Can Practical Knowledge About Medication Safety be Gained Through a Learning Module for Nursing Students?

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Abstract

Purpose: To evaluate the effectiveness of introducing an online learning module to nursing students in the fourth year of a BScN program as a way of (a) increasing student knowledge of specific system factors and their role in medication errors; and (b) increasing student perceptions of competence in identifying specific system factors which contribute to medication errors. **Methods:** An experimental, prospective, single-blind, pretest posttest design was used. **Conclusion:** There were no significant differences in knowledge of system factors that contribute to medication errors between those students who participated both in the learning module and clinical experience compared to those students who participated in clinical experience only. Nursing students in fourth year of BScN program who participated in a learning module, in addition to clinical experience had greater perceived competence to identify system factors that contribute to medication errors than students who participated in clinical experience only.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1:

Introduction

Patient safety has received increasing attention both in the media and within health care settings leading to public scrutiny of health care systems and critical analysis of both human and monetary costs associated with adverse events (Harding & Petrick, 2008). It has been estimated that adverse events account for 24,000 deaths in Canada each year and are the eighth leading cause of death each year in the United States (Harding & Petrick). Medication errors comprise a large portion of adverse events. In a Canadian study of adverse events, Baker et al. 2004 reported that nearly one quarter of reported adverse events are medication or fluid related. Medication error has been defined by the Canadian Medication Incident Reporting and Prevention System as:

> *Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer. Medication incidents may be related to professional practice, drug products, procedures, and systems, and include prescribing, order communication, product labelling/ packaging/ nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use* (Institute for Safe Medication Practices Canada [ISMP Canada], 2010).

From the monetary cost perspective, "preventable drug-related morbidity and mortality in the older adult population costs the Canadian health care system $11 billion per year" (Harding & Petrick, 2008, p. 44). Not all medication errors lead to death and the actual rate is difficult to determine as it is largely affected by reporting practices of any given institution (ISMP Canada, 2014). For example, a high rate of medication errors could be reflective of unsafe medication practices within an institution, or it could simply be indicative of the institution's culture that promotes reporting of errors (ISMP Canada). Conversely, a low rate of medication errors could be a reflection of safe medication practices and effective error prevention strategies, or it could be a reflection of a punitive institutional culture in which individual workers are hesitant and fearful to report errors (ISMP Canada). Furthermore, medication errors are vastly underreported due to additional reasons such as undetected errors, underreporting of omitted medications, and perception of unimportance/irrelevance especially if error resulted in no patient harm (Harding & Petrick).

The innate nature of the degree to which nurses are implicated in the process of medication administration positions the nursing profession to take a major role in preventing errors at individual as well as system levels (Harding & Petrick, 2008). Nursing practice has not been significantly informed by research findings concerning medication errors and contributing system factors (Harding & Petrick). System factors are any and all elements of the workplace setting where the process of medication administration is executed (Harding & Petrick). Examples of system factors include, but are not limited to: (a) illegibility of the medication administration record (MAR), (b) drug names that sound alike, (c) medications similar in appearance or available in multiple strengths and/or dosage forms, (d) dangerous abbreviations, (e) work environment such as poor lighting and excessive noise and distractions, (f) poor communication, (g) excessive workload, (h) personal factors such as stress, fatigue, poor health, decreased sensory perception, or boredom; (i) poor compliance with policies and procedures, (j) insufficient knowledge and/or inexperience, and (k) lack or inaccessibility of resources (Chuang, Wang, Chen, & Cham, 2012; Harding & Petrick; Lambert, Chang, & Lin, 2001; Wolf, Hicks, & Serembus, 2006). To accuse individual health care workers fosters a culture of blame which can impede the ultimate goal of medication error prevention. Rather, a systems approach acknowledges the complexity of the medication process and that other factors attributable to system design can be addressed in preventing medication errors (Harding & Petrick; Lambert et al.).

Papastrat and Wallace (2003) asserted that “medication administration is a high-risk area of nursing practice with direct implications for nursing education” (p. 459). Wolf et al. (2006) highlighted that even though faculty concentrate on teaching nursing students safe medication administration with focus on calculating dosages and intravenous flow rates, students still commit medication errors, thus affirming the role of system factors in medication safety within the population of nursing students. Considering the relationship between medication errors and system factors it is warranted that a closer look be taken at nursing student education regarding system factors given the direct implications of nursing education to nursing practice and associated patient outcomes.

Literature Review

Perspectives on Medication Errors Committed by Nursing Students

Diverging views exist on the interpretation of the role of system factors as contributors to medication errors by nursing students. Some authors acknowledge the role of system factors in medication errors, but believe that noncompliance with the rights of safe medication administration practices is the root cause of errors, thus the key to error prevention lies in strict adherence to the rights method. On the contrary, other authors believe that a system-based approach is a more productive way of addressing medication errors through more open reporting systems and a shift from individual blame to efforts on systems improvements. Each of these views will be briefly discussed.

A representative of the literature which supports the position that medication errors are caused by poor adherence to the rights method is a study by Valdez, de Guzman and Escolar-Chua (2013). To address the issue of continued occurrence of medication errors among nursing students, the authors conducted a factor analysis and structural equation modeling study to shed light on the factors at play in students' medication errors. From this study of 329 junior and senior nursing students at a university in the Philippines, five elements of causes of student medication errors were identified:

1.) "in-violation" – referred to violation of rules by nursing students which the authors attributed to the possibility of knowledge gaps in theory and policy, or to the students' inclination to deviate from policy and procedure in an effort to meet high workload demand and increase efficiency;

2.) "in-writing" – referred to students' difficulty in understanding abbreviations, instructions, unclear medication administration records and illegible writing;

3.) "in-tension" – described the students' personal stress such as:

a) schooling demands of examination,

b) perceived lack of practical skills,

c) overall busyness and dissatisfaction with self,

d) stress in interacting with others such as conflict with members of the health care team leading to poor communication and inability to get along with patients,

e) coping with work involving dying patients.

4.) "in-excess" – referred to students' distractibility when dealing with demands of multitasking and workload and patient acuity;

5.) “in-experience” – which authors interpreted as impacting factors 3 and 4 of “in-tension” and “in-excess” as it “positively impacts levels of stress and negatively influences coping and emotional competency” (p. 226). “In-experience” was also thought to be a contributor to the students’ overwhelming feelings caused by workload, multitasking and patient complexity.

The key message proposed by Valdez et al. (2013) is that poor adherence to the ‘five rights’ has a direct impact on medication errors among nursing students. To explain, the authors proposed that the identified factors of “in-violation”, “in-writing”, “in-tension”, in-excess” and “in-experience” interact with each other and lead to poor adherence to the ‘five rights’ thus leading to medication errors. On the other hand, the authors acknowledged that both human and system factors should be addressed in nursing education as an effort towards prevention of medication errors by nursing students. In fact, they suggested that system failures that impact patient safety should be given equal emphasis as the attention to pharmacology knowledge and medication safety. Authors also suggested interprofessional partnership in promoting the link between theory and practice by nurses, clinical instructors and other members of the health care team. Lastly, the authors suggested reconciliation between policies and student abilities to allow for optimization of learning opportunities within clinical placement settings.

There are several limiting factors and shortcomings to the study by Valdez et al. (2013). First, it is questionable to what degree the findings of this study can be generalized to the population of student nurses studying and practicing in universities and clinical sites in the Western side of the world as the similarity between nursing education and practice in Philippines and Western counties is not known. For example, despite being published in 2013, the study mentions the “five rights” of safe medication practices which contrasts the “eight rights” mandated by the College of Nurses of Ontario (2014). Second, Valdez et al. acknowledged that system factors contribute to the five elements they identified as causation of medication errors by nursing students, but they interpreted lack of adherence to the "five rights" as the primary cause of medication errors. This minimized the magnitude of the role of system factors in medication safety. For example, student nurses and registered nurses alike may genuinely be misreading the medication orders due to system factors such as drug names that sound alike, unclear MAR, trailing zeroes that alter the way dosages are read, or other abbreviations that alter the way frequencies are interpreted. Thus, following the "five rights" does not prevent misinterpretation of medication orders caused by system factors. The nurses may genuinely be following the "five rights", yet be unaware of interpretation errors.

Harding and Petrick (2008) presented an opposing view on the causes of medication errors by nursing students and argued in favour of system factors as significant contributors. Harding and Petrick conducted a 3-year retrospective review of 77 medication errors made and reported by nursing students in a 4-year community college baccalaureate program which admits 32 students annually. Medication errors were analyzed in light of semester of study, type of error as per rights of medication administration, classification of drug, time of error and contributing factors. However, these reports did not include near misses. The examined errors were grouped into errors of commission such as medications given incorrectly or in violation of rights of medication administration which comprised 66% of the reported errors, and errors of omission such as omitting medications which comprised 34% of the reported errors. System factors are most obviously related to errors of omission, as the most contributing factors were related to some aspect of the MAR such as difficulty reading/interpreting the MAR correctly (42%), followed by business and distraction (27%), wrong time or less common time (15%), and wrong route/patient (6%). However, system factors such as similarly-named drugs may have been at play in errors of commission as well. Consider an example of an error reported in this study where the wrong drug was administered because two drugs with similar names, Dimenhydrinate and Diphenhydramine, were included on the MAR but not differentiated. The error could be attributed to system factors of similarly named drugs *and* lack of differentiation of the two on the MAR, as well as to the student's lack of experience in identifying the difference between similarly named drugs *and* lack of awareness of potential for error. The authors reported three categories of factors contributing to medication errors by nursing students: violation of rights of safe medication administration, system factors, and lack of student knowledge and understanding.

From the analysis of medication errors by students in their own nursing program, Harding and Petrick (2008) concluded that "system factors, or the context in which medication administration takes place, are not fully considered when students are taught about medication administration" (p. 43) and that this should be addressed through incorporation of knowledge from experience. The authors questioned if teaching only the rights method, as per the nursing governing bodies, is static and ignores the depth of knowledge needed to participate in a complex system. The rights method is taught to students who do not have experience with how the system factors influence medication administration, as with the example of Dimenhydrinate and Diphenhydramine. The authors explained that the MAR is often introduced in a laboratory setting as part of required documentation, but its complexity is minimized as the interaction with the MAR by various members of the health care team is not reflected. The process of: physician prescribing; clerk, pharmacist, and nurse transcribing; nurse and nursing student administering is not reflected and thus the role of system factors is ignored and students are often oblivious to them. Moreover, the authors acknowledged that much of the literature supports that medication errors by nursing students are caused by nonadherence to the rights methods. However, they asserted that the consideration of medication errors in isolation of system factors can lead to individual blame and ignorance of the complexity of the medication administration process and the active role of system and organizational factors.

Harding and Petrick (2008) suggested teaching strategies such as problem-based learning, high-fidelity simulation, and intentional inclusion of medication safety knowledge throughout theory and clinical courses, as more effective ways to emphasize the complexity of the context in which medication administration is executed. Lastly, following this study, the university at which the study was conducted changed the process of documenting student medication errors. In order to move away from a punitive nature and toward acknowledgement of the system factors, the medication error incident reports are no longer placed in each student's file, but in a central file where they can later be used for pattern analysis.

Even though Harding and Petrick (2008) made a strong case for the role of system factors in medication errors by nursing students, their study had a few limitations as well. First, the small size of the nursing program at which the study was executed led to a relatively small amount of reported medication errors to be examined. However, considering that the cumulative number of students in the program was 96 and the number of reported medication errors was 77, the incidence of medication errors is relatively high at almost one error per student. The second weakness of this study is the lack of reporting of near misses which may have provided greater insight into the causes of medication errors.

A study by Wolf et al. (2006) not only supports the role of system factors in medication errors by nursing students, but also adds that student inexperience magnifies the risk medication errors. The authors conducted a descriptive, retrospective, secondary analysis study to examine characteristics of 1,305 medication errors committed by nursing students as reported to MEDMARX for a period of 5 years from January 1, 1999 to December 31, 2003. MEDMARX is an anonymous, national, voluntary, internet-accessible medication error database operated by the United States Pharmacopeia through the Patient Safety Program (Wolf et al.). MEDMARX has been used by over 700 hospitals and health care systems as part of their quality improvement initiatives and contains the largest known database for medication errors by nursing students (Wolf et al.). The most frequently reported medication errors by nursing students were those of omission followed by errors of wrong dose. The authors of this study noted that antimicrobials and opioid analgesics were two classes of drugs most commonly involved in medication errors by nursing students. Moreover, insulin was the single most frequently implicated medication in student errors. The limitation to this study is that reporting was voluntary, therefore, more severe errors may not have been reported.

Wolf et al. (2006) concluded that performance deficit is a predominant cause of medication errors by nursing students which implies that students had relevant skills and knowledge, but failed to execute the task correctly, thus affirming the role of system factors. Furthermore, the authors identified student inexperience as a chief contributing factor to medication errors by nursing students, followed by distraction as a second most reported contributing factor.

In addition to traditional education, Wolf et al. (2006) recommended that medications need to be studied in greater detail along with topics of error-prone abbreviations and high-risk medications. The most highlighted theme by the authors was the impact of student inexperience. The authors suggested that educators call students' attention to specific knowledge they otherwise would gain through experience such as frequently checking orders in order to avoid errors of omission. In fact, the authors called for additional research on teaching strategies for nursing students and inexperienced registered nurses in order to enhance clinical reasoning skills and medication administration skills. Lastly, due to vast number of medications which nurses encounter in their daily practice coupled with student inexperience, the authors recommended the use of digital assistants to increase accessibility of drug information.

