INVESTIGATION OF A CHECKLIST TO REDUCE MEDICATION ERRORS AMONG PRE-LICENSURE BACCALAUREATE NURSING STUDENTS

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The Sage Colleges

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INVESTIGATION OF A CHECKLIST TO REDUCE MEDICATION ERRORS AMONG PRE-LICENSURE BACCALAUREATE NURSING STUDENTS

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Revised October 2015

ABSTRACT

This experimental pilot study was aimed at the development of a quality standard to facilitate medication administration error detection, prevention, and reporting among pre-licensure baccalaureate nursing students. Based on both the literature review and peer review, sequential steps of the medication administration process were identified, bundled, and anchored in the mnemonic, C-MATCH-REASON, to form a new inquiry-based paper checklist that pairs clinical reasoning with rule adherence. The Checklist (independent variable), for nursing student utilization, was accompanied by an error tracking instrument (Observation Form) for nursing faculty (raters) to measure medication errors committed, recovered, and reported. Reason's (1990) error theory was applied to measure errors (dependent variable).

The hypotheses examining pre-licensure nursing students' processing of performance and system related errors included that the participants who utilized the C-MATCH-REASON checklist compared to those in a no-checklist control condition, individually and collectively would: (1) report more medication errors; (2) demonstrate greater rule adherence; (3) commit fewer skill-based errors; (4) commit fewer knowledge-based errors; (5) commit fewer confirmation bias errors; and (6) commit fewer errors in total.

A simulation environment with a 2x2 crossover design (two experimental groups and two practice periods) was utilized to conduct the study. The participants were randomly assigned to a crossover sequence AB or BA (A = checklist intervention and B = no-checklist control condition). Medication administration practice in both experimental conditions equalized the learning experience. Also, two peer-reviewed medication administration scenarios of equal difficulty were developed. Each scenario contained three embedded errors

and an answer key for consistency with error tallying among the raters. To assess the reliability and validity of the Observation Form, traditional and video-recorded instruction were utilized, and interrater agreement was established among the raters. A rubric, comprised of sub-scores that made up a Global Medication Administration Error Total Score for each scenario, was used by the researcher to total the data collected. Scenario One scores ranged from 0 to 78. Scenario Two scores ranged from 0 to 73. A Just Culture was applied to the simulation setting to facilitate error reporting (Frankel, Leonard, & Denham, 2006).

Final analysis included empirical data collected from 19 participants by two raters. SPSS ® V25.0 was utilized for all analyses related to the study. The Chi Square Test was conducted to analyze demographic differences among the experimental groups, which were determined to be balanced. Nonparametric tests were chosen because the sample was small (Kachigan, 1986). The Kruskal-Wallis test for independent samples and the Wilcoxin matched-pairs signed rank test were generated to analyze differences among continuous variables and assess learning across two periods. Debriefing was provided to elicit reflection.

The empirical findings, from Period One, support the use of the C-MATCH-REASON checklist for rule adherence ($p = 0.005$), knowledge-based error reduction ($p = 0.010$), confirmation bias error reduction ($p = 0.014$), and the reduction of Total Errors ($p = 0.010$). The null hypothesis was not rejected for embedded errors found ($p = 0.061$) nor Total Error Reporting ($p = 0.254$). Participant feedback from both periods identified that the C-MATCH-REASON checklist facilitated clinical reasoning, error awareness, and learning. All participants and raters endorsed the continued use of the instruments. Key words: Medication Errors, Checklists, Nursing Students.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Chapter I

INVESTIGATION OF A CHECKLIST TO REDUCE MEDICATION ERRORS AMONG PRE-LICENSURE BACCALAUREATE NURSING STUDENTS

Research identified not only that medication errors were widespread (Wittich, Burkle, & Lanier, 2014), but also that there were discrepancies in the reporting of medication errors (James, 2013). Furthermore, across educational settings, hospitals, and other clinical sites visited by nursing students, different protocols were utilized for medication management (Gregory, Guse, & Russell, 2007; Murphy, 2012). As a result, this study was aimed at the development of a quality standard to facilitate medication administration error detection, prevention, and reporting among pre-licensure nursing students. Medication administration errors were measured utilizing James Reason's error theory (1990). The literature review included: (1) the root causes of medication errors; (2) the application of cognitive load, clinical reasoning, and novice to expert theories to checklist development to facilitate accuracy with learning a complex skill; and (3) the utilization of simulation exercises by nursing educators to study errors. The collective scholarship was applied to the research problem of widespread medication errors and an original medication administration safety checklist that prompts higher order cognitive activity (clinical reasoning) was developed for nursing student utilization. This checklist was accompanied by an error tracking instrument for nursing faculty to track skill, rule, and knowledge-based medication errors.

Medication Management and Error Reporting

Accurate medication administration is paramount to patient safety and fundamental to quality healthcare. A key aspect of quality healthcare is accurate and timely reporting of medication administration-related errors (Curren, 2010; James, 2013; Kohn, Corrigan, & Donaldson, 2000). The National Coordinating Council for Medication Error Reporting and Prevention (1998) defined medication errors as the "inappropriate use of a drug that may or may not result in harm," and noted that medication errors can occur anywhere along the *medication management process* (The United States [U.S.] Department of Health and Human Services [HHS], 2014, p. 5). Depending on the reference, medication management may include selecting, procuring, storing, prescribing, transcribing, dispensing, administration, adherence, monitoring, reporting and educating (Center for Disease Control and Prevention [CDC], December 2015; Hughes & Blegen, 2008; HHS, 2014).

In hospitals, medication errors often occurred during the *medication-use process* [prescribing, transcribing, dispensing, administration, and monitoring] (Bates & Slight, 2014; Weant, Bailey & Baker, 2014). However, medication errors linked to management practices were preventable (Institute of Medicine [IOM], 2006). *Error recovery* is a preventive process comprised of the coordination of interdisciplinary actions for medical error detection, interruption, and correction (Henneman et al., 2010). Yet, Bates and Slight (2014) identified that medication errors involving harm to hospitalized patients were especially related to interferences during the prescribing (56%) and the administration (34%) of therapeutic drugs (p. 1027). Although prescribing errors were often interrupted (48%) by nurses and pharmacists,

administration-related patient harms were not interrupted (0%). Curren (2010), Hughes and Blegen (2008), and Wright (2013) explained that the administration stage was primarily accomplished *independently* by the nursing profession. Armitage and Knapman (2003) reported that as much as 40% of nurses' work involved medication administration, thus nursing was often identified with administration stage errors.

However, Hughes and Blegen (2008) also explained that other groups administer medications, for example, physicians, certified medication technicians, patients, and family members. The United States [U.S.] Food and Drug Administration [FDA] (2017) reported that medication errors may be related to improper use by the consumer because of product knowledge deficit. James (2013) and Curren (2010) suggested that medication standards include partnering with patients to cultivate safe medication habits, identifying root causes, and improving error awareness and error reporting. Cooper (2014) and James (2013) advised that all involved in medication management need to practice transparency in *error reporting* to prevent patient harm.

It was evident that a gap existed in the administration stage involving both error recovery and error reporting. Medication errors recovered before reaching the patient were categorized as *potential adverse drug events* (Agency for Healthcare Research and Quality [AHRQ], June 2017) or *close calls* (Institute for Safe Medication Practices [ISMP], 2009). James (2013) noted that errors that are not recovered go unreported. Curren (2010) and Wright (2013) stressed that failure to correct and report potential mistakes upon detection contributes to errors.

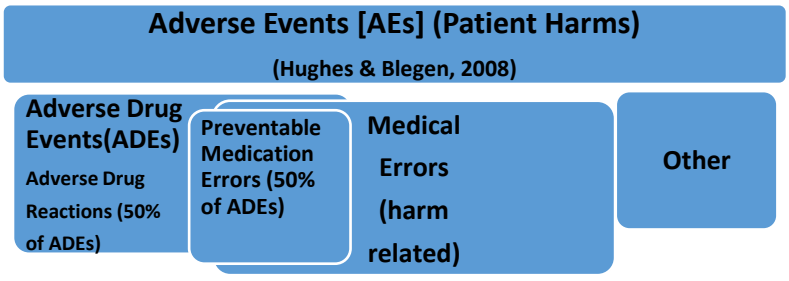
The ISMP (2017a) noted that error reporting is a complex system involving the tracking and analysis of adverse events. A *medical error* is "an act of omission or

commission in planning or execution that contributes or could contribute to an unintended result" (Grober & Bohnen, 2005, p. 42). *Adverse events* (AEs) are "any undesirable experience associated with the use of a medical product in a patient" (FDA, 2016). Yet, not all medication errors are adverse events (HHS, 2014), thereby reinforcing the existence of gaps in the reporting of errors that do not produce patient harm among nurses (Wright, 2013) and nursing students (Cooper, 2013).

Even so, Wittich et al. (2014) advised that research focused on medication errors that lead to harm. On the contrary, AHRQ (June 2017) stressed that improving safety with medication administration cannot be done without reducing preventable harm from all causes. Wilson et al. (1995) [as cited in Grober and Bohnen, 2005] explained that an adverse event is preventable "when… there is a failure to follow accepted practice… at an individual or system level" (p. 40). Hughes and Blegen (2008) noted that subsets of adverse events included adverse drug events (ADEs), medical errors and 'other.' Figure 1.0 provides a modified illustration of their representation of adverse events.

Figure 1.0

Adverse Events (AEs)

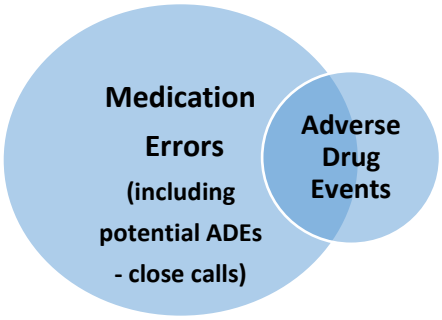


Note. Preventable medication errors are subsumed under three categories: adverse events, medical errors, and adverse drug events (ADEs). The subset *Other* involves

added situations [e.g. substandard care] (Hughes & Blegen, 2008). Also, 50%-100% of AEs are preventable (Classen et al., 2011; James, 2013), 30%-46% of AEs are ADEs (Classen et al., 2011; Levinson, 2016); and 50% of ADEs are also preventable medication errors, eliciting an overlap with medical errors (AHRQ, June 2017).

An *adverse drug event* (ADE) is **"**a deviation in the medication-use process… OR an undesirable clinical manifestation that is consequent to and caused by the administration or omission of medications" (ISMP, 2017b). Nonpreventable ADEs are *adverse drug reactions* (ADRs) that occur even though a drug was correctly prescribed and administered (AHRQ, June 2017). Preventable ADEs are medication errors that result in harm. Fifty percent of ADEs are preventable (AHRQ, June 2017); 16% of medication errors result in harm (Cousins, Gerrett, & Warner, 2012); potential ADEs (close calls) are medication errors (AHRQ, June 2017). Figure 2.0 provides a modified illustration of medication error occurrences and ADEs as reported by the above authors.

Figure 2.0 Medication Error Occurrences in Relation to Adverse Drug Events



James (2013) in a literature review reported that *preventable adverse events* (PAEs) were directly linked to 400,000+ hospital deaths in the U.S. annually, results that were double that of medical-record estimates. James (2013) calculated medical-record estimates using the weighted average of four studies. Subsequent error reporting discrepancies were based on: (1) evidence identifying errors of commission that were

not documented; (2) limitations of the *Global Trigger Tool* to capture pockets of omission errors associated with mortality; and (3) a "failure to make life-saving diagnoses" (James, 2013, p. 127). In addition, James (2013) identified polarized findings in medication error reporting ranging from no associated deaths to medication errors listed as the primary cause of deaths among PAEs.

Of relevance, Nichols, Copeland, Craib, Hopkins, and Bruce (2008) reported factors linked to medication errors in a hospital in Australia and found that 10 of the 26-medical staff interviewed were not aware that they caused an error; Lomas (2010) [as cited in Wright, 2013] suggested that errors that don't result in harm are rarely reported because nurses fear blame; and Cooper (2013) identified that errors perceived as having no potential patient harm were reported less by nursing students. Furthermore, AHRQ (June 2017) suggested that over 700,000 emergency department (ED) visits and 100,000 hospitalizations, annually, were attributed to ADEs, half of which may have been preventable medication errors. However, HHS (2014) estimated that 1,000,000 ED visits and 280,000 hospitalizations, annually, were credited to ADEs, results that were significantly higher than those of AHRQ.

The discrepancies in medication-related error reporting suggested that a landmark study, *To Err is Human: Building a Safer Health System,* remained relevant 20 years after its initial publication. Patient safety still warranted considerable improvement through the development of standards and educational strategies that improve error awareness, recovery, and reporting (Kohn et al., 2000). Figures 1.0 and 2.0 illustrate the complexity involved with accounting for medication errors, thereby reemphasizing the need for completeness when reporting errors (Classen et al., 2011;

Hughes & Blegen, 2008; James, 2013; Levinson, 2016). Of fiscal interest, medication errors cost $42 billion worldwide annually (World Health Organization [WHO] March 2017). Makary and Daniel (2016) suggested that medical error (inpatient and outpatient events combined) may be the third leading cause of death, following heart disease and cancer, if it were included on death certificates and officially ranked. It was surmised, medication errors need to be realized to reduce human and financial costs (Covell & Ritchie, 2009; Moore, Cohen, Furberg, & Mattison, 2015; James, 2013; Kohn et al).

Conceptual Framework

Leape et al. (1995) suggested in a seminal systems analysis study of adverse drug events among hospitalized patients, Reason's (1990) error theory was germane to medication error examination. Of importance, Dr. Lucian Leape was a member of the Institute of Medicine's Quality of Care in America committee that published the landmark patient safety report *To Err is Human: Building a Safer Health System* (Kohn et al., 2000) and *Crossing the Quality Chasm* (IOM, 2001). As a result, the conceptual framework that was used for this study to evaluate medication administration errors was James Reason's error theory.

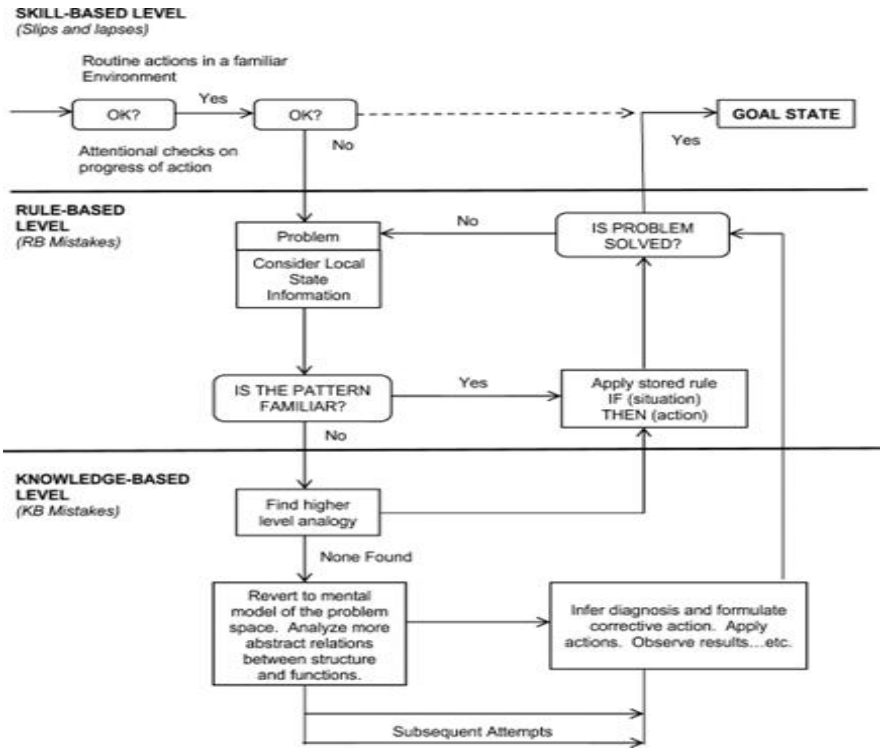
Human Performance Errors

Cognitive psychology [Rasmussen and Jensen, 1974; Rasmussen, 1983, 1986] (as cited in Reason, 1990) sorted human performance into three distinct types: skill, rule, and knowledge based. In addition, Reason (1990) explained that both Rasmussen and Jensen's (1974) performance model and Rasmussen's (1983) cognitive staging of error types (execution-slips; storage-lapses; planning-mistakes) were adapted to form

the Generic Error Modelling System (GEMS). GEMS integrates skilled-based slip and lapse errors, rule-based mistakes and knowledge-based mistakes (see Figure 3.0).

Figure 3.0

The Dynamics of the Generic Error-Modeling System (GEMS)



Note. Reprinted with permission from Reason, J. (1990). Human error (1st ed., p. 64). New York, NY: Cambridge University Press (see Appendix A).

Reason (1990) broadly defined errors as "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 change agency" (p. 9). More specifically, *skill-based errors* (e.g. slips and lapses) develop from the failure of an individual's saved habits (cognitive storage) and/or automatic (intuitive) behavior (cognitive execution) to achieve an intended objective (Reason, 1990, 1997, 2002).

Slips and lapses were often associated with fatigue or working in a busy environment.

Mistakes were more complex and harder to identify than slips, thus more dangerous (Reason, 1990). Mistakes were defined as "deficiencies or failures in the judgmental and/or inferential processes involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to plan" (Reason, 1990, p. 9). Mistakes were categorized as either knowledge-based or rule-based.

Reason (1990) identified that *knowledge-based mistakes* arose from the lack of understanding of a new situation and may require analysis, troubleshooting, diagnosis, and corrective action. External sources may be required to correct knowledge-based errors because high level cognitive processes (e.g. reasoning and judgment) were warranted (Mattox, 2012; Reason, 1990, 2013). *Rule-based mistakes* occurred when the wrong rule was utilized, or protocol was not followed. Specific to medication administration, *rule-based mistakes* were errors occurring within the medication-use process and included errors of commission (actual), omission (never administered) and close calls recovered before reaching the patient (Bates et al., 1995; IOM, 2004, 2007).

System-Related Errors

Reason (1990) identified not only that the coexistence of all three performance level errors were often noted in complex skill practice but also that faulty system designs contributed to failure. As a result, Reason's (1990, 1997, 2000, 2013) error theory widened in focus from error-prone people to error-prone systems. S*ystem-related errors* are categorized as active failures and latent conditions. *Active failures*

are “unsafe acts committed by people who are in direct contact with the patient or system” (Reason, 2000, p. 395). *Latent conditions* are problems within a system that may stem from protocol or management decisions that triggered conditions that led to errors (Reason, 2000, 2013). Most adverse events involved the interplay of active failures with latent conditions (Reason, 2000). The literature review in Chapter Two provides a more detailed explanation of errors.

Human information processing. Mechanisms that facilitated error detection were effective when immediate and valid feedback were given because feedback prompted error correction, reporting, and prevention (Reason, 1990). Therefore, in addition to Figure 3.0, Reason (1990) used a *feedback loop* to describe processing human errors (see Appendix B) and to explain how a system is error driven: “A basic feedback loop in which the output signal is compared to a reference input signal. The difference between the output and input signals (the error signal) constitutes input to the controller, which then acts to minimize the discrepancy” (Reason, 1990, p. 150). For example, if a nursing student compared the current date (reference signal) to a drug label with an expiration date that was before the current date (error signal) and detected the discrepancy (actuating signal), then error recovery (process) was enabled, leading to correction, prevention and reporting (output signal). If an expired medication went undetected (e.g. feedback is absent), then the error driven feedback loop continued.

Clinical reasoning and mental flexibility. Benner, Kyriakidis, and Stannard (2013) suggested that information processing with medication administration involved rule-based performance; a knowledge base of pharmacology; psychomotor ability; and *thinking-in-action,* a form of clinical reasoning. ‘Thinking-in-action’ is “the… *habits of*

thought and action that are directly tied to responding to patients and families and the demands of a changing situation and for noticing when clinical assumptions and expectations are not met" (Benner et al., 2013, p. 558). Furthermore, Benner and colleagues (2013) and Reason (2013) suggested that clinical reasoning involved having mental flexibility to solve knowledge-level problems when unexpected situations arose. However, Kahneman (2013) reflected that people were not as good at reasoning as they believed. More specifically, Tversky and Kahneman (1973) reported that "When events are coded into natural categories… these categories are learned with-out difficulty. It is the lack of an appropriate code that explains why people usually do not detect the biases in their own judgments" (p. 28).

In addition, Kahneman's (2003, 2013) *Two-Cognitive System View* suggested that intuition (system 1) interplayed with reasoning (system 2), and increased effort or mental processes in either system may alter completion of a procedure. Equally, Reason (1990) explained that the cognitive processes elicited for error recovery and reporting can be sorted into performance type and then ranked according to difficulty. For example, effective error corrections were highest in the skill-based slip level (e.g. attention returns, and the slip is recovered), followed by the rule-based level (e.g. application of a stored rule), and lowest at the knowledge-based level (e.g. may require analysis, diagnosis, evaluation, and utilization of external resources).

Reason (1990) noted that in response to error feedback, corrective action may be enhanced by utilization of a forcing function to prevent mistakes. Forcing functions are defined as "something that prevents the behavior from continuing until the problem has been corrected" (Lewis & Norman, 1986, p. 420). On the other hand, Mattox (2012)

suggested that the use of a *cognitive forcing* strategy (i.e. checklist) may improve human performance because it cues a requisite series of cognitive steps.

An Intervention to Improve Student Performance

A goal of this research study was the development of a safety checklist anchored in a mnemonic that facilitated medication administration, error examination and error prevention. The use of checklists from the airline industry provided an excellent model. The standard protocol provided by a paper cockpit checklist, with a sequential framework that limits variability with a non-linear process, may prevent a decrease in the user's mental or physical health [e.g. cognitive load, fatigue] (Degani & Wiener, 1990). Potter et al. (2005) and Westbrook, Woods, Rob, and Dunsmuir (2010) identified that the medication administration stage was associated with omission errors elicited by nurses increased cognitive load related to the non-linear steps and interruptions. Degani and Wiener also reported that the airline industry used safety checklists every time preflight procedures were performed to prevent errors; checklists were not memorized, but rather read together by the flight crew before takeoff; and checklist usage promoted fidelity as a *step-by-step challenge-and-response procedure*, which was better than an individual's short or long-term memory.

However, Dreyfus and Dreyfus (1979) reported that pilot emergency training included associated maxims which may reactivate a pilot's memory on how to proceed. Dreyfus and Dreyfus (1979, 1980) explained that to accurately perform skills in any situation, novice and advanced beginner pilots relied heavily on rules bundled in checklists and tasks learned in the form of maxims and mnemonics. Expert pilots also relied on mental flexibility when dealing with unexpected conditions. Of relevance,

Benner's (2001a) seminal work, *From Novice to Expert - Excellence and Power in Clinical Nursing Practice,* was based on Dreyfus' Model of Skill Acquisition (Dreyfus & Dreyfus, 1980). Benner's (2001a) work is utilized extensively in nursing education.

Gawande and Weiser (2008), both physicians, suggested that "Checklists counteract human failures of omission. Omissions were most likely to occur when there was information overload, multiple steps in a process, repeated steps and planned departures from routine procedures" (p. 127). Hales, Terblanche, Fowler, and Sibbald (2007) reported that a carefully delineated inquiry-based checklist with safety checkpoints can function as cognitive support for the prevention of omission errors related to slips or lapses because the user was directed through skill completion. Hales et al. (2007) and Mattox (2012) suggested that the use of a checklist to review options with external sources (i.e. other people) improved the processes of clinical reasoning and problem solving needed for the recovery of knowledge-based medical errors. Also, Degani and Wiener (1990) and Reason (1990, 2013) noted that standardized checklists could function as quality measurement tools for error reporting.

Statement of the Problem

Cooper (2014) and Wittich et al. (2014) reported that medication administration errors were widespread. The IOM (2006), Harding and Petrick (2008) and Weant et al. (2014) suggested that medication error prevention required standardization of medication management processes. Strategies that facilitated the standardization of medication administration included a non-punitive error reporting system and safety checklists (Weant et al, 2014). However, Cooper (2013) suggested that the discipline of nursing does not have a standardized non-punitive error reporting system. Moreover,

Cooper (2014) explained that safety interventions utilized in nursing education for learning medication administration included the *medication administration rights* (a traditional cue used for accuracy with protocol completion), electronic charting, case studies, and simulation experiences. Yet, the medication administration rights, including policies and procedures, have not been standardized (see Table C1, Appendix C). Furthermore, electronic medication administration records (eMAR) were documentation tools that varied from one healthcare facility to another.

As a result, neither the administration rights nor the eMAR were equivalent to a standardized skills safety checklist for student learning. Hence, an essential question was whether, in an era of high-tech solutions, a standardized low-tech paper checklist that prompted clinical reasoning with rule adherence throughout the medication-use process would influence accuracy with medication administration and error reporting among nursing students.

Reasoning with Rules

Henneman et al. (2010) suggested that the process of error prevention required that nursing students learn rule adherence associated with four rule-based error categories: verification, monitoring, intervention, and coordination. However, monitoring and coordinating activities would challenge students because those activities involved *higher order thinking skills* within the evaluation category of the cognitive domain in Bloom's Taxonomy of Learning (Anderson et al., 2001). Further, Eisenhauer, Hurley, and Dolan (2007) reported that nurses' thinking processes, involving judgment and reasoning when administering medications, extended beyond protocol rules. Likewise, Leufer and Cleary-Holdforth (2013) reported that the nurse's

role within the administration stage was complex and involved rule adherence, competence in skill and judgment, and collaboration before delivery of patient medications. Treiber and Jones (2012), suggested that critical thinking with adherence to standards was required to prevent fatal errors with medication administration**.**

Reason (1990) suggested that rule-based activities may be managed by a set of learned actions (e.g. checklist steps) that promote problem solving. Henneman et al. (2010) and van Klei et al. (2012) suggested that poor adherence to checklist steps increased the risk of patient harm and that proper-use training may facilitate rule adherence. However, if the rules were incomplete, misapplied or forgotten, then errors of commission and omission would occur despite training efforts (Reason, 1990). The National Patient Safety Agency (2009) reported that rule-based errors (wrong dose, wrong drug, and omitted/delayed medicines) accounted for 71% of fatal and serious harm medication occurrences, findings that were congruent with Reason's (1990) error theory. Added research suggested that the lack of skill in understanding the steps of medication administration made the situation particularly prone to omission type errors (Hales et al., 2007; IOM, 2006), but so are nursing students particularly prone (Harding & