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# Exploring Relationships Between Practicing Registered Nurses(RNs)Pharmacology Knowledge and Medication Errors

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Pharmacology Knowledge and Medication Errors

Coleen Kumar
Seton Hall University

Exploring the Relationships between Practicing Registered Nurses (RNs)

Pharmacology Knowledge and Medication Error Occurrence

By

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**DEDICATION**

**This dissertation and all my academic achievements are dedicated to my beloved husband, Dr. Sampath Kumar.  Thank you for all the encouragement, support and patience and most importantly thank you for believing in me even when I didn't .**

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ERRORS

Coleen Kumar

Seton Hall University, 2015

Dissertation Chair, Dr. Deborah DeLuca, MS, JD

*Background*: Medication errors result in significant negative patient outcomes and major costs to the health care system. Registered nurses (RNs) assume a major role in the medication administration process demanding high-level knowledge and skills.

*Aim:* This study aimed to determine if there was a relationship between practicing RNs' pharmacology knowledge and medication error occurrence.

*Methods:* A descriptive, correlational design was used to explore the relationship between RN pharmacology knowledge and medication error occurrence. Participants included 211 practicing nurses (RNs) from healthcare facilities in New York and New Jersey. The Medication Calculation Skills Test (MCS) (Grandell-Niemi, H., Hupli, M., Leino-Kilpi, H., & Puukka, P., 2005), (Appendix A) determined the perceived and actual pharmacological skills of RNs. Data were analyzed using descriptive and inferential statistics.

*Results:* The MCS survey explored the participants' perceived pharmacology knowledge and tested the participants' pharmacology and calculations abilities. The Demographic Questionnaire (Appendix B), developed by the researcher,

asked the participants' to self-identify in the following areas: age, gender, educational level, setting, specialty, shift time worked, certification status and employment status. In addition, participants were asked to identify their experience with a medication error and respond to the type, cause, harm to patient, and RN experience including the healthcare system culture.

The following shows the results of each research question.

**Findings 1**: There is a relationship between the composite MCS test score and the chance of a medication error. Composite knowledge (pharmacology and calculations) was predictive of a medication error. The result when measured with the MCS was statistically significant (p=. 05).

**Findings 2**:  It was not possible to predict the occurrence of a medication error (as determined from an RN's self report) if only the RN's pharmacology knowledge was known (as measured by the MCS test). The result for the logistic regression run for the pharmacology knowledge only score was not statistically significant (p = .271).

**Findings 3**: Certain characteristics of the population when added to the composite test score had a statistically significant impact on the medication error rate: specialty (p=.027), education (p=.023), certification (p=.010), setting (p=.040), and shift time (p=.005).

In addition, the following information was gleaned from the demographic survey.

**Findings 4**: The #1 cause of medication errors reported was distractions (43%). For nature of the error, the majority (39%) had to do with administering a medication to the wrong patient.  The majority of the participants reported that

the error had no consequence for the patient 57(72%) involved nor the RNs involved 84(58%). A punitive culture was reported by 27 percent of participants. *Conclusion :* If nursing leaders and educators recognize that there is a predictive relationship between  RN pharmacology knowledge and medication administration errors, they will have evidence to modify basic and continuing education with the goal of reducing the negative impact of medication errors. This predictive relationship should motivate nursing leaders and educators to foster an environment of continuing excellence and lifelong learning through education and certification of professional nurses.


Key words: medication error ; medication administration; Registered Nurse; knowledge; pharmacology knowledge ; patient outcomes; patient safety.

**Chapter I**

**INTRODUCTION**

Errors surrounding the use of medications by healthcare professionals are surprisingly common and have been identified as the most common type of error affecting the safety of patients. As many as 100,000 people die each year due to medical errors, including medication errors, according to the Institute of Medicine's report, *To Err Is Human*, (IOM, 1999). In a more recent study, published in the *Journal of Patient Safety* (2013), the reported number is much higher. According to James, 2013, "The numbers may be much higher, between 210,000 and 440,000 patients each year who go to the hospital for care suffer some type of preventable harm that contributes to their death" (p.127). If 440,000 people die each year because of care received during their hospitalization, this equates to one sixth (1/6) of all deaths in the United States per year and places medical errors as the third leading cause of death in the US, behind cardiac disease and cancer (James, 2013).

Medications are chemicals that are intended to cure, halt, or prevent disease; ease symptoms; or help in the diagnosis of certain illnesses. They are prescribed and administered to patients with the intention of achieving results that improve a patient's quality of life while minimizing patient risk (ASHP, 1993; 2012), yet according to the US Food and Drug Administration's Center for Drug Evaluation and Research (CDER, 2009) it is estimated that on average, there is at least one medication error per hospital patient per day, costing at least $3.5 billion in extra medical costs per year (US FDA, 2012). Medication errors are a universal problem occurring in hospitals,

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outpatient/office-based surgery centers, ambulatory practice settings/office-based practices, and long-term care/skilled nursing facilities (Chang & Mark, 2009, Kessels-Habraken, Van der Schaaf, DeJonge, Rutte, 2010).

**Incidence of Medication Errors**

The Department of Health and Human Services (HHS) is the Federal Government's principal agency for protecting the health of Americans. In the 2010 Inspector General's report on adverse events in hospitals, it was estimated that 13.5% of hospitalized Medicare beneficiaries' experienced adverse events during their hospital stay (Levinson, 2011). The incidence of medication errors is an important patient safety issue as these errors impact all patients (Lin, 2009). An estimated 400,000 preventable drug-related injuries occur each year in hospitals (Levinson, 2011). Another 800,000 medication errors occur in long-term care settings, and roughly 530,000 of these errors occur just among Medicare recipients in outpatient clinics (IOM, 2006).

In 1999, the Institute of Medicine published what is now considered a seminal report, *To Err is Human,* as a comprehensive strategy to address and reduce preventable medical errors. James Reason's definition of error was used by the IOM to explain medical errors. An error, according to Reason (1990), can be defined as "all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency"(p. 9). Planned actions that result in error, according to Reason, fail to achieve their desired outcome either because the actions did not go as planned or because the plan itself was deficient (1990). The report outlined a four-part plan that was intended to create a safer health care system. The

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four part recommendations include: to develop a national center for patient safety; incorporate mandatory and voluntary reporting systems; to include key stakeholders, patients, professionals, and accreditation groups in the initiatives; and to build a culture of safety.   The report assumes that errors occur in health care as in all complex systems that involve humans.  More than ten years after the publication of *To Err is Human,* extensive efforts and changes have occurred in the effort to recognize and implement actions to prevent errors. The literature abounds with descriptions of the work to change and improve patient safety as well as the progress that has been made towards improvement ("The Richard and Hinda Rosenthal Lecture", 2011).  The IOM report concluded by setting as a minimum goal a 50 percent reduction in errors over five years (IOM, 1999).

Six years after the 1999 publication of this landmark report, the IOM published a report on preventing medication errors.  This 2006 report, *Crossing the Quality Chasm*, set a national agenda for reducing medication errors based on estimates of the incidence and cost of such errors and the evidence on the efficacy of various prevention strategies (IOM, 2006). According to this report, medication errors are surprisingly common and costly to the nation (IOM, 2006). This report concluded that there are at least 1.5 million preventable adverse drug events (ADE) that occur in the United States each year (IOM, 2006). The true number may be much higher as these numbers are based on subjective reports such as hospital based incident reports.

Medication errors are often underreported because the reporting of errors may be influenced by the fear of punishment (Mayo and Duncan, 2004). In addition, errors that do not result in harm are often not reported not only because they caused no harm

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but also because of the lack of clarity as to what really defines an error. The Institute for Safe Medication Practices (ISMP) reports that a national or even regional medication error rate does not exist because each hospital and healthcare organizations' reporting system is different.

> A national or other regional medication error rate does not exist. It is not possible to establish a national medication error rate or set a benchmark for medication error rates. Each hospital or organization is different. The rates that are tracked are a measure of the number of reports at a given institution not the actual number of events or the quality of the care given. Most systems for measuring medication errors rely on voluntary reporting of errors (ISMP, 2015).

When all types of errors are taken into account, hospital patients can expect on average to be subjected to more than one medication error each day during their hospitalization (IOM, 2006). The cost of medical errors per year in hospitals nationwide is estimated between $17 billion and $29 billion per year (AHRQ, 2008). Not all errors lead to injury or death, but the numbers of preventable injuries that do occur are estimated to be more than a million per year (IOM, 2006). The 2006 IOM report outlines a comprehensive approach to decreasing the prevalence of medication errors requiring changes from doctors, nurses, pharmacists and others in the health care industry, from the Food and Drug Administration (FDA) and other government agencies, from hospitals and other health-care organizations, and from patients. As stated previously, the numbers of errors that occur each year are substantially greater and may account for almost 500,000 in hospitals each year (James, 2014).

Medication errors encompass all mistakes involving prescription drugs, over-

the-counter products, vitamins, minerals or herbal supplements and are the most common single preventable cause of adverse events (Levinson, 2010). According to the Office of Inspector General's 2010 report on adverse events, these errors have been identified as the most common type of error affecting the safety of patients and are the most common single preventable cause of adverse events (Levinson, 2010). Too many people are suffering unnecessary injuries, even death, as a result of preventable medication errors. Medication errors are broadly classified as any error in the ordering, transcribing, dispensing, or administration of a drug, irrespective of whether such errors lead to adverse consequences (patient harm) or not. The medication process is complex and an error can occur anywhere along the continuum with often-disastrous results (Simonsen, Johansson, Daehlin, Osvik and Farup, 2011). Medications for the most part are prescribed by physicians (and other healthcare professionals authorized to prescribe medications such as nurse practitioners and physician's assistants), dispensed by pharmacists and administered by nurses. (See Figure 1)
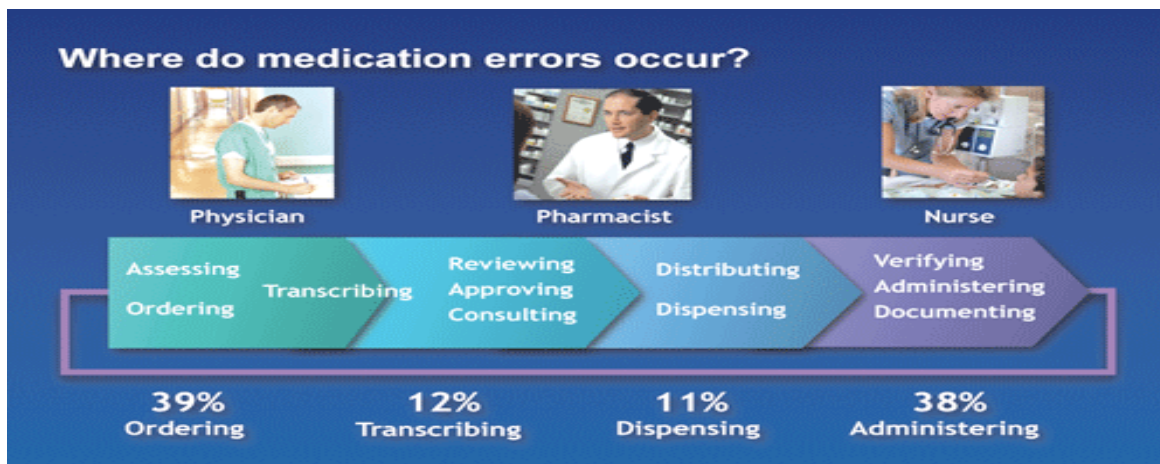


*Figure 1.The Medication Process. This figure illustrates the stages of the medication process, the key players in each stage and where medication errors occur along the continuum.* Leape et al. *(1995).*

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Registered nurses (RNs) devote a good portion of their workday to the administration of medication while struggling to provide safe patient care in today's complex healthcare arena. Medication administration is probably the highest risk task a nurse performs and errors in performance can lead to devastating consequences for both the patient and the nurse's career (Anderson and Webster, 2001; Ulanimo, O'Leary-Kelley, Connolly, 2007). A nurse's role in the medication process may include dispensing as well as preparing medications (such as when the nurse crushes pills, adds a medication to an intravenous solution or draws up a measured amount of medication for injection) for administration to a patient.   In 1988, thirty-seven percent of all medication errors occurred at the point of care when nurses were administering medication to the patient (Bayne and Bindler, 1988; Bates, Cullen, Laird, 1995). In a 2002 study that explored medication errors in health care facilities, the researchers found that one in five medication doses administered in hospitals were given in error (Flynn, Barker, Pepper, Bates and Mikeal, 2002).  In a longitudinal study reported to the FDA that evaluated reports of fatal medication errors from 1993 to 1998, the number of medication errors responsible for a patient's death was up to 41% (FDA, 2001).

According to the FDA report, 41% of fatal medication errors were related to administration of an improper dose of medicine (FDA, 2001). Giving the wrong drug and using the wrong route of administration each accounted for 16% of the medication errors that occurred at the point of care during administration (Stoppler, 2009). Medication administration is one component of the medication process and is not carried out in isolation (Wright, 2013). In a 2013 article exploring the commonly held belief that nurses are to blame for the high rate of errors, Wright, a leading expert in

nurses' role in medication management, argues that this mentality of pointing blame at individuals often present in healthcare institutions is particularly problematic for the practicing RN. According to Wright, "there is a need to move away from a culture of blame and to consider changes to medicine and the increasing complexity of administration as potential reasons for error" (2013, p. 35).

**Medication Errors Classified and Defined**

Simply stated, a medication error is" any error occurring in the medication use process" (Bates, Cullen, Laird, Peterson, Small, Servi, 1995). Lack of clarity surrounding what a medication error is and how it is defined may actually contribute to the underreporting of medication errors.  At both the organizational level and among healthcare professionals, the focus is on safe patient care.  However, organizations and healthcare professionals lack agreement regarding what characterizes a medication error. This is because medication error tracking rates differ among hospitals and healthcare organizations and the rates that are tracked are a measure of the number of reports at a given institution and not necessarily the actually number of medication errors that occur. An examination of the existing definitions of medication errors at all levels and various healthcare professions reveals a lack of agreement that can lead to potential patient harm.

Due to this lack of agreement regarding the definition of a medication error, the National Coordinating Council for Medication Error Reporting and Prevention (NCC-MERP) was formed in 1995 to address the issue of the safe use of medications and to increase awareness of medication errors through open communication, increased reporting and promotion of medication error prevention strategies (NCCMERP.Org,

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2013). The NCC-MERP and its initiatives represent an example of the ways in which healthcare reinforced and supported the four recommendations set forth by the *To Err is Human* report (IOM, 1999).

Twenty-seven leading national health care organizations (Joint Commission, Food and Drug Administration, the Institute for Safe Medication Practices, the Agency for Healthcare Research and Quality, the American Hospital Association) along with major professional organizations (American Medical Association, American Nurses Association, American Society of Health Systems Pharmacists, among others), meet and collaborate to address the causes of medication errors and to promote safe use of medications. As a result of this collaboration, the organization set out to determine a universal definition of a medication error with the hope that all healthcare professionals and organizations would adhere to it when identifying a potential error. The agreed upon definition of a medication error according to the NCC-MERP is:

> A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use (NCC-MERP, 1995; 2010).

This definition is endorsed by 27 of the leading healthcare organizations that deal with patient safety. While healthcare professionals are in agreement that there needs to be a comprehensive approach to decreasing errors, they often do not agree on how medication errors are classified and defined. Although the NCC-MERP has established a universally accepted definition of medication error, and the organization urges all

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health care professionals to use this definition as the only definition of medication errors, clinicians involved in direct patient care do not always use it.

There is consequently no single agreed upon definition of a medication error among health care professionals.  For physicians, the definition of a medication error may be determined by the circumstances surrounding the error. For example, in a 2005 qualitative study from Great Britain, 15 physicians were questioned regarding the definition of medication errors and the causes and methods to reduce these errors (McArdle, Burns, & Ireland, 2005). Responses from the participants varied depending on the description of the error. Pharmacists were seen by physician participants in this study as "a safety net checking prescribing, medication histories, highlighting drug interactions and in this way removed the need for some aspects of a doctor's role" (McArdle, et al., 2005,p. 330). For instance, the wrong route was considered a minor error with most physicians believing that as long as the patients received the correct medication, the route was less important (McArdle,et al, 2005). This type of error is rarely reported. According to McArdle, et al.,the wrong route is a minor error warranting very little intervention (2005). However, in the researchers' description of an error, they do not take into account the human physiology and the biotransformation of medication. Oral medications are absorbed overtime and must pass through the gastrointestinal system before being absorbed.  Intravenous medications are not absorbed; they are administered directly into the bloodstream where their action is felt almost immediately. Considering the wrong route of medication administration as a minor infraction as the researchers do is dangerous and may result in significant harm to the patient involved.

For pharmacists, errors that do not cause harm are not always viewed as errors.

According to the American Society of Hospital Pharmacists (ASHP), medication errors include prescribing errors, dispensing errors, medication administration errors and patient compliance errors.  Errors corrected by pharmacists in the pharmacy are often not reported because they were caught before the error reached the patient. In a 2004 qualitative study, Tamuz, Thomas & Franchois, found that medication errors were often defined away (the event did not fit the working definition of a medication error) because of the presence of formal and informal definitions. Pharmacists in this study reported that if the medication error were corrected in the pharmacy before it reached the patient, it was not identified as a medication error and no report was filed.  Obviously, this is problematic as the individual responsible for the incorrect medication order (the physician), cannot learn from the unidentified mistake and may continue to make the same errors.  Cook, Hoas and Kennedy, in a 2005 study of nurses, physicians, pharmacists and administrators from 30 hospitals across 9 states, 40% of pharmacists who responded to the researchers survey reported "a lack of agreement among healthcare providers about what constitutes an error" (p. 14). According to the researchers, pharmacists play a critical role in patient safety; pharmacist respondents to their survey supported the idea of a lack of agreement regarding what defines medication errors among pharmacists. Pharmacists in this study did not regard as error any erroneous medication order that was intercepted in the pharmacy (Cook, et al, 2005). Although the ultimate responsibility for ensuring the medications are prepared and labeled remains with the pharmacist, in a random sample study of more than 3200 pharmacy technicians responsible for delivering pharmaceutical services in a variety of healthcare settings, it was reported that higher rates of errors by technicians rather

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than pharmacists, resulted in a greater likelihood that a patients' medication order would be mislabeled or filled improperly (Desselle, 2005).

Nurses also lack agreement regarding how to define a medication error. Many nurses define medication errors as any deviation from the five rights (Baker, 1997). The "five rights" include the right medication, in the right dose, to the right person, by the right route using the right dosage form, at the right time. In addition, it is recommended that these "five rights" often include additional "rights" such as the right documentation (NCC-MERP, 2005; Gonzales, 2012). Findings from Baker's study revealed that nurses use criteria to redefine or reclassify medication errors, and after reclassifying, the nurse may decide it was not an error (1997). An example would be when a medication time is missed, a nurse may administer the medication at an alternate time and although there was a breach in one of the five rights: "right time", the nurse would no longer consider this an error as the medication was administered and no harm came to the patient (Hewitt, 2010). A 2005 qualitative study that explored nurses' management of medication errors by nurses reported that "while participants readily identified the "five rights" as the process of medication administration and prevention of medication errors they did not believe administering medications at the wrong time was not truly a medication error" (p.177). Mayo and Duncan conducted a study of nine hundred eighty-three practicing RNs surveying these nurses using the Gladstone tool, which is a tool that measures what nurses believe constitutes a medication error as well as causes of and reporting issues of medication errors (2004). The Mayo and Duncan study was replicated in the United States in 2007 by Ulanimo, O'Leary-Kelley, & Connolly, in 2007 and again in 2012 in Turkey by Unver, Tastan and Akbayrak . The results from all three

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studies reported that most nurses typically agree that a medication error can be defined as deviations from a physician's order, although most nurses do not always agree on the definition of a medication error (Mayo & Duncan, 2004). These results again illustrate the continuing confusion among nurses about what defines a medication error. It is difficult to identify a solution when few agree on how a medication error is defined.

Medication errors during the administration phase of the medication process may involve any incorrect or wrongful administration of a medication, such as a mistake in dosage or route of administration, failure to administer the correct medication or form for a particular disease or condition, use of outdated medications, failure to observe the correct time for administration of the medication, or lack of awareness of adverse effects of certain medication combinations (Thomas, 2009). For the purpose of this paper, a medication error is defined as any preventable event in the medication process (e.g., a wrong dose or infusion rate, a wrong route, a wrong administration time, omission of dose or additional dose, incorrect handling of drugs during administration) that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the registered nurse.

## Statement of the Problem

Medication errors have serious effects for both the patients and their caregivers. For the patient, a medication error may mean a longer hospital stay, disability and loss of trust in the healthcare system. The Institute of Medicine conducted a study of outpatient clinics and found that medication-related injuries there resulted in roughly $887 million in extra medical costs (IOM, 2006). This study looked only at injuries experienced by Medicare recipients, a subset of clinic visitors. The IOM estimates that

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400,000 hospitalized patients experience a preventable adverse drug event annually and estimates that at least 1.5 million preventable adverse drug events occur within the health care system each year (IOM, 2006). The impact of medication errors is far-reaching and frequently devastating. Along with losing trust in the healthcare system, the patient often experiences an increase in physical and psychological discomfort. Health professionals also feel the effects of medication errors. Medication errors are costly in terms of increased hospital stay, resources consumed, patient harm and lives lost (Webster & Anderson 2002; Schelbred & Nord, 2007).

Healthcare workers involved in a medication error experience loss of morale and frustration at not being able to provide the best care possible. Medication errors also have the potential for serious effects on the nurse involved ranging from feelings of guilt and fear to loss of clinical confidence and disciplinary action (Gladstone 1995; Treiber & Jones, 2010). Although patients are the obvious victims of medication errors, nurses are affected by the same errors: they, and other members of the healthcare team, are the second victims (Wu, 2000). One such example occurred in 2012 when an RN in Seattle committed suicide seven months after giving the wrong dose of a medication to an infant. The infant died and the RN was suspended and then fired (Brown, 2013).