Although the cost of medication errors either from human life or economic perspectives cannot be denied, the approach to preventing medication errors can be considered from individual responsibility or systems approach. Dennison (2005) wrote about creating an organizational culture for medication safety and acknowledged that humans inevitably make errors and although that cannot be changed, the environment in which humans work can be manipulated to minimize the potential for errors and to contain their effects. The unrealistic expectations of clinical perfection cause practitioners to feel guilt, shame and emotional distress when an error occurs (Dennison). Errors made in the prescription phase are intercepted by nurses 48% to 70% of the time, while errors made in the administration phase have little chance of interception by another profession – errors made by nurses are more likely to reach the patient, thus nurses are most likely to experience the distress of medication errors. Nurses often perceive errors as a failure of the moral and ethical obligation to do no harm (Dennison). Furthermore, Dennison acknowledged the rights method does not account for human factors in errors and that inexperience is also associated with increased risk for medication errors.

System Factors

The salient role of system factors in medication errors was illustrated in a study by Chuang et al. (2012) which evaluated the effectiveness of implementing an improved medication storage label as a strategy for reduction of dispensing errors by pharmacists. The newly designed label contained additional information which was not included on the previous label such as drug generic and brand name, other drugs similar in appearance, strength, dosage form, and quantity. Bold font and different colouring of letters were used to increase clarity of the label. The results of the study revealed that the rate of dispensing errors was significantly reduced and the pharmacists' degree of satisfaction with the storage label was increased. Chuang et al. recommended that "pharmacists need to increase their awareness of high-risk drugs and drugs with similar names and appearance/packaging, multiple strengths, and multiple dosage forms" (p. 1470) – all of which are examples of system factors. The authors acknowledged that the pressures of efficiency, limited access to information and the vast number of drugs all affect accuracy thus leading to errors. Furthermore, the authors acknowledged that greater access to information, together with adherence to the rights method should be employed to reduce errors. Although the participants in this study were pharmacists, the results are relevant to nursing as nurses engage in dispensing and the 3 checks and 8 rights in a similar fashion. The limitation of this study is that only one institution in Taiwan participated in the study and the degree of generalizability of the findings internationally is unknown. On the other hand, a study by Gabriele et al. (2011) evaluated use of tallman lettering and alternative typographic strategies with the purpose of contributing to design of paper and electronic applications, specifically where similarly named drugs are involved. The results indicated that tallman lettering may not be as effective as previously reported in distinguishing of drug names by nurses and pharmacists.

Lambert et al. (2001) conducted a study to evaluate the effect of spelling and sound similarity of medication names on the probability of memory recognition errors in 30 pharmacists and 66 college students. As a result of prospective, computer-based, recognition memory tests, they concluded that spelling and sound similarity "increase the probability that experts and novices will make false recognition errors when trying to remember drug names" (p. 1843). The authors reported that, according to the United States Pharmacopeia, 1 out of 4 medication errors voluntarily reported are due to confusion of drugs with similar names.

Lambert et al. (2001) subscribed to the idea that a culture of individual blame is a deterrent in reporting of errors. Instead, the authors advocated for adoption of a systems approach to analysis and prevention of medication errors by manipulating the system to minimize the opportunity for errors. In fact, the authors eloquently summarized their view: "we agree that excessive similarity between drug names is a frequent proximal cause of medication errors, and we assert that the existence of so many similar pairs of names reflects systematic flaws in the way drug names are evaluated and approved" (p. 1854). Moreover, the authors advocated for changes in the way new drug names are assigned, by implementing objective measures of similarity, which they argue would prevent further emergence of similar names with downstream effect of decreased incidence of drug name confusion errors. The limitations of this study are that the reported results should not be over interpreted as the focus of results is on *probability* of a memory recognition error which may be different in the real world practice (outside of controlled experiment environment). Also, it is questionable if the results are directly transferable to the nursing profession as the training between pharmacists and nurses may be different, and pharmacists are more likely to deal with much larger numbers of medications in more condensed time frame than nurses.

Brunetti, Santell, and Hicks (2007) conducted an analysis of the effect and characteristics of dangerous abbreviations based on 643,151 medication errors from 682 facilities voluntarily reported to MEDMARX between 2004 and 2006. The authors found that 4.7% of reported medication errors were attributable to use of abbreviations. The errors occurred most frequently at the prescription phase of medication process (81%), while errors at transcription and dispensing phase were much lower at 14% and 2.9%, and administration errors were lowest at 2%. The authors reported use of abbreviations frequently contributes to communication failures which in turn lead to medication errors - members of the health care team may misinterpret medication orders due to presence of abbreviations resulting in alterations of the intended meaning of the prescribed orders. For example, the abbreviation ‘u’ for units may be misinterpreted as a zero, thus leading to a ten-fold increase of intended dose of insulin and potentially harming the patient. As reported in this study, the abbreviations most commonly involved is medication errors were: QD for once daily, U for units, cc for ml, MSO4 or MS for morphine sulfate, and trailing zeroes. Other frequent error-causing abbreviations were: SC, HS, TID, BID, and D/C.

Brunetti et al. (2007) pointed out that, in 2004, The Joint Commission released a list of “do not use” abbreviations to be used as a requirement for meeting the National Patient Safety Goals and to address the barriers to communication among health care professionals. However, as the authors explained, according to Annual Joint Commission surveys, the compliance rate has exhibited a downward trend from 75.2% to 64.2% from 2004 to 2006, which explains the reported frequency of use of abbreviations in this study. The implications of these findings are most obviously the need for increase in compliance and education, particularly of prescribing professionals, as use of abbreviations is most common at that stage of the medication process. However, it could also be argued that, because the use of abbreviations is common at the prescription stage, nursing is likely to encounter them when interpreting and executing orders, thus it is relevant to increase the nurses’ awareness of the potential of error as well as to provide education to discourage further use of abbreviations by nurses. Brunetti et al. recommended targeted education to illustrate the pitfalls of use of dangerous abbreviations. The limitation of this study is that the results are reflective of practices in the U.S.A. which may not be applicable to the Canadian context.

However, similar trends are present in the Canadian health care system as the Institute for Safe Medication Practices Canada has also issued a safety bulletin which identifies the need for implementation of lists of “do not use” abbreviations in an effort to prevent medication errors and patient harm (ISMP Canada, 2006). According to ISMP Canada (2012a), the definition of dangerous abbreviations is: “Abbreviations, symbols and dose designations that have been identified as easily misinterpreted or involved in medication incidents leading to harm and should be avoided in medication-related communications”. Furthermore, ISMP (2011a; 2011b) published lists of commonly confused medications and drugs with sound alike names which affirms the assertions made by Lambert et al. (2001) - system factors such as sound alike drug names play a role in medication errors. In addition to increasing knowledge and awareness of drugs with similar names, Chuang et al. (2012) recommended that focused attention should also be given to drugs with multiple strengths and dosage forms, especially high-alert drugs. ISMP (2012b) has published a list of high-alert medications and has provided the definition of high-alert medications as: “drugs that bear a heightened risk of causing significant patient harm when they are used in error”. All of these elements are relevant insight for education of nursing students as system factors that contribute to medication errors by nursing students include, but are not limited to: (a) illegibility and/or elements of the medication administration record, exacerbated by use and misinterpretation of dangerous abbreviations; (b) drug names that sound alike and medications similar in appearance, multiple strengths and dosage forms; (c) other factors such as noise, distractions, and so on (Chuang et al.; Harding & Petrick, 2008; Lambert et al.).

Education to Address System Factors and Medication Errors

Papastrat and Wallace (2003) asserted that "medication administration is a high-risk area of nursing practice with direct implications for nursing education" (p. 459), therefore they recommended problem-based learning (PBL) as an approach to educate nursing students about elements of medication errors. As the authors explained, the purpose of PBL is to facilitate critical thinking through application of knowledge instead of just simple acquisition of knowledge. It is through active participation in nonclinical settings that novice practitioners are transitioned toward competency and ability to exercise clinical judgment by learning to explore all possible options, predict outcomes and create care plans that are applicable to real-life clinical situations (Papastrat & Wallace). The end result is health care professionals who are able to effectively manage clinical problems. The authors compared the process of PBL to that of critical thinking as it requires students to "examine data, draw inferences, make decisions, identify assumptions, delineate interpretations, and evaluate weak and strong arguments" (p. 460).

Papastrat and Wallace (2003) suggested that PBL can be used to help students understand the reasons for medication errors and devise strategies for prevention of these errors. Although the authors expressed appreciation of the complexity of the health care system and accepted that errors are inevitable, they proposed that students can be alerted to this in their education. One limitation of PBL in addressing system factors is that the students may not have adequate experience to have the capacity to formulate insight into why medication errors occurred. For example, the students may be more inclined to designate errors as violations of the rights methods, unless the educators draw their attention to the roles and examples of various system factors such as drugs with similar names or dangerous abbreviations.

Page and McKinney (2007) also recognized that nursing education should not only focus on theoretical knowledge of pharmacology, but also on other factors that are implicated in medication safety. As such, the authors collaborated with pharmacists from the Medicines Governance Team and developed and implemented a "Medication Safety Day" at the School of Nursing and Midwifery in United Kingdom. The day consisted of: (a) a lecture which provided an overview of the extent of the problem of medication errors and emphasized that system failures as well as individual deficits are contributors, and (b) series of workshops which explored medication errors at various points of the medication process – from prescription to administration. The workshops included topics such as: interpretation of prescriptions, dosage calculations, acknowledgement of patient allergies, and high-alert medications.

In justifying their decision to implement this educational strategy and its content, the authors stated that "the majority of dispensing errors appear to be caused by similar sounding and looking names, misreading of the prescription, transcription errors and inexperience on the part of staff amongst other factors" (Page & McKinney, 2007, p. 221). The authors acknowledged that poor handwriting and poor mathematical skills are additional elements of medication errors. Also, they recognized lack of medication knowledge as a significant issue, particularly for nurses due to their responsibility in the actual administration of medications. However, the authors related this to a possible systems failure, in addition to individual accountability, as educational institutions and hospitals may have failed to adequately prepare and train health care professionals. Large scale problems such as low staffing levels, high patient workloads and other distractions were also found to be contributors to human error (Page & McKinney).

The limitation of the educational intervention evaluated by Page and McKinney (2007) was that even though students provided positive feedback of the "Medication Safety Day" and reported increased awareness of individual and system factors in medication errors, there was little evidence of its effectiveness. The authors acknowledged that further research is needed to ascertain how these and similar educational efforts can be used to reduce medication errors. The topic of medication safety is of particular interest to the nursing profession as it has been estimated that as much as 40% of nurses' time is spent on medication administration (Page & McKinney). One of the highlights of the report by Page and McKinney was a statement that "nurses should consider that when they administer medicines they become responsible not only for their own errors but also for recognizing that due to various factors errors may occur amongst those who have previously prescribed and dispensed the medication" (p. 222).

Peeters, Kamm, and Beltyukova (2009) conducted an experimental study to determine the effectiveness of an online learning module in increasing the ability of doctor of pharmacy students to identify and correct prescribing errors. The students were randomized into two groups and were provided with computer access to the learning module and associated worksheets during scheduled class time. One group completed worksheet A, watched the presentation, and then completed worksheets B and C. The other group completed worksheets A and B, watched the presentation, and then completed worksheet C. Using this method allowed for the control group to also receive the education. The authors recognized that existing courses in the program did not address aspects of medication orders such as drug, dose, route, and frequency; therefore they created a learning module to address medication safety. The content of the module included: general background of medication errors; description of the medication process and error-prone aspects; specific types of prescription errors; and review of recommendations, standards, and policies and their rationale. Each of the worksheets contained 20 questions based on real medication errors detected by pharmacists at an affiliated medical center. The students were required to identify type of error within the prescription and then to provide the corrected version of the medication order. The scores between groups on worksheet B were significantly different, thus the authors concluded the module was effective at teaching pharmacy students to detect and correct prescription errors. The limitation of this study is threat of testing as the questionnaires were completed immediately following the presentation so the students were more likely to be able to recall the information. Retention and use of information could not be evaluated.

Warholak, Queiruga, Roush, and Phan (2011) assessed the rate of detection of prescription errors by nursing, pharmacy and medical students using a 10-minute questionnaire which contained three fictitious medication orders. Each question contained patient information (name, date of birth, weight, diagnosis relevant to prescription, drug allergies, and current medications) to aid students' decision-making. The students were asked to review the orders and identify presence or absence of error followed by type of error. The first prescription contained a sound alike – look alike medication; the second prescription was correct to discourage guessing; and the last prescription contained a dosage calculation error. The questionnaire was reviewed and amended by a pharmacotherapy expert to assure face validity. With participation of 175 students, the authors were able to detect that pharmacy students were significantly more successful in identifying prescription errors than their medical and nursing counterparts. There was no significant difference in rate of error detection between nursing and medical students.

The authors attributed the difference to the greater number of pharmacology and pharmacotherapeutics course hours completed by pharmacy students. The authors also acknowledged that pharmacy students may have been able to detect prescription errors at a higher rate due to repetition and familiarity with medications. However, the authors reported that regardless of program of study, students demonstrated an overall low ability to identify errors. The study participants did not have access to medication resources, but the authors argued that all health care professionals should have enough familiarity with medications in order to participate in medication therapy.

Based on these findings, Warholak et al. (2011) recommended that further education on medication error prevention is necessary for pharmacy, nursing, and medical students in order to improve their ability to detect errors on medication orders and thus potentially improve patient outcomes. The authors called for further research to determine best teaching strategies to address the topic of medication error-identification. In fact, the authors disclosed plans to implement educational sessions designed specifically for health professional students on the topic of medication errors. The authors did not disclose which teaching strategies they planned to use. Even though a statistical difference between pharmacy and nursing students was detected, a limitation of this study is that it used only three questions with only two types of error (similar drug names and dosage calculation), thus potentially generating skewed results and limiting the ability to further assess differences in students' detection of errors.

Summary

As can be observed in the review of literature, despite diverging views on the interpretation of the role of system factors in medication errors by nursing students, it cannot be denied that their role demands attention in nursing education (Harding & Petrick, 2008; Valdez et al., 2013). From examination of medication errors by nursing students, it can be concluded that system factors significantly contribute to error although they may not be the only contributing factors (Harding & Petrick; Wolf et al., 2006). Several authors suggested greater attention to system factors (specifically error-prone abbreviations, high-alert medications, similar-sounding medication names, medications with multiple strengths and dosage forms) in health professional education is necessary (Brunetti et al., 2007; Chuang et al., 2012; Harding & Petrick; Wolf et al.; Warholak et al., 2011). Furthermore, there was a call for research on teaching strategies on the topic of medication safety (Wolf et al.; Warholak et al.). Student inexperience has also been identified as a contributor to students' susceptibility to medication errors in light of system factors (Page & McKinney, 2007; Wolf et al.). The support for systems approach rather than individual blame in addressing medication safety is present in the literature (Dennison, 2005; ISMP Canada, 2014; Lambert et al., 2001).

To date, efforts have been made to implement educational strategies, such as an online learning module, to address pharmacy student ability to identify and correct prescription errors as reported by Peeters et al. (2009). However, aside from measuring nursing student satisfaction with education on system factors and medication errors, as reported by Page and McKinney (2007), actual effectiveness of education about system factors and medication safety with nursing students has not been evaluated.

Theoretical Framework – Patricia Benner: From Novice to Expert

Patricia Benner adapted the Dreyfus model of skill acquisition and development which consists of five levels of competency (ranging from novice to expert) and applied it to nursing practice (Brykczynski, 2006). In adapting this model, Benner made a distinction between theoretical knowledge (know that) and practical knowledge (know how) (Brykczynski).

Theoretical knowledge informs practice, while experience lends the context in which theoretical knowledge is understood (Benner, Tanner, & Chesla, 1992). From this perspective, humans come to know through being in situations (Brykczynski). Practical knowledge is gained from experience through the process of validation and modification and interpretation of past knowledge, preconceived notions and expectations (Brykczynski). Benner acknowledged that the process of learning from experience is risky both for the nurse and the patient; hence well-planned educational programs and sound educational base are necessary for safer and quicker skill acquisition (Waldner & Olson, 2007).

In Benner's work, the word 'experience' refers only to active participation in situations in which nurses apply, test, and reorganize theoretical knowledge based on actual clinical evidence (Waldner & Olson, 2007). As nurses gain experience, practical knowledge builds and can then be shared with others (Brykczynski, 2006). Benner believes that this practical knowledge that stems from experience should be captured and recorded through scientific investigation and observation in order to further the advancement of nursing theory with richness and uniqueness of clinical expertise (Brykczynski).

In order to explore Benner's theoretical framework as it applies to nursing practice and education, it is necessary to explore each of the levels of competency. The five levels of competency of novice, advanced beginner, competent, proficient, and expert are distinguished by the nurses' focus of attention, degree of involvement in situations, and view of responsibility and accountability (Benner et al., 1992). Nurses functioning at the novice level focus their attention on objective, measurable information and their actions are governed by theoretical knowledge and principles with little insight into context of situations (Benner et al.; Waldner & Olson, 2007). Their focus is primarily on individual signs or symptoms, thus leading to a limited sense of responsibility (Waldner & Olson,). At the level of advanced beginner, nurses begin to recognize independent signs and symptoms as manifestations of a disease profile (Waldner & Olson). Action is derived from knowledge of guides and protocols, but the focus shifts to organization and prioritization of tasks in an effort to maintain patient status quo and prevent deterioration (Benner et al.; Waldner & Olson). Nurses at this stage measure accountability and success based on own ability to accomplish set tasks, rather than on patient outcomes (Benner et al.; Waldner & Olson). Nurses who function at competent level of practice focus on patient outcomes and long term plans (Benner et al.). They begin to develop a more comprehensive understanding of the patient picture and feel a profound sense of responsibility and question the adequacy of formal, theoretical knowledge on which they previously heavily relied (Benner et al.). At the level of proficiency, nurses are able to distinguish fine changes in clinical situations and shift from heavy reliance on guidelines and protocols to own ability to 'read' situations and decide appropriate action (Benner et al.). Lastly, nurses at the expert level possess vast experience and an intuitive grasp and deep understanding of clinical situations with an ability to focus on the acute problems without wasteful consideration of other options (Benner et al.). Their sense of responsibility is realistic and nested in understanding of the larger system in which their role functions (Benner et al.). There is some consensus that upon entry into the profession of nursing, nurses should be able to function at least at the advanced beginner or competent level (Waldner & Olson). This infers that nursing students in educational programs can then be considered at the novice or advanced beginner level. For the purposes of this study, nursing students in fourth year of undergraduate education are considered to function at the level of advanced beginner given their nearing of the end of the educational program.

The perceptual work of advanced beginners is predominantly focused on matching theoretical knowledge to situations in clinical practice and witnessing manifestations of clinical signs and symptoms (Benner et al., 1992). Advanced beginners view clinical situations as challenges of their knowledge and abilities, rather than patient needs (Benner et al.). Situations are regarded "as is" in the moment with limited understanding of the bigger picture and future patient outcomes (Benner et al.). It is not the factual knowledge that is at stake, as most beginners are able to recite definitions, but it is the lack of experience that prevents them from noticing the presentation of theoretical knowledge (Benner et al). Furthermore, "preoccupied with recognizing clinical states and changes in those states, and lacking contrasts from past instances, advanced beginners are less likely to grasp variations and patterns within particular situations" (Benner et al., p. 17). They often miss subtle cues of changing situations and continue routine care, or if they notice changes they seek the advice of more experienced practitioners on whom they rely for decision-making (Benner et al.) Advanced beginners rely on following orders, protocols, routine practices and expectations of others (Benner et al.). Advanced beginners frequently practice on the edge of knowledge and comfort, and are distressed if they perceive their practice as unsafe or if they feel unable to organize, prioritize or complete tasks (Benner et al). The development from advanced beginner to competent level "is often preceded by a challenge to the advanced beginner's confidence due to clinical situations that did not turn out as planned" (Waldner & Olson, 2007, p. 8).

Therefore, education aimed at learning about medication errors and associated system factors might help advanced beginners progress without experiencing the distress of making medication errors and potentially inducing patient harm. Benner's theoretical framework validates the impact of inexperience on the way in which novice and advanced beginner nurses function. As explained by Benner's framework, novice and advanced beginner nurses rely on theoretical knowledge, guidelines and protocols. Therefore it can be extrapolated that they are naïve to the role of system factors in medication safety as was also illustrated in the review of literature. In congruence with Benner's beliefs, practical knowledge from experience, such as interaction with system factors, should be captured and shared with others who have not yet learned from experience. Any educational efforts to help nursing students learn about medication errors rather than learning from experience are also ethical in nature as the intent is to protect patients from harm.

CHAPTER 2:

Methodology

Purpose

The purpose of this study was to evaluate the effectiveness of introducing an online learning module to nursing students in the fourth year of an undergraduate BScN program as a way of: (a) increasing student knowledge of specific system factors and their role in medication errors; and (b) increasing student perceptions of competence in identifying specific system factors which contribute to medication errors.

This study aims to answer the question: Can practical knowledge of system factors and their role in medication errors be gained through a learning module for nursing students in fourth year of a BScN program? In addition, two hypotheses were tested: Hypothesis A: nursing students in fourth year of BScN program who participate in a learning module about system factors and medication errors, in addition to clinical experience, will have greater practical knowledge of specific system factors than students who participate in clinical experience only (which is the current way of learning about system factors). Hypothesis B: similarly, nursing students in fourth year of BScN program who participate in a learning module about system factors and medication errors, in addition to clinical experience, will have greater perceived competence to identify system factors that contribute to medication errors than students who participate in clinical experience only.

Design

An experimental, prospective, single-blind, pretest posttest design was used to evaluate the impact of a learning module on: (a) the practical knowledge of specific system factors in nursing students in fourth year of BScN program, and (b) the perceived level of competence to identify specific system factors contributing to medication errors in nursing students in fourth year of BScN program. Participants were assigned to a control or intervention group using block randomization according to clinical group, which allowed for control of possible pre-intervention confounding variables without explicit knowledge of which variables to control. Each clinical group was assigned a number and then the numbers were drawn from a hat in order to establish randomization. Block randomization was utilized to prevent contamination effects among students who were in the same clinical groups; however it allowed for protection against internal validity threats such as selection bias. Participants were masked to the research question and group assignment as an attempt to limit expectation bias and reactive effects, with possible benefit of decreasing the potential for contamination effects.

A pretest posttest design was chosen to evaluate change in dependent variables both between and within groups, thus allowing for a more accurate representation of the impact of learning module and evaluation of possible threats to internal validity such as maturation. To equalize participant burden and facilitate masking, both groups participated in a learning module about traditionally taught safe medication practices such as the rights method, but only the intervention group received additional education about specific system factors and their role in medication errors. This approach increased the confidence that potential differences in outcomes were attributable to education about the role of system factors in medication errors.

Measurement and Variables

From Benner's Novice to Expert theoretical framework (Benner et al., 1992), for the purposes of this study practical knowledge was defined as knowledge from experience. The conceptual variable of student practical knowledge of system factors was operationalized and measured as the students' ability to identify system factors within medication orders. The conceptual variable of student perceptions of competence in identifying system factors was operationalized and measured according to an established Perceived Competence Scale.

Primary outcome.

Direct measurement was utilized to evaluate the primary outcome of students' practical knowledge of system factors through use of a knowledge questionnaire. The same questionnaire was used for pretest and posttest in order to protect internal validity and to increase confidence that differences in scores among groups are not attributable to variations in the instrument. The internal validity threat of testing is limited due to a 4-week lapse between pretest and posttest. The students did not learn the answers to the questionnaire upon completion which further reduced the threat of testing. The questionnaire was comprised of 20 multiple choice questions. Each question contained necessary information to guide student decision-making (such as diagnosis, symptoms, or clinical situation) followed by a medication order. The students were asked to review the patient information and determine if the medication order is correct in light of system factors. Four same options were available for each question: (a) nothing wrong, (b) wrong dose, (c) wrong medication/indication, and (d) unsafe abbreviation. The same multiple choice options for each question were utilized as a strategy to prevent students from using deductive reasoning in determining answers. The answers were equally distributed between each category in order to prevent overrepresentation of any one type of error and to increase content validity (see Appendix A).

As informed by the literature review and lists published by ISMP, system factors of interest in this study were: (a) high-alert medications which are commonly confused due to similarly sounding names, multiple strengths and dosage forms; and (b) dangerous abbreviations which increase the risk of misinterpretation of medication orders. Students also received information about the medications' therapeutic indications as well as dosages. Specific medications that were included on the knowledge questionnaire were chosen if: (a) high-alert as defined by ISMP Canada (2012b) such as insulin, oral hypoglycemics, antithrombotics, and opioids - these were also reported as frequently involved in medication errors by nursing students (Harding & Petrick, 2008; Wolf et al., 2006); (b) frequently involved in medication errors by nursing students such as antimicrobials and antihypertensives (Harding & Petrick; Wolf et al.), (c) commonly seen in practice such as nitrates, analgesics, benzodiazepines, non-steroidal anti-inflammatory agents (NSAID), and proton-pump inhibitors. Furthermore, medications to be included on the questionnaire were chosen based on lists of commonly confused medications published by ISMP (2011a; 2011b). Medications with multiple strengths/dosage forms were also utilized, such as oxycodone vs. oxycontin. Dangerous abbreviations to be included were based on lists published by ISMP Canada (2012a) and if reported frequently implicated in medication errors as per Brunetti et al. (2007) who reported that "the most common abbreviation resulting in a medication error was the use of "QD" in place of "once daily," accounting for 43.1% of all errors, followed by "U" for units (13.1%), "cc" for "mL" (12.6%), "MSO4" or "MS" for "morphine sulfate" (9.7%), and decimal errors (3.7%)" (p. 578). The answer option of wrong dose was chosen as "approximately one third of the errors involved omission and administration of the wrong dose of medication" (Wolf et al., p. 48). The answer option of nothing wrong was utilized to discourage guessing as was also done by Warholak et al. (2011) who tested students' ability to detect prescription errors.

The structure of the 20-item knowledge questionnaire was based on the work of two previous studies on the topic of system factors by Peeters et al. (2009) and Warholak et al. (2011). Peeters et al. used a 20-item questionnaire to evaluate effectiveness of an online learning module in increasing the ability of doctor of pharmacy students to identify and correct prescribing errors. The authors were able to detect a significant difference using a 20-item questionnaire among 96 participants. Warholak et al. used a 3-item questionnaire among 175 students and were able to detect a significant difference between groups (see Appendix B). The validity of the knowledge questionnaire in this study was addressed in following ways: (a) the knowledge questionnaire is similar to the questionnaire used by Warholak et al. which tested the same concept of student ability to detect error on medication orders; and (b) the content validity of the knowledge questionnaire was increased in comparison to the questionnaire by Warholak et al. The questionnaire by Warholak et al. tested for only two types of error (similar sounding drug names and dosage calculation error) with one question each, and the knowledge questionnaire tested three types of error (dose, similar sounding drug names, and dangerous abbreviations) with five to six questions each; and lastly (c) validity of the knowledge questionnaire was addressed through review and amendments by Lecturer and Coordinator of Simulated Clinical Education at Western University as well as by Associate Professor of Graduate Program in Nursing at York University.

Secondary outcome.

Secondary outcome of students' perceived competence to identify system factors was chosen for several reasons identified from the review of literature. As Harding and Petrick (2008) explained, nurses are directly involved in the process of medication administration, thus they feel distressed about committing medication errors. Wolf et al. (2006) reported that "when nursing students or other health care providers make medication and other errors, they may be panicked, horrified, and apprehensive" (p. 40). Furthermore, from the perspective of Benner's theoretical framework, advanced beginners are concerned with their ability to meet the challenges of clinical situations, thus it is appropriate to examine their perceived competence to meet the challenge of identifying system factors that contribute to medication errors. Lastly, according to Page and McKinney (2007) students reported increased awareness of individual and system factors, but it is not certain if their knowledge actually increased. Thus it is appropriate that this study measured actual knowledge and perceived competence to evaluate if increase in knowledge corresponds to increase in perceived competence. Students' perceived competence was measured using the Perceived Competence Scale (PCS) with established alpha reliability of 0.9 (Williams, Deci, & Ryan, 2012). The PCS contains four items which are scored on a seven-point Likert scale reflective of participant's feelings of competence to execute a certain task (Williams et al.). To view this instrument, please refer to Appendix C.

Treatment/Intervention.

An online learning module was used as treatment for the intervention groups. The module designed for the intervention groups was a PowerPoint presentation of 24 slides which contained information on system factors specifically addressed in the knowledge questionnaire (see Appendix D). The module consisted of short stories of real and fictional medication errors to reinforce the salient role of eight rights, but also to introduce the role of specific system factors of interest in this study. The learning module designed for the control groups was in the same format, but was considerably shorter (12 slides) as it contained short stories of medications errors which focused on the eight rights only with no information pertaining to system factors (see Appendix E). The format of story-telling was utilized to simulate learning from experience. Benner et al. (1992) explained that meaning is attached to the emotional response of learning from experience. Thus, short stories of medication errors were utilized with the intent of evoking feelings and providing context for what would otherwise be theoretical knowledge of 8 rights and system factors.

Sampling

The target population for this study was nursing students who are exposed to medication administration as part of educational training in clinical settings. A sample representative of this population was nursing students in their fourth year of a BScN program at Western University who are entering 6-week acute care clinical placements in the Fall 2013 semester. Previous clinical skills lab performance tests were used as a baseline score for the knowledge questionnaire for the control group. To demonstrate a 10% difference in mean scores on the practical knowledge of system factors test (primary outcome), with power of 0.8, an alpha 0.05, and a standard deviation of 10%, a sample of 16 students per group was needed. To account for attrition, a sample of 30 students per study arm was sought. A typical size of fourth year nursing class at Western University is around 200, thus a cumulative sample size of 60 students was thought to be feasible.

The researcher presented the study to potential participants during the second week of the Fall 2013 semester at the beginning of a class for a required nursing course. This convenience sampling allowed the researcher to approach all potential participants at one time in one place. Permission to approach students during class was gained from Year 4 Coordinator of Undergraduate Nursing Program at Western University. A letter of information was provided to potential participants and informed consent was collected at that time. A total of 63 students were enrolled in the study. Inclusion criteria were: all students in fourth year of undergraduate nursing program at Western University who are entering acute care clinical placements within London Health Sciences Centre (LHSC) in Fall 2013. There were two placement sites which were outside of LHSC. Students placed at these sites were excluded due to possible variation in medication administration process and institution-specific system factors. For example, similarly named medications could be handled in a different way at those sites than within LHSC, therefore those sites were excluded for the purposes of consistency and protection of internal validity. Participants who agreed to participate in the study were randomly assigned to control or intervention groups in order to promote comparability between groups using block design as previously described.

Data Collection

In the Fall 2013 12-week semester, students were divided into groups. Half of the students in fourth year of the nursing program completed 6 weeks of simulated clinical education and then entered 6-week acute care clinical placements. The other half of the students in fourth year of the nursing program completed 6 weeks of acute care clinical placements first, and then entered 6 weeks of simulated clinical education. Thus, the students who agreed to participate completed the study while in the 6 weeks of acute care clinical placements. This means that some students completed the study in the first 6 weeks of the fall semester (from here on referred to as 1st cohort), while other students completed the study in the last 6 weeks of the fall semester (from here on referred to as 2nd cohort). Each cohort of students had a control and an intervention group.

The participants completed online pretests and their respective control or intervention online learning modules during the second week of their regularly scheduled clinical placement in an acute care agency where they have multiple opportunities to administer medications. The pretest for both the intervention and the control group consisted of: (a) a system factor knowledge questionnaire to evaluate primary study hypothesis (see Appendix A), and (b) the

Perceived Competence Scale to evaluate secondary study hypothesis (see Appendix C). Demographic information and other information regarding potential confounding variables such as clinical experience, years of experience with medication administration outside of the nursing clinical placements, and pharmacology education outside of the requirements of the nursing program was collected at that time as well (see Appendix F). During the sixth and last week of the acute care clinical placements, participants were asked to complete an online post-test knowledge questionnaire, as well as an online post-test PCS questionnaire. The online learning modules for each group were available to students at the time, but the students were not required to view them. It is not known if the students chose to review the learning modules again prior to completing post-tests.

Sakai, an educational software platform used by Western University, was used to house the pretests, learning modules, and post-tests in order to create ease of access for students. However, the pretests and posttests were powered by Survey Monkey so that scores could not be connected to Sakai student usernames. The study project site was separate from any other course sites within Sakai to communicate disassociation of study participation with academic performance.

Ethics

This study was approved by Health Sciences Review Ethics Board (delegated review) at Western University as well as Research Ethics Review Board at York University. The letter of information (see Appendix G) and informed consent form (see Appendix H) were created as per templates from Western University with incorporated requirements of York University (Western University, 2012a; Western University, 2012b). Only the students who signed the informed consent form were enrolled in the study.

As per Western University Ethics Board (2012), the informed consent contained information such as: (a) invitation to participate, (b) purpose of research, (c) inclusion and exclusion criteria, (d) study requirements/procedures, (e) voluntary participation and right to withdraw from the study at any time, (f) disclosure of any anticipated risks and benefits as well as reimbursement, (g) confidentiality and sharing of information including publication, and (h) contact information for researcher and supervisors as well as university ethics offices. When presenting the study as well as in the letter of information, it was reinforced that participation in study was not related to course evaluation.

Through the letter of information and presentation by the researcher, the potential participants were made aware of the need for the study and the relevance of the study which warranted the invitation for student participation. The purpose of the research was disclosed as well as inclusion and exclusion criteria and respective reasoning. The requirements of the study were clearly delineated indicating: (a) the time and place where participation is to take place (online during second and last week of acute care placements), (b) what participation entails (completion of online pretest, learning module, and posttest), and (c) an estimated amount of time needed (45 minutes during second week of clinical and 15 minutes during last week of clinical). Concerns of convenience and accessibility were addressed in reporting that the study would be available online through Sakai.

Participants were reassured of the confidentiality procedures including the collection and protection of identifying information and its handling. The participants were informed their names would not be used in any subsequent publishing of study results. Full names of participants were obtained on informed consent forms, however no personal information was collected on data collection tools, therefore it was not be possible to link results to participants.

Consent forms are kept in a locked cabinet at Western University. The last 4 digits of participant phone numbers were used to match pre-test and post-test results within Survey Monkey. The last 4 digits of a phone number are easily recalled by participants and are unique, yet cannot be connected to the student identity without the whole number. Information from pretest and posttest questionnaires is kept within Survey Monkey and is password protected. Any analysis of data is kept in password protected files on a memory stick. Participants were informed that in accordance with Western University policy, data would be kept for 5 years following completion of the study. After this period, signed consent forms will be shredded and electronic data on Survey Monkey and memory stick will be permanently deleted.

The participants were advised that participation is voluntary and that they can withdraw from the study at any time or choose to leave any question unanswered. Students were also reassured that participation in the study is independent of their academic requirements and evaluations. Furthermore, potential risks and benefits were disclosed. Potential benefits to participants in this study included heightened awareness of system factors contributing to medication errors which could contribute to safer medication administration practices and potential reduction in medication errors. The possible benefits to society included the potential for preventing patient harm through prevention of medication errors. There were no anticipated risks associated with this study.

Students were informed of reimbursement in form of a draw for 10 Tim Horton cards each in the amount of $10, and that leaving the study does not exclude them from the draw. Participant names from consent forms were entered into the draw as a strategy to compensate participant time, address attrition, and aid in recruitment. The draw was completed at the end of the Fall 2013 semester following the completion of the study. Clinical instructors were asked to communicate to winners that there is an envelope available for pick-up at the nursing school main office. The envelope contained the $10 gift card, which was appropriate to award students' time and effort, but not enough to take advantage of students' potential financial needs. Lastly, contact information for the researcher, supervisors, and ethics office was provided.

Analysis

Student demographic characteristics were reported using descriptive statistics. Chi square test was used to compare nominal measures between groups such as number of participants per cohort, number of participants taking the fourth year clinical placement course for the first time, number of participants with previous medication experience outside of the clinical placements of nursing school, number of participants with previous pharmacology education outside of the requirements of the nursing program. T-test was used to compare interval measures between groups such as years of previous work experience involving medication administration and years of pharmacology education outside of the nursing program, which were also considered as potential confounding variables.

Paired t-test was performed for each of the groups to assess whether the respective knowledge tests score (KTS) and summative 7-point Likert score (SLS) results from the Perceived Competence Scale differed from baseline to end-of-placement assessments within each group. The Kolmogorov-Smirnov test was used to assess normalcy of distribution for integral variables.

Linear regression analysis was used to assess correlations between various data and their impact on KTS and/or SLS in a practical stepwise fashion. First, the impact of participant demographics, characteristics, and previous experience on baseline KTS and SLS were assessed using multivariate linear regression. Next, factors that impact change in KTS (ΔKTS) or SLS

(ΔSLS) were assessed. This was initially performed using univariate linear regression to identify the isolated variable-response relationships and their respective correlation coefficients for each variable assessed. Multivariate linear regression was subsequently performed to identify the correlated impact of multiple variables on ΔKTS and ΔSLS (see Table 5). Finally, variables identified to be significant were subsequently re-assessed using multivariate linear regression to establish predictive formulas for ΔKTS and ΔSLS.

IBM SPSS version 21.0 was utilized for data analysis and the p-value was set to 0.05 for all tests. The operational hypotheses evaluated in this study were: 1a) null hypothesis: there is no difference between groups in scores on the knowledge test of system factors; 1b) alternate hypothesis: students in the intervention group will score higher on the knowledge test of system factors than students in the control group; 2a) null hypothesis: there is no difference between groups in summative 7-point Likert scores of the Perceived Competence Scale; 2b) alternate hypothesis: students in the intervention group will score higher summative Likert scores on the Perceived Competence Scale compared to students in the control group.

CHAPTER 3:

Results

Of 63 students who signed the consent form, 48 completed the pretests and 45 completed the posttest assessments. All three students who dropped out of the study between pretest and posttest were from the control group. Two were from the control group which completed clinical placements in the first 6 weeks of the semester (1st cohort), and one was from the control group which completed clinical placement in the last 6 weeks of the semester (2nd cohort). This resulted in 45 participants total, 26 randomized to intervention and 19 randomized to control, all completing initial and final assessments. The total attrition rate was 7%. All students who completed initial pretests and final posttests answered all questions on the instruments.

There were no significant differences between control and intervention group demographics (see Table 1).

Table 1: Demographics, Characteristics, and Experience per Group

Variable	Control (n=19)	Intervention (n=26)	P-Value
Age *years (SD)*	22.37 (2.24)	21.62 (1.70)	0.18
1st Cohort Participant *n (%)*	10 (52.6)	20 (76.9)	0.09
First Time Course Taker *n (%)*	18 (94.7)	26 (100)	0.24
PMAE *n(%)*	3 (15.8)	7 (26.9)	0.38
Mean Duration of PMAE *years (SD)*[1]	1.17 (0.29)	1.95 (2.70)	0.23
Previous Pharmacology Education *n (%)*	0 (0)	1 (3.8)	0.39

Chi-square and t-tests used for comparison between groups, as appropriate; PMAE = Previous medication administration experience outside of nursing program requirements

[1] 10 participants total (3 in the control group, 7 in the intervention group) had previous medication administration experience. Only these 10 participants were included in the calculation of the mean.

Since only one person had previous pharmacology education outside of the requirements of the nursing program, intergroup statistical analysis of the impact of the number of years of education was not possible. Aside from years of pharmacology education, all variables were found to display normal distribution around the mean – this was also true for Tables 2 to 4.

A paired t-test was performed for each of the groups to assess whether the respective knowledge tests score (KTS) and summative 7-point Likert score (SLS) results from PCS differed from baseline to end-of-placement assessments within each group. The control group's baseline and final KTS, reported as number of points out of maximum 20 points, differed significantly (1.11 points, SD 1.99 points, $p = 0.027$), but there was no significant difference in baseline to final KTS within the intervention group (0.00 point difference, SD 3.57, $p = 1.0$). Conversely, there was a significant change in SLS scores for the intervention group (4.31, SD 4.71, $P<0.001$) but no significant change in SLS scores for the control group (1.53, SD 4.70, $P=0.174$).

In comparing groups to each other, there were no significant differences in baseline KTS or change in KTS (ΔKTS) between groups (see Table 2). Similarly, there was no significant difference in baseline SLS between groups, but the change in SLS (ΔSLS) trended toward significance in favor of a greater increase in SLS in the intervention group with P-value 0.063 (see Table 3).

Table 2: Knowledge Test Scores per Group

Variable	Control (n=19)	Intervention (n=26)	P-Value
Baseline KTS *mean (SD)*	8.79 (2.28)	9.27 (2.49)	0.51
ΔKTS *mean (SD)*	1.11 (1.99)	0.00 (3.57)	0.23

KTS = Knowledge test score. t-tests used for comparison between groups.

Table 3: Summative Likert Scale Scores per Group

Variable	Control (n=19)	Intervention (n=26)	P-Value
Baseline SLS *mean (SD)*	17.32 (5.91)	16.62 (5.87)	0.70
ΔSLS *mean (SD)*	1.53 (4.70)	4.31 (4.71)	0.06

SLS = Summative Likert Score. t-tests used for comparison between groups.

When assessing 1st cohort participants compared to 2nd cohort participants, there were no significant differences when comparing baseline KTS and baseline SLS, but it is worth noting that 2nd cohort participants trended toward a greater improvement in the KTS (1.67, SD 3.22, p = 0.059) when compared to their 1st cohort counterparts (-0.13, SD 2.79, Table 4). This relationship and impact of participant's cohort, among other variables, on KTS and SLS was further analyzed using multivariate linear regression (see Table 5).

Table 4: Knowledge Test Results and Summative Likert Scores per Cohort

Variable	1st Cohort (n=30)	2nd Cohort (n=15)	P-Value
Baseline KTS *mean (SD)*	9.03 (2.47)	9.13 (2.29)	0.90
ΔKTS *mean (SD)*	- 0.13 (2.79)	1.67 (3.22)	0.06
Baseline SLS *mean (SD)*	16.90 (5.62)	16.93 (6.42)	0.99
ΔSLS *mean (SD)*	3.00 (4.48)	3.27 (5.66)	0.86

KTS = Knowledge test score, SLS = summative Likert score. t-tests used for comparison between groups.

Table 5: Linear Regression Modeling for Various Outcomes

Response Variable	Tested Variables	R	$a\text{-}r^2$	P-value	Explanatory Variable	Slope (B)	95% C.I.	P-Value
Baseline KTS	Age, PMAE, Baseline SLS, Cohort	0.356	0.039	0.236	(Constant)	6.89	-2.27 to 16.04	0.136
					Age	0.01	-0.41 to 0.42	0.980
					PMAE	0.41	-0.24 to 1.06	0.210
					Baseline SLS	0.11	-0.01 to 0.23	0.079
					Cohort	0.19	-1.32 to 1.69	0.803
Baseline SLS	Age, PMAE, Baseline KTS, Cohort	0.283	-0.012	0.489	(Constant)	10.88	-12.45 to 34.21	0.351
					Age	-0.01	-1.04 to 1.02	0.986
					PMAE	0.5	-1.69 to 1.71	0.954
					Baseline KTS	0.67	-0.08 to 1.46	0.079
					Cohort	-0.02	-3.80 to 3.75	0.990
ΔKTS	Baseline KTS	0.542	0.294	<0.001 *	(Constant)	6.69	3.63 to 9.77	<0.001*
					Baseline KTS	-0.69	-1.02 to -0.36	<0.001*
ΔKTS	Baseline SLS	0.023	0.000	0.318	(Constant)	1.80	-1.02 to 4.63	0.204
					Baseline SLS	-0.08	-0.24 to 0.08	0.318
ΔKTS	ΔSLS	0.132	0.017	0.389	(Constant)	3.57	-2.27 to 9.41	0.225
					ΔSLS	-0.08	-0.27 to 0.11	0.389
ΔSLS	Baseline SLS	0.615	0.364	<0.001 *	(Constant)	11.74	8.14 to 15.34	<0.001*
					Baseline SLS	-0.51	-0.71 to -0.310	<0.001*
ΔSLS	Baseline KTS	0.026	-0.023	0.865	(Constant)	3.57	-2.27 to 9.41	0.225
					Baseline KTS	-0.05	-0.68 to 0.57	0.865
ΔKTS	Group, Age, PMAE, Baseline KTS, Cohort	0.648	0.345	0.001*	(Constant)	7.60	-1.36 to 16.56	0.094
					Group	-0.55	-2.15 to 1.06	0.493
					Age	-0.07	-0.46 to 0.32	0.725
					PMAE	1.35	-0.45 to 3.14	0.136
					Baseline KTS	-0.68	-1.00 to -0.37	<0.001*
					Cohort	1.77	0.15 to 3.40	0.033*
ΔSLS	Group, Age, PMAE, Baseline SLS, Cohort	0.683	0.399	<0.001 *	(Constant)	3.26	-10.62 to 17.14	0.637
					Group	2.94	0.50 to 5.38	0.020*
					Age	0.29	-0.30 to 0.89	0.326
					PMAE	-1.04	-3.79 to 1.71	0.448
					Baseline SLS	-0.50	-0.69 to -0.30	<0.001*
					Cohort	1.00	-1.48 to 3.49	0.419

KTS = Knowledge test score; ΔKTS = change in knowledge test score; SLS = summative Likert score; ΔSLS = change in summative Likert score; r = correlation coefficient; $a\text{-}r^2$ = adjusted coefficient of determination; PMAE = previous medication administration experience (years);

Cohort = the impact of 2nd cohort participants (value = 1) when compared to 1st cohort participants (value = 0); Group = the impact of the intervention group (value = 1) when compared to the control group (value = 0); * = statistically significant

Multivariate linear regression analysis of the following variables was used to identify their correlation and impact on baseline KTS: age, previous medication administration experience (PMAE, values = “yes” or “no”), baseline SLS, and cohort. Control and intervention grouping was not incorporated into this analysis as that grouping would have had no impact on baseline assessment. It should be noted that the 1st cohort was assigned a value of “0” and the second cohort a value of “1” for the all analyses.

The R (0.356) and adjusted r^2 (a-r^2, 0.039) suggest a weak correlation between these factors and baseline KTS. Combined, these factors were not found to be significant predictors of baseline KTS values ($p = 0.24$) and no individual factor was found to be predictive of baseline KTS either (see Table 5). This did not change when PMAE was expressed in number of years, rather than the binomial “yes” or “no” answer.

Multivariate linear regression analysis of the following variables was used to identify their correlation and impact on baseline SLS: age, PMAE (values = “yes” or “no”), baseline KTS, and cohort of participant participation. Control and intervention grouping was again not incorporated into this analysis as that grouping would have had no impact on baseline assessment. As with correlates for baseline KTS, the R (0.283) and a-r^2 (-0.012) again suggest a weak correlation between these factors and baseline SLS. Again, no combined trend toward significance was identified ($p = 0.49$) and no individual factors were identified as having a significant correlation with baseline SLS. This did not change when PMAE was expressed in number of years, rather than the binomial “yes” or “no” answer.

To address the question of how baseline KTS impacted ΔKTS, a univariate linear regression analysis with KTS alone was performed (see Table 5). This showed a strongly significant relationship, noting that a 0.687 decrease in ΔKTS would be predicted with every point rise in baseline KTS by the following formula:

ΔKTS = 6.699-0.69[baseline KTS], p<0.001, Table 5

This relationship's correlation coefficient, R, was found to be moderately strong at 0.542, indicating that other variables were likely contributing to ΔKTS as well, and the a-r^2 was 0.294, indicating that only 29.4% of the variation in knowledge test score change can be explained by the baseline test scores.

Similarly, the question of how baseline SLS impacted ΔKTS was assessed using univariate linear regression (Table 5). This relationship was weak (p=0.32), suggesting that not only is there very little reliability in the relationship between baseline SLS and the ΔKTS, but that other factors contribute almost wholly to ΔKTS (R = 0.023, a-r^2 = 0.000). The correlation between ΔKTS and ΔSLS was also assessed using univariate linear regression, also identifying a weak relationship (p=0.39, R = 0.132, a-r^2 = 0.017, Table 5). This suggests that only 13.2% of ΔKTS and only 1.7% of variability of response in ΔKTS could be explained by ΔSLS.

Univariate linear regression analyses were performed to assess the impact of baseline SLS and KTS on ΔSLS, with similar findings. As baseline KTS was significantly correlated to ΔKTS, baseline SLS was also found to be statistically significantly correlated to ΔSLS as depicted in the following formula:

ΔSLS = 11.74 – 0.51[baseline SLS], p<0.001, Table 5

The correlation coefficient indicated strong predictive reliability of baseline SLS (R = 0.615), but only 36.4% of variability could be attributed to baseline SLS alone (a-r^2 = 0.364).

Similarly, as baseline SLS had poor correlation with ΔKTS, baseline KTS was also found to have poor correlation and weak reliability as a predictive variable for ΔSLS ($R=0.026$, $a\text{-}r^2 = -0.023$, $p=0.87$).

To assess multiple correlations and identify their individual contributions to predicting ΔKTS, multivariate linear regression analysis was employed with the following variables: group allocation (control vs. intervention), age, PMAE (values = "yes" or "no"), baseline KTS, and cohort of participant participation (1st or 2nd). Of note, for purposes of effective statistical analysis, allocation to the control group was given an arbitrary value of "0" while allocation to the intervention group was given a value of "1". The first cohort was assigned the value "0" and the second was assigned the value "1." Overall, this analysis provided strong correlation and predictive reliability ($R = 0.648$, $a\text{-}r^2 = 0.345$, $p=0.001$), but there were only two variables that correlated with statistical significance to ΔKTS: baseline KTS (B = -0.68, 95% C.I. -1.00 to -0.37, $p<0.001$) and 2nd cohort (B = 1.77, 0.15 to 3.40, $p=0.033$, Table 5). This multivariate linear regression assessment for predicting ΔKTS shows that 2nd cohort participants would have scored an additional 1.77 mean points compared to their 1st cohort counterparts, regardless for group allocation. As group allocation, age, and PMAE were not found to be significantly correlated with ΔKTS, these variables were subsequently removed for the purpose of generating the following predictive formula consisting solely of independently correlated predictive factors for ΔKTS:

ΔKTS = 7.60 + 1.77[cohort] – 0.68[baseline KTS], p<0.001, Table 5,

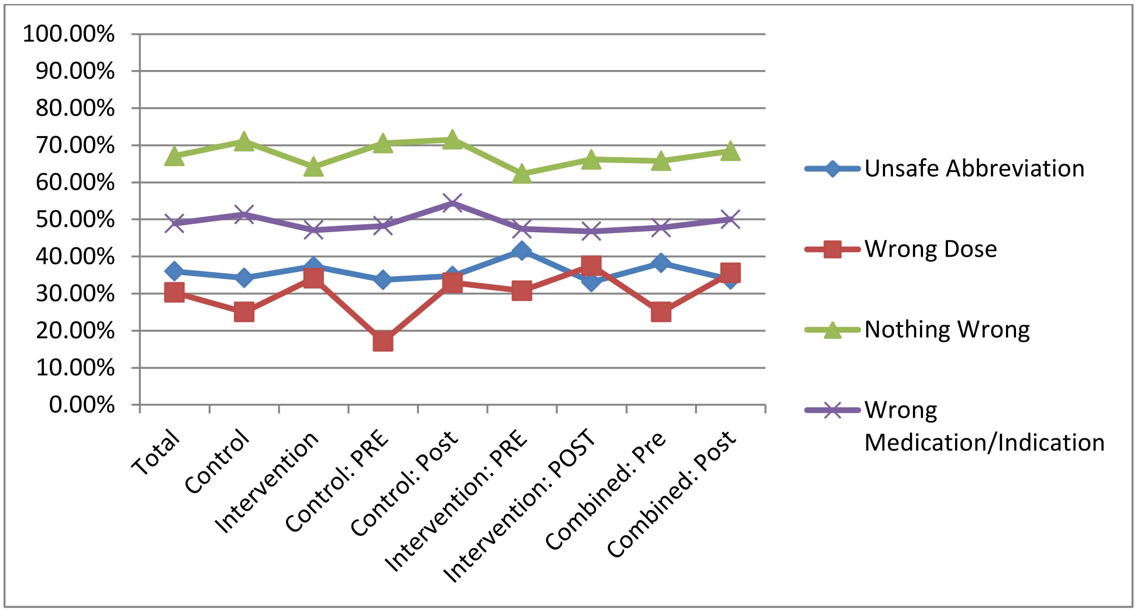
Similar analyses were undertaken to assess multiple correlations and identify their individual contributions to predicting ΔSLS. Multivariate linear regression was again utilized with the following variables: group allocation (control vs. intervention), age, PMAE (values =

“yes” or “no”), baseline SLS, and cohort of participant participation. Overall, this analysis provided strong correlation and predictive reliability (R = 0.683, a-r^2 = 0.399, p<0.001), and there were only two variables that correlated with statistical significance to ΔSLS: baseline SLS (B = -0.50, 95% C.I -0.69 to -0.30, p<0.001) and group allocation favouring the intervention group (B = 2.94, 0.50 to 5.38, p=0.020, Table 5). This multivariate linear regression assessment for predicting ΔSLS shows that the intervention independently resulted in an additional 2.94 mean SLS points compared to the control group, when controlling for age, PMAE, baseline SLS, and cohort. As was done for assessment of predictive variables for ΔKTS, variables found not to be independent predictors of ΔSLS were subsequently removed for the purpose of generating the following predictive formula:

ΔSLS = 3.26 + 2.94[group] – 0.50[baseline SLS], p <0.001, Table 5

The distribution of correct and incorrect answers on the knowledge test per type of question identified several patterns (see Figure 1). Generally, all groups at all points of evaluation: (a) scored lowest on the type of error of wrong dose, (b) scored higher on questions regarding wrong medication/indication than questions regarding wrong dose, (c) despite nearing the end of their education (4^{th} year BScN Nursing), generally poor awareness of unsafe abbreviations was evident, and (d) students were most successful at correctly identifying medication orders which had nothing wrong.

