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Educational Strategies for Reducing Medication Errors Committed by Student Nurses: A Literature Review

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Abstract
Medication errors cause harm, yet most of them are preventable (Institute of Medicine, 2006). Nurses spend 40% of their time administering medications; therefore they play a key role in the reduction of medication errors. Little empirical evidence has been collected about the effectiveness of nursing education in reducing medication errors committed by nursing students. Traditional educational interventions focus on the five rights of medication administration; however, the literature shows that interventions focused on instilling a culture of safety have a greater impact on reducing medication errors. The purpose of this article is to review educational strategies that have been implemented and tested in pre-licensure nursing programs to reduce medication errors committed by nursing students.

Keywords
Pre-licensure nursing education, medication error prevention, patient safety

Introduction

Medication errors cause harm, yet most of them are preventable (Institute of Medicine, 2006). Nurses spend 40% of their time administering medications; therefore they play a key role in the reduction of medication errors. Little empirical evidence has been collected about the effectiveness of nursing education in reducing medication errors committed by nursing students. Traditional educational interventions focus on the five rights of medication administration (right patient, dose, time, drug and route); however, the literature shows that interventions focused on instilling a culture of safety have a greater impact on reducing medication errors. The purpose of this article is to review educational strategies that have been implemented and tested in pre-licensure nursing programs to reduce medication errors committed by nursing students.

Background and Significance

Medication Errors Cause Harm

In 2000, the Institute of Medicine (IOM) issued a seminal report demonstrating the urgency of applying quality and safety to healthcare systems (Kohn, Corrigan, & Donaldson). Subsequent reports have confirmed that medication errors are the most common errors in health care (Aspden, 2007; Kohn, 2001). In the United States, medication errors sicken, injure or kill 1.5 million patients per year, with about 400,000 preventable adverse events, resulting in upward of $3.5 billion in extra medical costs (Aspden). Reports indicate that on average, a hospitalized patient is subjected to more than one medication error each day (Bates, 2007).

The Agency for Healthcare Research and Quality (AHRQ; 2001) reported that patients who suffer adverse drug events remain in the hospital an average of 8 to 12 days longer than patients who do not experience such events. Each medication error can incur greater costs to the patients and the hospitals. The IOM reports that 7,000 deaths result from adverse drug events per year.

In addition to the effects medication errors cause to patients, nurses are impacted psychologically and professionally as well. Schelbred and Nord (2007) studied ten nurses who had committed medication errors that resulted in, or had the potential to result in, significant harm to the patient. They found that making a medication error was devastating to both the personal and professional life of the nurses. Nurses were exposed to criticism and reproach from their supervisors and their coworkers. Nurses blamed themselves for their errors and accepted responsibility for their actions, but they reported being unwilling to report future mistakes due to fear of consequences. A culture of blaming and criticizing an individual nurse for a medication error hinders reporting and prevents finding ways to improve safety and the quality of care (Hughes, 2008).

The definition of what constitutes a medication error varies, making comparison of medication errors between institutions difficult (Institute for Safe Medication Practices, 2010). The National Coordinating Council for Error Reporting and Prevention (2009) approved the following definition.

> A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient or consumer. Such events may be related to professional practice,

> health care products, procedures, and systems, including the prescribing; order communication; product labeling, packaging and nomenclature; compounding; dispensing; distribution; administration; education; monitoring and use.

Nursing and Medication Errors

Medication administration involves three components: ordering, dispensing and administering. Nursing is responsible for the administration phase, which includes monitoring for effectiveness and adverse effects, and is therefore the profession most likely to discover a medication error (Kohn, 2001), because they have the responsibility of checking the medication before administering it to the patient (Leape, Epstein, & Hamel, 2002). Nurses are the last line of defense for the prevention of medication error, and catch up to 70% of medication errors before they occur (Bates, 2007). However, nursing has no safety system or "check" by another professional and reports have suggested that nurses are responsible for 26% to 38% of medication errors (Bates; Leape et al.). In a 2010 survey, 78% of nurses indicated they had made a medication error (Jones & Treiber, 2010). The most common types of medication errors that result in patient death are wrong dose (40.9%), wrong drug (16%) and wrong administration route (9.5%; Hughes, 2008). The likelihood of a nurse completing a professional career without making a medication error is very low (Anderson & Webster, 2001).