For RNs, medication errors are a tremendous problem because the administration of medication is for the most part a responsibility of the nurse. In today's healthcare arena medication errors continue to occur despite efforts to reduce such events. The medication process involves many elaborate steps and an error can occur at any point in this complex process (Williams, 2007). The order in which the medication process occurs (prescribing, dispensing and administering) places the nurse at the

sharp end, as the final check point for ensuring safe medication delivery and avoidance of error (Ulanimo, et al, 2007).

## Purpose of the Study

Medication administration involves a multifaceted structure and errors may occur at any point from prescription to the actual administration of the drug. Nurses' knowledge of pharmacology provides the information necessary to competently administer medications and avoid errors.  As indicated previously, medication errors are broadly classified as any error in the ordering, transcribing, dispensing, or administration of a drug, irrespective of whether such errors lead to adverse consequences (patient harm) or not.  Through this discussion it has been established that since nurses are most commonly involved in the process of medication administration, it is the nurse who most often is blamed for the error.

In order for the nurse to administer medications safely and avoid errors, the nurse must demonstrate medication competence (Sulosaari, Suhonen and Leino-Kipli, 2010).  Safe medication administration practices are linked to medication competence that rely heavily on the nurse having the requisite pharmacology knowledge. Medication competence begins with a nurse's education preparation to practice. To review, medication competence is a necessary component of a safe medication process and a nurse's skill set.  Medication competence is developed over time, beginning with a nurse's undergraduate nursing education (Coyne, Needham, Rands, 2012). According to the National Quality Forum in their *Safe Practices for Better Healthcare-2009 Update: A Consensus Report,* safe practice involves the nursing workforce and states that the objective of ensuring safe practice for nurses is to "ensure that nursing

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staff services and nursing leadership at all levels, including senior administrative and unit levels, are competent and adequate to provide safe care" (2009). Knowledge categories are included in medication competence: anatomy and physiology; pharmacology; communication; collaboration; information seeking; math and medication calculation ability; numerical and calculations ability; medication education; assessment and evaluation; documentation; and promotion of safety (Sulosaari, et al, 2010). Medication competence includes knowledge and skill as well as the ability to perform (Sulosaari, etal, 2010) and lends itself to an avoidance of medication errors.

The purpose of this study is two-fold. This study aims are to determine the pharmacology knowledge of practicing nurses and to determine if there is a predictive relationship between the pharmacology knowledge of practicing RNs, as measured by the Medication Calculations Skills test (MCS) and known medication administration errors as determined from an RN's self-report.

## Significance of the Study

As stated previously, safe medication administration and medication competence begins with a nurse's education preparation to practice. Medication competence in nursing can be a challenging skill to maintain, due to technological systems designed to facilitate medication administration. Smart pumps (intravenous pumps) that calculate drip rates; as well as bar- coding medications and, E-prescribing (computer physician order entry-CPOE) are examples of technological tools used to decrease and prevent medication errors. For instance, E-prescribing systems have dramatically cut drug errors. In a study that spanned 2005-2007 and looked at E-prescribing as a deterrent to medication errors, it was found that medication errors decreased from 42.5 errors per

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100 to 6.6 errors per 100 (Kaushal, Kern, Barron, Quaresimo, Abramson, 2010). But these medication error prevention tools may serve only as a "band-aid" as their use leads to a reduction in mathematical practice in the clinical setting (McMullan, Jones, Lea, 2010). Errors during administration are particularly problematic for the nurse during emergency situations because the RN is called upon to interpret physician's orders meant to be administered immediately (or stat) and recall essential information regarding a specific medication and the effect it may have on the individual patient, all while administering the medication safely. This often involves recalling complicated calculation formulas.

Patient safety and prevention of all patient related errors relies on competence in practice. For the nurse, who is at the "sharp" end of a medication error, the basis of medication competence thus lies in the pharmacology knowledge that begins with nurses' basic education and training (Benner, 2004). The literature identifies the multi-disciplinary nature of the problem and highlights the important contribution that nurses make with regards to ensuring medication safety. However, limited evidence exists in the literature regarding the pharmacology knowledge of practicing nurses and the occurrence of medication errors.

### Research Questions and Hypotheses

There are multiple research questions. The first is general:

RQ1. Is there a relationship between practicing RNs' pharmacology knowledge, as measured by the MCS test, and the occurrence of a medication error, as determined from an RN's self-report.

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H1: There is a relationship between practicing RNs pharmacology knowledge, as measured by the MCS test, and the occurrence of a medication error, as determined from an RN's self-report.

The literature speaks clearly to the idea that where the pharmacology knowledge of practicing RNs is concerned, practicing RNs may demonstrate general competency for practice as measured by the National Council Licensure Examination for Registered Nurses (NCLEX-RN) exam but may not have correspondingly high levels of pharmacology knowledge when measured in practice.

Following these findings, the second question is based on the very simple idea that it is not possible to predict an individual medication error, such as a medication administration error, if the practicing RNs pharmacology knowledge is known, as measured by the MCS test.

RQ2: Is it possible to predict the occurrence of a medication error (as determined from an RN's self-report) if the RN's pharmacology knowledge is known (as measured by the MCS test)?

H2 Lack of pharmacology knowledge as measured by the MCS is associated with higher odds of medication error occurrence.

The following research questions are based on the demographic data that was collected from the survey using the MCS test which allows analysis at a greater level of understanding among and between groups and practicing RNs' pharmacology knowledge as follows:

RQ3: In practicing RNs, is their pharmacology knowledge related to an increased risk for the occurrence of a medication error differentially by characteristics of the population

(age, gender, level of education, experience/length of time in practice, or area of

practice)?

H3. There is a relationship between practicing RNs pharmacology knowledge by

population characteristics and an increased risk for medication error occurrence.

<div align="center">**Theoretical Underpinnings**</div>

**James Reason's *Human Error Theory***

According to James Reason in his *Human Error theory* (1990),

> … more effective methods of predicting and reducing dangerous errors emerge
> from a better understanding of mental processes, it has also become
> increasingly apparent that such theorizing, if it is to provide an adequate picture
> of cognitive control process, must explain not only correct performance, but also
> the more predictable varieties of human fallibility. (p.1)

Reason professed that there are two approaches to the human error problem:

the person and the system approach (1990).  The person approach blames the

individual and focuses on the person and his or her frailties.  The system approach

looks at the errors of the individual from the point of view of the climate and conditions

under which the individual works (Reason, 1990). Reason proposes that there are two

basic error types: slips (and lapses) where the actions do not go according to plan and

mistakes, where the plan itself is inadequate to achieve its objectives. An explanation

for these error types is presented in Reason's *Generic Error Modeling System* (GEMs),

which relates the basic error types to performance levels (1990). Slips and lapses,

according to Reason are those errors that are skill based, errors that occur with routine

activities in familiar situations. Mistakes are further delineated by Reason as rule-based

and knowledge-based and are differentiated by the conscious control of the individual

involved. Knowledge based errors, unlike slips and lapses and rule based mistakes,

<div align="center">18</div>

"occur when the individual has run out of applicable problem solving routines and is forced to resort to attentional processing within the conscious workplace." (p. 57)

**The Swiss Cheese Model of Accident Causation**

*The Swiss cheese Model of Accident Causation* (Reason, 2000) explains the role systems play in errors. It is often easier to blame the individual who is at the sharpest end of the error, but Reason explains that systems such as the highly complex healthcare system, have many defensive layers that can be breached by fallible decisions (decisions made by designers and high level decision makers), line management deficiencies (the consequences of the fallible decisions manifest here) and psychological precursors of unsafe acts (these are introduced directly by the human condition and may lead to potential unsafe acts)(Reason,1990). The function of these various layers (labeled by Reason as latent conditions) or levels of defense is "to protect potential victims and assets from local hazards" (Reason, 2000, p. 769). Mostly they do this very effectively, but there are always weaknesses. In an ideal world each defensive layer would be intact. In reality, however, they are more like slices of Swiss cheese, having many holes, see figure 2, (which are caused by lack of knowledge, poor design, senior management decision-making, procedures, lack of training, limited resources). However, according to Reason's model, unlike in Swiss cheese, these holes are continually opening, shutting, and shifting their location (2000).
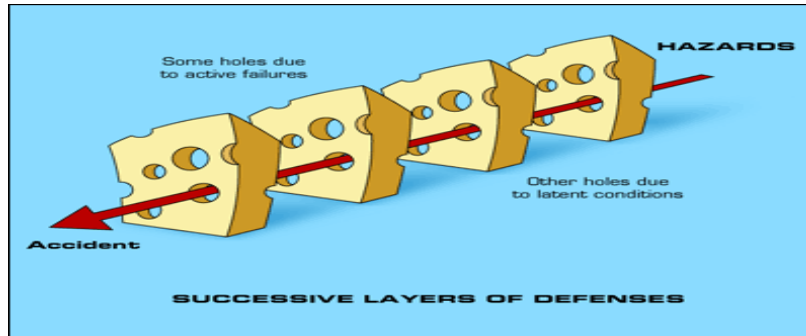
*Figure 2. Reason's Swiss Cheese Model of Accident Causation. This figure illustrates*

*the conditions involved in human error (Reason, 1990).*

Reason explained:

The presence of holes in any one "slice" does not normally cause a bad outcome. Usually, this can happen only when the holes in many layers momentarily line up to permit a trajectory of accident opportunity—bringing hazards into damaging contact with victims. The holes in the defenses arise for two reasons: active failures and latent conditions. Nearly all adverse events involve a combination of these two sets of factors. Active failures are the unsafe acts committed by people who are in direct contact with the patient or system. Latent conditions are the inevitable "resident pathogens" within the system. (p. 769).

When a combination of active failures (the point of contact between a human someone

in the frontline like the RN administering medications) and latent conditions, some

aspect of a larger system (e.g., pushing an incorrect button, ignoring a warning light) are

aligned, all levels of defenses are breached and a patient safety incident occurs.

Reason's theory and model are effective at investigating the form, type

and contributing factors associated with medication errors but not in examining

complexities associated with the medication management process, such as those

related to the role of the RN in safe medication administration.  A further look at the

development of an RN's pharmacology knowledge is required.

**Patricia Benner's *Novice to Expert Model***

To review, a Registered Nurse's pharmacology knowledge is the basis for competence in medication administration. Medication competence is a complex combination of knowledge, skills, performance, values and attitudes (Cowan & Coopamah, 2005). In 1984, Dr. Patricia Benner and a team of researchers published their findings from a large study that sought to describe the development of knowledge in nursing practice (2001). Benner's model, an application of the *Dreyfus Model of Skill Acquisition* (2001) allows exploration of factors influencing the development of knowledge in the RN.

Benner used the *Dreyfus Model of Skill Acquisition* (developed based on the study of a pilot's performance in emergency situations) and applied it in studies of skill acquisition in nursing to the learning needs and styles of learning at the different levels of skill acquisition. The *Novice to Expert model* explains, according to Benner, (2001),

> … the limits of formal rules and calls attention to discretionary judgment used in actual clinical situations. To understand specific meaning of any behavior (or nursing care measure) one must know the specific context, and knowing the context inherently limits the possible meanings of behavior into manageable and relevant wholes. The interpretive approach always relies on the particular context of the situation-the timings, meanings, intentions of the particular situation. (p.40).

Benner did not recommend the abandonment of rules but claimed that a more skilled advanced understanding of the situation allows orderly behavior without rigid rule following. Knowledge embedded in actual nursing practice is knowledge that accrues over time in the practice of an applied discipline. Nurses accrue clinical knowledge over time and lose track of what they have learned. A great deal of what a nurse knows is demonstrated as the clinical situation arises. Benner's work sought to explain nursing

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practice from a holistic view rather than as a procedure based occupation (Benner, 2001).

According to Benner, "Knowing that and knowing how are two different things" (2001,p. 3). "Knowledge development in an applied discipline such as nursing consists of extending practical knowledge (know-how) through theory based scientific investigations and through the charting of the existent 'know-how' developed through clinical experience in the practice of that discipline" (Benner, 2001,p. 3). Through the acquisition and development of a skill a nurse passes through five levels of proficiency according to this model. These levels of proficiency are novice, advanced beginner, competent, proficient and expert.

Briefly, this model describes the levels of skilled performance with the specific behaviors and knowledge acquired which impact the development of competence in practice. The "novice" is a beginner with no experience of the situations in which they are expected to perform. To give them entry to these situations and allow them to gain the experience necessary for skill development, they are taught about the situations in terms of objective attributes (weight, height, temperature, blood pressure) features of the task world that can be recognized without situational experience and context-free rules to guide action in respect to different attributes. The rule-governed behavior typical of the novice is extremely limited and inflexible. This is because novices have no experience of the situation they face; they must be given rules to guide their performance. Nursing students enter a new clinical area as novices; they have little understanding of the contextual meaning of the recently learned textbook terms. Benner's model (2001), "distinguishes between the level of skilled performance that can

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be achieved through principles and theory learned in a classroom and the context dependent judgments and skill that can be acquired only in real situations" (p. 21). The Dreyfus model of skill acquisition is a developmental, situational model rather than a trait or talent model.

The "advanced beginners" (example would be newly graduated nurses), are the ones who can demonstrate marginally acceptable performance, ones who have coped with enough real situations to know (or to have pointed out to them by a mentor) the recurring meaningful situational components that are termed aspects of the situation in the Dreyfus model. Experience is needed before the nurse can apply the guidelines to individual patients. The advanced beginner (or person's instructor) can now formulate principles that dictate actions in terms of both attributes and aspects.  The guidelines integrate as many attributes and aspects as possible but they tend to treat all attributes and aspects as equally important and ignore important differences. Novices and advanced beginners can take in little of the situation: it is too new, too strange, and besides, they have to concentrate on remembering the rules they have been taught.

"Competence" is typified by the nurse who has been on the job in the same or similar situations for two or three years, and develops according to Benner (2001) when "the nurse begins to see his or her actions in terms of long range goals or plans of which he or she is consciously aware" (p26).  The competent nurse's plan dictates which attributes and aspects of the current and contemplated future situation are to be considered most important and those which can be ignored. In other words the competent nurse plans actions based on deliberate analysis of the presenting problem.

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Competent nurses are is not as fast or as flexible in their thoughts as the proficient nurses but do have a feeling of mastery and the ability to cope with and manage the many contingencies of clinical nursing. The conscious deliberate planning that is characteristic of this skill level helps achieve efficiency and organization.

The "proficient nurse" perceives situations as wholes rather than in terms of aspects, and performance is guided by maxims (p.27). Perception is a key word for the proficient nurse as it presents itself based upon experience and recent events. Proficient nurses understand a situation as a whole because they perceive its meaning in terms of long term goals. Proficient nurses learn from experience what typical events to expect in a given situation and how plans need to be modified in response to these events (p.28). Aspects stand out to proficient nurses as being more or less important to the situation at hand. Proficient nurses use maxims as guides but a deep understanding of the situation is required before a maxim can be used.

The 'expert nurse' according to Benner (2001), "no longer relies on an analytic principle (rule, guideline, maxim) to connect her or his understanding of the situation to an appropriate action. The expert always knows more than he or she can tell" (p. 43). The clinician's knowledge is embedded in perceptions rather than precepts. As long as the beginner is following rules, his performance is halting, rigid, and mediocre. "But with the mastery of the activity comes the transformation of the skill which is like the transformation that occurs when the blind person learns to use a cane" (Benner, 2001,p. 33), the performer is no longer aware of features and rules, and his/her performance becomes fluid and flexible and highly proficient.

**Conceptual Framework**

Reason's Theory of Human Error and the Swiss Cheese Model explain how errors happen.  Benner's model allows us to explore factors influencing the development of knowledge in the RN. The PI created conceptual framework presented here (Figure 3) served as the conceptual framework for this study.
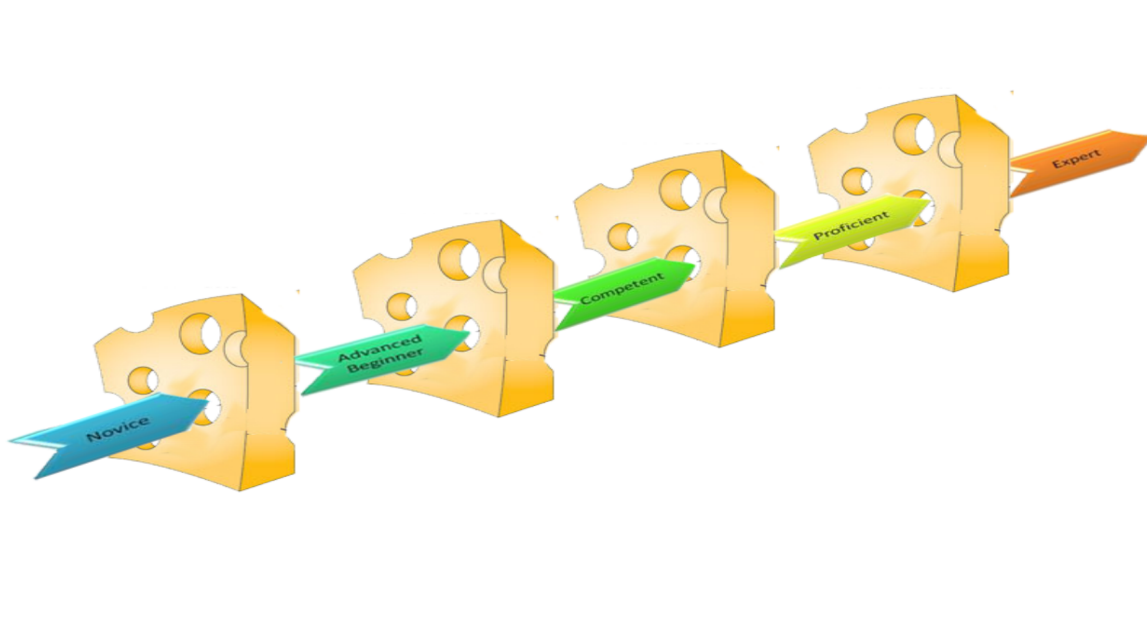


*Figure 3.* PI Created *Conceptual Framework of Knowledge Development as a Deterrent for Medication Errors . This figure illustrates the conceptual framework that emerges after combining Reason's Swiss Cheese Model of Accident Causation and Benner's Novice to Expert Model. ©2015 C. Kumar*

In summary, if medication competence begins with a nurse's education to practice and preparation to practice (Benner, et al, 2010), then sound knowledge of pharmacology should ensure a safeguard against error in medication administration. As stated previously, safe medication administration and medication competence begin with a nurse's education preparation to practice. Medication administration involves a

multifaceted structure and errors may occur at any point from prescription to the actual administration of the drug. Nurses' knowledge of pharmacology provides the information necessary to competently administer medications and avoid errors.  Patient safety and prevention of all patient related errors rely on competence in practice.  For the nurse, who is at the "sharp" end of a medication error, the basis of medication competence thus lies in the pharmacology knowledge that begins with his or her basic education and training (Benner, 2004). Information regarding practicing RNs level of pharmacology knowledge may provide an understanding of medication errors during the administration of medications.

**Summary**

Chapter 1 provides the area of interest and its significance, medication errors classified and defined, the statement of the problem and the purpose of the study, the significance of the study, research questions and hypotheses, and the theoretical underpinnings. Chapter 2 contains the literature review that explains the factors that impact medication error development, and the summary and need for the study. Chapter 3 presents the methodology, which includes a clarification of important terms, the research design and procedure, sample size determination, sampling procedure, inclusion-exclusion criteria, setting, instrumentation, and data analysis. Chapter 4 presents the outcomes of the research questions; Chapter 5 includes the interpretations of the outcomes and their implications and recommendations based on the outcomes, as well as limitations and future research areas.

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**Chapter II**

**REVIEW OF RELEVANT LITERATURE**

**Factors that Contribute to Medication Errors**

Since the publication of the 1999 landmark IOM report "To Err is Human" and the subsequent IOM report "Crossing the Quality Chasm" in 2006, there has been a focus on the staggering numbers of patients who die each year as a result of preventable medical error including those errors due to a breach in the medication process. Studies have focused on medication errors and their causes, antecedents, severe and non-severe errors, and the definition of or lack of agreement on what a medication error is. Although there has been a great deal of attention given to medication errors, the incidence remains relatively unchanged. According to the Food and Drug Administration (FDA) Event Report ending December 31, 2010, there were 471,291 serious errors and almost 85,000 deaths reported that resulted from medication errors in the year 2010 (US FDA, 2011). These numbers only include errors that were reported.

**Systems Factors**

Medication errors are never the result of a single isolated human error but comprise a chain of events leading to an error (Anderson and Webster, 2001; Ulanimo, et al, 2007; Choo, Hutchinson, and Bucknall, 2010). Most errors in complex environments like healthcare institutions are not a result of a single contributing factor alone, such as the nurse administering the medication, but result from underlying contributing factors in the healthcare system. Systems, according to Leape, 2009, include "almost all of the processes and methods we use to organize and carry out

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virtually everything we do — whether simple or complicated" (p. 2). The misfortune surrounding well-intentioned medication administration gone awry is greater when the mistake is the result of action or lack of action on the part of a healthcare professional (Ferner, 2009).

The Institute of Medicine's seminal work also shifted the focus from blaming an individual making an error to blaming the system for its failures (Kohn, L., Corrigan, J., Donaldson, M.eds, Institute of Medicine, 2000; Institute of Medicine, 2006). A system can be defined as a set of interdependent components interacting to achieve a common specified goal (Henriksen, Dayton, Keyes, Carayon, and Hughes, 2008). The healthcare system is composed of a large set of interacting components. More specifically, healthcare is a system of care that is composed of several interdependent components (nursing, medicine, other allied health services, the physical environment, the nature of the work, the organizational culture, etc.) that interact to achieve the common goal of safe patient care. In the instance of the medication process gone wrong, there are external and internal contributions coming together for a perfect storm: a medication error. A single medication error is due most often to the convergence of multiple systems factors (Kohn, et al, 2000).

Systems failures can occur at anytime in the medication process. A medication error resulting from a systems failure can be a result of errors related to the selection, acquisition, storage and administration of medications, as well as in patient assessment during the administration process (The Joint Commission, 2006). Medication errors result from small breakdowns in the system in medication management including workplace stress, distractions, inadequate training, lack of knowledge and fragmented

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information (Pape, Guerra and Muzquiz, 2005; Ulanimo, et al. 2007). Systems errors that contribute to medication errors are pervasive and exceed the boundaries surrounding each practicing healthcare profession (Brady, Malone, and Fleming, 2009). According to Wright, 2009, "medication administration is one component of the medication process and is affected by the environment it occurs in, the structures and systems in place to support the process, as well as the culture and expectations of those in the healthcare setting" (p. 37). Unfortunately, healthcare professionals do not always view things from a systems approach and look to blame the individual who is at the sharpest end of the error.

In healthcare, it is nurses who most commonly administer medications to patients and it tends to be nurses who are blamed for any medication errors that occur during administration or their consequences (Armitrage,Knapman, 2003).  It is often easier to look for faults in the individual nurse then to examine the underlying conditions in the system that led to the error. The National Coordinating Council for Medication Error Reporting and Prevention (NCC-MERP) also published recommendations to enhance the accuracy of administration of medications and thus reduce medication errors.  It was recommended by the council, that nurses, to enhance the accuracy of medication administration, use a series of checks known as the "five rights" (NCC-MERP, 2010). These recommendations were revised in 2005 and state that the "five rights"(knowledge of the right medication, in the right dose, to the right person, by the right route, using the right dosage form, at the right time) be performed immediately prior to medication administration.  RNs learn about the "five rights" of medication use during their undergraduate education and training. The Institute for Safe Medication Practices

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(ISMP) recommends that the "five rights" be viewed as a checklist and not the definitive method that will always ensure avoidance of medication error (ISMP, 2007; Schoenecker, 2007).   With the five rights as the standard, any deviation from them is, by definition, an error.  Although seemingly useful as a guide to safe medication practices, relying on rules like the five-rights can lead to a victim–blaming mentality. Treiber and Jones, 2010, reported the findings from their study that analyzed 158 nurses' self identified accounts of medication error occurrence. Although the literature speaks to the systems failures that actually contribute to error, it is often the individual at the sharpest end, in the case of medication errors this is the nurse) who is blamed.  The researchers' recommendations concluded by stating that:

> The five-rights model focuses on the individual nurse's responsibility, thus diverting attention from systems issues. As a result individualist solutions become the norm.  When a nurse does not follow the five-rights standard, it is the nurse, not the workplace, who is blamed (Treiber & Jones, 2010, p. 1340).

It is necessary to acknowledge that errors are only the manifestations of the defects in the system and not the defect themselves. According to James Reason, errors rise from three factors.  These are the nature of the task and its environmental circumstances, the mechanisms governing performance, and the nature of the individual (1990). Medication errors will continue to occur so long as the focus is solely on blaming the individual at the sharp end of the error instead of exploring the factors that led up to the error. In order to understand the error, the focus needs to widen from the individual to include the underlying system problems that are present in any complex working environment (Henriksen, et al, 2008).

To review, the transition from nursing school and the safety of the clinical skills practice laboratory to a hospital floor are especially challenging. The primary training for

medication administration for nursing students include laboratory simulation activities, didactic content in pharmacology and calculation, and often only one patient assigned to their care during clinical rotations. Within a clinical skills practice laboratory, it is impossible to incorporate the systems factors that come into play on a daily basis for the practicing RN.  These system factors include handoffs from one shift to the next, acuity of the unit, and other patient demands during high activity times. The clinical skills laboratory experiences are limited to performing of the five rights of medication administration. While the laboratory experiences are low stress, they fail to depict the systems challenges of the nurse in practice, which include multiple patients, distractions, and unanticipated problems (Papastrat & Wallace, 2003) and thus the student's learning is limited.

**Avoiding Medication Errors: Competence in Nursing Practice**

Avoiding medication errors and promoting medication safety is a multidisciplinary challenge and it is important for nurses to understand their role in it. Nurses are at the sharp end of the medication process and the occurrence of medication administration errors as it is mainly RNs who administer medications to patients. The American Association of Colleges of Nursing, the national voice for baccalaureate (and graduate) nursing programs in the United States, in the document "*The Essentials of Baccalaureate Education for Professional Nursing Practice*", 2008, emphasized patient safety among the core knowledge components necessary for all healthcare professionals.  The document includes nine essentials of which Essential II is: *Basic Organizational and Systems Leadership for Quality Care and Patient Safety*.  The proposed rationale for Essential II is "an important component of quality is safety.

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Safety in health care is defined as the minimization of "risk of harm to patients and providers through both system effectiveness and individual performance" (Cronenwett, et al., 2007). Research has demonstrated that nurses, more than any other healthcare professionals, are able to recognize, interrupt, evaluate, and correct healthcare errors. The baccalaureate graduate implements safety principles and works with others on the interprofessional healthcare team to create a safe, caring environment for care delivery (Rothschild, et al., 2006, p. 13).

Competent practice is a major legal safeguard for nurses. Medication competence is defined as a complex combination of knowledge, skills, performance, values and attitudes (Cowan & Coopamah, 2005). For a nurse to practice competently, it is necessary for the nurse to have a working knowledge of the pharmacology behind each prescribed medication. Medication competence is influenced by the nurse's knowledge, understanding and judgment in different clinical situations; her cognitive, psychomotor and interpersonal skills; and her personal attributes and attitudes (Alexander & Runciman, 2003). Components of medication competence include pharmacology knowledge, mathematical and medication calculations skills and the incorporation of communication, documentation and decision making skills (Sulosaari, Kajander, Hupli, Huupponen, & Leino-Kilpi, 2010). However, nursing research currently lacks a definition that integrates the various competencies that encompass medication competence. General competence is an expectation of a new graduate confirmed by the individual passing the licensure examination, NCLEX-RN (NCSBN, 2013). Entry into practice is determined by passing this examination that measures the competencies needed to perform safely and effectively as a newly licensed, entry-level registered

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nurse (NCSBN, 2013).

The focus of most nursing studies has been on the mathematical and medication calculations skills component of medication competency (Gladstone, 1995; Brown, 2002, 2006; Grandell-Niemi, Hupli, Leino-Kipli & Puuka, 2005; McMullan, Jones & Lea, 2010; Eastwood, Boyle, Williams, & Fairhall, 2011; Arkell & Rutter, 2012). However, medication competence includes pharmacology knowledge, which is the knowledge base necessary for safe and effective medication administration (Sulosaari, et al, 2010). Nurses must be able to assess the patients' conditions and their need for the prescribed medication. Along with this, the nurse must also have knowledge of the employer's policies (internal standards of care) related to medication administration. In addition, a nurse must have the skill to calculate, administer and evaluate the effects of medications. Nurses also need to have good communication and documentation skills, patient education skills and the ability to work in multidisciplinary teams (ISMP, 2007; Creadon-Shanks and Zelko-Enlow, 2011). In 2003, the Institute of Medicine (IOM) issued a report, *The Education of Health Care Professionals: A Bridge to Quality*, in which professional competency was viewed as a shared responsibility. The IOM report recommended that all professional licensing boards move toward requiring licensed health care professionals to periodically update and demonstrate their ability to deliver care within five competencies including the delivery of patient centered care and participating in an interdisciplinary team, while emphasizing evidence-based practice, quality improvement, and informatics (IOM, 2003). For nurses, competent practice remains the major safeguard against error. To summarize, medication competence in nursing practice is complex and involves cognitive and psychomotor competence.

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**Competence in practice is a nurse's safeguard against error**.

Nurses' knowledge of the theory and clinical principles of pharmacology influences their practice (King, 2004; Manias and Bullock, 2002a). Professional nurses' Scope and Standards of Practice (ANA, 2008) requires that the nurse must adhere to the scope and standards of practice in order to ensure safe, high–quality patient care and avoid errors (2008). The nurse must maintain clinical competence and continually update his or her knowledge. This includes knowledge and understanding of pharmacology (ANA, 2008) along with the incorporation of the protocols and standards learned in school.

The five rights of medication administration, learned by nurses in their undergraduate training, is a protocol that provides a rule to follow to administer medications safely. Correct use of the five rights is another way of looking at the pharmacology knowledge of the nurse because the five rights ensures that the nurse has knowledge of each prescribed medication: action, side effects, interactions with other medications and the ability to assess the patient's need for a specific prescribed medication (King, 2004). The right dose is assured by the nurse's knowledge of medical math to calculate the correct amount. The right route is assured by the nurse's skills to administer the medication (orally, parenterally, etc). What all this means is that protocols put into place to assure the avoidance of error works when employed each time a medication is administered.

Unfortunately, due to systems issues such as inadequate staffing, increased patient acuity, and multiple interruptions, along with deficient pharmacology knowledge on the part of the nurse, these steps are often circumvented. "Competent practice

based in sound knowledge remains the safeguard against error because a lack of pharmacological knowledge and calculation skills can cause medication errors" (Dilles, 2010, p. 504).  The medication administration process is one of the critical aspects of professional nursing care and competence in this area plays a highly important role in the safety of patients. The educators of future nurses have the responsibility to prepare efficient and competent graduates to manage the patients' medication effectively (Ghamari-Zare , 2008).

According to the American Nurses Association (ANA), regardless of the nursing role, the nurse must adhere to the scope and standards of practice set forth by the ANA, when performing or assigning the duties within that role in order to ensure safe, high–quality patient care (2008) that include the safe administration of medication and the avoidance of medication errors. In order to practice safely and avoid errors, nurses must maintain competence in practice and continually update their education. This includes the acquisition of a broad knowledge of anatomy and physiology, an understanding of pharmacology and the impact of culture, gender and age on medication effectiveness. The definition of professional competence is derived from the ANA's Position Statement on Competence and Competency, Definitions and Concepts in Competence (2007), "an individual who demonstrates competence, is performing successfully at an expected level and achieves competency. Competency refers to a level of performance that results from an integration of knowledge, skills, abilities, and judgment" (American Nurses Association, 2007).

**Medication competence.**

In 2009, in a comprehensive review of the literature, Sulosaari and associates attempted to describe the medication competence required of registered nurses. According to the researchers, medication competence encompasses three major categories: decision-making, theoretical competence and practical competence. The literature review of 21 research studies identified eleven categories of medication competence which include anatomy and physiology, pharmacology, communication, interdisciplinary collaboration, information seeking, mathematical and medication calculations skills, medication administration, medication education, assessment and evaluation, documentation and promoting medication safety as part of patient safety (Sulosaari, et al 2010).

Pharmacology knowledge is a requirement for drug administration, patient assessment, and medication education, as well as being able to collaborate with other professionals to determine appropriate care, seek information regarding a specific patient and a specific medication order, and effectively document and promote medication safety.  A major component of both the overall medication competence and medication administration is mathematical and calculations skills. The nurse must possess the psychomotor skills to effectively draw medication into a syringe for instance but basic to this is the ability to calculate the correct dose necessary to draw into the syringe. Mathematical competencies are considered to be a critical skill for nurses who are expected to perform medication calculations correctly. The individual must have good problem solving and mathematical skills. Medication calculation skills can be divided into mathematical, dosage calculation and pharmacological skills. For the

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purposes of this paper, the literature review will focus on the two essential components of medication competence: pharmacology knowledge and mathematical and medication (dosage) calculations skills.

In order for a nurse to develop medication competency, an RN's education must consist of a balance between theoretical knowledge, decision-making and real world experiences. Appropriate nursing education guides students from theory to practice and supports their development of knowledge and understanding which will enable them to make clinical decisions as graduates (Benner, Sheets, Uris, Malloch, Schwed, Jamison, & Dwayne, 2010). As part of promoting patient safety, nurses have the responsibility to continuously update their knowledge. Knowledge is defined as facts, information, and skills acquired through experience and education (Oxford University Press, 2014). Pharmacology knowledge involves an understanding of the theory and principles of pharmacology as well as the ability to contextualize the medication process with respect to the complex and changing needs of the patient (Sulosaari, et al, 2010).

For the RN, pharmacology knowledge includes the knowledge of the incompatibilities and effects of the medication, along with the ability to critically think and be able to perform medication calculations to assure the dosage is safe for the patient are required each time a nurse administers a medication (Rainboth and DeMasi, 2006). To be able to administer medications safely and provide effective medication education to their patients, nurses need to know how to administer a medication as well as why a medication has been prescribed for their assigned patients, the reasons for the dose and route of administration, what to expect and how effective the medication should be.

### RNs pharmacology knowledge.

The literature abounds with studies that explore practicing nurses (RNs) and nursing students' pharmacology knowledge. The overall consensus is that nurses and nursing students do not have the requisite knowledge of pharmacology for their role in the medication process.   (Bullock & Manias, 2002; Grandell-Niemi, Hupli, Leino-Kilpi & Puukka, 2005; Ndosi & Newell, 2008; Dilles, VanderStechele, VanBortel & Elseviers, 2010; Daouphars, Magali, Beretrrand, Basuyau, Violetter, & Varin,2012; Ghamari, Purfarzad & Adib-Hajbaghery, 2013).

There is an increasing body of research that focuses on components of RNs' pharmacology knowledge.  The literature indicates that undergraduate education of nurses may inadequately prepare them for the administration and management of medications.  Several studies reviewed have found that the actual pharmacology knowledge of nurses and nursing students is insufficient.  In an attempt to explore the perceptions of nursing faculty regarding the pharmacology education and preparation of undergraduate nursing students, Bullock and Manias, 2002, surveyed 78 nursing faculty in their study from 13 universities in Australia.  The researchers' aim was to determine the integration of pharmacology teaching in nursing curricula.  Information regarding the range and depth of pharmacology taught in the undergraduate nursing classrooms and the approaches to teaching and learning of pharmacology, the professional background of academics teaching pharmacology to undergraduate nursing students and how this impacted nursing practice in a clinical context was an additional aim of this research study (Bullock and Manias, 2002).

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In their 2002 study, Bullock and Manais, defined pharmacology education as "developing a knowledge base necessary for safe and effective medication management" (2002, p. 8). Pharmacology content generally includes pharmacodynamics, pharmacokinetics, actions, interactions, adverse affects, how to administer specific medications, decision making and patient education (Bullock & Manias, 2002). Findings from this study indicate that the pharmacology content of nursing curriculum in undergraduate nursing programs varies in terms of when the content is taught, and how much pharmacology ins taught. Essentially there are two main approaches to pharmacology for nursing education at the undergraduate level. Either a specific course or courses in pharmacology is provided or content related to pharmacology is threaded in other required courses (Gigi-Lim & Honey, 2005). Bullock & Manias found that although participants felt that the pharmacology content should be taught before students begin clinical rotations, only 61% reported that this occurred at their university (2002). The researchers found that the great variability in the presentation of pharmacology within the curriculum was due in large part to the individual university needs and not student learning outcomes (Bullock & Manias, 2002).

The pharmacology knowledge of nurses and nursing students has been investigated in several international studies. In 2005, a group of nursing researchers and educators conducted a study exploring the pharmacological knowledge of more than 500 nurses and nursing students in Finland (Grandell-Niemi, Hupli, Leino-Kipli, Puukka, 2005). The researchers had multiple purposes for their study. They sought to investigate the perceived and actual pharmacology knowledge of Finnish nurses and graduating nursing students and to determine if their pharmacology knowledge was

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related to background factors. Because they were looking at two groups, (nurses and nursing students) they sought to identify differences between the two groups. Finally, the researchers sought to examine a tool they had developed for the study; the Medication Calculation Skills test (MCS test), and determine how it works. The MCS test includes 24 questions that specifically targets pharmacology knowledge (including calculations ability). Out of a possible 100% if all 24 questions were answered correctly, the nurses (N=364) mean score was 18.6 or 77.5%. For students, (N=282), the mean score for the pharmacology section of the MCS test was 16.3(or 67.9%) (Grandell-Niemi, et al, 2005). None of the students scored 100% and 50% scored 67%. Of the 364 nurse participants, only 6 attained a score of 100%. Fifty seven percent of nurses who participated in this study attained a score of 79%, which can be considered more than adequate (Ives, Hodge, Bullock & Marriot, 1996) but indicates a serious knowledge deficit if this score were applied in actual patient care. The results for the influence of background factors on pharmacology knowledge revealed that previous healthcare experience and level of education positively impacted pharmacology knowledge (Grandell-Niemi, et al, 2005). Nurses and students, who reported that they maintained and updated their pharmacology knowledge, reported that the "depth and dynamic nature of pharmacology knowledge necessary for an RN to practice safely requires continuous lifelong learning. These findings indicate that perhaps calculation abilities develop with experience in the clinical environment as opposed to the classroom. Pharmacology as a subject was found to be difficult for both nursing students and nurses (Grandell-Niemi, Hupli,Leino-Kipli, Puukka, 2005).

In a 2008 correlational study from the United Kingdom, Ndosi & Newell sought to determine if nurses had adequate pharmacology knowledge of medications they commonly administered.  Using a semi-structured interview, 42 practicing nurses working in a surgical unit, (24 were senior nurses and 18 were junior nurses) were surveyed by the researchers (Ndosi & Newell, 2008). Four commonly used medications were chosen for use in the study (chosen from a review of the annual drug usage report from the hospital pharmacy). The survey included standard questions about the medication focused on pharmacology knowledge. Findings revealed that the mean average score for pharmacology knowledge was 6 (on a scale of 0-10).  There was a relationship between experience and pharmacology knowledge that demonstrated that pharmacology knowledge increased with experience.  There was significant difference in pharmacology knowledge dependent on degree level with the higher degree nurses scoring significantly higher (mean score 8) than those with only undergraduate degrees (mean score 5.7). The Ndosi and Newell study findings highlight nurses' pharmacology knowledge deficits that are critical to error prevention and safe administration of medications.

Because medication administration is a critical part of a practicing RNs daily schedule, it is important to explore the pharmacology knowledge of graduating nursing students just prior to their entering the practice setting.  In 2011, in a descriptive cross-sectional study, Dilles, Van der Stichele, Van Bortel and Elseviers attempted to evaluate graduating nursing students' (from Belgium) pharmacological knowledge and medication calculation skills.  The researchers' second aim was to describe the organizational and content characteristics of the pharmacology curriculum in Belgium.

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Six hundred and thirteen graduating students completed the Medication Knowledge and Calculation test (MKC).  The mean score was 53% for pharmacology knowledge, and 58% of the participants rated their perceived readiness for medication administration in practice on a scale of 1-10 as 5-8.  Their mean score on the MKC test for calculations skills was 59% which clearly indicates that nurses' perceived and actual readiness for medication administration are aligned. Twenty-nine nursing schools participated in the 2nd part of the study.  The findings from this study suggest that newly graduated nurses do not know enough basic principles of pharmacology to deliver safe medication care. This lack of pharmacology knowledge and medication calculations skill could lead to medication errors in practice and threaten patient safety (Dilles, et al, 2011, p. 503). In the second part of the 2010 study, Dilles et al, sought to explore graduating nurses pharmacology knowledge and to describe the characteristics of pharmacology education in Belgium (hours spent, who taught the course, was content threaded or presented separately). Of the 29 universities that participated, the researchers found a large diversity in the pharmacology curricula. Hours spent studying pharmacology ranged from 7 to 30 hours (m=12).  The majority of schools integrated pharmacology in the curriculum and there was a variation in the lecture of pharmacology content (12 reported that pharmacology was taught by a pharmacist, 7 by a nurse and 2 MDs); only one nurse lecturer had additional pharmacology training.

In a 2013 descriptive study from Iran, Ghamari, Purfarzad & Adib-Hajbaghery, extended the evaluation of nursing students' pharmacology knowledge through a comparison of the self-evaluation of nursing students in their own medication skills and the evaluation done by their clinical instructors. One hundred and forty one students and

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10 nursing instructors participated in the study.  Student participants completed a self-report questionnaire and nursing instructors completed a medication administration observation checklist on each student participant.  The researchers concluded that the results of their study showed that the nursing students are not completely competent in the process of medication therapy both from their own and their clinical instructor's perspective.

In an effort to explain the challenge of medication errors, researchers from Singapore conducted an exploratory study of 238 practicing RNs to evaluate their level of pharmacology knowledge (Phua & Tan, 2011).  The researchers also sought to determine if there were differences in the RN participants' pharmacology knowledge by seniority, years of experience, medical discipline or training location.   The mean score on the pharmacology knowledge test was 60.2% (out of a possible 100%).  Fourteen percent (34) of the participants failed the exam. Findings from this study identified rank and years of experience as a nurse as being positively correlated with pharmacology knowledge. Phua and Tan's findings further support the findings of Ndosi & Newell, 2008.  This 2011 study also highlights the global nature of this issue that practicing nurses' current pharmacology knowledge needs to be improved.

Several international studies reveal that practicing RNs pharmacology knowledge may not be adequate. A group of pharmacists in France, surveyed oncology nurses knowledge of medications. Using a 3-part survey, the researchers questioned 26 RNs. The tool included demographics, pharmacology knowledge questions and pharmacology support questions.  The findings included that the preparation, methods, time of administration, and infusion duration for cytotoxic drugs were not well known

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among nurse participants.  54% (n=26) estimated they experienced problems d/t lack of knowledge about medications and evaluated their own pharmacology knowledge as intermediate.  79% reported having a problem with calculation and dilution of medications (Dauphars, Magali, Beretrrand, Basauyau, Violetter, & Varrin, 2012).  In this study, nurses evaluated their knowledge as intermediate, indicating a limited understanding of pharmacology.  While participants recognized the need for pharmacology knowledge in practice, they were dissatisfied with nursing schools teaching of pharmacology, which agrees with findings in the Dilles, et al, 2009 study.

Medication errors are particularly problematic when dealing with pediatric patients. According to Lan, Wang, Chen, Wu & Tang, in a 2013 study from Taiwan, "hospitalized children are more susceptible than hospitalized adults to complications resulting from medication errors" p. 827. The researchers sought to evaluate 262 pediatric nurses' knowledge of pharmacology and to analyze known pediatric administration errors. The mean score for pharmacology knowledge was 72.9% (n=262). Insufficient knowledge (61.5%) was the leading obstacle nurses encountered when administering medications. Sixty percent of the errors reported in this study were wrong doses. The findings discussed herein on nurses' medication competence and pharmacology knowledge, reveals that although all nurses in practice pass the NCLEX-RN exam and demonstrate minimal competence to practice, nurses do not have the requisite knowledge of pharmacology for their role in the medication process.

### *RNs math and dosage calculations skills.*

As stated previously, a major component of practicing RNs' medication competence is their ability to calculate a drug dosage correctly.  This skill requires a

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solid foundation in basic math. Nursing students, regardless of degree program, are underprepared mathematically for medication dosage calculation (Brown,2002, 2006; Wright, 2006; Wolf, Hicks, and Serembus, 2006; Eastwood, Boyle, Williams & Fairhall,2011; Arkell & Rutter, 2012). Additionally, nurses in practice, often lack the math skills necessary for medication dosage calculations (Gladstone,1995; McMullan, Jones & Lea,2010; Phua & Tan,2011, Lan, Wang, Chen, Wu &Tang,2013). Studies show that nurses and nursing students struggle with performing drug calculations.  A review of the literature identified several international research studies, spanning 1995 to 2012, that explored practicing RNs' and /or nursing students', calculation abilities.  A recurring theme resonated from the studies findings: Nurses and student nurses do not have the requisite skills necessary for safe medication administration.

Two skills are necessary in order to perform accurate drug calculations in practice: basic mathematical skills to calculate mathematical problems and the ability to conceptualize the clinical information presented and extract the relevant information in order to formulate a math calculation to be solved (Brady, Malone & Flues, 2009). In the literature, there continues to be a focus on nurses' calculation abilities and their contribution to medication administration errors.  Nurses receive their basic training in pharmacology, drug management (regulations, storage, preparation of drugs and administration to patients) and drug dose calculation from university colleges and from on-the-job training (Simonsen, Johansson, Daehlin, Osvik & Farrup, 2011). A review of the  literature reveals an abundance of research studies highlighting the medication error rate. Assumptions have been about the limited drug (dosage) calculations and arithmetic skills among nurses (Harvey, et al, 2010; Gladstone, 1995; Grandell-Niemi, et

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al, 2005).

The strategy commonly used to teach drug dosage calculation skills to student nurses is to demonstrate how to calculate a problem and then allow the student to practice this method using similar problems. The student's knowledge is then evaluated with an exam. Although this approach is thought to teach students to follow a step-by-step approach to calculations, they may not understand the process underlying the solution, and more crucially may not realize their limitations until an error is made in clinical practice. If a student does not perform the medication dosage calculation correctly on an exam in a classroom setting, the student's self-esteem is affected. If this same individual does not perform the calculation correctly in a clinical setting, a medication error may occur, and the patient is affected. According to Brady, Malone, Fleming, 2009, "the acquisition and maintenance of mathematical competency for nurses in practice is an all important issue in the prevention of medication error" (p. 679).

In a study from the UK, Gladstone, 1995, surveyed nurses to identify their perceptions as to causes of drug errors, their views on reporting of errors and their training for the task. In this study, Gladstone also reviewed 79 actual incident reports that were submitted over a 12-month period. Over 50% of the errors reported were dose related indicating that nurses involved in these errors had difficulty with calculations. The majority of these errors were via the intravenous route.

Nursing faculty strives to educate students in a manner that prevents errors, promotes quality and is patient centered (Krautscheid, Orton, Chorpenning and Ryerson, 2011). The literature indicates current medication administration teaching and

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evaluation strategies may not be preparing nursing students for clinical practice (Krautscheid, et al, 2011). In two exploratory studies from the United States, Brown, 2002; 2006, sought to determine associate and baccalaureate degree nursing students' computational math abilities. A second aim of the researcher was to determine nursing faculty's expectations of their students in regards to computations. In 2006, Brown conducted a retrospective study of a cohort of BSN nursing students (n=525) in their first semester. In this study the research sought to determine the basic math competencies of BSN nursing students using a Computational Placement Exam from the College Board. The students were not allowed to use a calculator during the exam. The mean score on the exam was 76%. Because 75% is a passing grade this indicates adequate ability. In a real life setting this equates to medication errors due to inability to compute dosage calculations 25% of the time. Most student participants were able to do basic level math such as addition, subtraction, multiplication and division of whole numbers. However, for questions dealing with fractions, decimals and percents, the average correct response ranged from 40% to 95%. Findings indicate that nursing students may not have the requisite math skills necessary for safe medication administration.

As discussed previously under pharmacology knowledge, in Grandell-Niemi, et al, 2005 study from Finland, researchers used a tool they developed, MCS test, to determine practicing RNs' and nursing students' pharmacology knowledge and mathematical skills. According to the findings of this study, nurses and nursing students lacked accurate mathematical skills. The MCS has a total of 29 calculations problems along with questions pertaining to pharmacology knowledge. None of the students

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scored 29(100% correct).  66% of students attained a score of 72%.  While 71% of the practicing RNs attained a score of 86%, both RNs and nursing students had some difficulty with calculations problems.  According to the results, "while half of nurses and four out of 10 students often calculated dosages at work, participants did not find mathematics an easy subject, … and considered their own skills insufficient" (p. 158).  Interestingly, age, previous occupation or working experience of the participants was not associated with actual performance on the MCS test.  This study demonstrated that few participants attained 100% correct in the MCS math portion.  This is remarkable because even one mistake in calculation in the clinical setting can lead to a medication error and a life-threatening situation for the patient.

In a study from the UK in 2006, Wright aimed to investigate the barriers that prevented 72 nursing students in their second year of study from performing accurate drug calculations.  The student participants were surveyed and tested using a tool developed for the study.  Content validity was determined by review from experienced math teachers.  Scores on the test raged from 7-29 out of a possible 30 points with the mean score being 16.5.  96% of the student participants (N=68) were unable to complete 75 % of the questions correctly.  The most difficult math skill determined by the students was multiplying fractions and interpreting information.  Results indicated that nursing students in this study had considerable difficulty with basic math calculations.  This is important because nurses need arithmetic skills as well as conceptual skills to complete drug calculations correctly.  This study highlights that nursing students' poor performance on drug calculations may be due to a lack of

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knowledge of fundamental mathematical principles required for drug calculations (Wright, 2006, p. 45).

Wolf, Hicks, and Serembus (2006) reviewed 1,305 student nurse medication errors and found that the leading cause of medication errors was student performance deficit. What this means is that although the student had the requisite knowledge and skill, they failed to perform the task competently. Not surprising, one of the chief factors contributing to the mistakes was the student's inexperience in performing the actual skill of medication administration (Wolf, Hicks, & Serembus, 2006).

In 2010, McMullan, Jones, & Lea reported on a correlational study of 229 undergraduate nursing students and 44 practicing RNs.  This study explored the relationship between age, status, experience, and drug calculation ability of two cohorts of undergraduate nursing students and practicing RNs. The participants were surveyed and tested on their numerical and calculation ability.  The numerical ability of the 229 students was reported as a mean 54.8. For nurses the mean score for numerical ability was 63.1.  On a scale of 0-100, 55% of the students and 45% of the RN participants would have failed the numeracy exam if the passing score were 60%.  Even though numerical skills is a key competency for RNs, both nursing students and RNs performed poorly in numerical ability in this study. There was no statistically significant correlation for numerical ability and years qualified (McMullan, et al, 2010). Even though numerical skills is a key competency for RNs, both nursing students and RNs performed poorly in numerical ability in this study.  This study also highlights the growing problem that the introduction of technology has on nurses' numeracy ability.  For instance, smart pumps have made infusion administration less complicated because the pump calculates the

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dose based on the infusion of specific parameters entered into the pump. However, according to McMullan, et al, 2010, registered nurses tend to become complacent in the type of calculations they need to do daily in their work with the result they flounder when they are put in a different context and have to perform unfamiliar calculations. Nurses, according to the researchers, "have become deskilled due to lack of practice" (McMullan, et al, 2010, p. 897).

In 2011, a study was conducted in Australia that sought to determine undergraduate nursing students' ability to accurately calculate the drug dosages they would encounter in the workplace (Eastwood, Boyle, Williams & Fairhall, 2011), in response to the alarmingly low level of accuracy when performing mathematical calculations. The researchers surveyed 52 undergraduate nursing students to determine if they could accurately calculate drug dosages and perform basic mathematical calculations required in the workplace (Eastwood, et al, 2010). The participants were given a 3-part questionnaire that included a series of calculation and mathematical equations. Only 3.8% of the participants achieved 100% accuracy. The overall average score on the questionnaire was 56%. The study identified a deficiency in mathematical competence amongst nursing students. Arithmetical errors accounted for 38.9% of all errors and dominated in the study. Students made 25.1% computational errors. This, again, reinforces the significance of this issue in regards to the frightening numbers of daily medication errors in the clinical setting.

In response to the lack of mathematical proficiency among nurses and nursing students, in a larger 2010 study researchers sought to assess undergraduate nursing students' abilities in math (Harvey, Murphy, Lake, Jenkins, Cavanna & Tait, 2009). The

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researchers' findings were similar to Wright's in 2006. Three hundred and four nursing students participated in this study that utilized a tool that was composed of 25 multiple choice math questions.  Results revealed that only nineteen percent (53/323) of students passed the diagnostic mathematics test with a pass rate of 72%. If math skills are a necessary component of safe medication administration and one medication error is too many, the results of this study reinforces the need to address this issue.

RNs must also develop competency in psychomotor skills such as handling syringes: including choosing the appropriate syringe for the prescribed medication, calculating and drawing up the correct amounts and administering the medication in the correct anatomical site. Parenteral medications often require the knowledge to be able to correctly mix powdered medications for reconstitution. Once students graduate, they are immediately expected to be able to administer medications competently and safely including being able to read mixing instructions provided with each vial of medication and apply calculation principles. In 2011, Krautscheid, Orton, Chorpenning, & Ryerson conducted a qualitative study to explore nursing students' perspective regarding their medication administration education and the transferability of pharmacology knowledge and skills from the academic simulated clinical environment to clinical practice settings. The researchers attempted to understand student nurse perceptions regarding teaching strategies and learning activities that prepared them for safe medication administration in acute care clinical settings. Students reported that their learning and ability to transfer education into the clinical setting would have been improved if they had learned how to use relevant technology and that they felt underprepared for their role in medication administration.

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**Need for the Study**

Nursing research lacks a definition of medication competence which integrates pharmacology knowledge- thus there are varied approaches and determinants of medication competence in nursing education and little or no research studies exploring all knowledge categories of medication competence. The Nursing Scope and Standards of Practice and Accrediting Nursing Bodies, the American Association of Colleges of Nursing (AACN), and the National League for Nursing (NLN) do not address medication competence or outline specific standards and guidelines for pharmacology curriculum in nursing programs nationwide (AACN, 2008;ANA, 2010).Medication errors have been researched and strategies developed to address many of the contributing factors but few if any studies have been conducted that explore the RNs' role in the medication process, particularly what their pharmacology knowledge is and the possible relationship it may have in regards to  the number of medication errors that occur. There is little or no research exploring the role of RNs' pharmacology knowledge and how it relates to medication error occurrence.

**Summary**

For registered nurses, medication competence is one of the most vital skills necessary for safe practice (Boxer & Kluge 2000, Gerrish, 2000). However, according to several studies, nurses do not always have the requisite medication competence (Bullock & Manias, 2002, Grandell-Niemi et al, 2005). Medication competence can also be a challenging skill to maintain, due to technological systems designed to facilitate medication administration. Smart pumps or intravenous pumps that calculate drip rates are an example of a technological tool used to decrease and prevent medication errors.

But these medication error prevention tools may serve only as a "band-aid" as their use leads to a reduction in mathematical practice in the clinical setting (McMullan, Jones, & Lea, 2010). Errors at the point of care are particularly problematic for the nurse as the RN is called upon to interpret physicians' orders meant to be administered immediately (or stat), recall essential information regarding a specific medication and the effect it may have on the individual patient, all while administering the medication safely. This often involves recalling complicated calculation formulas.

Patient safety and prevention of all patient related errors relies on competence in practice.  For the nurse, who is at the sharp end of a medication error, the basis of medication competence thus lies in the pharmacology knowledge that begins with their basic education and training (Benner, 2004). The literature identifies the multi-disciplinary nature of the problem and highlights the important contribution that nurses make with regards to ensuring medication safety.  The findings discussed herein regarding practicing RNs pharmacology knowledge, reveals that although all nurses in practice demonstrate minimal competence to practice by passing the NCLEX-RN licensing exam, nurses' do not have the requisite knowledge of pharmacology for their role in the medication process. Limited evidence exists in the literature relating the pharmacology knowledge of practicing nurses to the occurrence of medication errors.

**Chapter III**

**METHODOLOGY**

Errors in healthcare, especially medication errors, are a tremendous problem. In 1999 the IOM funded what is now considered a landmark report "To Err is Human" that highlighted the enormous problem of medical errors including medication errors. The 1999 report and subsequent 2006 IOM report, "Crossing the Quality Chasm" not only addressed this issue but led to major changes in the safe delivery of medical treatments including medications and yet with all this attention medication errors continue to occur. Medications are chemicals administered to improve a patient's quality of life (ASHP, 1993; 2012). Today, tens of millions of people in the United States depend on prescription and over-the-counter (OTC) medications to sustain their health. Medication errors that result in harm are the number one cause of inpatient fatalities (Levinson, 2010). On average there is at least one medication error per hospital patient per day, costing at least $3.5 billion in extra medical costs (US FDA, 2009). Too many people suffer unnecessary injuries, and some die as a result of preventable medication errors. The medication process is complex and involves many healthcare professionals (MDs, Pharmacists and Nurses) and an error can occur at any time. Factors that contribute to errors are basically divided into systems and individual factors with as much as 40% of medication errors occur during the administration phase.

**Clarification of Important Terms**

For the purpose of this paper a Registered Nurse is a graduate trained nurse who has been licensed by a state authority after passing qualifying examinations for registration and may also be called *RN.* For this study I will be using the definition

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endorsed by the NCCMERP, that explains a medication error 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 health care professional, patient, or consumer. A System is a set of interconnected components within an organization that all interact to achieve a common goal. As presented previously, in the healthcare system these interconnected components include nursing, medicine, other allied health services, the environment and the organizational culture that all interact to achieve safe patient care. Actually medication errors result from small breakdowns in the system: the complexity of the medication process, distractions, lack of training, and the complexity of the environment itself. The Institute of Medicine's seminal work: "To Err is Human", "Crossing the Quality Chasm" and most recently "The Future of Nursing" shifted the focus from blaming an individual making an error to blaming the system for its failures (Kohn, etal, 2000).

Through a literature review it has been established that major safeguard against errors is competence and medication competence. An individual, in this case the RN, who demonstrates competence, is performing successfully at an expected level and with adequate ability. Competency refers to a level of performance that results from an integration of knowledge, skills, abilities, and judgment (American Nurses Association, 2007). Medication Competence Involves the ability to assess a patient before the patient takes a medication, administer medications safely and effectively, evaluate the effectiveness of medications administered, provide counsel to patients about their medications, and collaborate effectively with each other and with doctors and pharmacists in averting potential problems and setting goals of care. In summary,

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medication competence involves pharmacology knowledge and skills in order to administer medications safely.

**Research Design and Procedure**

This is a descriptive, exploratory, cross-sectional and correlational survey study . Descriptive research involves describing a group of individuals on a set of variables (Portney and Watkins, 2009). In this case, the researcher attempted to describe practicing nurses' (RNs') pharmacology knowledge. In an exploratory study, the researcher examines a phenomenon of interest and explores its dimensions, in this case data regarding practicing RNs was collected. According to Polit and Beck, cross-sectional studies are also used to study the effect of a potential cause that the researcher cannot manipulate (2008). Cross-sectional studies are used when data was collected at one point in time to prevent testing or history effects; in this case data collected from practicing nurses (RNs) at one point in time. Demographic characteristics of the sample were organized and summarized through a descriptive design. A correlational design was used to explore if a relationship exists between a practicing nurse's (RN's) pharmacology knowledge and medication error occurrence. The researcher did not attempt to control or manipulate the variables under study, but rather to measure how they varied (if they varied) with respect to each other. The purpose of a descriptive and correlational design is to describe variables and examine relationships among them. No attempt is made to control or manipulate the variables. The decision to use this design is supported by Polit and Beck (2008) and Portney and Watkins (2009) who suggests that a descriptive design is for observing, describing, and documenting aspects of a situation as it naturally occurs, while a correlational design is

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appropriate for use in describing the interrelationship or association between two variables. Data was  gathered from anonymous electronic and paper format surveys which was  administered to practicing RNs at SUNY Downstate Medical Center (SUNY DMC) via the electronic survey site at Seton Hall University: asset$^R$ . No participant identifiers were recorded.  Please see attached forms for survey samples. Survey forms were included or discarded based on inclusion and exclusion criteria.

**sampling procedure.**

Participation in this study required the individual to be a licensed registered professional nurse. The New York State Education Department (NYSED), Office of the Professions defines a Registered Nurse as an individual who practices in a variety of settings including hospitals, schools, clinics, private offices, private homes and industry and is a licensed health professional who has an independent, a dependent and a collaborative role in the care of individuals of all ages, as well as families, groups and communities. Such care may be provided to sick or well persons. According to the NYSED Office of the Professions, to be licensed as a registered professional nurse in New York State, a candidate must be of good moral character; be at least eighteen years of age; meet education requirements; complete coursework or training in the identification and reporting of child abuse offered by a New York State approved provider; and meet examination requirements (www.op.nysed.gov/(2014). In addition, according to the New Jersey Administrative Code Title 13 Law and Public Safety Chapter 37 New Jersey Board Of Nursing, a written certification from the registrar or program administrator authorized by the registrar, attesting that the applicant has successfully completed all requirements for graduation from a registered professional

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nursing program accredited by the Board or a board of nursing in another state must be submitted. The certification must indicate the date of graduation or the date the degree or diploma was conferred http://www.state.nj.us/lps/ca/nursing/(2014).

Practicing RNs from Lutheran Medical Center, and Horizon Health Center, Inc. were invited to participate in this study.  Although approval was received from SUNY Downstate Medical Center College of Nursing, data collection was completed prior to receipt of IRB amendment approval from Seton Hall University and thus this site was not included in the results.

**recruitment procedures.**

This study required a convenience sample size of 206 practicing nurses (RNs). A power analysis was used to determine the sample size. The issue of sample size is an essential one, as it directly affects the statistical power of the study.  The power of a statistical test is the probability of detecting a true relationship or group difference (Polit and Beck, 2008, Portney and Watkins, 2009).  According to Polit and Beck, a power analysis can reduce the risk for Type II errors (a false negative) by estimating in advance how big a sample is needed (2008).  An a priori power analysis was calculated because the effect size chosen was d=0.5 (according to Cohen this is a large effect), the alpha was 0.05, and the power (1-beta) was  0.95. The total sample size calculated using G*Power was 206.

Figure 4. A priori G* Power Analysis for Sample Size Calculation
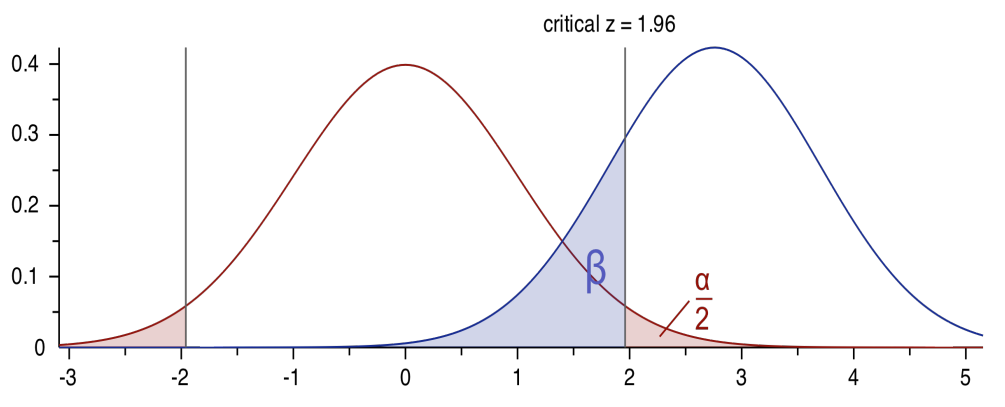
| Analysis: | A priori: Compute required sample size | | |
|---|---|---|---|
| **Input:** | Tail(s) | = | Two |
| | Odds ratio | = | 1.555556 |
| | Pr(Y=1\|X=1) H0 | = | 0.3 |
| | α err prob | = | 0.05 |
| | Power (1-β err prob) | = | 0.8 |
| | R² other X | = | 0 |
| | X distribution | = | Normal |
| | X parm μ | = | 0 |
| | X parm σ | = | 1 |
| **Output:** | Critical z | = | 1.9599640 |
| | Total sample size | = | 206 |
| | Actual power | = | 0.8015422 |

Figure 4  *Sample Size Calculation* of practicing RNs using
*A priori G*Power Analysis*

With permission from Lutheran Medical Center, and Horizon Health Care, Inc.,
(Appendix C and Appendix D), and the receipt of the study research proposal approval
from the Institutional Review Board of Seton Hall University, the Principal Investigator
(PI)  trained a research assistant(RA) who  learned the appropriate procedures needed
to assist with the entire data collection process. As part of the pending research, the PI
and RA completed the required Human Subjects Protection training.  The PI, following a
training checklist (Appendix E-1), familiarized the RA with a script (Appendix E-3) and

checklist of actions/steps(Appendix E-1) to be carried out during the entire recruitment and collection processes, which was used with each and every participant as a memory aid and quality control measure to ensure consistency and completeness in performing the process and procedure from participant to participant.  Once training of the research assistant was completed, participant recruitment began.

The RA referred to the PI provided training script (Appendix E-1) when directing interested participants to the survey on the asset site. The RA also used the PI provided script (Appendix E-3) to explain that participation in the study was voluntary and anonymous. In addition, interested participants were informed by the RA that they were free to pass the survey information and link to the website for the survey in asset, on to their friends, colleagues, or other nurses they may know. Interested participants were encouraged to share the email addresses of potential participants with the RA who would then contact them with the survey link and information directly.