Figure 1:
Percentage of Correctly Answered Knowledge Test Questions per Type of Answer



In conclusion, results of this study failed to reject the null hypothesis that there was no significant difference between groups on the knowledge test scores. Therefore nursing students in fourth year of BScN program who participated in a learning module about system factors and medication errors, in addition to clinical experience showed no significant difference in knowledge of system factors than students who participated in clinical experience only, which is the current method of learning about system factors. It is important to note that post-hoc power analysis to detect differences in change in mean knowledge scores was calculated to be low at 0.27, thus raising doubt of type 2 error. In regards to the secondary hypothesis, the results of this study rejected the null hypothesis that there was no significant difference between groups on the Perceived Competence Scale scores. Therefore nursing students in fourth year of BScN program who participated in a learning module about system factors and medication errors, in addition to clinical experience had greater perceived competence in identifying system factors which contribute to medication errors than students who participated in clinical experience only.

CHAPTER 4:

Discussion

Primary Study Outcome

Despite the initial finding that change in knowledge test scores significantly improved in the control group, but not the intervention group, no statistically significant difference was seen when comparing the two groups' change in knowledge test scores to each other. Subsequently, with the use of multivariate linear regression analyses to assess correlations of variables to change in knowledge test scores, the impact of group allocation was again not found to be a statistically significant predictor, but the cohort of the participant was. Although the impact of additional time in simulated clinical education among 2nd cohort participants prior to participation cannot be ruled out as a significant contributing factor as it was not explicitly assessed, baseline knowledge test scores did not differ between cohorts ($p = 0.896$), suggesting that this factor did not play a significant role. As the baseline knowledge test scores did not differ in either cohort, it may be postulated that a broader knowledge base and/or better test taking skills likely did not play significant roles either.

The significant cohort-associated difference in change in knowledge test scores may have been the result of specific yet-unidentified participant characteristics within the 2nd cohort. Two such characteristics which were not included as variables in the demographics of the cohorts are specific clinical units at which the students were placed and the students' overall grades. It is possible that the 2nd cohort participants practiced on clinical units which provided more experiences with certain medications, thus giving them an advantage compared to 1st cohort participants. Since the 2nd cohort completed the study and respective acute care clinical placement in the last 6 weeks of the fall semester as opposed to the first 6 weeks of the semester, it could be possible that the students' performance in the 2nd cohort was increased as a function of studying for any final exams at the end of the semester. It could also be argued that students in the 1st cohort which completed the study and respective acute care clinical placements in the first 6 weeks of the fall semester had to prepare for midterms which were at the end of their placements, but the improvement in scores of the 1st cohort did not resemble the improvement in scores of the 2nd cohort. The researcher is not aware of any historic events that could have impacted the performance of the 2nd cohort.

Peeters et al. (2009) conducted an experimental study to determine the effectiveness of an online learning module in increasing the ability of doctor of pharmacy students to identify and correct prescribing errors using an instrument which consisted of 20 questions based on medication errors as was very similar to the instrument (knowledge questionnaire) in this study. The authors concluded the module was effective at teaching pharmacy students to detect and correct prescription errors. This study did not find that the learning module was effective at teaching nursing students to detect prescription errors. The lack of congruence in results could be assigned to one of the differences in study design. The students in the study by Peeters et al. (2009) completed posttests immediately following the intervention of a learning module. In this study, there was a 4-week lapse between completion of intervention of a learning module and completion of posttest, which allows for evaluation of use and retention of information.

Overall, majority of the groups at all points of evaluation scored lowest on the type of error of wrong dose, which correlated to findings by Wolf et al. (2006). This could be attributed to poor knowledge of medication dosages or lack of experience in working with medication doses, thus negatively impacting the students' ability to recognize incorrect doses. Furthermore, it could be an indicator of need for targeted education regarding medication dosages among nursing students. Overall, students were more knowledgeable of wrong medication/indication than wrong dose, which could be reflective of in-class education focus. Students were most successful at correctly identifying medication orders which had nothing wrong. This is consistent with Benner's Novice to Expert theoretical framework, as students considered as advanced beginners for the purposes of this study, are able to identify normalcy, but have difficulty identifying its deviations (Benner et al., 1992).

As noticed by Warholak et al. (2011) in their study of the ability of pharmacy, medical and nursing students to detect prescription errors, regardless of program of study, students demonstrated an overall low ability to identify errors. From the short list of 3 prescriptions, 2 of which contained errors, in their study, most of the nursing students detected 1 error, but only 7.5% of nursing students answered all 3 questions correctly. The overall low ability of students to identify errors was also confirmed in this study as the mean score on the knowledge test was low at 9 out of possible 20 correct answers.

Secondary Study Outcome

Summative Likert scores on the Perceived Competence Scale were initially shown to have a significant improvement from baseline within the intervention group but not the control group, and again no statistically significant difference was identified when groups' change in summative Likert scores was compared to each other. Subsequently, when the analysis was controlled for potential confounding variables, the intervention group resulted in a significant change in summative Likert scores improvement (3.196 points, $p = 0.012$) compared to the control group. R and a-r^2 were 0.696 and 0.418, respectively, indicating a strong degree of reliability, implying that there were few unaccounted variables in this assessment of the intervention's impact on change in summative Likert scores (Table 5).

Page and McKinney (2007) implemented a "Medication Safety Day" which focused on education of nursing students about system factors and medication errors similar to the learning module in this study. The authors reported that students provided positive feedback and increased awareness of system factors as a result of the "Medication Safety day". Similarly, the students in this study who viewed the learning module on system factors and medication errors reported significantly higher level of perceived competence compared to their counterparts who did not view the learning module. Page and McKinney did not evaluate the effectiveness of the "Medication Safety Day" on the students' actual knowledge of system factors. This study evaluated actual knowledge of system factors as well as perceived competence to identify system factors, and it was found that even though students reported a significant increase in perceived competence, this did not translate into actual knowledge.

Even though the intervention did not contribute to change in knowledge, its contribution to perceived competence may still be important for nursing students. According to Benner's Novice to Expert theoretical framework, nursing students as advanced beginners are concerned with their ability to meet the challenges of clinical situations. The learning module of this study increased the students' perceived competence to meet one of the challenges of clinical situations – system factors that contribute to medication errors. Furthermore, as Wolf et al. (2006) reported, nursing students feel distressed about committing medication errors - this implies that efforts to address perceived competence are important.

Other Considerations

Both change in knowledge test scores and change in summative Likert scores had significant negative correlations with their respective baseline values, which may not be surprising because those participants who initially scored poorly had greater capacity for improvement than those who initially scored well, having relatively little room for improvement.

Demographic variables which were identified as potential confounding variables such as previous medication administration experience and pharmacology education outside of the nursing program were not found to be significant contributors to change in knowledge tests scores and summative Likert scores. There is no indication that this is true for the whole population as there were only 10 participants with previous medication administration experience and 1 participant with pharmacology education outside of the nursing program in this sample of the population.

A larger sample size would create greater power in making inferences about the effectiveness of the learning module and could decrease to the possibility of type 2 error which cannot be dismissed at present. On the contrary, the failure to reject the null hypothesis may simply be a confirmation of Benner's Novice to Expert theoretical framework which postulates that learning from experience helps nurses advance to higher levels of competency (Brykczynski, 2006; Waldner & Olson, 2007).

Limitations

There are several limitations to this study:

1. Students were asked to complete pretest first and then view the learning module. There was no checkpoint built into the study design to confirm the participants followed these instructions. If participants chose not to follow the study instructions and viewed the presentation first and then completed the pretest, this could have minimized the change in knowledge scores.

2. This study evaluated only *select* system factors reported as frequently implicated in medication errors by nursing students.
3. The results have limited generalizability outside of the nursing program in this study as it was a single-site study.
4. It is not known if students utilized any pharmacological resources to aid in answering questions.
5. The overall scores on the knowledge tests were low, which could indicate that the questionnaire was too difficult or the learning module did not provide adequate or clear information.
6. It is uncertain if the material regarding system factors contained within the learning module was sufficient to produce difference in knowledge test scores between groups, or if the teaching strategies/format were effective at teaching students about system factors.
7. Even though block randomization of group assignment according to clinical group was used as a strategy to prevent contamination effects, many nursing students live together and spend time together, therefore, the degree of controlling contamination is not certain. This could have contributed to minimization of the difference in knowledge scores between groups.
8. Students did not have the opportunity to learn from their test in order to protect reliability/validity but it could have been a useful teaching strategy.
9. A larger sample size could increase the confidence in the findings of this study. A post-hoc power analysis of 0.27 revealed a low power of this study to detect

differences in change in mean knowledge test scores, thus raising the question of type 2 error.

Implications

Nursing Research

From the results of this study, it is evident that student nurses' perceived level of competence regarding identification of system factors does not translate into actual ability to identify system factors. The implication of this finding is that future studies that evaluate effectiveness of interventions regarding system factors should measure actual student ability in addition to students' perceived ability. Further research to assess various teaching strategies most effective for teaching about system factors is warranted – comparing the effectiveness of various teaching strategies could provide insight into the most effective way to teach students about system factors. Comparison of learning through experience to various teaching strategies should also continue.

Furthermore, inclusion of multiple educational institutions in future research may increase the generalizability of the results to a wider population of nursing students. A multi-site study would also allow for increase in sample size and power to detect differences. Inclusion of demographic variable of overall grades and exact clinical unit placements among cohorts may help explain any differences in student performance not attributable to educational interventions. Allowing the students to learn the answers of the tests may be used as a teaching strategy, and the design used by Peeters et al. (2011) may be an appropriate approach for this.

Nursing Education

As consistent with findings by Warholak et al. (2011) participants in this study demonstrated an overall low ability to identify prescription errors, with a mean score of 9 out of possible 20 correct answers, which raises questions regarding the amount and quality of nursing student education regarding medication safety. Students scored lowest on the type of error of wrong medication dose, as was consistent with findings by Wolf et al. (2006), followed by second lowest score on the type of error of wrong medication indication. Considering that 40% of nursing practice time is spent on medication administration, it is reasonable to expect that medication knowledge should be one of nursing's strongest suits. As noticed by Warholak et al. (2011) in their study of the ability of pharmacy, medical and nursing students to detect prescription errors, pharmacy students scored significantly higher compared to their medical and nursing counterparts. Warholak et al. (2011) attributed this finding to greater number of hours of pharmacology education along with repetition. Based on the findings by Warholak et al. (2011), it can be extrapolated that one of the strategies toward improving nursing student medication knowledge is greater focus on pharmacology education, particularly around medication indications and dosages, along with the role of other system factors that contribute to medication errors such as dangerous abbreviations. Faculty development may also need to be explored as one of the strategies toward improvement in student medication education. Paige and McKinney (2007) recognized lack of nursing medication knowledge as a significant issue and as a possible indication of a system failure of educational institutions to adequately educate and train health care professionals.

Moreover, this study reported that an online learning module did not have a significant impact on nursing student knowledge of system factors contributing to medication errors compared to learning from clinical experience alone. However, effectiveness of other educational efforts should be explored in an effort to improve nursing student medication knowledge. Educational efforts toward increasing awareness of system factors may also improve the students' satisfaction with the program of study if they feel the received education increased their competence to meet the challenges of clinical situations related to medication errors and safety. The nursing school in this study does not have a reporting system for student medication errors. It may be advantageous to consider collaborating with associated teaching hospitals to share reports of student medication errors – this would help evaluate the learning needs of students per educational program thus leading to better targeting of educational efforts.

Nursing Practice

One of the ways in which nursing practice could support nursing education is through practitioner's participation in helping students learn about system factors "in the moment". Other strategies for prevention of medication errors by nursing students could be explored such as increased supervision of students during medication administration as experienced nurses may be more skilled at recognizing system factors.

Conclusion

System factors play a major role in medication errors, especially in the context of students' limited experience (Wolf et al., 2006). System factors are not adequately addressed in nursing education about medication safety which identifies an area of education with ample potential for intervention (Harding & Petrick, 2008). This study evaluated whether current knowledge acquisition from experience can be accomplished through an online learning module about identified system factors and their role in medication errors. The contributions from this study for nursing research are recommendations such as: (a) continued inclusion of measures of actual knowledge as well as measures of perceived competence, (b) further evaluation of effectiveness of various teaching methods/strategies, (c) continued efforts to compare teaching strategies to clinical learning from experience, (d) inclusion of multiple sites to increase generalizability as well as to increase sample size and power, (e) inclusion of demographic variable of overall grades, and (f) use of innovative study design as used by Peeters et al. (2011) in executing further similar research studies. The contributions from this study for nursing education are: (a) support for continued efforts toward education regarding system factors as it improves student perceived competence with potential downstream effect of increased student satisfaction with the nursing program, and (b) support for university-based student error reporting database which would allow for site-specific pattern analysis thus granting insight for program improvement and development. Lastly, the findings from this study suggest possible implications for nursing practice such as the need for nurses to draw the students' attention to system factors during real-time clinical experience.

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APPENDIX A

Knowledge Questionnaire

Can Practical Knowledge from Experience About Medication Safety be Simulated Through a Learning Module for Nursing Students?

In order to link your answers before and after completion of the learning module, please write in the last four digits of your phone number:________________

Please identify all UNSAFE aspects in the following orders (choose the BEST answer ONLY for each question):

1.) Your patient is experiencing hyperglycemia. The order reads: Regular insulin 6u subcutaneous now

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

2.) Your patient is experiencing pain. The order reads: Acetaminophen 650 mg suppository per rectum q 6 hours

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

3.) Your patient has hypertension. The order reads: Metformin 50 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

4.) Your patient has coronary artery disease. The order reads: Aspirin 81 mg PO OD

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

5.) Your patient has anxiety and insomnia. The order reads: Diltiazem 5 mg PO BID PRN

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

6.) Your patient has atrial fibrillation. The order reads: Metoprolol 250 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

7.) Your patient has diabetes mellitus. The order reads: NPH insulin 8.0 units subcutaneous at bedtime

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

8.) Your patient is experiencing chest pain. The order reads: Nitro 1 spray q 5 min for three doses PRN

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

9.) Your patient has insomnia. The order reads: Lorazepam 1 mg PO at bedtime PRN

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

10.) Your patient has atrial fibrillation. The order reads: Digoxin 12.5 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

11.) Your patient is experiencing pain. The order reads: Oxycontin 5 mg PO q 3 hours PRN

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

12.) Your patient is experiencing pain. The order reads: Hydromorphone 40 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

13.) Your patient is experiencing nausea. The order reads: Dimenhydrinate 25-50 mg PO q 4 hours

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

14.) Your patient has hypertension. The order reads: Haloperidol 5 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

15.) Your patient has diabetes mellitus. The order reads: Metronidazole 500 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

16.) Your patient has a history of arthritis. The order reads: Ibuprofen 200.0 mg PO TID PRN

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

17.) Your patient has a history of pulmonary embolism. The order reads: Warfarin 25 mg PO at bedtime

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

18.) Your patient is experiencing acute hyperglycemic event. The order reads: NPH insulin 10 units subcutaneous STAT

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

19.) Your patient is experiencing pain. The order reads: Oxycodone 5 mg PO q 4 hours PRN

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

20.) Your patient has a history of gastroesophageal reflux disease. The order reads: Lansoprazole 40 mg PO BID

(a) nothing wrong (b) wrong dose (c) wrong medication/indication (d) unsafe abbreviation

APPENDIX B

Assessment Instrument Developed and Utilized by Warholak et al. (2011)

For each of the 3 prescriptions below, use the patient information to determine if there are any prescribing errors. If there are, please indicate the type of error you found.

Prescription 1

Name: GT DOB: 7/14/81
Diagnosis: GERD Drug Allergies: None
Weight: 65 kg
Current Medications: Multivitamin PO Q Day

Name: GT DOB: 7/14/81
Address: 123 E. 4th Place, Tucson AZ 85745

Aripiprazole 20 mg PO Q day
for GERD

#30

1. Is this prescription correct as written? (circle)
   Yes No

2. If not, please indicate the type of error you found. (circle)

   Drug-Allergy interaction
   Wrong dosage
   Wrong directions for use
   Wrong route or dosage form
   Wrong duration of therapy
   Drug-Drug interaction
   Wrong drug for indication
   Drug-Condition interaction

3. Comments (optional):

Prescription 2

Name: SL DOB: 3/7/1952

Diagnosis: Atrial Fibrillation

Drug Allergies: Penicillin

Weight: 60 kg

Current Medications: TUMS 1-2 tablet PO prn heartburn

Name: SL	DOB: 3/7/1952
Address: 456 E. 4th Place, Tucson AZ 85745	
Warfarin 5 mg PO Q day #30	

4. Is this prescription correct as written? (circle)
   Yes No

5. If not, please indicate the type of error you found. (circle)

   Drug-Allergy interaction

   Wrong dosage

   Wrong directions for use

   Wrong route or dosage form

   Wrong duration of therapy

   Drug-Drug interaction

   Wrong drug for indication

   Drug-Condition interaction

6. Comments (optional):

Prescription 3

Name: TB DOB: 4 month old

Diagnosis: URI, fever Drug Allergies: none

Weight: 5 kg

Current Medications: none

Name: TB	DOB: 4 months old
Address: 789 E. 4th Place, Tucson AZ 85745	
Acetaminophen 80mg/0.8 mL, Give 1.25 mL PO q 4-6 hours prn fever no more than 5 doses per day	
# 4 ounces	

7. Is this prescription correct as written? (circle)
   Yes No

8. If not, please indicate the type of error you found. (circle)

   Drug-Allergy interaction

   Wrong dosage

   Wrong directions for use

   Wrong route or dosage form

   Wrong duration of therapy

   Drug-Drug interaction

   Wrong drug for indication

   Drug-Condition interaction

9. Comments (optional):

APPENDIX C

Perceived Competence Scale

Can Practical Knowledge from Experience About Medication Safety be Simulated Through a Learning Module for Nursing Students?

In order to link your answers before and after completion of the learning module, please write in the last four digits of your phone number:________________

Please read each item and select the number that indicates your level of agreement.

1 – Strongly Disagree

2 – Moderately Disagree

3 – Slightly Disagree

4 – Neutral

5 – Slightly Agree

6 – Moderately Agree

7 – Strongly Agree

I feel confident in my ability to identify factors contributing to medication errors.

1 2 3 4 5 6 7

I feel capable of identifying factors contributing to medication errors.

1 2 3 4 5 6 7

I am able to identify factors contributing to medication errors.

1 2 3 4 5 6 7

I am able to meet the challenge of identifying factors contributing to medication errors.

1 2 3 4 5 6

APPENDIX D

Intervention Group Online Learning Module

MEDICATION SAFETY

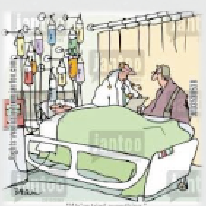
HOW DO I DO THIS?

✓First, thank you for participating in this study.

✓Please complete the questionnaire **before** continuing to view the presentation. It is imperative to the integrity of the study that the questionnaire be done FIRST. Thank You!

✓To access the questionnaire, please copy and paste into your browser:
https://www.surveymonkey.com/s/P29PBQD

WHAT ARE WE DOING HERE?



- ✓ Here you will learn about the role of system factors relevant to **YOUR medication administration performance**. This will be done through story-telling and review of important tips to help **YOU prevent medication errors.** The presented stories are real!
- ✓ Currently, the main method by which nurses learn about system factors and their implications in medication errors is through experience.
- ✓ **The purpose of this presentation is to raise your awareness of existence of system factors, to teach you about selected factors, and to attempt to teach knowledge from experience.**

I NEED TO KNOW MORE THAN THE 8 RIGHTS TO BE SAFE?

- ✓ System factors are any and all elements of the workplace setting where the process of medication administration is executed.
- ✓ This presentation will focus on system factors such as: drug names that sound alike, multiple strengths and dosage forms, and error-prone abbreviations.
- ✓ Other examples of system factors include illegibility of the medication administration record (MAR), medications similar in appearance, poor lighting, noise, distractions, inexperience, poorly organized tasks, etc.

DON'T MEMORIZE THE EIGHT RIGHTS, PRACTICE THEM!

- **Common thought:** I know my patients, why do I need to check their arm band every time?
- **Real life story:** A nurse was caring for two patients in a semi-private room. After preparing the medications, the nurse walked up to the wrong patient and administered the medications that were intended for the other patient in the same room.
- **Take away:** ALWAYS check the armband and confirm the **RIGHT PATIENT!**

IT'S NOT THE DESTINATION, IT'S THE ROUTE!

- **Common thought:** Of all the medication rights, getting the right route seems obvious!
- **Real life story:** A nurse crushed *oral* medications for administration and was about to administer them through the peripherally inserted *central catheter* when another nurse caught her mistake. This prevented a potentially fatal event from solids entering the blood stream and acting as emboli.
- **Take-away:** Considering the **RIGHT ROUTE** is not to be overlooked!

DO IT FOR THE RIGHT REASON!

- **Common thought:** If I just follow the Medication Administration Record (MAR) closely, I am unlikely to make mistakes.
- **Real life story:** Warfarin 10 mg orally at bedtime was on a patient's MAR in error. The nurse did not realize that this blood thinner medication was not indicated for the patient and administered it. As a result, the following day procedure had to be delayed due to increased patient risk for bleeding.
- **Take away:** Following the MAR is not fool proof! The nurse must ensure the **RIGHT REASON** for the **RIGHT MEDICATION.**

ALWAYS HAVE THE SITE IN SIGHT!

- **Common thought:** How can someone get the wrong site?
- **Real life story:** A nurse administered Atropine eye drops (used to dilate pupils for eye exams) to left eye instead of right eye. As a result, planned eye surgery could not proceed as the right eye was not adequately dilated.
- **Take-away:** Always confirm the **RIGHT (correct) SITE!**

MEDICATION ERRORS CAN BE A MATTER OF LIFE AND DEATH

- **Common thought:** I've done this a thousand times, it's a no-brainer!
- **Real life story:** A patient was prescribed potassium chloride for low potassium levels. When programing the infusion pump, the nurse entered 100 ml/hr instead of 10 ml/hr. The patient received a 10-fold dose and died of a heart attack as a direct cause of this nursing error.
- **Take away:** ALWAYS double-check the **RIGHT** medication **DOSAGE!**

TIPS TO AVOID ERRORS

✓ Treat blood thinners with extra caution! Know the standard dosages for common blood thinners such as warfarin (Coumadin) which is 2-10 mg per day.

✓ Double-check all your calculations and infusion rates for medications capable of causing serious patient harm such as Heparin and Potassium Chloride!

DO I NEED TO KNOW STANDARD MEDICATION DOSAGES?

Knowing standard medication dosages will help you prevent mistakes like these:

YOU CAN SAVE A LIFE!

- **Common thought:** If I follow Doctor's orders, I am unlikely to make a mistake.
- **Real life story:** A Physician ordered an oral dose of Digoxin (given to treat heart failure and arrhythmias by lowering heart rate) four times daily instead of once daily. The nurse noticed this mistake prior to administration, and potentially saved a patient's life.
- **Take-away:** Following orders is not an adequate safe-guard. The nurse must be knowledgeable of the **RIGHT FREQUENCY** and **TIME** for administration of each medication.

"DANGEROUS ABBREVIATIONS" – WHAT IS SO DANGEROUS ABOUT THEM?

Consider the two images to the right:

In the first example, the patient received 4 times the intended dose.

Figure 2. "QD" Mistaken for "QID." Image provided courtesy of ISMP

In the second example, the patient received 11 times the intended dose of insulin.

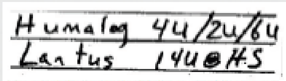
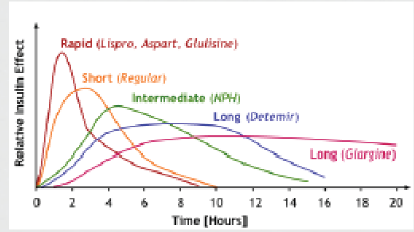


Figure 1. "4U" Mistaken for "44." Image provided courtesy of ISMP

Writing out words rather than using short forms is worth the time to prevent errors like these.

TIPS TO AVOID ERRORS WITH INSULIN

Insulins are among most commonly confused medications because they have similar names and come in many variations . The trick to prevent mistakes is to remember the action of each type of insulin. Feel free to print and use this chart in your clinical practice:



DO NOT DEPEND ON THE NAME TO TELL YOU THE ACTION OF THE DRUG

- Although suffixes often hint to which family of medications a drug belongs, it is **not** always a safe bet.
- At a quick glance, the "ol" in **Haloperidol** may mislead you to think it belongs to family of beta-blockers used to decrease heart rate and blood pressure, otherwise known as the "olol" family. Haloperidol is, in fact, an **antipsychotic**.
- As you may have learned in pharmacology, "prazole" usually refers to proton pump inhibitors used to decrease stomach acids, however aripiPRAZOLE is a perfect example of a rule breaker. AripiPRAZOLE is NOT a proton pump inhibitor, it is an antipsychotic with antidepressant properties!

"Mr. Osborne, may I be excused? My brain is full."

TRY TO REMEMBER THESE…IT WILL COME IN HANDY IN YOUR PRACTICE!

It is not just your brain playing tricks on you… the Institute of Safe Medication Practices has published a list of commonly confused medications based on names that look and sound similar. A few examples include:

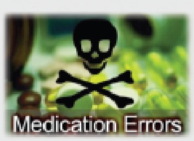
Metronidazole – Metformin
(antibiotic vs. oral hypoglycemic)

Metoprolol – Metformin
(beta-blocker vs. oral hypoglycemic)

Diazepam – Diltiazem
(benzodiazepine for anxiety vs. calcium channel blocker for hypertension)

If you wish to see a full listing of commonly confused medications for your own interest visit the Institute of Safe Medication Practices website:
http://www.ismp.org/Tools/confuseddrugnames.pdf

BE MINDFUL OF SHORT-ACTING AND LONG-ACTING VERSIONS OF THE SAME DRUG



- **Real life story:** A nurse crushed medications to be given via nasogastric tube, however failed to notice that one of the medications was an extended-release calcium channel blocker (decreases blood pressure and heart rate). As a result, a medication that was intended to be absorbed over an extended period of time was absorbed in a much shorter time-frame. About one hour later, the patient's heart stopped and he died as a direct cause of this error.
- **Take-away:** Be aware of various dosage forms and follow special instructions such as "do not crush" when indicated.

TIPS TO AVOID ERRORS WITH NARCOTIC MEDICATIONS

Narcotic medications are among most commonly confused medications. Here are two examples of drugs with similar names and tips to help you avoid confusing them:

How not to confuse Oxycodone and Oxycontin:

✓ OxycoDONE is short-acting; OxyCONTIN is long-acting
✓ Oxycodone is given more frequently or as PRN
(Remember: CONTIN is CONTINous acting, therefore it is given less frequently and NEVER as PRN)

How not to confuse Morphine and Hydromorphone:

✓ Oral Morphine 5mg = Oral Hydromorphone 1mg
✓ Another hint: Hydromorphone oral dosages are usually much smaller at 2-4 mg, than short-acting oral Morphine dosages at 10-30 mg.

