDL design provided participants six weeks to complete the assigned educational intervention. Of the 48 participants, 20.8% ($n = 10$) completed the intervention and post assessment in four weeks, thus the retention data was measured six weeks after the post-assessment. The retention data was collected four weeks after the post-assessment data for 79.2% ($n = 38$) of the participants. To address this concern, participants did not receive feedback on correct or incorrect errors at any point in the study. However, the data collection timing may have contributed to knowledge gains. Participants may have had additional self-study or discussion about the errors impacting the post- and retention scores. During chemotherapy administration, participants may have also had increased awareness of the errors. Future studies should consider extending measurement of KR at four to six weeks. Studies should also measure KR at three months and assess the transfer of knowledge to practice.

Another potential bias was the sample and target population. A retention study was a significant limitation due to the attrition rate. Although this study met the power analysis, there was greater than 30% attrition rate. Larger samples may have yielded different results. Furthermore, the target population was oncology nurses. The educational materials involved chemotherapy errors which cannot be applied in other specialties. Therefore, the findings may only be applied to oncology nurses. Additionally, the sample was also primarily female nurses practicing in medical oncology. A sample with more males and representation from hematological nurses may have strengthened the study's findings. The geographical proximity was another potential study limitation. Although six different facilities were used, they only represented one geographical region.

Only three demographic variables were controlled in this study. This study did not investigate how other variables such as gender, age, highest degree, type of work environment,

and primary oncology specialty may have potentially impacted knowledge retention. Although the type of work environment (inpatient/outpatient) was equally represented in this sample, a limitation was not assessing how much chemotherapy participants administered in a designated time frame. Participants who were exposed and administered chemotherapy more frequently may have biased the results by having a greater knowledge base and application of the standards after completing the pre-test. Another concern involved how the participants viewed the error SELV. For example, if viewed on a small device, participants may not have been able to see the errors as clearly as a larger computer screen. Unfortunately, this study also did not match the pre-, post-, and retention errors of each participant to track which errors they retained over time. Developing an understanding of which errors were retained over time may provide more information for educators to apply in healthcare facilities.

Although content validity and inter-rater reliability was established on the vignettes and the educational interventions, and used in a previous pilot study, the instruments present study limitations. Critics have reported numerous concerns about the lack of reliability and internal validity of these tools. Minimal research has reported reliability or validity on these tools. Furthermore, the time commitment involved to complete the educational interventions may have impacted study participation. Although validated by an expert panel, perhaps the educational interventions and chemotherapy error SELV lacked pertinent information related to chemotherapy administration and errors. Future studies are discussed in the recommendations section.

Implications

The implications of this study's findings corroborate with Lewin's theory of planned change. According to Lewin (1947b), changing behaviors successfully requires commitment and

involvement of everyone. The findings of this study can be used to provide oncology nurses, nurse educators, and administrators with information concerning oncology nurses' knowledge of chemotherapy administration errors and how they learn. These findings include commonly omitted chemotherapy errors by oncology nurses and how they learn and retain knowledge over time using two different SDL methods. Results of this study should be used to standardize chemotherapy administration processes and to develop or redesign educational programs. The following sections discuss implications with suggestions for oncology nurses, nurse educators, and administrators in regards to chemotherapy errors and KR of nurses.

Oncology Nurses' Implications

The results of this study have several implications for oncology nurses. Multiple errors may occur during the chemotherapy prescribing, dispensing, and administration process. Although chemotherapy errors often involve several disciplines, the RN verifies the last safety check prior to the administration of chemotherapy. This underscores the importance of identifying the oncology nurses' knowledge of chemotherapy errors. The results of this study revealed that oncology nurses were able to identify an average of six errors in the process. A significant problem exists when more than 60% of the oncology nurses failed to identify the following errors in the process: validation of the height, review of the order to the protocol, verification of drug calculations and lab parameters, and patient teaching. There were six additional errors less commonly missed across three time points: inadequate consents, double check processes, bedside verification, proper personal protective equipment, improper connections of the chemotherapy, incorrect disposal of the hazardous waste. This clearly has implications for nurses administering chemotherapy. Omitting even one step in the process increases the risk of fatal outcomes. Oncology nurses must first develop an understanding of the

10 evidenced based errors. Disseminating the results of this study through publishing and presentations will increase the nurses' knowledge of these errors. Nurses must develop an understanding of chemotherapy errors to potentially change practice.

Lewin's theoretical framework upholds that nurses must understand the necessity of change. The findings of this study revealed that oncology nurses did not identify key errors in the chemotherapy administration process. Nurses need to understand the risks associated with chemotherapy administration and then evaluate their current practice. For instance, chemotherapy errors may occur more often than reported. Therefore, nurses must report chemotherapy related errors without fear of retribution in a culture of safety. Using peer review to examine errors should create a culture of safety not retribution. During this process nurses should be encouraged to review the error, discuss the process, and examine policies, procedures, standards, and evidence based practice. Nurses must openly discuss the error to examine their practice and make recommendations for system and self-improvement. Nurses should also actively participate in chemotherapy related failure mode and effect analysis (FMEA) quality assessments.

Another implication for practice relates to the need for continuing education and lifelong learning. Assumptions exist that attaining oncology certification implies increased knowledge. However, results of this study found that oncology certification did not impact KR. Assumptions also exist that more experienced nurses have increased knowledge. Although findings of this study indicated that nurses with more experience identified more errors, no nurse identified all 10 errors. This underscores the importance of lifelong learning. Nurses must understand that they have learning needs regardless of their years of experience or certification status. Therefore, disseminating these findings to oncology nurses is imperative to heighten awareness

and address safe practice. Recommendations to involve nurses include discussing this study in a journal club or research council activity. Nurse educators and administrators have a vital role to engage nurses in learning activities. The oncology nurses then must actively engage in processes to change practice.

The final stage of Lewin's theory assesses if "refreezing" or crystallization of a new mindset occurred. The findings of this study assessed crystallization of new knowledge in oncology nurses. The results indicated that both the SLP and SELV methods increased knowledge over time. There were not significant findings that one SDL method increased knowledge over time more than another. Oncology nurses should understand that despite the type of SDL methods provided or their generational age preference, both demonstrated KR. Although the results revealed that the SLP was the preferred method of learning, nurses should understand that learning occurred despite their SDL preference.

Despite learning, certification status, and years of experience, nurses must also understand that continuing education is necessary. Not all of the errors were identified and four significant errors were omitted consistently. Ideally, nurses should be permitted to choose from either method when completing continuing education to potentially increase active engagement in the learning activity. The results of this study revealed that although nurses learned and retained knowledge over time using with SLPs or SELVs, the participants preferred SLPs. Therefore, providing autonomy among the nurses to choose a SDL method may increase compliance in completing the learning activity. Nurse educators and administrators must also share these findings along with developing organizational and educational strategies to change, reinforce, and evaluate best practice.

Educator Implications

The study also has implications for nurse educators. As discussed, the results of this study indicated oncology nurses did not identify all of the high risk steps in the chemotherapy administration process. This warrants further education to ensure that oncology nurses have a sound understanding of the American Society of Clinical Oncology (ASCO) and the Oncology Nursing Society (ONS) chemotherapy safety standards. According to Lewin (1947b), planned change is facilitated through learning. The first phase of this approach involves “unfreezing” the current state or processes. This requires understanding the organization and individual’s current state from within the field and engaging the group’s dynamics to understand the necessity of change. Utilizing Lewin’s concepts of field theory and group dynamics, nurse educators are often in leadership roles to facilitate this change and ‘unfreeze’ current practice.

Nurse educators should assess nurses learning needs related to chemotherapy administration. The data should help educators develop programs addressing safety and practice. Both the Institute of Medicine (IOM) (2014) and Quality and Safety Education for Nurses (QSEN) (2009) also support the necessity for quality and safety in healthcare settings. The IOM (2014) encouraged development of a non-punitive system for reporting and analyzing errors along with establishing interdisciplinary team training programs. QSEN (2009) fostered the development of nurses’ knowledge and skills to improve quality and safety in healthcare. However, research has suggested that nurses underreport chemotherapy errors for fear of retribution (Ford et al., 2006; Markert et al., 2009; Rinke et al., 2007).

One suggestion for nurse educators includes engaging oncology nurses in multidisciplinary processes that examines chemotherapy errors within the organization. Conducting a retrospective review of chemotherapy related errors engages a group to examine

the current state of the organization. Utilizing a FMEA or flow chart approach with a multidisciplinary team also increases awareness by identifying where the breakdown in process occurs that potentially contributes to the errors. This type of intervention promotes a culture of safety as opposed to a punitive environment. Engaging nurses in these types of activities may increase error reporting and facilitate change. This underscores the importance for nurse educators to discuss the results of this study about chemotherapy errors to disseminate the significance of the problem. When nurses understand the necessity for change, they may choose to become more actively involved and committed. Nurse educators must lead these initiatives to engage nurses.

Once nurse educators engage the nurses in “unfreezing” the current state of practice, Lewin (1947b) emphasized the importance of utilizing action based research. This study provided education of the ASCO/ONS standards either using SLP or SELV methodology to introduce change. During times of change, Lewin (1947b) stressed the importance of leaders reinforcing the necessity of change. Suggestions for nurse educators include reviewing the standards at staff meetings, roundtable discussions, or journal clubs to create dialogue about the necessity to implement changes for best practice. Nurse educators must also reinforce to nurses that oncology certification and years of experience does not negate the necessity of lifelong learning. Results of this study revealed KR occurred despite oncology certification and years of experience, but nurses were not able to identify all 10 significant administration errors.

The results of this study revealed that oncology nurses missed common chemotherapy administration errors including checking height with weight, reviewing the order protocol, verifying drug calculations and lab parameters, and completing patient teaching. The other six chemotherapy administration errors were also omitted. Therefore, nurse educators must use

these findings to develop future educational offerings and re-educate nurses. Nurse educators must also reinforce the steps in the chemotherapy administration process by following-up with ongoing education, observing nurses in practice, and continuously reviewing the 10 most common errors.

Lewin (1974b) stressed the importance of measuring the success once the intervention has occurred. This study investigated if oncology nurses use of SLPs versus SELVs increased their KR of the ASCO/ONS chemotherapy standards. As previously discussed, the results of this study indicated an increase in the number of chemotherapy errors identified by oncology nurses across three time points. These findings support Lewin's theory that "refreezing" occurred and sustained over time. More importantly, the results of this study showed that despite the assigned group and learner preferences, knowledge was attained and retained. Although both SLPs and SELVs have emerged as the most common educational methodologies in healthcare, the results of this study suggest that both types of SDL are effective in increasing knowledge. These findings have significant implications for educators.

The changing healthcare environment challenges educators to stay innovative when using approaches to education. Therefore, it is crucial to develop effective education for nurses without making assumptions about how nurses learn. Furthermore, measuring outcomes to ensure a change occurred, demands the development of effective education materials. The findings of this study have implications for design and delivery of education for professional practice. Nurse educators often use online learning with enhanced flexibility structured to meet the needs of healthcare. However, the findings showed that nurses retained knowledge despite the type of SDL they were assigned. Furthermore, the results indicated that learners preferred SLP despite their generational learning preference. This study supports the effectiveness of both

SLPs and SELVs when developing educational materials. Based on these findings nurse educators should consider offering both methods as options for nurses to complete educational requirements. Ongoing educational programs should be offered using both methods to promote learning autonomy among nurses. Perhaps if nurse educators avoid making assumptions about learning and provide options to meet staff diversity and preferences, compliance and learning outcomes may increase.

Evaluating the re-crystallization of knowledge and change often requires more frequent education and follow-up. Kirkpatrick and Kirkpatrick (2006) stressed the importance of measuring knowledge beyond the immediate education. The results of this study indicated that despite increased KR, nurses missed key errors in chemotherapy administration. The study did not examine application of knowledge in practice or KR of the ASCO/ONS chemotherapy safety standards at prescribed intervals over time. Therefore, nurse educators should use these findings to develop ongoing educational initiatives and follow-up on safe administration of chemotherapy. Nurse educators often develop programs and follow-up, but lack reporting the measureable outcomes. Suggestions for measuring outcomes include reevaluating knowledge at selected intervals after the initial education. For instance at three, six, nine, and 12 month intervals. This reevaluation may involve post-tests, onsite observations, competencies, or focus groups to assess KR. Offering nursing education balanced with employer constraints presents ongoing challenges for educators. Administrators must engage and support the potential additional resources required for follow up assessment.

Administrator Implications

The study's findings should also be considered from an administrative perspective. Nurse administrators hold great potential to shape their facilities. According to Lewin (1947b),

administrative leaders play key roles in establishing the climate and culture of organizational change. Lewin contested that merely changing individual behavior would not occur if they were constrained by group pressure. Previous research (Adams & McNicholas, 2007) contented that robust stakeholder engagement facilitates the “unfreezing” of the current state. Therefore, administrators must actively engage in “unfreezing” the current state within their organizations by understanding the ASCO/ONS standards and reviewing organizational policies, procedures, and processes for chemotherapy.

Although this study revealed KR occurred, errors were not identified during chemotherapy administration. Administrators must also understand that the results of this study indicated that oncology nurses missed identifying errors in the chemotherapy process that may significantly impact patient outcomes. This underscores the importance for administrators to create a culture of safety. Suggestions for administrators include participating in multidisciplinary meetings, engaging in the FMEA team, and monitoring facility chemotherapy related errors. For example, administrators can support the development of a team to prospectively review near misses and errors related to chemotherapy. Womer et al. (2002) reported that establishing a culture of safety with sustained improvement requires a long term commitment that must be supported by administrators. Active involvement of administrators engaging in the multidisciplinary team fosters nursing empowerment to initiate change.

Administrative leaders are also key role models for nurses and nurse educators. Education should not involve a one-time program without measuring outcomes. Adequate resources must be allocated for nurse educators to develop programs using both SLPs and online methods to offer nurses. Administrators cannot make assumptions that certified nurses and

nurses with more years of experience have more knowledge that does not require additional education. Administrators must support initiatives for lifelong learning.

Administrators not committed to providing resources may experience decreased safety and negative patient outcomes. Therefore, administrators must recognize the problem, mobilize the group, see the need for change, and create a shared vision for change. These examples require investment and resources with administrative support that hold staff accountable for noncompliance to standards of practice. Without attention and support by administrators, “refreezing” or sustainable change may not occur.

Recommendations

Several recommendations can be made to explore future research. First, it is important to state that no other study has investigated oncology nurses’ knowledge of chemotherapy administration errors. Therefore, the results contribute to the literature, but are presumptuous and warrant future research. Several research studies have examined learning outcomes using either SLP, SELV, or comparing SDL to traditional classroom education. The majority of previous research has also involved pre- post-test or post-test only designs. This study is the first to investigate how two different SDL interventions impact knowledge over time. Therefore, comparisons from previous literature in regards to the findings are innovative and warrant future research.

The current study identified that oncology nurses effectively retained knowledge of the ASCO/ONS chemotherapy safety standards across three time points using SLPs and SELVs methods. This is the only study comparing two different types of SDL methods to measure KR across time. Since the results were statistically significant for time, yet insignificant for

methods, additional studies are recommended. As new SDL methods emerge, future studies should measure KR using multiple types of SDL methods.

Although SLP and online learning have become increasingly popular in healthcare, studies should investigate the impact of these methods on performance. Kirkpatrick and Kirkpatrick (2006) recommended measuring outcomes at four levels: reaction, learning, transfer, and results. This study did not measure satisfaction or reaction with the methods. The results of this study indicated a preference for SLPs, but future studies should explore staff satisfaction with technology and written materials. Although this study examined immediate and four-week post retention, future research should measure knowledge at three-month, six-month, and one-year intervals. Studies should also explore the transfer of knowledge in the practice setting such as observational studies to measure compliance and adaptation of the standards. Qualitative or mixed-method studies should identify factors that facilitate or impede the transfer of knowledge.

This study also did not investigate the impact on patient outcomes. Therefore, future recommendations include conducting studies that retrospectively and prospectively examine chemotherapy near misses and errors pre- and post- education. Future studies should also track specific chemotherapy errors related to computerized physician order entry (CPOE). Additionally, a cost-benefit analysis to assess the return on investment using SLP and SELV materials is also warranted. Since both SLPs and SELVs were effective in KR, examining the cost of materials and resources necessary for the development, implementation, and evaluation of both methods may assist educators and administrators in future planning.

The current study only assessed oncology nurses' knowledge of chemotherapy errors in a specific geographical region. Although six different facilities were used, future studies should include larger areas and compare how different regions may potentially retain knowledge using

these interventions. A multi-site study encompassing a larger geographical area may yield a more diverse sample for comparison. Although chemotherapy administration is a multi-disciplinary process, the target population for this study was oncology nurses. Examining knowledge of chemotherapy errors with physicians and pharmacists may contribute additional findings to the literature. The findings of this study may only be applied to oncology nurses. Therefore, future research should replicate this study in other specialties or provide general mandatory education for nurses to assess KR and expand to other disciplines.

Only three selected demographic variables (generational learning preferences, oncology certification, and years of administering chemotherapy) were controlled for in this study. These and other variables of the learning environment require further examination. Investigating how other variables such as age, highest degree, type of work environment, and how often they administer chemotherapy in a designated time frame is warranted. Studies exploring the relationships, predictability, and variability among selected demographic variables may also provide additional findings contributing to KR.

Although this study identified commonly omitted chemotherapy errors in the administration process, the study did not match the pre-, post-, and retention errors of each participant to track which errors each participant retained over time. Gathering more data in future studies of which errors were retained over time by each participant may provide more information for educators to apply in follow-up educational initiatives. Providing participants with feedback on their responses is also recommended.

Conclusions

This study sought to add to the body of knowledge regarding oncology nurses knowledge of chemotherapy errors using two SDL methods. Results of the study indicated that knowledge

was retained across three points in time despite the type of SDL provided. Furthermore, the findings revealed that learning occurred despite participant learning preferences. Additional findings revealed that oncology nurses only identified six of the 10 common chemotherapy administration errors. These findings lead to numerous nursing, educator, and administrative implications regarding chemotherapy errors and learning. Nurses need specific education related to chemotherapy administration regardless of their age, certification, or years of administering chemotherapy. The findings also supported Lewin's planned theory of change showing that "unfreezing" current practice using a pre-error SELV and providing robust education using SLPs or SELVs to impact "change" lead to "refreezing" or KR. Despite limitations of this study, the strength lies in the use of a rigorous design that addressed many of the flaws evident in previous research. This study provided results that contribute to the goal of quality improvement in healthcare and offered educator's findings to consider when designing quality educational programs in healthcare settings.

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APPENDIX A

Sample Cooperating Institution Letter of Approval

[Institutional Letterhead]

Date:

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research titled 'Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies'. I understand what she is asking of the individuals and grant her permission to conduct her study at [insert name of facility]. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide to my office a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at any time, I understand that I can contact Anna at (412) 956-1674 or via email at lwmq@iup.edu

For any questions or concerns regarding this agreement, please contact me at XXXXXXXX.

Sincerely,

Signature of facility leader

Date/Time

Printed name of faculty leader

APPENDIX B

Cooperating Institution Letter of Approval Regional Cancer Center



July 29, 2013

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research titled "Chemotherapy and Targeted Therapy Standards of Practice". I understand what she is asking of the individuals and grant her permission to conduct her study at The Regional Cancer Center. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide to my office a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at anytime, I understand that I can contact Anna at 412-956-1674 or via email at AVIORAL@wpahs.org

For any questions or concerns regarding this agreement, please contact me at 814-838-0431.

Sincerely,



Sarah C. Kaveney MSN RN OCN NEA-BC
Director of Clinical Operations

APPENDIX C

Cooperating Institution Letter of Approval Saint Vincent Health Center

SAINT VINCENT HEALTH CENTER
232 West 25 Street
Erie, Pennsylvania 16544
814/452-5000



July 31, 2013

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research entitled "Chemotherapy and Targeted Therapy Standards of Practice." I understand what she is asking of the individuals and grant her permission to conduct her study at Saint Vincent Hospital. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide my office with a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at any time, I understand that I can contact Anna at (412) 359-4408 or via email at avioral@wpahs.org.

For any questions or concerns regarding this agreement, please contact me at (814) 452-5866.

Sincerely,

Brenda Maroglio, MSN RN Director Medical-Surgical
services

Signature of facility leader and Title

Brenda Maroglio, MSN, RN

Printed name of facility leader

July 31st, 2013

Date

APPENDIX D

Cooperating Institution Letter of Approval St. Clair Hospital



1000 Bower Hill Road | Pittsburgh, PA 15243 | tel 412.942.4000 | www.stclair.org

Date: 8/1/2013

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research titled Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies. I understand what she is asking of the individuals and grant her permission to conduct her study at St. Clair Hospital. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide to my office a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at anytime, I understand that I can contact Anna at 412-956-1674 or via email at AVIORAL@wpahs.org.

For any questions or concerns regarding this agreement, please contact me at 412-942-5065.

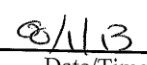
Sincerely,



Signature of facility leader and Title

Joan Massella, CNO, St. Clair Hospital

Printed name of facility leader



Date/Time

8/1/2013

APPENDIX E

Cooperating Institution Letter of Approval Jefferson Regional Medical Center



Date: August 1, 2013

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research titled Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies. I understand what she is asking of the individuals and grant her permission to conduct her study at Jefferson Regional Medical Center. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide to my office a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at anytime, I understand that I can contact Anna at (412) 956-1674 or via email at lwmq@iup.edu.

For any questions or concerns regarding this agreement, please contact me at (412) 469-7060.

Sincerely,

A handwritten signature in black ink, appearing to read "Richard F. Collins", written over a horizontal line.

Signature of facility leader and Title

8/1/2013

Date/Time

Dr. Richard F. Collins

Printed name of facility leader

P.O. Box 18119
Pittsburgh, PA 15236-0119
412-469-5000
jeffersonregional.com

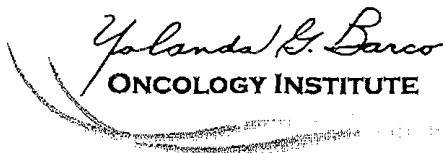
APPENDIX F

Cooperating Institution Letter of Approval Meadville Medical Center

08-02-'13 10:55 FROM-YGB Oncology Inst

814-373-2338

T-761 P0002/0002 F-987



Date: July 31, 2013

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research titled *Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self Directed Learning Strategies*. I understand what she is asking of the individuals and grant her permission to conduct her study at Yolanda G Barco Oncology Institute of Meadville Medical Center. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide to my office a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at anytime, I understand that I can contact Anna at (412) 359-4408 or via email at anna.vioral@alleghenyhealthnetwork.com.

For any questions or concerns regarding this agreement, please contact me at 814-373-2335.

Sincerely,

A handwritten signature in cursive that appears to read "Calvin Han".

Calvin Han, M.D.
Medical Director of Research and Professional Development
Yolanda G Barco Oncology Institute
Meadville Medical Center
July 31, 2013

APPENDIX G

Cooperating Institution Letter of Approval Sharon Regional Cancer Center

SHARON
REGIONAL
HEALTH
SYSTEM



August 2, 2013

RE: Cooperating institution letter of approval

I have reviewed Anna Vioral's research protocol, including any letters of consent, for her research titled "Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies". I understand what she is asking of the individuals and grant her permission to conduct her study at Sharon Regional Health System Cancer Care Center. I have the authority to do so.

I understand Anna is seeking Institutional Review Board (IRB) approval from Indiana University of Pennsylvania. She has agreed to provide to my office a copy of the IRB approval letter received from Indiana University of Pennsylvania before she recruits participants at our facility.

If I have any further questions about this research study at any time, I understand that I can contact Anna at 412-956-1674 or via email at AVIORAL@wpahs.org.

For any questions or concerns regarding this agreement, please contact me at 724-983-3801.

Sincerely,

Lisa Bertolasio, RN, BSN, MS, CDE
Vice President of Patient Care Services
Chief Nursing Officer

Advanced Wound Recovery Center
Bariatric Surgery
Behavioral Health Services
Brain Attack/Stroke Team
Breast Care Center
Cancer Care Center
Center for Digestive Diseases
Corporate Health Services
Diabetes Center
Diagnostic & Imaging Center
Ear, Nose, Throat & Hearing Center
Family Medicine Centers
Heart & Vascular Institute
Home Health Agency
Hospice/Palliative Care
Hospital
Inpatient Rehab Unit
Interventional Pain Management
Physician Services
Rehabilitation Services
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John R. Janoso, Jr.
President and
Chief Executive Officer

A Smoke/Tobacco
Free Facility

John R. Janoso, Jr.
President and CEO

8/5/2013 10:40 a.m.
Date/Time

APPENDIX H

IUP IRB Letter of Approval



Indiana University of Pennsylvania

www.iup.edu

Institutional Review Board for the
Protection of Human Subjects
School of Graduate Studies and Research
Stright Hall, Room 113
210 South Tenth Street
Indiana, Pennsylvania 15705-1048

P 724-357-7730
F 724-357-2715
irb-research@iup.edu
www.iup.edu/irb

August 30, 2013

Anna Vioral
185 Lager Drive
Gibsonia, PA 15044

Dear Ms. Vioral:

Your proposed research project, "Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies," (Log No. 13-167) has been reviewed by the IRB and is approved as an expedited review for the period of August 30, 2013 to August 30, 2014.

It is also important for you to note that IUP adheres strictly to Federal Policy that requires you to notify the IRB promptly regarding:

1. any additions or changes in procedures you might wish for your study (additions or changes must be approved by the IRB before they are implemented),
2. any events that affect the safety or well-being of subjects, and
3. any modifications of your study or other responses that are necessitated by any events reported in (2).

Should you need to continue your research beyond August 30, 2014 you will need to file additional information for continuing review. Please contact the IRB office at (724) 357-7730 or come to Room 113, Stright Hall for further information.

Although your human subjects review process is complete, the School of Graduate Studies and Research requires submission and approval of a Research Topic Approval Form (RTAF) before you can begin your research. If you have not yet submitted your RTAF, the form can be found at <http://www.iup.edu/page.aspx?id=91683>.

This letter indicates the IRB's approval of your protocol. IRB approval does not supersede or obviate compliance with any other University policies, including, but not limited to, policies regarding program enrollment, topic approval, and conduct of university-affiliated activities.

I wish you success as you pursue this important endeavor.

Sincerely,

A handwritten signature in blue ink, appearing to read 'J. Mills', with a long horizontal flourish extending to the right.

John A. Mills, Ph.D., ABPP
Chairperson, Institutional Review Board for the Protection of Human Subjects
Professor of Psychology

JAM:jeb

Cc: Dr. Kristy Chunta, Dissertation Advisor
Ms. Brenda Boal, Secretary

APPENDIX I

Participation Confirmation Email

Dear _____,

My name is Anna Vioral and I am presently seeking participation in my dissertation research. I am attending Indiana University of Pennsylvania (IUP) in the Department of Nursing and Allied Health Professions. I am conducting a quasi-experimental study on chemotherapy errors and knowledge retention in oncology nurses.

We had spoken a few weeks ago about the possibility of recruiting participants from [*insert name of facility here*]. I am pleased to inform you that I have received Intuitional Review Board (IRB) approval from IUP to proceed with my study. If you remain interested in participating, I would like to set up times to speak with your staff to describe the study and obtain consents from interested participants.

I have attached a flyer to post in your area(s) to promote the study as well as an invitational email should you wish to proceed in the study.

Please notify me by replying to this email as to whether you wish to proceed or not proceed with the study.

If you wish to participate in the study, please notify me with dates and times that I may come to speak with your staff. I would also be appreciative if you would please post this promotional flyer and forward the attached invitational email to your staff.

I appreciate your interest and support and look forward to completing my study with your healthcare facility to advance the science of oncology nursing!

Sincerely,

Anna Vioral
PhD Candidate
Indiana University of Pennsylvania

APPENDIX J

Invitational Email

Study Title: Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies

My name is Anna Vioral and I am completing my dissertation at Indiana University of Pennsylvania in the Department of Nursing and Allied Health Professions.

I am conducting quantitative research on the American Society Clinical Oncology (ASCO) and Oncology Nursing Society (ONS) national standards for chemotherapy administration. You are invited to participate in the study if you are a registered nurse competent in the administration of chemotherapy per the organizations employment requirements.

The purpose of this study is to determine if oncology nurses' use of self-learning packets (SLPs) or simulated e-learning vignettes (SELVs) increases their knowledge of the ASCO and ONS chemotherapy safety standards.

If you decide to participate in this study, you will have access to either the SLPs and/or the SELVs in your work designated areas or at home using a learning management system (LMS) via the computer.

- You will have two weeks to complete the demographic questionnaire and a chemotherapy administration error SELV to identify administration errors. While viewing the video, you will be asked to write down the errors you identified in the chemotherapy administration process and your level of certainty for each response. You will enter your responses into the LMS upon completion of the vignette. Completion time will be approximately 30 minutes.
- After two weeks, that vignette will be removed from access.
- Next, you will have six weeks to complete either seven SLPs **or** seven SELVs at your own pace. You will be randomly assigned to one of the groups. The SLPs and SELVs provide you with the education on the new ASCO and ONS standards as a review of current best practice. After each section of the SLP or end of each SELV, you will complete post-assessment questions. These are not graded. Completion time for the SLP is about 12-16 hours, and approximately 4 hours for the SELV.
- After six weeks those modules will be closed for access. You will then have 10 days to repeat the SELV to identify administration errors. While viewing the video, you will be asked to write down the identified errors in the chemotherapy administration process and to enter your responses into the LMS upon completion of the vignette. Completion time will be approximately 30 minutes.

Your research participation allows the investigator to use your scores from completing the pre-assessment, SLP/SELV, post-assessment, and additional SELV 4 weeks after the final vignette and entering your responses into the LMS.

If you consent to the research you will be asked to return four weeks after the post-vignette to once again view the simulated EL administration error vignette module to identify administration errors. Completion time will be approximately 30 minutes. You will have 10 days to log into the LMS to view the error SELV and enter the identified errors. The researcher will remind you when the SELVs will be re-opened for completion along with additional reminders via email on several occasions. You will enter the LMS with your employee number and confidentiality will be maintained. I will be the only person who has access to your data which will be maintained in a locked filing cabinet.

Upon completion of **ALL** the components of the study, the SLP and SELV group participants will be entered into a random drawing for a \$50.00 gift cards. Two participants from the SLP group and two participants from the SELV group will be randomly drawn for one \$50.00 gift card each.

Participants who complete all components of the study will also receive continuing education (CEs) (12 CEs for the SLP and 4.5 CEs for the SELV)

Thank you very much for your time and consideration.

If you are interested in participating I will be attending staff meeting in the next few weeks, or you may reply to me by email at lwmq@iup.edu to obtain consent.

Thank you very much for your time and consideration

Sincerely,

Anna Vioral MSN, MEd, RN, OCN
PhD Candidate
Indiana University of Pennsylvania
Department of Nursing and Allied Health Professions
1010 Oakland Avenue
248 Johnson Hall
Indiana, PA 15705
412-956-1674
lwmq@iup.edu

ONCOLOGY NURSES

**Do you administer Chemotherapy and/or
Targeted Therapy?**

Chemotherapy and Targeted Therapy Standards of Practice

New Best-Practice Standards Coming Soon



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HYPERSENSITIVITY/ANAPHYLACTIC PROTOCOL

EXTRAVASATION

MONITORING AND ASSESSMENT

SAFE HANDLING

MEDICAL EXPOSURE



Interested in an exciting upcoming Research Study?

**Contact Anna Vioral for more details
412-956-1674 or lwmq@iup.edu**

APPENDIX L

Invitation to Participate in Study

Study Title: Examining Oncology Nurses' Knowledge of Chemotherapy Errors Using Two Self-Directed Learning Strategies

You are invited to participate in this quantitative research on the American Society Clinical Oncology (ASCO) and Oncology Nursing Society (ONS) national standards for chemotherapy administration. The following information is provided in order to help you to make an informed decision whether or not to participate. If you have any questions please do not hesitate to ask. You are eligible to participate because of your experiences with chemotherapy administration. This is not a treatment study.

Purpose

The purpose of this study is to determine if oncology nurses' use of self-learning packets (SLPs) or simulated e-learning vignettes (SELVs) increases their knowledge of the ASCO and ONS chemotherapy safety standards.

Your research participation allows the investigator to use your scores from completing a pre-assessment, SLP/SELV, post-assessment, and additional SELV 4 weeks after the final vignette and entering your responses into a learning management system (LMS).

Procedures

You will be asked to:

1. Watch a video vignette (SELV) on chemotherapy administration principles.
 - a. Log into the LMS using your employee number.
 - b. Identify errors in the administration process while viewing the video.
 - c. **Please focus on chemotherapy administration related errors while viewing this vignette.**
 - d. You will only be able to access the error vignette once.
 - e. After viewing, you will enter your errors and rate your level of certainty on a scale from 1 (not certain) to 5 (very certain) of your response.
 - f. You will need 30 minutes to complete the components of step one.
 - g. You will have two weeks to complete the SELV and receive frequent email reminders for completion.
2. Complete a demographic questionnaire via the Learning Management System (LMS).
3. Complete seven additional educational SLPs **or** seven SELVs within a six week time frame.
 - a. You will be randomly assigned to a group (SLP or SELV).
 - b. After each packet or video, you will complete post-assessment questions. These are not graded.
 - c. You will receive frequent email reminders for completion.

- d. At the end of the sixth week, the SLPs will be returned and the SELVs will be closed for access.
4. For the immediate post-assessment.
- a. Log into the LMS using your employee number.
 - b. View the same chemotherapy error SELV.
 - c. You will be asked to identify errors in the administration process while viewing the video.
 - d. **Please focus on chemotherapy administration related errors while viewing this vignette.**
 - e. You will only be able to access the error vignette once.
 - f. After viewing, you will enter your errors and rate your level of certainty on a scale from 1 (not certain) to 5 (very certain) of your response.
 - g. You will need 30 minutes to complete the components this step.
 - h. You will have 10 days to complete the SELV and receive frequent email reminders for completion.
5. Four weeks after the completion of the post-assessment.
- a. Log into the LMS using your employee number.
 - b. View the same chemotherapy error SELV.
 - c. You will be asked to identify errors in the administration process while viewing the video.
 - d. **Please focus on chemotherapy administration related errors while viewing this vignette.**
 - e. You will only be able to access the error vignette once.
 - f. Complete two demographic questions at the end of this SELV in the LMS.
 - g. You will need 30 minutes to complete the components of this step.
 - h. You will have 10 days to complete the SELV and receive frequent email reminders for completion.

The researcher will remind you when the SELVs will be re-opened for completion via email or phone.

Your total length of time for participation in the study is not expected to last more than 20 hours for the SLP or 10 hours for the SELV.

Upon completion of the study, participants may contact the researcher to review their scores and identified errors.

Also, any participant who was assigned to the SLP will have the opportunity to view the SELVs on work time.

Benefits

You may find the experience informative. The information gained from this study may help to better develop and analyze standards of practice to safely order, administer, and handle chemotherapy agents with competent staff. The findings of the study can be used to direct

further research on quality performance improvement and assist other facilities in the development and implementation of the recommended national standards.

Risks

There are no known risks or discomforts associated with this research. Your participation in this study is voluntary. You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators. Your decision will not result in any loss of benefits to which you are otherwise entitled. If you choose to participate, you may withdraw at any time by notifying the researcher. Your supervisor will not be made aware of your participation. Upon your request to withdraw, all information pertaining to you will be destroyed. If you choose to participate, all information will be held in strict confidence and will have no bearing on your employment services you receive from the System. Your response will be considered only in combination with those from other participants. The information obtained in the study may be published in scientific journals or presented at scientific meetings but your identity will be kept strictly confidential.

Costs

There is no cost to you and you will not be paid for your participation. All research participants from each participant group who completes the pre-test, post-test, 4-week follow-up test, and demographic questionnaire in entirety will be entered into a random drawing for a \$50.00 gift card. (two for the SLP group and two for the SELV group). Participants who complete all components of the study will also receive continuing education (CEs) (12 CEs for the SLP and 4.5 CEs for the SELV)

Principle Investigator Information

If you are willing to participate in this study, please sign the statement below and return to me personally, via email at lwmq@iup.edu or when I am visiting your facility. Keep the extra unsigned copy with you. If you choose not to participate, please return the unsigned copies via email at lwmq@iup.edu

Student of Indiana University of Pennsylvania

Department of Nursing and Allied Health Professions
Ms. Anna N. Vioral
Indiana University of Pennsylvania
1010 Oakland Avenue
248 Johnson Hall
Indiana, PA 15705
724-357-3269

Associate Professor of Indiana University of
Pennsylvania
Nursing and Allied Health Professions
Dr. Kristy Chunta
Indiana University of Pennsylvania
1010 Oakland Avenue
233 Johnson Hall
Indiana, PA 15705
724-357-2408

This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

VOLUNTARY CONSENT FORM:

I have read and understand the information on the form and I consent to volunteer to be a subject in this study. I understand that my responses are completely confidential and that I have the right to withdraw at any time. I have received an unsigned copy of this informed Consent Form to keep in my possession.

Name (PLEASE PRINT)

Signature_____ **Date**_____

Name of your Facility_____

Phone Number_____

Email_____

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participating in this research study, have answered any questions that have been raised, and have electronically received the above signature.

_____ Signature of subject	_____ Date/Time
-------------------------------	--------------------

_____ Printed name of subject

_____ Investigator Signature	_____ Date/Time
---------------------------------	--------------------

APPENDIX M

Standards of Practice for SLP and SELV

1. Introduction
 2. Planning, Consent, Education, Patient Treatment Summary
 3. Ordering and Administration
 4. Hypersensitivity and Anaphylaxis
 5. Extravasations
 6. Monitoring and Assessment
 7. Safe Handling HCP
-

APPENDIX N

Registered Nurse Pre-Assessment Demographic

Survey Instructions

The self-assessment survey will take approximately 15 minutes to complete. Please open and complete this demographic survey.

Part I: Demographics

Please select the best response.

1. What is your age?
_____ (write-in)
2. What is your gender?
☐ Female ☐ Male
3. How many years have you been a nurse?
_____ (write-in)
4. How many years have you been an oncology nurse?
_____ (write-in)
5. How many years have you been administering chemotherapy agents?
_____ (write-in)
6. Which credentials through the Oncology Nursing Certification Corporation (ONCC) do you hold (choose all that apply)?

☐ OCN [®]	☐ AOCN [®]	☐ CPON [®]	☐ AOCNP [®]
☐ AOCNS [®]	☐ CBCN [®]	☐ CPHON [®]	☐ None
7. What is your highest completed nursing degree?

☐ Diploma	☐ Associate	☐ Baccalaureate	☐ Master's
☐ PhD	☐ DNP	☐ RN to BSN	☐ RN to MSN
☐ Post Masters Certificate	☐ Other Please Specify _____		

8. Which is your primary work environment?

- ☐ In-patient ☐ Out-patient

9. What is your primary oncology specialty?

- ☐ Medical Oncology ☐ Hematology-Oncology ☐ Stem Cell Transplant
☐ Surgical Oncology ☐ Home Care ☐ Radiation Oncology
☐ Other Please Specify _____

These two additional questions will be completed at the completion of the 4-week follow-up SELV.

Part II: Demographics

Please select the best response.

1. Which week did you complete the SLP or SELV in entirety?

- ☐ Week 1 (date will be here) ☐ Week 2 (date will be here)
☐ Week 3 (date will be here) ☐ Week 4 (date will be here)
☐ Week 5 (date will be here) ☐ Week 6 (date will be here)

2. If you could have picked the educational intervention, which method would have you chosen?

- ☐ Self-Learning Packet (SLP) ☐ Simulated EL Vignettes (SELV)

APPENDIX O

Email Correspondence for LMS Licenses

This was email from the STAR Center on July 2, 2013:

>From: Dona Marie Wilfong
>
> Sent: Tuesday, July 02, 2013 6:55 AM
>
> To: Anna Vioral
>
> Subject: RE: License inquiry
>
>
> HI Anna: I spoke with John and he is working on creating
>an account under STAR that will enable you to have I
>believe 100 licenses free of charge. When do you need
>these by? Thanks and I hope you are well and have a nice
>holiday. I will wait to hear from you. Best: Dona

This was email from the STAR Center on July 17, 2013:

>From: Sue Lebanik
> Sent: Wednesday, July 17, 2013 9:05 AM
> To: Anna Vioral
> Cc: 'susan.frank@highmark.com'; Dona Marie Wilfong
> Subject: License inquiry
>
> Good morning Anna, STAR has signed the agreement
>establishing permission for you to use 100 licenses
>through Healthstream for a period of 8 months. We wish
>you luck with your research project and if there is
>anything else you need please let us know.

APPENDIX P

Email with LMS Link for Participants

Dear _____

Thank you again for consenting to participate in my research study.

This email provides you with the instructions to access the [chemotherapy errors SELV/educational intervention SELV] via the learning management system (LMS).

DIRECTIONS TO ACCESS THE LMS:

- 1. *Website link once created***
- 2. Click on left side menu = course catalog**
- 3. Click under that = staff education courses**
- 4. Search for course name “_____”**
- 5. Log in with employee number for both user name and password**
- 6. Click on courses**
- 7. Complete training- step by step instructions are included**

Once entered, there will be step by step instructions. If you experience any problems or have any questions, please do not hesitate to contact me.

Sincerely,

Anna Vioral
PhD Candidate
412-956-1674
lwmq@iup.edu

APPENDIX Q

LMS Chemotherapy Error Data Entry

Thank you for participating in this research study to help determine if the education will be effective in helping you administer chemotherapy safer and more efficiently according to the new ASCO/ONS chemotherapy/targeted therapy standards of practice. This video and assessment will take about 30 minutes of your time. During the video, please write down the chemotherapy errors you viewed – please focus only on errors related to the administration of chemotherapy. Next, rate your level of certainty for each response with 1 = not certain and 5 = very certain.

1. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

2. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

3. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

4. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

5. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

6. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

7. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

8. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

9. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)

10. _____
Level of Certainty _____ (rate 1 = not certain) – (5 = very certain)