Multiple studies have surveyed nurses seeking causes and types of medication errors, and the results vary widely. Causes of medication errors identified by nurses have included (1) carelessly failing to follow the five rights, (2) nursing incompetence, (3) distractions (4) interruptions, (5) inadequate staffing, (6) illegible written orders, (7) incorrect dosage calculations, (8) similar drug names and packaging, (9) failure to check name band with the medication administration record, and (10) failure to follow policies and procedures (Armitage & Knapman, 2003; Cohen, Robinson, & Mandrack, 2003; Jones & Treiber, 2010; Mayo & Duncan, 2004; Ulanimo, O'Leary-Kelley & Connolly, 2007). Armitage and Knapman reported deference to authority as a cause of medication errors. For example, during second checks for high risk medications, new nurses are hesitant to state that a medication drawn up by an experienced nurse is incorrect. Six direct observation studies of medication administration by ICU nurses identified wrong dose, wrong administration time, wrong administration rate, and dose omission as the most common types of medication errors (Kiekkas, Karga, Lemonidou, Aretha, & Karanikolas, 2011).

Medication Error Prevention in Pre-licensure Nursing Education

Student nurses are expected to learn safe medication administration practices to ensure the safety of their patients. Safe medication administration has its foundations in the traditional five rights of medication administration, which can be traced back to the 1800s (Wall, 2001). To the traditional five rights, nursing scholars have added other dimensions of safe administration of medication which include: right documentation, right action, right form, right response, right education, right client education, a client's right to refuse, right assessment, and right evaluation of the client after the medication is administered. Increasing the number of rights has made no impact on the number of medication errors made by nurses (Landrigan et al., 2010).

Lucian Leape (1994) coined the term *The Perfectibility Model,* which proposes that if a professional is sufficiently trained and is properly motivated, s/he will not make a mistake. Although empirical data strongly support that mistakes are *inevitable* in complex human activities, this model proposes that education and motivation can somehow reduce errors to an absolute zero level. The corresponding assumptions of the Perfectibility Model are that errors are based on individual, not systemic failures. It becomes the individual's duty to seek adequate training and maintain appropriate motivation. If an error occurs, it becomes the individual's fault, and peers and supervisors actively seek an individual to blame. The combination of the perception of failure and the reaction to blame give rise to secrecy, limited disclosure, discounting, and feelings of anger, fear, and sadness by the one who is deemed responsible for the error (Morgan, 2011). Blaming the individual for not following the five rights does not reflect the responsibility and accountability associated with medication administration or multidisciplinary approaches to medication management.

In summary, harm to patients from medication errors has not been reduced in the past 15 years, despite significant efforts to the contrary. The profession of nursing has the potential to play a key part in the reduction of error; however the role of the nurse in medication error reduction remains elusive. We know that nurses make medication errors due to deficits in knowledge, calculations skills and performance, yet research efforts directed at these problem areas have affected no change (Lee & Lin, 2013; Pauly-O'Neill, 2009). The healthcare environment is shifting to a culture of safety in which transparency surrounding medication error is paramount to error reduction. Only 10% of nurse executives stated they believed new graduate nurses were ready for practice, with only 41% believing new nurse graduates were satisfactorily proficient at administering medication (Berkow, Virkstis, Stewart, & Conway, 2009). There are few articles in the literature in nursing education that identify the diversity of educational strategies which have been employed to address the complexity of systems in which students are learning to administer medications. Nurse educators must identify interventions that address both human and system failures that students can use to reduce medication errors (Valdez, Guzman, & Escolar-Chua, 2013). The purpose of this article is to review educational strategies that have been implemented and tested in pre-licensure nursing programs to reduce medication errors committed by nursing students.