DOSE DESIGNATIONS CAN BE JUST AS UNSAFE AS ABBREVIATIONS

Can you spot the difference?
Placing a zero after a decimal point is unnecessary, yet makes it very easy to misread the dose as 50 mg instead of 5 mg.

FOR YOUR PATIENT'S SAFETY, TAKE A MOMENT TO READ AND REMEMBER THESE:

LET'S REVIEW

- Write drug names in full!
- Write out ONCE DAILY instead of OD, QD, or QID.
- Remember: ZEROS always BEFORE DECIMALS, never after!
- Do not use symbols like @, <, >, and U. Spell them out!
- Do not use "D/C" (it can mean 'discharge' or 'discontinue').
- Do not use abbreviations.

THE TAKE AWAY MESSAGE:

- As illustrated in the narratives throughout this presentation, it is imperative to continue to follow the 8 rights of safe medication administration irrespective of how routine or basic it may seem. Always ensure the right: patient, medication, dose, frequency, time, route, site, and reason.
- Additionally, system factors play a major contributing role in sabotaging medication safety. In this presentation you learned about the existence of system factors, what they are, and how to prevent them from leading to compromise in patient safety.

Please be sure to complete the follow-up questionnaire in 6 weeks. Not to worry, you will receive a reminder! Without YOU, this study will not work!

We hope this was a meaningful learning experience for you and that you will find it useful in your practice!

THANK YOU FOR YOUR TIME AND ATTENTION!

REFERENCES

Anderson, P. & Townsend, T. (2010). Medication Errors: Don't let them happen to you. *American Nurse Today, 5*(3), 23-27.

Author. (2011, February 23). Mother-of-four dies after blundering nurse administers ten times drug overdose. *Daily Mail.* Retrieved from http://www.dailymail.co.uk/health/article-1359778/Mother-dies-nurse- administers-ten-times-prescribed-drug.html

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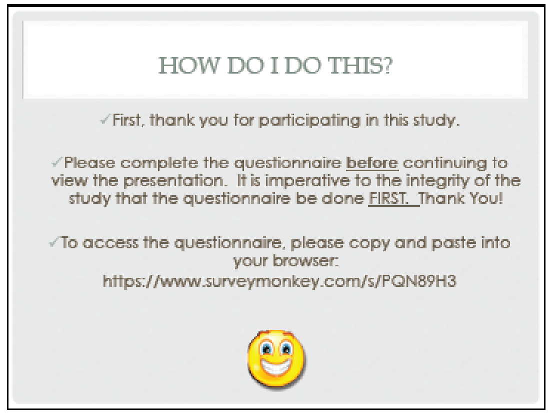
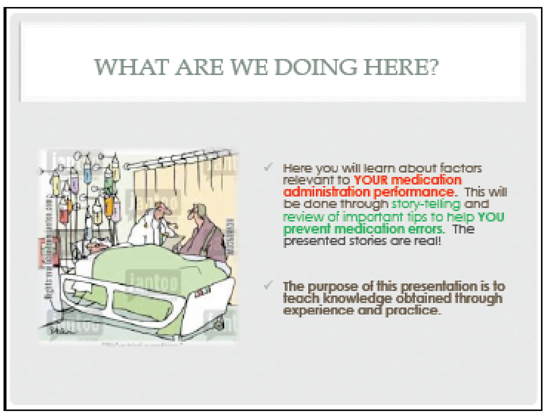
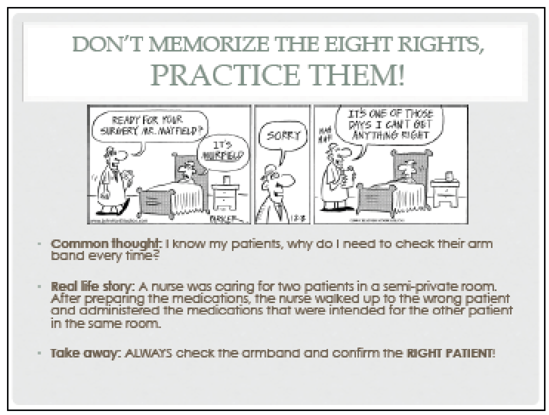
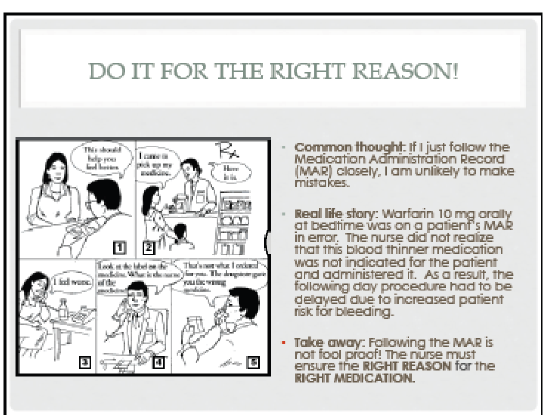
APPENDIX E

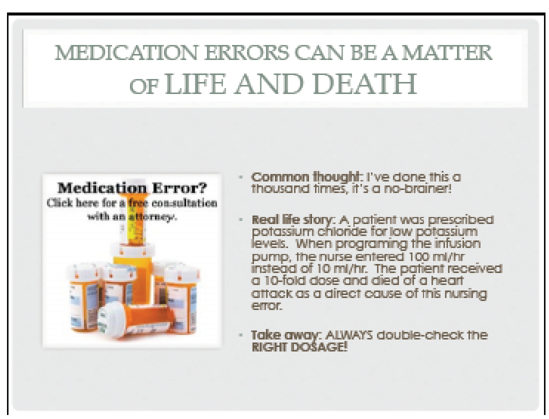
Control Group Online Learning Module







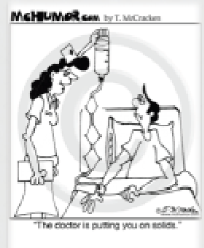




YOU CAN SAVE A LIFE!

- **Common thought:** If I follow Doctor's orders, I am unlikely to make a mistake.
- **Real life story:** A Physician ordered an oral dose of Digoxin (given to treat heart failure and arrhythmias by lowering heart rate) four times daily instead of once daily. The nurse noticed this mistake prior to administration and potentially saved a patient's life.
- **Take-away:** Following orders is not an adequate safe-guard. The nurse must be knowledgeable of the **RIGHT FREQUENCY** and **TIME** for administration of each medication.

IT'S NOT THE DESTINATION, IT'S THE ROUTE!



- **Common thought:** Of all the medication rights, getting the right route seems obvious!
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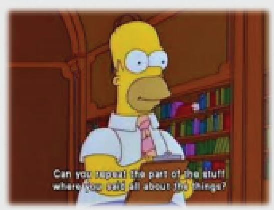
ALWAYS HAVE THE SITE IN SIGHT!

- **Common thought:** How can someone get the wrong site?
- **Real life story:** A nurse administered Atropine eye drops (used to dilate pupils for eye exams) to left eye instead of right eye. As a result, planned eye surgery could not proceed as the right eye was not adequately dilated.
- **Take-away:** Always confirm the **RIGHT (correct) SITE**!

THE TAKE AWAY MESSAGE



✓As illustrated in the narratives throughout this presentation, it is imperative to continue to follow the 8 rights of safe medication administration irrespective of how routine or basic it may seem. Always ensure the right: patient, medication, dose, frequency, time, route, site, and reason.

Please be sure to complete the follow-up questionnaire in 6 weeks. Not to worry, you will receive a reminder! Without YOU, this study will not work!

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Lambert, B. L., Chang, K. Y., & Lin, S. J. (2001). Effect of orthographic and phonological similarity on false recognition of drug names. *Social Science & Medicine, 52*, 1843-1857.

APPENDIX F

Demographic Information

Can Practical Knowledge from Experience About Medication Safety be Simulated Through a Learning Module for Nursing Students?

Directions: Please answer the questions by writing in the space provided or circling Y for yes or N for no.

Age on your last birthday: _________

Is this the first time you are participating in the 4th year clinical placement? Y/N

Do you have work experience outside of nursing clinical placement where you administered or dispensed medications?   Y/N

If yes, how many years have you been administering medications? _______

Do you have pharmacology education outside of what you learned in the nursing program? Y/N

If yes, what is the type of education? _____________

And how long was the education program?   _____________

APPENDIX G

Letter of Information

Study Name: Can Practical Knowledge About Medication Safety be Gained Through a Learning Module for Nursing Students?

Principal Investigator: Barbara Sinclair, MScN, Western University

Co-Investigator: Tanja Krunic, Master of Science in Nursing student, York University

Contact Information: tkrunic@yorku.ca

Faculty Supervisor: Professor Mina Singh, York University

Faculty Advisors: Professors Janet Jeffrey and Sandra Gabriele, York University

Letter of Information

You are invited to participate in a research study about medication safety. Individuals who are in their fourth year of undergraduate nursing education and entering acute care clinical placements within London Health Sciences Centre where they are expected to administer medications are eligible to participate in this study. The intent of this letter is to provide you with information required to make an informed decision regarding participation in this research. Despite education regarding safe medication practices, medication errors still occur, which implies that additional forces are at work such as various system factors. System factors are any and all elements of the workplace setting where the process of medication administration is executed. Currently, the main method by which nursing students learn about the role of system factors in medication safety is through experience. The purpose of this study is to evaluate the effectiveness of a learning module as a way of (a) increasing student knowledge and awareness of specific system factors and their role in medication errors; (b) increasing student perceptions of competence in identifying specific system factors contributing to medication errors.

Study Requirements

If you agree to participate, you will be asked to complete a demographic questionnaire, two online questionnaires and an online learning module during scheduled clinical placement hours or on your own time as an alternative; this will take approximately 45 minutes during second week of clinical placement. You will also be asked to complete two online questionnaires during the last week of the clinical placement that will take approximately 15 minutes to complete. The online questionnaires and learning module will be provided via Sakai for ease of access, however the questionnaires will be powered by Survey Monkey to ensure your scores cannot be connected to your Sakai username. To compensate for your time, all participants will be entered for a draw to win 1 of 10 Tim Horton's cards in the amount of $10 dollars each at the end of the study and semester.

Risks and Benefits of Participation

The possible benefits to participating in this research include learning about medication safety and improving your practice through prevention of potential medication errors. The possible benefits to society may be preventing patient harm through prevention of medication errors. There are no anticipated risks associated with this study. Your participation may be known to other students in your clinical group should you decide to use clinical time for completion of the study.

Voluntary Participation

Your participation in the research is completely voluntary and you may choose not to answer a question by leaving it blank. You may also withdraw from the study at any time with no effect on your future academic status because no one in the university will know whether or not you participate in this research. Your decision to withdraw from the study will also not influence your relationship or the nature of their relationship with researcher or with staff at the university either now or in the future. In the event that you withdraw from the study, all associated data collected will be immediately destroyed. If you decide to withdraw, you will still be entered into the draw to win a Tim Horton's card.

Protection of Confidentiality

Confidentiality will be provided to the fullest extent possible by law. There will be no collection of identifying information in any of the questionnaires. The collected data and questionnaire scores will not be connected to you in any way; therefore they cannot have any impact on your academic grades. You will be asked for the last 4 digits of your phone number for the purposes of matching your answers to the pre and post questionnaires, but without the full phone number your identity will not be known. All collected data will remain confidential and accessible only to co-investigator. All electronic data will be password protected and printed data will be kept in a locked cabinet for 5 years after which time printed information will be destroyed by shredding and electronic files will be permanently deleted. If the results are published, your name will not be used. Representatives of The University of Western Ontario Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research.

Contact Information

If you require any further information regarding this research project or your participation in the study you may contact principal investigator Barbara Sinclair at blsincla@uwo.ca, or co-investigator Tanja Krunic at tkrunic@yorku.ca, or Prof. Mina Singh at minsingh@yorku.ca. You may also contact York University Nursing Graduate Program at gradnurs@yorku.ca. If you have any questions about the process, your rights as a participant in the study, or the conduct of this study, you may contact The Office of Research Ethics at Western University (519) 661-3036, email: ethics@uwo.ca. Alternatively, you may also contact the Senior Manager and Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University, telephone 416-736-5914 or e-mail ore@yorku.ca. If you would like to receive a copy of any potential study results, please provide your name and e-mail separately from the Consent Form. If you agree to participate please sign below. Thank you.

This letter is yours to keep for future reference.

APPENDIX H

Consent Form

Study Name: Can Practical Knowledge About Medication Safety be Gained Through a Learning Module for Nursing Students?

Principal Investigator: Barbara Sinclair, MScN, Western University

Co-Investigator: Tanja Krunic, Master of Science in Nursing student, York University

Contact Information: tkrunic@yorku.ca

Faculty Supervisor: Professor Mina Singh, York University

Faculty Advisors: Professors Janet Jeffrey and Sandra Gabriele, York University

I have read the Letter of Information and have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

I ______________________________ consent to participate in "Can Practical Knowledge About Medication Safety be Gained Through a Learning Module for Nursing Students?" study conducted by principal investigator, Barbara Sinclair and co-investigator Tanja Krunic. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

____

Name of Participant (Print) Signature of Participant **Date** (yyyy-mm-dd)

Person Obtaining Informed Consent:

My signature below signifies that I have explained the nature and purpose of the study and the risks involved to the study participant, and I have answered all questions to the best of my ability.

____

Name of Person (print) Obtaining Informed Consent **Signature of Person Obtaining Informed Consent** **Date** (yyyy-mm-dd)