At each of the study locations, Lutheran Medical Center (LMC), and Horizon Health Center, Inc., prior to recruitment, office staff was made aware of the study and prepared, by the Principal Investigator (PI), for the recruitment as part of the organization's procedure. Once potential participants were identified at each of the study locations and communicated to the PI. The PI introduced the Research Assistants (RAs), all at a minimum, mastered prepared registered nurses, to the office staff at each of the study locations.

A contact list of potential participants was identified by the office staff at each study location for recruitment purposes, where permission to conduct the study has been received.   The office staff provided a contact list to the RA who then emailed each

RN listed, and invited them to participate, if interested, in a survey regarding practicing RNs' pharmacology knowledge. A flyer, advertising the study was posted at all nursing stations in each participating facility (Appendix G). The RA invited each RN to participate, utilizing the script provided during the research assistant training (Appendix F). In this process, the RA explained to each interested participant that the study would involve completing surveys to learn about their general pharmacology knowledge, and to learn about their experiences with medication errors. Participants were informed of the purpose of the informed consent and asked to review the letter of solicitation/informed consent (Appendix G). Consent is implied by their participation and completion of the survey documents. They were also told that the entire survey process should take about 20-30 minutes to complete. Eligibility was determined based on inclusion/exclusion criteria.

**Sample size.**

This study required a convenience sample size of 206 practicing nurses (RNs). As stated previously, in order to participate in this study the individual must be an RN. In addition, to be included, the individual had to be:

- Males (may be students)

- Females (may be students and may be pregnant)

- RNs practicing in healthcare settings involved in actual administration of medications (graduates from an accredited RN nursing program).

- RNs who have passed NCLEX-RN or State "Boards" (for individuals who were licensed prior to the institutionalization of the NCLEX-RN exam)

- Between the ages of 18-80

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- English speaking

Individuals excluded from this study were:

- Licensed Practical Nurses ( LPN ) or Unlicensed Assistive Personal (UAP)

- Individuals who are practicing in healthcare who do not have responsibility for direct patient care

- Individuals who have not passed NCLEX-RN or did not pass "State Boards"

- Under the age of 18 or over the age of 80 years

- Non-English speaking

- Individuals who did not graduate from accredited nursing program.

Because it was possible that the participant completing the survey electronically would not be able to complete the entire survey in one sitting, participants were instructed to save their answers and return to the survey via asset to complete the incomplete survey.  The survey engine, asset[R], allowed the participant to start, stop and restart the survey several times. If the survey was not submitted as complete within one week, the survey was marked that the participant had withdrawn from the study. If participants were unable to complete the paper format of the survey, they were instructed to place the paper survey back into the envelope and seal it and return it to the RA at which time the survey envelope was coded incomplete.

There were minimal risks anticipated by participating in this research study. If there was any discomfort with questions, participants were advised to discontinue the survey. There were no proposed or foreseeable direct benefits by participating in this study.  However, the results of this study might help clinicians, nursing educators and researchers, to determine if there was a predictive relationship between the

pharmacology knowledge of practicing RNs and known medication administration errors. There were no HIPAA or FERPA risks since this is a prospective social science survey study design and confidentiality and privacy was maintained throughout the duration of the research study. Participation in the study and completion of the survey implied consent.

**Setting**

The study consisted of a convenience sample of practicing RNs from a medical center and an ambulatory health center in the tri-state area. Once IRB approval was obtained, the study sample was be obtained from RNs practicing at Lutheran Medical Center (LMC) and Horizon Health Center, Inc.

The age range of the participants was 18 through 80 years old. The number of participants: 206 (gpower3; Polit & Beck, 2008). Subjects were recruited until 206 completed surveys were attained from participants to fulfill all inclusion criteria. The support office staff of LMC, and Horizon Health Center, Inc, provided a contact list of practicing RNs from their facilities. A flyer advertising the study (see Appendix G) was posted at all nursing stations in each participating facility, as well as on all approved public bulletin boards at each facility.

Additionally, the snowball sampling technique was used as a recruitment mechanism to increase the number of subjects included in the study. Snowball sampling is a method that is carried out in stages. In the first stage, participants who meet selection criteria are identified and surveyed. In the second stage, these participants are asked to identify others who have the requisite characteristics. Sampling continues until an adequate sample is obtained (Portney and Watkins, 2009).

All research was conducted at the following locations:

- Lutheran Medical Center, located at 150 55th Street Brooklyn, New York 11220, is a 450-bed teaching hospital. LMC offers a full range of services including a Level I Trauma Center, N.Y.S. designated regional Stroke Center and a Bariatric Center of Excellence.

- Horizon Health Center, Inc., located at 714 Bergen Avenue, Jersey City, New Jersey, 07305 Horizon Health Center is a Federally Qualified Health Center in Hudson County, NJ that offers a comprehensive range of healthcare and educational services to care for a diverse and dynamic population. Horizon Health Care Center has two sites based in Jersey City, NJ and one site in Bayonne, NJ that serves 19,000 patients and 60,000 visits per year.

No research was begun at any location listed until the approval to conduct research at that facility was received from each respective IRB office at each study location and final IRB approval was received from the Seton Hall University (SHU) IRB office. With permission from Lutheran Medical Center (LMC)(Appendix C), and Horizon Health Care, Inc. (Appendix D), the Principal Investigator (PI) trained the research assistant (RA). Each institution's RA, also known as the "institution specific" research support person, completed the National Institutes of Health Protection of Human Subjects Training Module for SHU and its institutional requirement as well. Once training of the RA was completed, participant recruitment began. Protection and confidentiality were maintained throughout the duration of the research project. No personal identifying information was collected from participants. Completion of the survey indicated

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consent. A letter of solicitation explained consent and confidentiality to interested participants (Appendix F).

Upon completion of the study, all electronic data was stored on a USB memory key with access to the file protected by use of a password only known to the principal investigator. The memory key remains in a secured filing cabinet for three years, upon which time the data will be destroyed. The Principal Investigator has no conflict of interest with regards to the research study.

**Instrument**

The tool, (see Appendix A), used in this study was the Medication Calculations Skills test (MCS). This tool was developed in 2005 in Finland by a team of nursing researchers led by Dr. Heidi Grandell-Niemi. The tool was first used to assess the perceived and actual pharmacology knowledge of 364 RNs and 282 nursing students from five university based hospitals in Finland. The tool has three parts: part one seeks to determine an individual's perceived pharmacology knowledge; part two seeks to determine an individual's actual pharmacology knowledge and part three asks demographic questions and self report (if any) (Appendix A) of a medication error experience. The MCS test comprises structured questions and computations. The original tool was available in paper format but with permission from the author (see Appendix A-1), the survey was uploaded to asset[R]. In this study, the Medication Calculations Skills test was used to determine the perceived and actual pharmacology knowledge of practicing RNs and to explore the relationship to medication error occurrence.

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One independent variable (practicing RNs pharmacology knowledge, measured with the MCS test) and one dependent variable (medication error occurrence, measured by RNs self report) were measured in this study.  According to Alreck & Settle, surveys are data-gathering tools used to gather information about a specific population to establish attitudes, beliefs, values, demographics, behaviors, opinions, habits, desires, ideas and other types of information (2004).  Constructing clear questions that measure the intended construct is an essential task in developing a valid survey. Questionnaires used in survey research should be clear and well presented, simple, appropriate for the intended use, acceptable to respondents, and should include a clear and interpretable scoring system (Kelley & Colby,2003). Participants in this study were surveyed using the three (3) part electronic version or paper version of the MCS survey.    The Medication Calculation Skills Test (MCS) was used to find out the perceived and actual (Appendix A) pharmacological skills of practicing registered nurses (RNs). The MCS test includes 75 questions. The MCS test comprises structured questions and computations and was designed by nurse researchers in Finland based on the research literature and pharmacology textbooks (Grandell-Niemi et al. 2005).

The MCS test (Appendix A) consists of two sections. In Section 1, participants are asked to assess their basic level (BL) (4/4 items) and higher level (HL) (4/4 items) pharmacological skills, mathematical skills (4/4 items) and their interest in pharmacology (3/3 items), in mathematics (3/3 items) and in dosage calculation (3/3 items); Section 2 tests actual BL (12/12 items) and HL (12/12 items) pharmacological and mathematical skills (29/29 calculation problems). The statements used in the self-ratings are arranged on a 5-point Likert-type scale (1=strongly disagree to 5 = strongly

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agree); in the section testing actual pharmacological skills, the items were right–wrong statements and in that testing mathematical skills, there were mathematical problems. According to Grandell-Niemi et al (2005), the content validity of the instrument was established by review of the previous research literature and pharmacology textbooks and through a pilot study carried out on a group of nurses (n =69) and graduating nursing students (n =59). According to Polit and Beck, the reported Cronbach alpha for the pilot test was adequate (0.72 – 0.92) (2008; Grandell-Niemi, *et al*, 2005).

**demographic survey.**

An additional section of this questionnaire included a demographic survey developed by the principle investigator (Appendix A). According to Alreck & Settle (2004), demographic factors included in research surveys are such variables as age, gender, marital status, family status, family lifecycle state, education, employment, occupation, income and residential location and type, among others. A 3rd section of the MCS test is concerned with the socio demographics of the participants and practicing RNs' self-report of experience (if any) with medication administration error. To that end, the demographic survey was compiled using demographic questions derived from the original demographic survey developed by Grandell-Niemi and her colleagues (2005). Questions such as age, gender, educational and employment status were used for this purpose. An additional section was added to the original to obtain a practicing RN's self reported experience with a medication administration error.

**Data Collection**

Prior to the first day of the study, the PI uploaded the survey (the Medication Calculations Skills test to the survey, Seton Hall University's Academic Survey System

and Evaluation tool (asset[R]). The uploaded survey contained each of the following documents: a letter of solicitation/implied consent (Appendix F), the two-part MCS test and a demographic survey.  The PI assembled copies of the flyer advertising participation in the study (Appendix G) and provided these to the RA.  Along with the flyer, the PI  provided the following stationary supplies for the RA to use: thumb tacks, tape, scripts, checklists, pens and pencils and other materials.

In addition to uploading the MCS survey, the PI also prepared a paper delivery format of the survey in the event that an interested participant expressed a desire to complete the survey using paper and pencil.  Each survey package and envelope was given a numerical code by the PI that was written on the outside of the envelope and on each document within the envelope.  Each packet contained: a letter of solicitation/implied consent (Appendix F), and the MCS survey: Parts 1, 2, and 3(Appendix A ). The envelopes were assembled in ascending numerical order in a box, and given to the RA on each morning of the data collection. If the number on the manila envelope and the survey did not match, the participant was directed to return the envelope and blank survey to the RA and another numbered envelope with numbered survey inside was given to the participant.  In addition, in the event the RN participant could not finish or chose not to complete the survey, the survey was placed back into its envelope and sealed.  The outside of the envelope was marked withdrawal/incomplete. The envelope was then placed in the box and given to the PI at the end of each day of data collection.   The RN participant completed the survey in a private and separate office on location. The completed survey was placed back into the manila envelope and sealed by the participant and handed back to the RA. The RA placed the completed

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survey envelopes in a box and returned them to the PI at the end of each day the survey event was conducted. As a contingency plan, participants were asked to share the survey link with other practicing RNs in the event that fewer participants agreed to complete the survey than necessary for sufficient power.
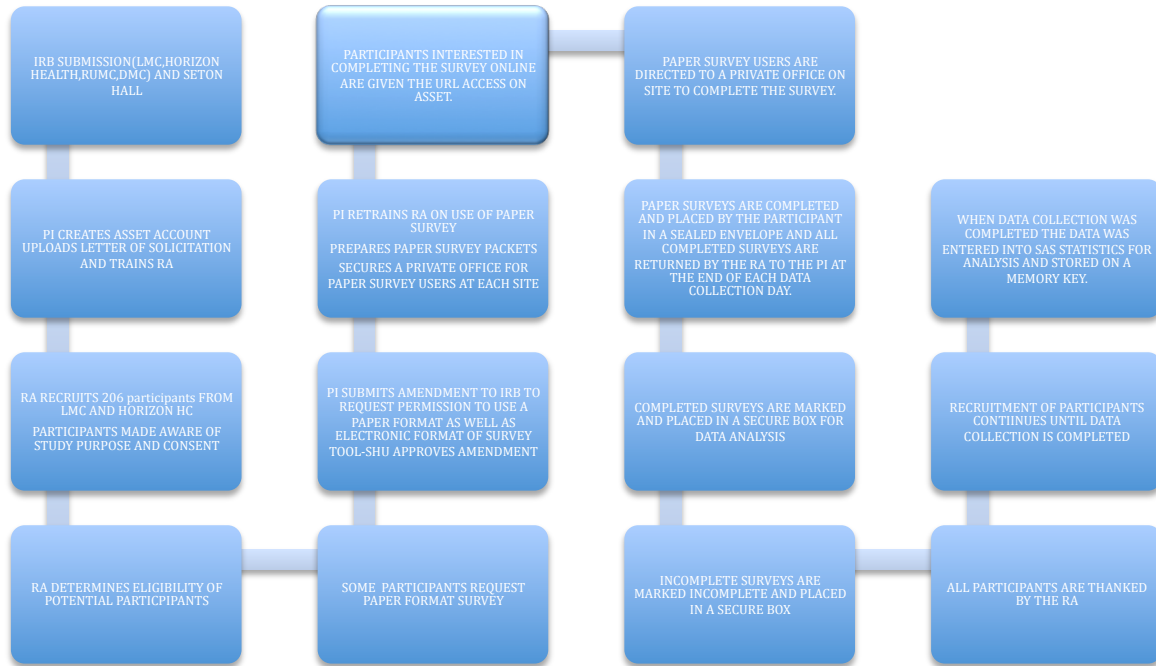


*Figure 5 Data Collection Flow chart*

*This figure illustrates through this flowchart the outlining of the data collection process from IRB approval through actual submission.*

**Data analysis**

  **statistics.**

As soon as the survey submission to asset$^R$ reached the targeted sample size of 206, (the actual number of participants was 218) the PI screened the survey instruments for missing responses on key survey items not on demographics. Because

the sample size was large (N=311) cases with missing values were removed from the analysis.  Eighty-nine cases had at least one missing value.

The data was entered in the SAS Statistics and stored on a memory key. Prior to analysis of variables, each variable was examined separately for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis.  If a survey was missing any responses, the data was not included in the analysis; further, the entire package of survey information corresponding to any incomplete survey was not used in the analysis, and was segregated and marked as such prior to storage. The PI securely locked the memory key in a filing cabinet in her home office.

The data was analyzed using both descriptive and inferential statistics, using SAS/STAT version 9 (DiCenso, 2015).  Demographic characteristics were presented in tabular form using descriptive statistics. For the demographic characteristics collected, the following descriptive statistics are reported: means, standard deviation, ranges and frequencies.  The research hypotheses were tested using logistic regression for research questions one and two and multiple logistic regressions for research question three.  Logistic regression is the correct choice when there is one independent variable (IV) measured on an ordinal level that is continuous (RNs pharmacology knowledge) and a dependent variable (DV) (medication error occurrence) that is nominal and categorical and yields a predictive relationship.  Applied to this study, when testing a relationship between two variables, here one independent (RNs' pharmacology knowledge) and one dependent (medication errors), bi-variate regression is used to predict a relationship between or among dependent variable and an independent

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variable. The IV or predictor variable must be continuous while the DV or outcome variable must have two categories and be measured on a nominal level. Logistic regression was used to produce an odds ratio to see if the IV predicted a higher odds of the DV.

Multiple logistic regressions were used because they analyze the relationship between multiple IVs and a categorical DV and yield a predictive relationship. In this case, the PI wanted to produce an odds ratio and see if the IV(s) RNs pharmacology knowledge and based on the literature and potential variables gleaned from the demographic data that the researcher thought most compelling, predicted a medication error by controlling for RNs level of education, level of experience and area of specialization.

**Chapter IV**

**RESULTS**

**Introduction**

The purpose of this study was to was to determine if there was a relationship between practicing RNs' pharmacology knowledge, as measured by the MCS test and medication error occurrence,as determined from an RNs self-report. The analysis consisted of three major components.

The first component involved compiling and summarizing the survey responses. Prior to analysis of variables each variable was examined separately for accuracy of data entry, missing values, and fit between their distributions and the assumptions of multivariate analysis. The data was analyzed using both descriptive and inferential statistics, using SAS/STAT version 9 (DiCenso, 2015). For the demographic characteristics collected, the following descriptive statistics are reported: means, standard deviation, ranges and frequencies.

The researcher viewed the MCS Composite score as an ordinal, continuous variable. The dependent variable (DV) (medication error occurrence) is nominal and categorical. The research hypotheses were tested using logistic regression for research questions one and two and multiple logistic regressions for research question three. Logistic regression was be used to produce an odds ratio to see if the IV predicted a higher odds of the DV.

The final component of the study examined whether RN participants had an experience with a medication error. If the participant responded yes they were directed to 7 additional questions, which explored the nature, cause, consequences to the

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patient, consequences to the RN and the nature (punitive versus non punitive) of the culture of the healthcare setting.   Frequencies and percentages were reported for each of the categories.

**Characteristics of the sample**

Of the 311 Registered Nurses who consented to participate in  the Medication Calculations Skills test, 222 completed the survey.  Included in the analysis were 212 practicing RNs.  Ten completed surveys were excluded because the participants identified as currently not practicing and therefore did not meet the inclusion criteria.

| Table 1 | | |
| --- | --- | --- |
| *Currently Practicing as an RN* | | |
| Actual Participants (n=212) | | |
| | n | % |
| Yes | 212 | 95% |
| No | 10 | 5% |

The survey was administered in English using the electronic format asset[R] and in paper format (as it was originally designed) .  Academic Survey System and Evaluation Tool (asset[R]), the web-based survey tool developed at Seton Hall University was chosen to administer the electronic surveys. The online version of the survey(with permission from the survey's author, Dr. Heidi Grandell-Niemi) was used because it is eco-friendly and makes data collection more efficient and cost effective. It offers convenience and immediate survey data analysis and ensures anonymity. However, after data collection began, older of nurses were hesitant to participate because they were ill at ease completing an electronic survey.  An addendum was filed with the SHU IRB and participants were given the paper option as well.  If they opted for the paper

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format, in order to maintain anonymity, the participant was given access to a private office at the site where they completed the survey. Once completed, they returned the survey to the research assistant (RA) in a sealed envelope. These envelopes were placed in a designated box and returned to the principle investigator (PI) at the completion of the day.

**Data analysis**

    **statistics.**

Descriptive analysis of the participant background characteristics was conducted and included frequencies and percentages.  For the inferential statistics, Logistic Regression Models used (significant if $p < .05$) Parametric Models ([SAS/STAT] software, Version [9] of the SAS System for [UNIX] to analyze the data. Copyright©[2012] SAS institute Inc. (DiCenso, 2015)

The data categories were as follows.  For the independent variables, composite knowledge (pharmacology and calculations ability) and pharmacology knowledge only for research questions 1 and 2 respectively, the variables were continuous, ratio level variables.  Nominal level variables (the demographics) were included in research question # 3. The dependent variable, medication error occurrence was nominal and categorical.

**Findings**

    **demographics.**

Descriptive analysis of the participant background characteristics was conducted and included frequencies and percentages.  The majority of participants were females (n=167, 79%). Participants ages were grouped into four categories by age in years: <

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25, 25-30, 31-40, 41-50.51-60 and >61. According to the ANA (2012), the average age of employed RNs is 44.6 years.

In this study, only 13% of the participants represent the 41-50 age group . The majority of participants were between the ages of 25 and 30 years (n=70, 33%).

| Table 2 | | | |
|---|---|---|---|
| *Practicing RNs by Gender and Age* | | | |
| Actual Participants (n=212) | | | |
| Gender | | n | % |
| | Female | 167 | 79 |
| | Male | 45 | 21 |
| Age | <25 | 16 | 8 |
| | 25-30 | 70 | 33 |
| | 31-40 | 61 | 29 |
| | 41-50 | 27 | 13 |
| | 51-60 | 33 | 16 |
| | >61 | 5 | 2 |
| *Note.* According to the U.S. Nursing Workforce Report, 2013, about one-third of the nursing workforce is older than 50(HRSA, 2013). | | | |

According to the American Association of Colleges of Nursing (2015),  "there are three routes to becoming a registered nurse: a 3-year diploma program typically administered in hospitals; a 3-year associate degree usually offered at community colleges; and the 4-year baccalaureate degree offered at senior colleges and universities.  Graduates of all three programs sit for the same NCLEX-RN© licensing examination (p. 1). Because RNs can enter practice through a variety of educational programs, education was subdivided by highest degree in nursing and highest degree outside of nursing.  The sample consisted of diverse educational backgrounds, the

majority of RNs in this study reported that they held a baccalaureate in nursing degree

(n=126, 59%) followed by Associates Degree in Nursing (ADN) (25%) while Diploma

graduates (2%) and RNs holding a doctorate degree were the minority (1%).

Table 3

*Numbers of Practicing RNs with a nursing degree*

| Education (Degree in Nursing) | n | % |
|---|---|---|
| Diploma | 4 | 2 |
| Associate Degree | 53 | 25 |
| Bachelors Degree | 126 | 59 |
| Masters Degree | 27 | 13 |
| Doctorate | 2 | 1 |

*Note.* "Currently, about 55 percent of the RN workforce holds a bachelor's or higher degree. An associate's degree in nursing was the first nursing degree for many nurses" (HRSA, 2013).

RN participants in this study held additional degrees outside of nursing. This

Information was also collected during data collection and is presented here.

| *Table 4* | | |
|---|---|---|
| *Numbers of Practicing RNs with additional degree outside of nursing* | | |
| Education (Degree Outside of Nursing) | | |
| Associate Degree | 28 | 13 |
| Bachelors Degree | 65 | 31 |
| Masters Degree | 7 | 3 |
| Only Nursing Degree | 112 | 53 |

*Note.* Due to the strong relationship between the two variables (p < 0.001), only the data from the highest degree in nursing was used in the analysis.
[a] "Currently, about 55 percent of the RN workforce holds a bachelor's or higher degree. An associate's degree in nursing was the first nursing degree for many nurses" (HRSA, 2013).

Certification is the formal recognition of advanced knowledge, skills and experience in nursing. Certification was categorized in the survey question as either yes or no. The participants who identified yes to being certified were then directed to fill in which certification they held.  The majority of participants were not certified (n= 144, 68%). Only 32% of participants were certified.

| Table 5 | | |
|---|---|---|
| *Number of Certified Nurses* | | |
| | N | % |
| Yes | 68 | 32 |
| No | 144 | 68 |

The employment status of the RN participants was grouped as full time and part time. According to the HRSA Nursing Workforce report, 2013:

> The average number of hours worked by RNs held remarkably steady over the time period covered by this analysis, hovering at about 37 hours per week. When examined by age [*sic*], it is clear that older nurses are, as expected, working fewer hours than younger nurses (p 29).

The majority of RNs in this study worked full time, n=150, 72%.

| Table 6 | | |
|---|---|---|
| *Practicing RNs Employment Status: Full-time or Part-time* | | |
| Full-time | 150 | 72 |
| Part-time | 59 | 28 |
| *Note.* These results are in line with the average number of hours worked by RNs= 37 hours per week or full time as reported in the US Nursing Workforce Trends in Supply and Education Report (2013 ) | | |

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The number of years of experience as an RN was classified under four groups: <1 year, 1-4 years, 5-10 years, and > 10 years. The majority of the participants were practicing 1-4 years (n=77, 36%) followed by > 10 years (n= 59, 28%).

Table 7

*Years of Experience as an RN*

| | Actual Participants (n=212) | |
| --- | --- | --- |
| | n | % |
| <1 year | 30 | 14 |
| 1-4 years | 77 | 36 |
| 5-10 years | 46 | 22 |
| >10 years | 59 | 28 |

Shift time was grouped as 8 hours and 12 hours shifts.  The participants in this study were split 50/50 with 49 % reporting they worked 8-hour shifts and 51% reporting that they were working 12-hour shifts.

Table 8

*Practicing RNs Shift time Worked*

| | Actual Participants (n=212) | |
| --- | --- | --- |
| | n | % |
| 8 hours | 106 | 49 |
| 12 hours | 102 | 51 |

According to the 2013 U.S. Nursing Workforce Report, the majority of RNs (63 percent) are providing inpatient and outpatient care in hospitals and the number of RNs working in hospitals increased by more than 350,000 (about 25 percent)(HRSA, 2013). In this study, practice setting was grouped into 6 categories: hospital, medical office,

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ambulatory care, community/homecare, long-term care, managed care and other.   The

majority of nurses in this study, n=153 (72%), practice in a hospital setting, this is

greater than the national average of 63.2%. Long- term care was the second most

popular setting with n=32 (15%).  This is greater than the national average, 7.4% of RNs

practice in long term care, as reported in the US Nursing Workforce (HRSA, 2013).

| Table 9 | | |
|---|---|---|
| *Practice Settings where RNs are Employed* | | |
| Actual Participants (n=212) | | |
| | n | % |
| Hospital | 153 | 72 |
| Medical Office | 3 | 1 |
| Ambulatory Care | 6 | 3 |
| Community/Homecare | 7 | 3 |
| Long-term care | 32 | 15 |
| Managed care | 2 | 1 |
| Other | 9 | 4 |

Specialty area of practice was grouped into 7 categories including medical

surgical, pediatrics, obstetrics, psychiatric, critical care, emergency room and other.

Participants who chose other were directed to "fill-in" the specialty area where they

worked. The majority of participants reported that they worked in the medical surgical

specialty area (43%). Operating Room ranked #1 as an "Other" choice with 19

participants identifying as operating room nurses.  Next "other" choice was geriatrics

with 9 participants identifying in this area. The remainder of the other choices (oncology,

hospice, PACU, palliative care, rehab, education and hemodialysis) all had less than 5

participants in their respective areas.

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Table 10

*Specialty Areas of Practice for RNs*

| | Actual Participants (n=212) | |
| --- | --- | --- |
| | n | % |
| Medical Surgical | 88 | 43 |
| Pediatrics | 6 | 3 |
| Obstetrics | 17 | 8 |
| Psychiatric | 4 | 2 |
| Critical Care | 20 | 10 |
| Emergency Room | 8 | 4 |
| Other | 63 | 31 |

Shift time of day was divided into three groups: day shift , evening shift and night shift.  The majority of participants worked the day shift n=138, (66%) followed by the night shift n=51, (24%). The evening shift accounted for 10% of the participants.

**Research findings**

For part 2 of the Medication Calculations Skills test (MCS) survey that tested the actual pharmacology and math calculations knowledge (the independent variable), the data was categorized as the composite knowledge (pharmacology and medication calculations knowledge), the actual pharmacology subscale score and the actual math calculations subscale score. The descriptive statistics: mean median, standard deviation, interquartile range and range was reported for each of the independent variables.

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The MCS composite knowledge is the percentage of correctly answered items on part 2 of the survey. The possible range was 0-100%. On average, participants got 50% of the questions correct. The best score was 67% and the worst was 19%.

Table 11

*MCS Composite (Actual Pharmacology and Math Calculation) Knowledge Score*

| | |
|---|---:|
| Mean | 50 |
| Median | 51 |
| Standard Deviation | 9 |
| Interquartile range | 12 |
| Min, max | 19, 67 |

*Note.* Results were not as expected. This was not what I expected. I expected scores to be much higher because the original publication using the MCS test reported the average score for practicing RNs was 79% (Grandell-Niemi, et al, 2005).

For the MCS actual pharmacology subscale score the participants were diverse in their actual pharmacological knowledge. On average, participants got 42% of the questions regarding pharmacology knowledge correct. The minimum score achieved was 0 with the max score= 77%.

Table 12

*MCS Pharmacology Knowledge Score*

| n=212 | Actual | Perceived |
|---|---:|---:|
| Mean | 42 | 35 |
| Median | 39 | 32 |
| Standard Deviation | 14 | 13 |
| Interquartile range | 17 | 18 |
| Min, max | 0, 77 | 0, 82 |

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For the MCS actual math calculation subscale score, on average, the participants got a little more than half the answers correct (55%).

| Table 13 | | |
|---|---|---|
| *MCS Math Calculations Score* | | |
| n=212 | Actual | Perceived |
| Mean | 55 | 8 |
| Median | 56 | 2 |
| Standard Deviation | 11 | 14 |
| Interquartile range | 16 | 9 |
| Min, max | 20, 76 | 0, 91 |

**MCS subscales.**

Even though only the actual knowledge was used to test the research hypotheses I did want to see whether there was a correlation between perceived and actual knowledge, separately for pharmacology and calculation. Therefore I ran two Pearson's correlations. The correlation coefficients were obtained by running a simple regression between perceived and actual knowledge for each area. Taking the square root of the $R^2$ and using the sign of the slope coefficient in the regression model to obtain the sign of the correlation coefficient found the coefficient of determination. The first Pearson's correlation, correlated perceived with actual pharmacology knowledge. The correlation of .63 indicates a strong positive relationship between perceived and actual pharmacology knowledge. This result is statistically significant as evidenced by the low p value ($<.0001$).

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The second correlated perceived with actual math calculation knowledge and the - .04 correlation result indicates that there is virtually no relationship between perceived and actual calculation ability for this group of RNs. The high p value of .55 also says that this result is not statistically significantly different from a 0 correlation between these two variables.  In regards to the actual math calculations knowledge scores for the participants in this study, perceived knowledge was much lower than actual knowledge. Perceived and actual knowledge of pharmacology were strongly correlated: r = .63, p < .0001. Perceived and actual knowledge of math calculations were not correlated: r = -.04, p = .549.

**Research Questions Results**

For research question (RQ) 1&2, logistic regression models were fitted to determine the effect of practicing RNs composite knowledge (pharmacology and calculations) and pharmacology knowledge respectively on medication error occurrence. For RQ3, in order to see if there were any demographic variables that had significant impact on medication error incident rates, using the logistic regression model of the composite test score predictor variable, each demographic (independent) variable was entered into the model.

**research Question #1.** The analysis of data for  research question #1, "Is there a relationship between practicing RNs composite (pharmacology and calculations) knowledge, as measured by the MCS test and the occurrence of a medication error, as determined from an RNs self-report?", a model was fitted with the MCS composite score as a predictor variable for medication error occurrence.

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| Table 14 | | | | |
|---|---|---|---|---|
| *SAS Logistic Regression Results: RQ#1 Is There a Relationship Between Practicing RNs Composite (Pharmacology and Math Calculations) Knowledge, as Measured by the MCS Test, and the Occurrence of a Medication Error, As Determined From an RNs Self Report?* | | | | |
| Odds Ratio Estimates | | | | |
| Effect | Point Estimate | 95% Wald Confidence Interval | | p value |
| Test score | 1.03 | 1.00 | 1.07 | .05 |

To understand these results one must have an understanding of what an odds ratio is.  The odds ratio for this study is the ratio of subjects who experienced a medication error to the number of subjects who did not.

The Point Estimate is the ratio of the medication error odds ratio for those who had high MCS test scores to the medication error odds ratio for those who had low-test scores. The $p$ value of .053 indicates that this result is not statistically significant at the .05 level. However one can perceive this result as marginally significant because it is less than .10. I found higher scores associated with increased risk. This result was surprising and the opposite of what I expected.

**research Question #2.** For RQ 2,"Is it possible to predict the occurrence of a medication error (as determined from an RNs self-report) if the RNs pharmacology knowledge is known (as measured by the MCS test)?", another logistic regression analysis was performed.  It is similar to the analysis performed for RQ 1, the only exception being that the score on the actual pharmacology knowledge section of the MCS test is the predictor variable. This result is non-significant as indicated by the large $p$ value of .27, which is much greater than the .05 significance level. The pharmacology knowledge score in this sample has no influence on the incidence of medication errors.

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Table 15

*SAS Logistic Regression Results: RQ#2 Is It Possible to Predict the Occurrence of a Medication Error(As determined from an RNs Self-report) if the RNs Pharmacology Knowledge is Known(as Measured by the MCS Test)?*

| | Odds Ratio Estimates | | | |
| --- | --- | --- | --- | --- |
| Effect | Point Estimate | 95% Wald Confidence Interval | | p value |
| Pharm. MCS | .99 | .99 | 1.00 | .271 |

**research Question #3.** Research question 3, "In addition to practicing RNs composite (pharmacology and calculation) knowledge do their demographic characteristics influence the occurrence of medication errors?", explored the influence of characteristics of the population on medication error incidence rate. Of note is that certain demographic characteristics, when added to the composite test score had a statistically significant impact on the medication error rate. These included: specialty (p=.027), education (p=.023), certification (p=.010), setting (p =.040), and shift time (p =.005). The regression model in this study provided information on which categories of a particular demographic variable tend to increase the error rate and which tends to decrease the rate. The regression model output also gives some idea of the relative magnitudes of these impacts.

In order to see if there were any demographic variables that had a significant impact on the medication error incidence rates, I started with the logistic regression model using the composite test score predictor variable. I then separately added each of the demographic variables to the model. The results of this were a set of separate logistic regression models, each one including the composite test score and one of the demographic variables as predictor variables.

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Two items were recorded.  The p value associated with the particular

demographic variable itself and the p value for the overall logistic regression model.

These values are shown in table.

Recalling that the logistic regression model using the composite test score only

as a predictor variable had a marginally significant p value of .053.  Adding the following

demographic variables to the model makes the overall p value more significant:

specialty, education, certification, setting and shift time (days/eve/night). This means

that these five variables tends to have a significant impact on medication error rate.

Table 16

*Logistic Regression using each Demographic Variable and Composite Test*
*Score in Predicting Medication Errors*

| Predictor Variables: | p-value for  demographic variable | Overall p-value for logistic regression model |
| --- | --- | --- |
| Composite test score only | -- | .053 |
| Composite test score and: | | |
| Age | .250 | .135 |
| Specialty | .067 | .027 |
| Experience | .386 | .160 |
| Education | .043 | .023 |
| Certification | .016 | .010 |
| Hours (FT/PT) | .247 | .070 |
| Setting | .060 | .040 |
| Shift length (12h/8h) | .739 | .151 |

In addition, the regression model provided information on which categories of a

particular demographic variable tends to increase the error rate and which tends to

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decrease the rate. The regression model output also gave some idea of the relative magnitudes of these impacts.

**Medication Error Experience**

The dependent variable, medication error experience, was a dichotomous, categorical variable. Participants were asked if they or a nurse they knew had an experience with a medication error. Of the 212 participants, 147(69%) RNs in this study had an experience with a medication error.

| Table 17 | | |
|---|---|---|
| RNs Experience with Medication Errors* | | |
| N=212 | | |
| | Frequency | Percentage |
| Yes | 147 | 69% |
| No | 65 | 31% |
| *Note.* * Represents the dependent variable in this study which involves both committing and/or witnessing a medication error. | | |

If the participant answered yes to a medication error experience, the participant was directed to 7 additional questions that were categorized as the nature (aligned with the 5 rights for medication administration-right patient, drug, route, amount and time), cause, consequences for the RN and consequences for the patient and reporting of the error. Frequencies and percentages were reported for each of the categories.

For nature of the error the majority (39%) had to do with administering a medication to the wrong patient. The majority of the participants 57 (72%), reported that the error had no consequence for the patient involved. Causes of errors were classified under 8 groups: distractions and interruptions, patient off unit, unfamiliar with the drug,

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unfamiliar with the route of administration, lack of staffing, unfamiliar with the unit/patients (floated), high acuity of the patients on the unit, and working overtime. The #1 cause of medication errors reported in this study was distractions (43%). This is corroborated by Mayo and Duncan (2004) where the top cause was MD handwriting is difficult to read or illegible and the second cause was distractions. Computerized Physician Order Entry (CPOE), has ameliorated the problem related to deciphering difficult handwriting by increasing patient safety through the elimination of common medication errors such as those stemming from illegible handwriting or a breakdown in the transcription process (The Sentinel Watch, 2015). In this study, the majority of errors reported had no consequence for RNs involved 84 (58%).  However, 27 percent of participants reported that there was a punitive culture in their healthcare institution.

| Table 18 Medication Error Experience n=212 | | |
|---|---|---|
| Nature | Frequency | Percentage |
| Wrong Patient | 57 | 39 |
| Wrong Drug | 33 | 23 |
| Wrong Route | 32 | 22 |
| Wrong Amount | 6 | 4 |
| Wrong Time | 17 | 12 |
| Cause | | |
| Distractions and Interruptions | 63 | 43 |
| Patient off unit | 11 | 8 |
| Unfamiliar with drug | 18 | 12 |
| Unfamiliar with route of administration | 25 | 17 |
| Lack of staffing | 16 | 11 |
| Unfamiliar with the unit/patients (floated) | 6 | 4 |

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| | | |
|---|---|---|
| High acuity of patients on the unity | 5 | 3 |
| Working overtime | 2 | 1 |
| *Pt. Consequences* | | |
| No consequences | 106 | 72 |
| Mild, patient monitored on unit, little or no treatment | 33 | 22 |
| Patient was transferred to the ICU, no permanent effects | 2 | 1 |
| Patient was transferred to the ICU, permanent effects | 5 | 3 |
| Patient Expired | 1 | 1 |
| *RN Consequences* | | |
| No consequences for RN | 84 | 58 |
| Nurse disciplined | 49 | 34 |
| Nurse suspended | 8 | 5 |
| Nurse fired | 5 | 3 |
| *Reporting* | | |
| Just culture reporting encouraged | 111 | 73 |
| | | |
| Punitive culture-errors punishable | 41 | 27 |

## Summary of Findings

Results of this study reveal that there is a relationship between the composite

MCS test score and the chance of a medication error. Composite knowledge

(pharmacology and calculations) was predictive of a medication error. The result when

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measured with the MCS was marginally statistically significant (p=. 053). The interesting thing to note is that a higher composite MCS test score results in a slightly higher chance of a medication error, which was somewhat counterintuitive.

It was not possible to predict the occurrence of a medication error (as determined from an RNs self report) if the RNs pharmacology knowledge was known (as measured by the MCS test). The result for the logistic regression run for the pharmacology knowledge only score was not statistically significant (p = .271). Therefore, the pharmacology test score alone, as measured by the MCS test was not predictive of the medication error rate.

Certain characteristics of the population when added to the composite test score had a statistically significant impact on the medication error rate: specialty (p=.027), education (p=.023), certification (p=.010), setting (p=.040), and shift time (p=.005).

Additional findings included information regarding an RNs experience with a medication error. Of the 212 participants, 147 RNs in this study reported that they had an experience with a medication error. Further, findings from this study reveal that the majority of errors had to do with administering the medication to the wrong patient. Most errors reported in this study were due to distractions and although the majority of these medication errors had no ill effects for the patients or nurses involved, 27% of the participants reported that they worked in a punitive healthcare setting.

# CHAPTER V

## DISCUSSION AND CONCLUSION

**General Discussion of Study Findings**

Medication errors have been identified as the most common type of error affecting the safety of patients (Kohn, Corrigan & Donaldson, 2000; US FDA, 2012; Brady, 2009; US FDA, 2012). The factors that contribute to medication errors are complex and multifaceted but can be divided into two basic sub groups: systems factors and individual health care professionals' factors (Brady, 2009, McBride –Henry, 2006). For the Registered Nurse healthcare profession, medication errors are particularly problematic because medications are administered by RNs and account for almost 40% of all medication errors (Bayne and Bindler, 1988; Bates, Cullen, Laird, Petersen, Small, Servi, Laffel, Sweitzer, Shea, Hallisey, 1995 Anderson and Webster, 2001; Mayo & Duncan, 2004;Ulanimo, O'Leary-Kelley, Connolly, 2007). Pharmacology knowledge is essential for safe drug administration (Manias & Bullock, 2002; Sulosaari, Suhone & Kilpi, 2010). Results from several studies indicate that registered nurses lack pharmacological knowledge and calculation skills required for safe practice (Latter, Rycroft,-Malone, Yerell, Shaw, 2000; Manias & Bulock, 2002).

Nursing literature lacks a definition of medication competence which integrates pharmacology knowledge- thus there are varied approaches and determinants of medication competence in nursing education and little or no research studies exploring all knowledge categories of medication competence.

This study aimed to determine the pharmacology knowledge of practicing nurses and to determine if there is a predictive relationship between the pharmacology knowledge of practicing RNs, as measured by the Medication Calculations Skills test (MCS) and known medication errors as determined from an RN's self-report.

Based on the literature and my experience, medication errors continue to be a tremendous problem. In respect to medication errors, a significant portion of the medication errors that occur are attributed to the administration of medications, i.e. the registered nurses' role. What I sought to do in my study was to see if there is a predictive relationship between knowledge (as I have defined it) and the incidence of medication error. In this study I used an existing instrument, the Medication Calculation Skills test that has been used in previous research and represented as having reliability and validity (.72-.92 and content validity (Grandell-Niemi, etal, 2005). I expected to find an inverse relationship between knowledge and the incidence of error, but when I analyzed the data I found the reverse, more knowledge is related to more error. This led me to analyze the data further.

What happened in my study is not atypical in that I set out in this study to answer a question(s); I designed the method, collected the data and then analyzed it. In research, in the analysis, we frequently notice things that were unexpected and when we follow those observations we often conduct unanticipated analyses and we arrive at findings that, while not expected, may be more interesting than what we originally sought to find out. In considering the findings of this study, there are several things that deserve discussion.

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**Discussion: Research Question results**

In response to Research Q1: Is there a relationship between practicing RNs composite (pharmacology and math calculations) knowledge, as measured by the MCS test, and the occurrence of a medication error, as determined from a RNs self-report?, findings in this study indicate that an RNs composite knowledge as measured by the MCS test has a marginal impact on the prediction of medication errors.  RNs with passing MCS test scores had a slightly higher incidence of medication errors than those with failing test scores. When the data was analyzed, it was found that more knowledge is related to more error. The fact that RNs with high MCS test scores had a slightly higher incidence of medication errors than those with low-test scores appears counterintuitive. This led to a further analysis of the data, specifically dealing with experts and expertise, which supports the notion of increased knowledge related to increased error.

Increased knowledge leading to increased error may in fact be related to the 3 deadly practices of the expert:

- myopia (I do everything right),

- hubris (I am so much smarter than others) and

- egocentricity (I know better, I am the expert) (Mittlestaedt, 2005).

 Experts' range of thinking often becomes narrower as the expert becomes overconfident in their ability.  The expert has developed what Covey refers to as "functional blindness" to his/her own deficits (2004). Unfortunately an expert over

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thinking becomes more automatic overtime and contributes to skipping through information and making quick decisions (Kerfoot, 2005). This often times leads to errors.

The non-significant results related to Research Q2, "Is it possible to predict the occurrence of a medication error (as determined from an RNs self-report) if the RNs pharmacology knowledge is known (as measured by the MCS test)?" was surprising. The reason why this result was surprising is that the literature suggests that there is a close relationship between predictability of errors and the degree of expertise. The expert registered nurse according to Benner, with an enormous background of experience, has an intuitive grasp of each situation and zeros in on the accurate region of the problem (Benner ,2001). According to Reason this establishes a close relationship between the predictability of error and the degree of expertise; the more skilled an individual is in carrying out a particular task, the more likely his or her errors will take ' strong but wrong' forms at the rule based level of performance (Reason, 1990).  Coming back to the practical aspect of the problem – medication administration is based on rules of administration. As I become more expert, I forget the simple rules. It takes me longer to get back to that. Behaviors of experts can be a mixed blessing.

The study findings related to Research Q3, "In addition to practicing RNs composite (pharmacology and calculation) knowledge do their demographic characteristics influence the occurrence of medication errors?" had a statistically significant impact on medication error rates underscores the importance of the relationship between nursing characteristics, in this case an RNs knowledge and patient outcomes (medication error rates). The regression model provided information on which categories of a particular demographic variable tended to increase the error rate and

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which tended to decrease the rate.  The regression model output also gave some idea of the relative magnitudes of these impacts. A further discussion of the individual demographic characteristics that significantly impacted medication error rates will be presented by characteristic.

**Specialty.** According to the American Nurses Association, 2010 scope of practice and standards of practice for specialty nursing on recognition of a nursing specialty, the profession of nursing is continually evolving in conjunction with healthcare consumer needs and desires, expanding healthcare and nursing knowledge, and the evolution of healthcare delivery sites, systems, and technologies. As nurses focus their practice in new and different areas of health care, clear statements of the scope of specialty nursing practice and standards of specialty practice and professional performance help assure continued understanding and recognition of nursing's diverse professional contributions (ANA 2010). According to the Bureau of Labor Statistics, 2014, registered nurses are the largest healthcare occupation that practices in hospitals, nursing and residential facilities, medical offices home care and other specialties.  For the purpose of this study, specialty was defined as pediatrics, medical/surgical (M/S), emergency room/ department (ED), obstetrics, critical care and other. In Table 19, these are presented in order from biggest impact to least impact on error rate.  For the increased error rates by specialty, pediatric was followed by M/S and ER. For decreased rates the biggest decrease in error rates was in obstetrics followed by other and finally critical care.

Table 19

*Impact of Specialty on Medication Error Rates*

| Increased Error Rate | Decreased Error Rate |
| --- | --- |
| Pediatrics | Obstetrics |
| Med/Surg | Other |
| ER | Critical Care |

*Note.* Caution should be used in interpreting these results. There are only 6 pediatric nurses and 8 ER nurses hence the results for these two categories should be interpreted with caution.

**Education.** When broken out by type of nursing degree, one sees that RNs with an Associate degree have the highest medication error rates. These findings are supported in the literature. For instance, Aiken and associates found in hospitals with higher proportions of nurses educated at the baccalaureate level or higher, surgical patients experienced lower mortality and failure-to-rescue rates" (2003). On the other hand, nurses with a doctorate degree tend to have lower error rates.

Table 20

*Impact of Education on Medication Error Rates*

| Increased Error Rate | Decreased Error Rate |
| --- | --- |
| Associates Degree | Diploma |
| Baccalaureate Degree | Doctorate |

*Note.* Despite the statistical significance of the education variable, the results for the doctorate degree and diploma are questionable as there are only 2 RNs in this study with a doctoral degree and only 4 with a diploma.

**Certification.** Specialty nursing certification is the standard by which the public recognizes quality-nursing care (ABNS. 2009). Certification, as defined by the American Board of Nursing Specialties (ABNS), is the formal recognition of the specialized knowledge, skills, and experience demonstrated by the achievement of standards identified by a nursing specialty to promote optimal health outcomes (ABNS, 2009). Further, according to ABNS, certification refers to an earned credential that

demonstrates the individual's specialized knowledge, skills, and experience. After meeting defined eligibility criteria, a certification candidate achieves a nationally recognized credential through successful completion of a rigorous examination. According to the findings from this study, certified RNs have a lower medication error incidence rate than non-certified RNs. Sixty-eight (32%) of participants held certifications.

Specialty certification is one method of validating clinicians' knowledge in a specific area of practice. According to Kendall-Gallagher, 2009, understanding the role that a clinician's knowledge and skill play in the prevention of adverse events is essential for developing effective strategies for reducing the risk of harm to patients. Certification is the formal recognition by nursing specialty organizations of an RNs advanced knowledge and experience in nursing. An RN license signifies a nurse has entry-level knowledge to care for patients, and is the minimum requirement for professional nurses. The American Board of Nursing Specialties (ABNS) defines certification as "the formal recognition of the specialized knowledge, skills, and experience demonstrated by the achievement of standards identified by a nursing specialty to promote optimal health outcomes" (Niebuhr & Biel, 2007, p.176).

According to Benner, experience is a requisite for expertise (Benner, 2001). It is not surprising that the demographic characteristic of certification when added to the composite test score has a statistically significant impact on the medication error rate: Certified RNs have a lower medication error incidence rate than non-certified RNs (p = .010). These results then are not surprising and are supported in the literature. For example, in Grandell-Niemi, etal, 2005, 2006; Ndosi and Newell, 2008; Phua and Tan

2011 their results identified a positive relationship between experience and pharmacology knowledge and demonstrated that pharmacology knowledge increased with experience.

An RN license signifies a nurse has entry-level knowledge to care for patients, and is the minimum requirement for professional nurses. An RN license doesn't indicate whether a nurse has obtained knowledge beyond the minimum requirements, but certification does.   Certification is a commitment on the part of the RN to professional development and lifelong learning. Knowledge gained from this ongoing professional development may foster safe patient care practices. The process of certification, and its requirements, may serve to fill a void in the knowledge base of all nurses (Stobinsk, 2015). The IOM report, The Future of Nursing: Leading Change, Advancing Health states that

> "Nurses who receive certification, including those serving in all advanced practice roles, provide added assurance to the public that they have acquired the specialized professional development, training, and competencies required to provide safe, quality care for specific patient populations. Certification is time-limited, and maintenance of certification requires ongoing acquisition of both knowledge and experience in practice"(2010, p197).

Certification and the recertification process serve as a means not only for the acquisition of knowledge but also require some level of practice for nurses to retain the credential. Presently, certification is a voluntary process and requires continual updating of this specialized knowledge to maintain this recognition. Several professional nursing organizations support the certification of practicing RNs.

**Specialty.** When added to the composite test scores specialty had a statistically significant effect on medication error rate (p=.027). RNs that reported working in the specialty of medical surgical, which was the largest of all the specialties in this study, had a higher than average medication error incidence rate. This is possibly due to a small percentage of certified RNs in this specialty in this sample. A certified nurse distinguishes themselves through a lifelong commitment to learning and career (AACN, 2015). When asked to identify which organization they were certified with only 3 of the 74 certified nurses were certified in Medical/Surgical.

**Education.** The education demographic characteristic of practicing RN participants, when added to the composite test score had a statistically significant impact on the medication error rate: education (p = .023). The literature supports the notion that increased education leads to better patient outcomes. In a landmark study from 2003, Aiken and associates sought to examine whether the proportion of hospital RNs educated at the baccalaureate level or higher is associated with risk-adjusted mortality and failure to rescue (deaths in surgical patients with serious complications) and found that hospitals with a larger percentage of nurses who had baccalaureate degrees and certification had lower 30-day mortality rates for patients (Aiken, Clarke, Cheung. Sloane, Silber, 2003). Krueger, Funk and Kruznar in a comprehensive review of the literature, 2013, sought to describe recent empirical literature regarding nurse-related variables that impact patient outcomes. The authors found that very few recent studies explored education as a variable impacting patient outcomes. However, it was reported that an increase in nurses with BSN or higher degrees significantly decreased the odds of patient deaths. (Krueger, Funk and Kruznar, 2014).

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**Shift time.** Shift time when added to the composite test score also had a statistically significant impact on the medication error rate (P = .005). Registered nurses working nights reported the most experience with error.  The literature supports the notion that fatigue and sleep deprivation that occur when a person works nights are linked to decreases in vigilance, memory, information processing, reaction time and decision making and may diminish a nurses' ability to recognize subtle patient changes (Anderson & Townsend, 2010). In a 2012 study that explored hospital staff nurses and the relationship between hours worked and the frequency of errors, the researchers found that there were 199 errors and 213 near errors reported during the data-gathering period (Rogers, Hwang, Scott, Aiken & Dinges, 2012). The researchers found that work duration, overtime, and number of hours worked per week had significant effects on errors. The likelihood of making an error increases with longer work hours (Rogers, et al, 2012).

**Discussion: Theoretical Framework**

In error avoidance, expertise may be a mixed blessing (Reason, 1990). James Reason supports this notion of increased knowledge leading to increased error in his Human Error theory (Reason, 1990).  Reason divides types of errors into failures of expertise (the plan is applied inappropriately) or lack of expertise (when the plan of action requires knowledge outside that which the individual currently possesses). According to Reason, (1990), knowledge based errors (those made by the expert) are errors made when the expert needs to resort to the less familiar, more rule based problem solving routines (Reason,1990). The expert is less familiar with these rule

based problem solving routines and hence will be more prone to error than their less expert counterparts.

The development of competence in this study was explained using Patricia Benner's Novice to Expert model (2001). According to Patricia Benner in her Novice to Expert model, (2001), with experience and mastery, skills are transformed (Benner, 2001). Experts perform at a more abstract level. The confidence that experts have in their ability actually may lead them to rely on inadvisable problem solving behavior. Experts tend to be overconfident in evaluating the correctness of their knowledge, and they will tend to justify their chosen course of action by focusing on evidence that favors it and by disregarding contradictory signs.

In contrast, when alternative perspectives are not available to the less experienced clinician, the only way out of a wrong grasp is by using logical rule-based problem solving tools (Benner, 2001, p.34) These tools are necessary also for those times when an expert gets a wrong grasp of the situation and then finds that events and behaviors are not occurring as expected. In situations that require the use of these rule-based tools, the expert when forced to regress back to these simpler rules may actually find their performance deteriorates. In other words what this means is that although as the individual, in this case the practicing RN, becomes more expert, their thinking becomes more abstract and their ability to recognize an error increases their ability to apply rule based behaviors when required in a novel situation actually deteriorates and errors can and do occur.

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**Practical Implications of the Study**

The extent and depth of pharmacology knowledge amongst registered nurses has been lacking as the findings in this study support. Learning is lifelong-results support the importance of ongoing education to maintain expertise thus impacting safe patient outcomes. Much of the criticism has been on RNs lack of pharmacology knowledge and the application of knowledge in the clinical setting.

The results of this study provided information regarding causes of medication errors. The #1 cause of medication errors in this study, (43%) was distractions during medication administration. This is supported in numerous studies in the literature. It has been established that medication administration is part of a highly complex medication process and errors can and do occur anywhere along the continuum. According to the results of an observation study reported in the Archives of Internal Medicine, 2013, registered nurses who are interrupted while administering medications may have an increased risk of making medication errors. In order to decrease medication errors, consideration should be given to this finding and identification of interventions that alleviate these distractions should be considered and implemented (2013).

**Limitations of the Study**

**Design.** As with any study there are several limitations for the present study. First this study used a cross-sectional design to investigate the relationship of RNs knowledge to medication error occurrence at only one point in time. A longitudinal study design, which involves taking multiple measures over a defined length of time, could possibly give more information about changes that occur in RNs in terms of exposure to formal and informal education over time that would influence their knowledge level and

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may impact medication error occurrence. The study design is descriptive and correlational and as such no cause and effect can be determined as there was no control or randomization.

**The survey itself.**  The survey, the Medication Calculations Skills test (MCS) is a two part questionnaire that surveys practicing RNs perceived knowledge of pharmacology and dosage calculations. In addition the MCS tests the actual knowledge of pharmacology and dosage calculations. A third part of the MCS included questions that had to do with an RNs' demographic characteristics and included a part B that allowed the participant to describe a medication error.  The first question in part B was "Have you or a nurse you know been involved in a medication error?" This is a double-barreled question concerning the occurrence of a medication error. This question is somewhat ambiguous as it is difficult to determine if the RN witnessed an error or committed the error?  This study relied on self-reports of medication error experience, which may result in underreporting as there is still an emotional component attached, even anonymously, to admitting to making an error.

**Sample.** This study was based on a convenience sample of healthcare organizations in the NY/NJ metropolitan area therefore these results may not reflect the population of RNs across the nation. To make findings generalizable, it would be essential to randomize the sample selection and include different locations and more varied areas of RN practice because this may influence the knowledge levels and reporting of known errors.

**Data collection process.** There was no monitoring during electronic survey completion. There was no way of knowing if participants sought/used help. Although the survey was anonymous some may have felt uncomfortable reporting an error.

**Future Research**

Clearly a link exists between error and the development of expertise or knowledge in the RN. The findings of this study lends support to James Reason's theory of Human Error and Patricia Benner's Novice to Expert model. Although the goal of the present study was not to test theories, the findings of a significant relation between knowledge and error are consistent with the conceptual framework framing this study. This study has implications for future research including a replication of this study with a larger sample from a more diverse population. Findings from this study led to the identification of areas for future research. These include:

**Replication of the study.** Future research should include a replication of this study with a revision to the double-barreled question in the survey. In addition, this study could be replicated using different samples, adding more healthcare facilities from a broader geographic area. For example, the majority of participants in this study practiced in a hospital setting. With the advent of the Affordable Care Act (ACA) and the move toward health promotion, the nursing profession is poised to practice in different and unique settings outside the traditional hospital setting. Community based practice may provide additional important information**.**

**Further exploration of undergraduate pharmacology education and medication competence.** Responsible practice requires that each error lead to experiential learning so that future practice improves (Benner, 2002). Nurse educators

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have a responsibility to develop a curriculum that reflects both theory and practice to enable student nurses to become competent in medication administration.  E-learning programs for improving nurses' mathematical skills should be explored.

**Simulation as an intervention for learning.** In a safe situation such as that in a simulation lab setting, students learning may be enhanced by linking theory to practice in the clinical setting.  In the simulated lab setting, students have the opportunity to administer medications and build on the required competence in a safe and effective way (Emmanuel & Miller, 2009). Simulation provides a safe means for nursing students to practice medicine administration with new technology.  It may also serve as a means for practicing RNs to reinforce skills sets so no "use it or lose it" occurs thus building on required competencies in the environment of the electronic health record (EHR).

**Exploration of medication competence and certification.** Top down driven patient safety programs miss out on the intellect of those at the frontline (Kerfoot, 2005, p105).  Results from this study support the need for future research that would explore further the impact validated and current expertise as evidence by certification has on patient safety outcomes.

A further area of research would include exploring the use of visual prompts (reminders and checklists) during medication administration. The registered nurses' working environment is an important determinant of medication errors.  This study provides support for additional research that would highlight interventions directed at decreasing interruption during medication administration which was identified as the #1 cause of medication errors for this sample.  An interventional study that explores the use of printed protocols and reminders (signage) alerting others to "Do Not Disturb" the nurse

during medication administration may provide essential information that may support the reduction of error in practice.

## CONCLUSIONS

This study sought to explore the relationship between a RNs knowledge, specifically pharmacology knowledge, and medication error occurrence.  Most research studies that have investigated medication errors have focused on causes, antecedents and systems factors.  Findings from such studies do not adequately explain the role the practicing RN plays in patient outcomes.  Thus this study contributes to the limited research regarding understanding possible RN knowledge determinants of positive patient outcomes.  The literature reinforces the fact that medication errors are a tremendous problem.  Most medication errors are attributed to the administration of medications that falls into the purview of the registered nurses' role.

As previously established, a valid and reliable tool exists, that has been used in research to assess knowledge and the incidence of medication error, called the Medication Calculation Skills test (MCS-t).  When I assessed the relationship between practicing RNs' pharmacology knowledge and medication error occurrence, I expected to find an inverse relationship between knowledge and the incidence of error.  There is a relationship that exists between knowledge and error such that more knowledge is related to more error.  However, caution is warranted because the MCS-t, as interesting, valid and reliable a tool as it is, in the population of RNs in question, did not actually measure the "incidence of medication error" but instead measured "recognition of medication error either by yourself or another."

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**Importance of this Study**

Ultimately, anything that contributes to the improvement of patient outcomes is important. The literature identifies the multi-disciplinary nature of the problem and highlights the important contribution that nurses make with regards to ensuring medication safety. Patient safety and prevention of all patient related errors relies on competence in practice. Medication competence in nursing can be a challenging skill to develop (and maintain).

For the nurse, who is at the sharp end of a medication error, the basis of medication competence lies in the knowledge that begins with their basic education and training (Benner, 2004) and is a lifelong pursuit. Limited evidence exists in the literature regarding the knowledge of practicing RNs and the occurrence of medication errors. In order to decrease medication errors we must recognize the complex nature of this issue and realize that solutions will be as complex as the issue they address.

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Appendix A

Medication Calculation Skills Test  (MCS) Section 1 sample page) with PI created

Demographics Section 3(sample page)

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**The Medication Calculation Skills Test (MCS)**
**Section 1   BACKGROUND VARIABLES RELATED TO WORK**
**Please circle the most appropriate alternative below or write your answer in the space provided. It is important that you answer every question.**

| | very frequent | frequent | Neither frequent nor infrequent | infrequent | Very infrequent |
|---|---|---|---|---|---|
| 1. I deliver medicine on a patient tray. | 5 | 4 | 3 | 2 | 1 |
| 2. I deliver ready-made doses. | 5 | 4 | 3 | 2 | 1 |
| 3. I calculate dosages on the ward. | 5 | 4 | 3 | 2 | 1 |
| 4. My calculating skills are regularly tested on the ward. | 5 | 4 | 3 | 2 | 1 |
| 5. I check my own computations by another mathematical method (reasoning, equation). | 5 | 4 | 3 | 2 | 1 |
| 6. I let someone else check my computations. | 5 | 4 | 3 | 2 | 1 |
| 7. I maintain my calculations skills by practicing. | 5 | 4 | 3 | 2 | 1 |

In the following questions please answer in which ways and how often you have studied medication calculation. Please circle the appropriate alternative.

| | very frequent | frequent | Neither frequent nor infrequent | infrequent | Very infrequent |
|---|---|---|---|---|---|
| I have studied medication calculation after graduation by : | 5 | 4 | 3 | 2 | 1 |
| 8. attending lectures. | 5 | 4 | 3 | 2 | 1 |
| 9. self-study with text books. | 5 | 4 | 3 | 2 | 1 |
| 10. self-study by computer. | 5 | 4 | 3 | 2 | 1 |
| 11. together with someone else. | 5 | 4 | 3 | 2 | 1 |

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**SECTION 3 Socio-Demographic Data**

Introduction
The medication process is defined as a cycle where medications are for the most part
prescribed by physicians, dispensed by pharmacists and administered by nurses. It is a
complex process with many stages and an error can occur at any point often with disastrous
results.  In the case of a medication error, it is the nurse who is most often blamed because it is
the nurse who most often administers medications.
This demographic questionnaire has been designed to gain insight about registered nurses who
dispense medications to patients.

Instructions
Please choose only <u>one</u> response for each question unless otherwise indicated. It is important
that you answer every question.

Part A
<u>Demographics:</u>
    1. Gender
  o  Male
  o  Female

    2. Age
  o  <25
  o  25-30
  o  31-40
  o  41-50
  o  51-60
  o  61-70
  o  > 71

<u>Education</u>
    1.  Highest Level of Education in Nursing
  o  Diploma in Nursing
  o  Associates Degree
  o  Bachelors Degree
  o  Masters Degree
  o  Doctorate (eg. PhD, EdD, DNP, DNS)

    2.  Highest Degree Earned (outside of Nursing)
  o  Only earned in Nursing
  o  Associates Degree
  o  Bachelors Degree
  o  Masters Degree (eg. MA, MS, MEng, Med, MSW, MBA, MS-OT)
  o  Doctorate (eg, PhD, EdD, DPT, DOT)

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3. Have you earned any Nursing Certifications?
- o  Yes
- o  No


Which organization(s) are you certified with?(eg. CCRN, CNOR, etc) Please list all.

_____

Employment Status
1. Are you practicing currently as a Registered Nurse?
- o  Yes
- o  No


a.  If yes, are you practicing full time or part time?
- o  Full time
- o  Part time(< 30 hours/week)

b. If yes, how many years are you working as a Registered Nurse?(full or part time)
- o  < 1 Year
- o  1 year- 4 years
- o  5 years to 10 years
- o  > 10 years

3. What Healthcare Setting do you work in? (select all that apply)
- o  Hospital
- o  Medical Office
- o  Ambulatory Care Center
- o  Community Health/Home Care
- o  Long-term care
- o  Managed care
- o  School Nurse
- o  Other(identify)_____


4. Which specialty area(s) do you practice regularly in as a registered nurse?
- o  Medical- Surgical
- o  Pediatrics
- o  Obstetrics
- o  Psychiatric
- o  Critical Care
- o  Emergency Room
- o  Other (identify)_____

5. What shift do you commonly work?
- o  8 hour

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o   12 hour


6. Which time of the day do you commonly work?
o   Day
o   Evening
o   Nights
Please proceed to Part B of the demographic survey.


Part B
The following anonymous and voluntary self-report involves your account of a known medication error that you or another nurse was involved in and that you are personally familiar with. Please do not answer this survey if you do not have personal knowledge or experience of any sort with medication errors and please do not make up a fictitious experience just to complete the survey. Honesty is key and important to the integrity of the results obtained.


1. Have you or another nurse you know been involved in a medication error?
o   Yes
o   No
If the answer to the above question is yes please respond to the following questions.
Nature
The error involved
o   The wrong patient
o   The wrong drug
o   The wrong route
o   The wrong amount
o   The wrong time


Cause
o   Distractions and interruptions
o   Patient off the unit
o   Unfamiliar with the drug
o   Unfamiliar with the route of administration
o   Lack of staffing
o   Unfamiliar with the unit/patients (floated)
o   High acuity of patients on unit
o   Working overtime


Consequences faced as a result of the error:
RN
o   No consequences
o   Nurse disciplined
o   Nurse suspended
o   Nurse fired
Patient
o   No consequences
o   Mild, patient monitored on the unit, little or no treatment needed
o   Patient was transferred to ICU; no permanent effects
o   Patient transferred to ICU; permanent effects
o   Patient Expired

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Reporting conditions of known medication errors
- o Just culture- reporting encouraged
- o Punitive culture-errors punishable

Other (please include any additional pertinent information regarding this incident)

_____

_____

_____

_____

_____

_____

_____

_____

**THANK YOU FOR TAKING PART IN THIS STUDY AND SUPPORTING MY RESEARCH ENDEAVOR.**

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Appendix A-1

Consent to Use Medication Calculation Skills Test (MCS)

Heidi Grandell-Niemi                                    Agreement form
RN, PhD, Analyst
Hiidenkatu 4
20360 TURKU
Finland
heidi.grandell-niemi@sydan.fi                           08/11/2014

AGREEMENT FOR USING MEDICATION CALCULATION SKILLS TEST (MCS-Test)

I agree to abide the following principles in using the MCS-Test as a research tool in my study:

- The MCS-Test should only be used in its original form. If any changes are done they should be discussed with Heidi Grandell-Niemi.
- Any research reports that have used the MCS-test should acknowledge the original source by using the following reference (Grandell-Niemi, H. 2005. The medication calculations skills of nursing students and nurses. Developing a medication calculation skills test. Annales Universitatis Turkuensis D 682. Painosalama Oy, Turku).
- The copy of the research report or publication in which the MCS-Test is used as a research instrument should be sent to Heidi Grandell-Niemi

Name of the re-user:                    Coleen Kumar, PhD student and Principal Investigator

                                        *Coleen Kumar*
                                        Signature


Research organisation:                  C/O Dr. Deborah A. DeLuca, MS, JD
                                        Dissertation Chair and Research Advisor

Address:                                Seton Hall University
                                        School of Health and Medical Sciences
                                        400 South Orange Avenue
                                        South Orange, New Jersey 07079

Name of the research:                   Exploring relationships between Practicing Registered
                                        Nurses (RNs) Pharmacology Knowledge and Medication
                                        Error Occurrence.


I give the permission:                  _____
                                        Heidi Grandell-Niemi

Date:                                   Turku  18.8.2014


Please, complete the agreement form, sign it and send (email, pdf) it to Heidi Grandell-Niemi. A signed copy of the agreement form will be returned to you by email.

Appendix B

IRB Approvals from Seton Hall University: original study request and amendment

**SETON HALL ⛪ UNIVERSITY**

1 8 5 6

September 24, 2014

Coleen Kumar
26 Highpoint Road
Staten Island, NY 10304

Dear Ms. Kumar,

The Seton Hall University Institutional Review Board has reviewed your research proposal entitled "Exploring Relationships between Practicing Registered Nurses' (RNs) Pharmacology Knowledge and Medication Error Occurrence" and has categorized it as exempt.

Two research locations have been approved:
     (1) Lutheran Medical Center
     (2) Horizon Health Center, Inc.

The two other research locations can be added via amendment once approval to do research has been granted by Richmond University Hospital and SUNY Downstate College of Nursing.

Enclosed for your records is the signed Request for Approval form.

Please note that, <u>where applicable</u>, subjects must sign and must be given a copy of the Seton Hall University current stamped Letter of Solicitation or Consent Form before the subjects' participation. All data, as well as the investigator's copies of the signed Consent Forms, must be retained by the principal investigator for a period of at least three years following the termination of the project.

Should you wish to make changes to the IRB approved procedures, the following materials must be submitted for IRB review and be approved by the IRB prior to being instituted:

- Description of proposed revisions;
- *If applicable*, any new or revised materials, such as recruitment fliers, letters to subjects, or consent documents; and
- *If applicable*, updated letters of approval from cooperating institutions and IRBs.

At the present time, there is no need for further action on your part with the IRB.

*In harmony with federal regulations, none of the investigators or research staff involved in the study took part in the final decision.*

**Office of Institutional Review Board**
Presidents Hall · 400 South Orange Avenue · South Orange, New Jersey 07079 · Tel: 973.313.6314 · Fax: 973.275.2361 · *www.shu.edu*

A   HOME   FOR   THE   MIND,   THE   HEART   AND   THE   SPIRIT

Sincerely,

*Mary F. Ruzicka, Ph.D.*

Mary F. Ruzicka, Ph.D.
Professor
Director, Institutional Review Board

cc:     Dr. Deborah DeLuca

Appendix C

Lutheran Medical Center Permission Letter

**LUTHERAN MEDICAL CENTER**
**Institutional Review Board**

## EXPEDITED REVIEWER FORM

PROTOCOL TITLE:  Exploring Relationships Between Practicing Registered Nurses (RNs) Pharmacology Knowledge and Medication Error Occurrence

PROTOCOL NUMBER:  577

AUTHORS:  Coleen Kumar, (PhD Candidate), Theresa DeRosa

REVIEW REQUESTED BY: Claudia Lyon, DO

DATE SUBMITTED:  August 29, 2014

COMMITTEE MEMBER REVIEW / DISPOSITION

IRB MEMBER:    Dr. Claudia Lyon

COMMENTS:    _____

_____

_____

**CATEGORY OF EXEMPTION:**

__ Drug or device meeting conditions       __ Data collected for nonresearch purposes
__ Approved collection of blood samples   __ Voice, video, digital, or image recordings
__ Noninvasive biological specimens        ✓ Survey or behavior research
__ Routine noninvasive clinical procedures  __ Retrospective chart review

**DISPOSITION:**        ____Approved____ Not Approved and Referred to Full IRB

____Pending modification / further information

(See above "Comments")

✓ This project does not require IRB approval or continuing review.

If approved, please check time period for continuing review:

☐ 1 year      ☐ 7 months      ☐ 3 months      ☐ Other: _____

Signature: _C. Lyon_____

Date: _9_/ _30_ / _14_

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**LUTHERAN MEDICAL CENTER HEALTH SYSTEM**
**INSTITUTIONAL REVIEW BOARD (IRB)**
**APPROVAL DISPOSITION FORM**

**Principal Investigator:** Coleen Kumar, (PhD Candidate)
**Other Pertinent Investigators:** Theresa DeRosa

The Institutional Review Board (IRB) made a decision on your research protocol entitled:

"Exploring Relationships Between Practicing Registered Nurses (RNs) Pharmacology Knowledge and Medication Error Occurrence"

☐ At the IRB meeting on _____ ☐ Through expedited review

☐ **After reviewing subsequent revision** ☐ **Continuing review**

    **Protocol #:** 577     **Time period for continuing review:** Not yet determined

**Next review date:**

**Disposition:** ____ Approved ____ Not Approved ____ Reapproved

    ____ Request modification / additional information

    _✓_ IRB approval not required

    _✓_ HIPAA waiver of informed consent was granted or is not needed.

**Comments:**

---

**IRB requirements for all approved protocols:**

In carrying out this study, the investigators agree to the following:

1. To accept responsibility for the scientific and ethical conduct of this research study;
2. To obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form, except when needed to eliminate hazard to the patient;
3. To use consent forms date-stamped by the IRB only during the period in which it is valid to enroll subjects;
4. To promptly report in writing to the IRB any severe/adverse medical events pertaining to this project, any unanticipated problems regarding risks to subjects or others, and any changes in the protocol or consent form;
5. To keep copies of the informed consent of all LMC patients enrolled in the protocol in the patient's chart and the principal investigator's file.
6. To fully complete the continuing review form sent from the IRB and return it promptly to the IRB.

    _9/2/14_             _C. Ly_
    (Date)                 Claudia Lyon, DO, Chair, IRB

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Appendix D

Horizon Healthcare Permission Letter

**Site Approval Letter**

To Dr. Mary Ruzicka:

It is acceptable for the research that Coleen Kumar is planning for her dissertation study is conducted at Lutheran Medical Center under the supervision of the Research Principal Investigator. This research will be conducted for partial fulfillment of Coleen's dissertation requirements toward completion of her doctoral studies at Seton Hall University School of Health and Medical Sciences.

**Principal Investigator/Student:** Coleen Kumar, RN, MSN

**Education Affiliation:** Seton Hall University

School of Health and Medical Sciences

400 South Orange Avenue

South Orange, NJ 07079

**Dissertation Research Study Title:** Exploring relationships between Practicing Registered Nurses(RNs) Pharmacology Knowledge and Medication Error Occurrence.

**Research Site:** Research will be conducted at the following site, located at:

Horizon Health Center, Inc.
714 Bergen Avenue
Jersey City, NJ 07305

Effective Date: July, 2014-December 2015.

Signed: 

_____

Sylvester Foote, MHA, BSN, RN

Director of Clinical Operations at Horizon Health Center, Inc

Horizon Health Center
Institutional Review Board

## EXPEDITED REVIEWER FORM

PROTOCO TITLE:    Exploring Relationships between Practicing Registered
Nurses (RNs) Pharmacology Knowledge and Medication En-or Occurrence

PROTOCOL NUMBER: 577

AUTHORS: Coleen Kumar, (PhD Candidate), Sylvester Foote

REVIEW REQUESTED BY: Arlene Simon COO

DATE SUBMITTED: August 29, 2014

COMMITTEE MEMBER REVIEW / DISPOSITION

IRB MEMBER:

COMMENTS: _____

_____

_____

CATEGORY OF EXEMPTION:

__ Drug or device meeting conditions          __ Data collected for non-research purposes
_Approved collection of blood samples       __ Voice, video, digital, or image recordings
__ Noninvasive biological specimens          /survey or behavior research
__ Routine noninvasive clinical procedures   __ Retrospective chart review

DISPOSITION:       ____Approved____Not Approved and Referred to Full IRB

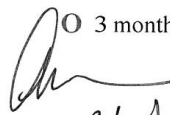____Pending modification / further information

(See above "Comments")

___This project does not require IRB approval or continuing review.

If approved, please check time period for continuing review:

O 1 year     O 7 months     O 3 months     O Other: _____

Signature: _____

Date: _____ 9/5/2014

**Horizon Health Center**
**INSTITUTIONAL REVIEW BOARD (IRB)**
**APPROVAL DISPOSITION FORM**

Principal Investigator: Coleen Kumar, (PhD Candidate)
Other Pertinent Investigators: Sylvester Foote

The Institutional Review Board (IRB) made a decision on your research protocol entitled:

"Exploring Relationships between Practicing Registered Nurses (RNs) Pharmacology Knowledge and Medication Error Occurrence"

    O At the IRB meeting on             O through expedited review

O After reviewing subsequent revision     O Continuing review

    Protocol #: 577     Time period for continuing review: Not yet determined

Next review date:

Disposition: ____Approved    ____Not Approved    ____Reapproved

    ____Request modification / additional information

    ⟋IRB approval not required

    ⟋HIPAA waiver of informed consent was granted or is not needed.

Comments:

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IRB requirements for all approved protocols:

In carrying out this study, the investigators agree to the following:
1. To accept responsibility for the scientific and ethical conduct of this research study;
2. To obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form, except when needed to eliminate hazard to the patient;
3. To use consent forms date-stamped by the IRB only during the period in which it is valid to enroll subjects;
4. To promptly report in writing to the IRB any severe/adverse medical events Pertaining to this project, any unanticipated problems regarding risks to subjects or others, and any changes in the protocol or consent form;
5. To keep copies of the informed consent of all LMC patients enrolled in the protocol in the patient's chart and the principal investigator's file.
6. To fully complete the continuing review forms sent from the IRB and return it promptly to the IRB.

9/5/2014
Date)

                          Arlene Simom, COO

8/29/14,s:\irb\forms\irb pre-irb first time review forms merge mastcr.doc

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Appendix E

Training Checklists

Appendix E-1.

Research Assistant Training Checklist

**Checklist of Actions**
**Research Assistant**

| Task | Completed | | Comment |
|---|---|---|---|
| | Yes | No | |
| 1. Meet with Principal Investigator(PI) to discuss role as Research Assistant. | | | |
| 2.Review asset[R] user Manual and tutorial with Principal Investigator on Seton Hall University Website. | | | |
| 3. Obtain computerized information from the Principal Investigator with information which includes all employed professional staff nurses and their E-mail addresses . | | | |
| 4. Meet with each Principal Investigator and review the Training Script. | | | |
| 5. Upload a Letter of Solicitation, the Medication Calculation Skills test and the Demographic Questionnaire into system seeking Bill Otskey. | | | |
| 6. Initiate the survey on electronic system. | | | |
| 7. PI will give you start date clearance and how long the system will stay active (information from Shayle Benay Adrian at Seton Hall University) | | | |
| 8. Email RNs from contact list provided by PI and send message asking RNs to participate in the study | | | |
| 9.Monitor Participation<br>        Reinforce to nursing staff that participation is voluntary and there is no way to link the completed surveys with the individuals.<br>        After 7 days send out reminder notice to employed registered staff nurses reminding them to participate/ or thanking them for participating and asking them for snowball participation. | | | |
| 10. After 14 days/ 2 weeks  send out reminder notice to employed registered staff nurses reminding them to participate/ or thanking them for participating and asking them for snowball participation. | | | |
| 11. After 21 days/3 weeks send out reminder notice to employed registered staff nurses reminding them to participate/ or thanking them for participating and asking them for snowball participation. | | | |
| 12.After 28 days/4 weeks send out reminder notice to employed registered staff nurses reminding them to participate/ or thanking them for participating and asking them for snowball participation. | | | |
| 13.After 35 days/5 weeks send out reminder notice to employed registered staff nurses reminding them to participate/ or thanking them for participating and asking them for snowball participation. | | | |
| 14.After 42 days/6 weeks send out reminder notice to employed registered staff nurses reminding them to participate/ or thanking them for participating and asking them for snowball participation. | | | |
| 15.a. Meet with the Principal Investigator to evaluate whether research time frame needs to be extended (based on number of participants) with additional reminder notice.<br>15. b. If time frame is extended , send out additional email reminder notice. | | | |
| 16. Review data with Principal Investigator to assure surveys are complete. Remove those that are incomplete from the research data. | | | |

Appendix E-2.

Principal Investigator Training Checklist

**Checklist of Actions**
**Principal Investigator**

| Task | Completed | | Comment |
|---|---|---|---|
| | Yes | No | |
| 1. Contact Bill Otskey to create an account for the ASSET system. | | | |
| 2. Meet with ResearchAssistant at each facility to discuss their role. | | | |
| 3.Review ASSET user Manual and tutorial with Research Assistant on Seton Hall University website. | | | |
| 4.Obtain approval from the IRB of Lutheran Medical Center, Downstate Medical Center, Richmond University Medical Center, and Horizon Health Center inc. | | | |
| 5. Obtain computerized information from Lutheran Medical Center, Downstate Medical Center, Richmond University Medical Center, Horizon Health Center inc. which includes all employed professional staff nurses and their E-mail addresses and give this information to the Research Assistant at each of these facilities. | | | |
| 6. Direct RA to upload a Letter of Solicitation, the Medication Calculation Skills test and the Demographic Questionnaire into system seeking Bill Otskey. | | | |
| 7. Meet with each Research Assistant and review the Training Script. | | | |
| 8. Purchase specific USB memory stick specifically for the research information. | | | |
| 9. Initiate the survey on electronic system. | | | |
| 10. Remind Research Assistant to initiate reminder notice to employed registered staff nurses after 7, 14, 21, 28,35,42 days. | | | |
| 12. Monitor Participation after week 1. | | | |
| 13.Remind Research Assistant to initiate reminder notice to employed registered staff nurses after 14 days. | | | |
| 14. Remind Research Assistant to initiate reminder notice to employed registered staff nurses after 21 days. | | | |
| 15. Remind Research Assistant to initiate reminder notice to employed registered staff nurses after 28 days. | | | |
| 16. Remind Research Assistant to initiate reminder notice to employed registered staff nurses after 35 days. | | | |
| 17. Remind Research Assistant to initiate reminder notice to employed registered staff nurses after 42 days. | | | |
| 18.Evaluate whether research tone frame needs to be extended (based on number of participants) with additional reminder notice. If time frame is extended , ask RA to send out additional email reminder notice. | | | |
| 19. Review data to assure surveys are complete. Remove those that are incomplete from the research data. | | | |
| 20.Analyze Data. | | | |
| 21. Review with Advisors. | | | |
| 22. Include results in dissertation proposal. | | | |

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Appendix E-3

Training Script

**Training Script**

You are asked to assist with a study entitled "Exploring relationships between Practicing Registered Nurses(RNs) Pharmacology Knowledge and Medication Error Occurrence". The purpose of this study is two-fold. First, practicing Registered Nurses (RNs) pharmacology knowledge is measured by the Medication Calculation Skills test (MCS).The second purpose is to determine if there is a predictive relationship between RNs pharmacology knowledge and medication administration errors.

You will be provided with a checklist explaining each task to be performed as a reminder of what to do(Appendix H). You will also be receiving a computer generated list from the Human Resources department listing all registered staff nurses employed at the medical center with their e-mail addresses. You will be asked to upload a Letter of Solicitation and the web link to the Academic Survey System and Evaluation Tool (asset$^R$) which includes the MCS test and a Demographic Questionnaire.

Participants will be instructed to read the Letter of Solicitation carefully then complete the surveys. Once complete, the surveys are returned via asset$^R$. Snowball sampling will also be employed. Encourage interested participants to ask other RNs to participate. Reinforce to nursing staff that participation is voluntary and there is no way to link the completed surveys with the individuals.

Please thank the individuals in advance for participating. You will also be asked to e-mail the registered staff nurses on six additional occasions to remind them of the survey and elicit their participation with a message that states the following:

"Dear Staff Nurse:

If you have not already participated in the survey titled: (Exploring relationships between Practicing Registered Nurses(RNs) Pharmacology Knowledge and Medication Error Occurrence) We once again invite you to do so. Attached, please find the Letter of Solicitation and the web link to the Academic Survey System and Evaluation Tool (asset$^R$) through Seton Hall University. As a reminder this survey is totally confidential. Questions regarding participation can be addressed through contacting the "Institution Research Support Person". *

Your invaluable participation in this survey is very much appreciated."

*The name and contact information for each Research Assistant also known as the "Institution specific"research support person will be included in the institution specific script and reviewed with each individual RA prior to the start of this study.*

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Appendix F.

Letter of Solicitation

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Dear Registered Nurse,

You are being invited to take part in a study that will explore the *relationship between Practicing Registered Nurses (RNs) Pharmacology Knowledge and Medication Error Occurrence.*

My name is Coleen Kumar, PhDc, RN and I am a doctoral student at Seton Hall University in the Department of Interprofessional Health Sciences & Health Administration. The purpose of this study is to look at practicing RNs knowledge of pharmacology and find out if there is a relationship to medication errors.

If you decide to participate you will be asked to complete 1 survey with the following section(s):

1. The Medication Calculations Skills Test (MCS) section 1 which asks you about your perceived pharmacology knowledge as a practicing RN's
2. The Medication Calculations Skills Test (MCS) section 2 which asks you about your perceived pharmacology knowledge as a practicing RN's
3. Demographic Questions, section 3: which asks you for information such as (but not limited to) your gender, age, years of education, income level and experience (if any) with a medication administration error.

The survey is completely online. You may complete the survey at your convenience, on your own time, and using a calculator. Completion of the survey does not require additional assistance from the researcher or research assistants. Completing the survey will give you the chance to express your thoughts regarding what you know about pharmacology and medication errors. Please respond honestly to all questions.

It is important that you complete each section of the survey in its entirety. The survey will take you approximately 20 – 30 minutes to complete. I am asking you to share the link to the survey with other RNs you may know that would also be interested in participating. Your assistance in sharing the link to this survey with your colleagues is greatly appreciated. Please feel free to ask other practicing RNs you may know, to participate in this survey.

The survey is available via Seton Hall University's asset[R] electronic survey. By accessing and completing the survey through the link listed below, you are conveying your informed consent to participate in this study. The survey link(url) is:

## http://asset.tltc.shu.edu/asset/asset.AssetSurvey?surveyid=6578

Copy and paste the URL into your browser and it will prompt you to input a user name. There is no password required. Your user name can be any name you choose (your own, your favorite movie star or fictional character). Your participation in this study is strictly anonymous and voluntary. There will be nothing that links you to the your completed survey.

You may decide at any time not to participate in this study without penalty. You will not be asked to provide your name if you agree to participate in this study. You will not be identified by name or description in any reports or publications about this study. Protection and confidentiality will be maintained throughout the duration of the research project. However, upon completion of the study, any paper data will be kept in a locked filing cabinet in the Principal Investigator's home for three years after which time all data

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will be destroyed.  Similarly, all electronic data will be stored on a USB memory key with access to the file protected by use of a password only known to the principal investigator.  The memory key will also remain in a secured filing cabinet for three years, upon which time the data will be destroyed.

There is no predictable risk factor or discomfort for participating in this research study. By participating in this study you will be contributing to the body of knowledge that will help clinicians, nursing educators and researchers, to determine if there is any relationship between the pharmacology knowledge of practicing RNs and known medication administration errors.

If you have any questions or concerns about this study please don't hesitate to contact me. You can contact me  via email at <u>coleenkumar@aol.com</u> or via phone at 917 697 0162. You have the right to ask questions concerning this study at any time.

Thank you for considering participating and contributing to my dissertation research. Your time and consideration is greatly appreciated.

Sincerely,

Coleen Kumar, PhDc,RN
Principle Investigator

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Appendix G.

Recruitment Flyer

# Pharmacology: An Important Part of a Practicing RNs Everyday!

## Practicing Registered Nurses(RNs) (ages 21-70)

### Volunteers needed for a Research Study Investigating the Pharmacology Knowledge of RNs in Practice .

**Purpose of the Study:** To determine practicing RNs pharmacology knowledge and to determine if there is a predictive relationship between the pharmacology knowledge of practicing RNS as measured by the Medication Calculations Skills test(MCS) and known medication administration errors as determined from an RNs self-report.

**Expected Duration of Participation:** Estimated length of time to complete the electronic survey is 20 minutes.

**Description of Procedures:** You will be asked to complete 1 questionnaire(s)  via ASSET electronic survey with the following section(s):
4.  Medication Calculations Skills Test  (MCS) section 1: the purpose of this section is to determine a practicing RN's perceived pharmacology knowledge.
5.  MCS section 2: the purpose of this section is to determine a practicing RN's actual pharmacology knowledge.
6.  Demographics section 3: the purpose of this section is to collect demographic information including but not limited to gender, age, years of education, income level and experience (if any) with a medication administration error.

It will take you approximately __**20**__ minutes to complete.

**Voluntary Nature of the Study:** Participation is completely voluntary and subjects can withdraw at any time with no penalty, prejudice or questions asked.

**Anonymity and Confidentiality:** All information will be kept strictly confidential and anonymous. You will not be asked to provide your name if you agree to participate in this study. You will not be identified by name or description in any reports or publications of this study.

***For More Details Please Contact:*** Coleen Kumar, PhD student in the Graduate Programs in Health Sciences, Seton Hall University, 973/275-2076, <u>coleen.kumar@student.shu.edu</u>