Method

Inclusion Criteria and Search Strategies

A thorough literature search was performed to better understand and synthesize the literature and data surrounding educational strategies for medication error prevention with nursing students. Key search terms used in CINAHL, PubMed and Google Scholar databases included *medication, administration, error(s), education, intervention study, strategy* and *safety.* All key terms were cross-referenced with *nursing student(s)* and then evaluated for inclusion based upon whether or not the students had completed licensure examination. The search range included studies published in English from 2000-2014. The beginning of the range coincides with the publication date of the IOM report on medication errors *To Err is Human: Building a Safer Health System (*Kohn, Corrigan, & Donaldson)

Inclusion criteria included all articles that examined the effects of educational strategies for pre-licensure nursing students on the reduction of medication errors. Eighty-seven article abstracts were reviewed. Articles that did not mention components of medication error reduction such as recovery (identification, interruption and correction) or reporting were removed. In addition, articles that utilized interventions or instruments focused solely on calculation skills were not included. Only studies of nursing students were included. After a review of bibliographies, additional relevant references were obtained, resulting in 33 articles to be evaluated for quality.

The quality of the literature was evaluated using Whittemore's (2005) Quality Criteria in Research Reviews as well as Polit and Beck's (2008) guide to an overall critique of quantitative and qualitative research reports. All articles were reviewed and evaluated for their contribution to an understanding of the role of pre-licensure nursing education in medication error prevention. The articles were then analyzed to discover themes that were prevalent, inconsistencies in the literature, gaps in current knowledge, and recommendations for future research and practice. After careful analysis of all articles, seven articles met the criteria for selection.

Summary of Articles

The articles examined suggest that nurse educators have little evidence to support teaching methods for error reduction and recovery (Table 1). This review adds to nursing knowledge by demonstrating that use of simulation and carefully designed self-study, in addition to traditional educational methods, can reduce errors made by nursing students.

Table 1: Summary of articles reviewed

Reference	**Strategy**	**Sample**	**Methodology/ Instrument**	**Results**
Hemingway et al. (2012) UK	Medicines with Respect Competency Framework	Senior mental health students (n=41)	Mixed methods approach/survey on student attitudes developed for study	Improved confidence, viewed as being preventative of medication errors.
Henneman et al. (2010) US	Simulation	Senior BSN students (n=50)	Retrospective analysis of videotapes/ direct observation tool developed for study using Eindhoven model. Inter rater reliability 95%	Errors occurred in all rule-based categories; all students committed at least one error. Most frequent errors were in verification. Chi-square and Fishers exact test used.
Lambton et al. (2008) US	Simulation and case studies	Junior BSN, pediatrics students (N=47)	Quasi experimental, repeated measures survey developed for study	Self-reported significant improvement in error recognition.
Lee & Lin (2013) Taiwan	E-learning	BSN & RN-BSN pediatrics (n=349)	Quasi experimental /knowledge on test developed for study using Gagne's	Intervention group scored significantly higher on knowledge and calculation ability.

			learning theory – content validity > .8, KR of .9	
Pauly-O'Neill (2009) US	Simulation	Pre-licensure master's degree, pediatrics students (n=50)	Quasi experimental/direct observation of adherence to five-rights using checklist developed for study	Students in simulation group made fewer errors. Adherence increased for all rights except for right dose.
Pauly-O'Neill & Prion (2013) US	Simulation	Junior, BSN, pediatrics students (n=32)	Quasi experimental/ knowledge test developed for study	Statistically significant increase in knowledge, increase in self-reported confidence.
Sears et al. (2009) US	Simulation	Sophomore BSN students (n=54)	Randomized controlled trial/ direct observation for adherence to the five rights using checklist developed for study	Fewer medication errors in intervention group. Lack of knowledge was a common contributing theme. Reported power.

Students in clinical placement generate fewer medication errors if they have had prior exposure to a related, simulation-based experience (Sears, Goldsworthy, & Goodman, 2009). Obstetric and medical-surgical nursing experts designed simulation scenarios to reduce medication errors made by nursing students. The scenarios included normally encountered situations and emergency situations to challenge students with rapidly changing situations. Two seasoned clinical professors evaluated the nursing students' assessment, planning, interventions (including medication administration), and evaluation of outcomes based on program-established competencies for a second-year nursing student. Students were given one hour to prepare and were then taken through the initial simulation. Following the initial simulation, students were debriefed about their performance and given two hours of preparation time. Students then returned to the laboratory and reengaged with the same simulation.

Hemmingway et al, (2012) designed The Medicines with Respect (MwR) Competency Framework to give students the opportunity to review and remediate their own perceived or apparent deficits in medication administration. Medicines with Respect is delivered in four distinct stages: (1) psychopharmacologic knowledge base (development of a workbook in collaboration with experts in pharmacy and nursing), (2) assessment of competence in medication administration, using an Observed Structured Clinical Examination (OSCE), (3) a postgraduate review course, and 4) transition to prescribing psychopharmacologic medications.

Lambton, Pauly-O'Neill, and Dudum (2008) studied simulation and case studies to improve student error recognition within the pediatric population. Seven case-based scenarios written by content experts and refined over two semesters were presented. The cases were made available to students prior to the simulation. The cases described children of varying developmental levels,

interactive family and health care personnel roles, emergency situations that required immediate action and embedded errors in physician orders. In each case, students were presented with a set of physician orders that required them to set priorities and "think on their feet." The cases were implemented in a predetermined order that built on the educational objectives of the prior cases. Students assumed several roles including the role of a bedside nurse and "worried mom".

Pauly-O'Neill (2009) attempted to improve pediatric medication administration safety, through the use of faculty evaluating student errors using simulations that included high-risk drugs and built-in prescribing errors. All students in pediatric inpatient units were rotated through the simulation center and given the opportunity to practice reconstitution, dilution, and intravenous (IV) administration. The full context of medication administration was reinforced. In addition, lecture material related to pediatric administration, realistic resources including drug dosage handbooks, calculators and drug containers, modeling of nursing practices that address patient safety issues. Medications were treated as if they were authentic, and all medication errors resulted in incident reports.

Significant gains in knowledge was demonstrated by Lee and Lin (2013) and Pauly-O'Neill and Prion (2013). Lee and Lin used medical and nursing experts to develop an e-learning program to improve pediatric medication safety. The program consisted of eight modules: basic equipment, administration routes and techniques, principles of medication administration to children at different ages, medication dosage calculation, educating parents about pediatric medication safety, medication errors and near-miss events, resources about pediatric medications and orientation to clinical settings. Complex topics had PowerPoint presentations with audio and used Articulate (Articulate Global, Inc.) to include pictures, videos, quizzes, interactive content and direct links to websites.

Pauly-O'Neill and Prion (2013) had faculty develop high fidelity simulations that addressed specific practice deficits to improve medication administration skills in the pediatric population. Five pediatric content experts established the validity of the simulations prior to their use. Medical prescribing and system-based pharmaceutical error, unpredictable medication administration dilemmas and acute drug reactions were written into simulation scenarios. Students spent 90 clinical hours working with an experienced pediatric faculty member in simulation laboratory (1 instructor to 6 students). Each scenario contained medication administration opportunities including complex IV preparation, administration using infusion pumps, weight-based dosing, manipulating powder-form vials requiring reconstitution and dilution, the presence of confounding drugs in the medication area and embedded prescribing errors.

An increase in confidence was demonstrated by Hemingway et al. and Pauly-O'Neill & Prion. Self-study such as e-learning (Lee & Lin) and MwR (Hemingway et al., 2012) can lead to significant increases in calculation ability, knowledge and error reduction. Other benefits of simulation and self-study include increased problem solving skills, communication skills, situational awareness, and priority setting abilities.

Henneman et al, (2010) used clinical simulation to assess senior nursing students' ability to identify and to recover from medication errors. Nursing faculty developed two scenarios using a

template to ensure consistency. The first scenario was an elderly patient with congestive heart failure following blood transfusion, and the second was a patient with chest pain following a motor vehicle accident. Both scenarios provided the case study, the equipment/supplies, bedside monitor information, initial mannequin set-up instructions, and support roles. Errors built into the simulations included an IV pump set at an incorrect hourly rate, a physician's telephone order that did not include the route of administration, and a piece of equipment that was ordered but was not being used.

These studies and future interventional research are hampered by a lack of validated and reliable tools. All the studies reviewed (Table 1) used instruments developed by study authors. None of the studies utilized previously developed instruments. The majority of outcomes were assessed by self-report using surveys. Lee and Lin (2013) and Pauly-O'Neill and Prion (2013) utilized objective knowledge exams to assess medication administration skills. There is difficulty in measuring clinical performance compared with quantifying knowledge, critical thinking, self-efficacy on standard measures like written tests. Henneman et al. (2010), Pauly-O'Neill (2009) and Sears et al. (2009) used direct observation using scoring sheets created for their studies. In all three of these studies, the scoring sheets were based upon the five rights method of medication administration. The OSCE has been used routinely as a reliable and valid method for determining skills competency in medicine, but is used inconsistently and often incorrectly in schools of nursing (Rushforth, 2007). Future research should explore rigorous use of the OSCE to evaluate safe medication administration skills.

Implications for Nursing Education

Implications for nursing education include a need for curriculum reform, incorporation of a Just Culture, and the use of evidence based teaching strategies. Curriculum reform should include the Quality and Safety Education for Nurses (QSEN) competencies. These competencies were created to define what it means to be a respected and qualified nurse (Cronenwett et al., 2007). QSEN standards include the expectation that students will participate in error analysis and use organizational error reporting systems for near-miss and error reporting (Cronenwett et al.). The National Council of State Boards of Nursing (2009), in their Transition to Practice model, has recommended that the QSEN competencies be incorporated into nursing education programs. Sherwood (2011) described worldwide initiatives for integrating quality and safety science into both nursing education and practice, which include the development of patient safety educational standards, incorporation of safety competencies into the 'essentials documents' of accrediting organizations, and curriculum mapping for spreading the competencies across the curriculum.

Nursing education should adopt the use of Just Culture. In his book, *Managing the Risks of Organizational Accidents* (1997), Psychologist James Reason states that in a Just Culture, clinicians feel safe reporting issues, but there is a line between acceptable and unacceptable behaviors. A Just Culture recognizes that competent clinicians make mistakes, but has no tolerance for reckless behavior. The Joint Commission on Accreditation of Healthcare Organizations (2009) now requires that accredited organizations administer and analyze safety culture surveys each year as part of the National Quality Forum's list of safe practices for better healthcare. The American Nurses Association issued a position statement in 2010 endorsing the Just Culture concept as a strategy to reduce errors and promote patient safety. Healthcare

organizations are utilizing incident reporting systems that are voluntary; yet nursing education has no similar method for reporting and tracking student error. Error reporting and near-miss reporting should be embedded into curricula so students learn and experience transparency from the beginning of their educational experiences (Cooper, 2013). To reduce patient harm, Gregory, et al. (2009) suggest student data related to adverse drug events, near misses and medication errors needs to be collected, aggregated, analyzed and acted on by educators in partnership with clinical units.

Patient harm is reduced when errors are recovered instead of committed. Error recovery, a term used in high-risk organizations such as nuclear power and aviation, could be adapted to nursing and would involve identifying, interrupting and correcting medication errors. The term has more recently been adopted by health care organizations as a means of reducing harm (Henneman et al., 2010; van der Schaaf, 1992). Error recovery has the potential to transform potentially negative outcomes into "near-miss" situations in which the patient is not impacted by the error (Henneman et al.). Error recovery tools include Root Cause Analysis (RCA) and Failure Mode Effects Analysis (FMEA). RCA is used to identify systems factors that led to the error and suggest solutions to prevent similar errors from causing harm in the future, while FMEA provides a rough estimate of the hazard posed by each step in a high-risk process such as medication administration (Wachter, 2009). Students should use RCA and FMEA with case scenarios to develop evidence-based change plans based on identified root causes. Faculty can take advantage of available resources describing how to conduct RCAs and FMEAs that are found on the AHRQ web site (AHRQ, 2014; AHRQ 2013). The Joint Commission on Accreditation of Healthcare Organizations (2009) has suggested these processes be used for all sentinel events and that organizations take appropriate actions to eliminate risks associated with sentinel events that have occurred.

Teaching strategies focusing on reducing patient harm should begin in the first year of nursing education (Gregory et al., 2009). Medication management and pharmacology should be incorporated into the teaching curriculum for nursing students, as well as continuing professional development opportunities. Inter-professional educational opportunities improve student learning and outcomes. When designing curricula, students and instructors from other disciplines, especially pharmacy should be involved (Rothschild et al., 2010). Educational strategies should include simulation as well as self-paced active learning interventions to provide instruction that is separate from evaluation. Strategies should focus on realism and repetition in a no-risk environment (Hemingway et al., 2012). The more teaching/learning situations in which faculty can facilitate student development of safe, responsible and accountable medication administration behaviors, the greater the likelihood that these knowledge, skills and values will become lifelong professional habits (Pauly-O'Neill & Prion, 2013).

Recommendations for Future Research

Recommendations for future research include a need to discover the types of errors students make and strategies students use to reduce error. Additional research needs to be done to determine what factors in addition to the "five rights" are useful for teaching error recovery strategies and what is the ideal structure for students to follow when administering medications. Research also needs to be done on objective assessment of the effects of error reduction

strategies. Objective competency evaluation tools are needed to evaluate the impact of risk free practice and integrated simulation on student skills. These skills need to be assessed throughout programs and assessed for retention through transition to practice. In addition, the role of the environment needs to be examined to determine what effect realistic simulations with environmental distractions have on reducing error in the workplace. The role of simulation versus traditional clinical experience needs to be quantified in the classroom.

Research should be rigorous in design with a conceptual framework or theory to guide the development of educational intervention studies to reduce medication errors. The findings of many of the previous studies have been conducted in a single nursing school, using a convenience sample. Many of the studies are underpowered, with only one study with sufficient sample size (Lee & Lin, 2013). Despins, Scott-Cawiezell, & Rouder (2010), van der Schaaf (1992) and Benner et al. (2002) have theories that need to be tested in regard to student error prevention. Although developed for use in the chemical process industry, the Eindhoven model (van der Schaaf) is applicable to other settings and has been used to develop an error classification system in medicine. Tools that have been developed need to be tested for reliability and validity, as well as for predictive value. A tool that could predict who is most likely to commit a medication error would be invaluable. Goodstone and Goodstone (2013) developed a standardized Medication Administration Safety Assessment Tool (MASAT). Instructors should consider using the MASAT to assess students, as well as utilizing the OSCE as a standardized method of assessing performance. Research studies should triangulate data using multiple outcomes measures such as surveys of student perceptions, direct observation and retrospective analysis of error reporting. There is no nationally accepted standardized instrument for reporting medication errors, making it difficult to compare data or detect change. When data are available from error reports, they should be aggregated to the fullest extent possible. Researchers should look for interventions that will increase error recovery and decrease errors and participate in research with other disciplines such as pharmacy and medicine.

Conclusions

In conclusion, safety is the main benefit of using simulation and self-study interventions for teaching safe medication administration. Beyea, Slattery, and von Reyn (2010) have shown that scenario based simulation experiences can increase confidence, competence and readiness in new nurses, raising the question – what can be accomplished by nursing faculty prior to graduation? The use of simulation and self-study in conjunction with traditional methods of instruction promotes patient safety in multiple ways. Well-designed educational strategies facilitate the identification of unsafe practice, allowing errors to be picked up before an incident occurs. Nursing students should be involved in systematic analysis of their practice to increase self-awareness of habits that lead to medication errors. Nurse educators need to recognize that education beyond the five rights will better prepare graduates and may reduce errors in nursing practice. The results presented in this paper challenge the idea that traditional clinical education is the gold standard when compared with the ability of simulation to provide unique and standardized learning opportunities.

In response to the Institute of Medicine's report *To Err is Human* (Kohn, Corrigan & Donaldson, 2000), The American Association of Colleges of Nursing (AACN) Tri-Council (2000) issued a

supporting statement with multiple recommendations. To prevent error, nursing must lead the way in data collection to illuminate the complex interaction of multiple factors within the health care environment. Systems must be designed to overcome the multiple factors that create the potential for errors to occur. Nurses must be involved in the evaluation, development, and implementation of efforts to overcome medication errors. Nursing must work to foster a culture that encourages the prevention of errors, and supports a research agenda that identifies and examines the root causes and drivers of errors, approaches for error prevention, and what adverse patient outcomes are due to errors versus other causes (AACN Tri-Council for Nursing). It is now 2016, yet the state of the science surrounding nursing education and medication error reduction shows little progress has been made towards satisfying these recommendations.

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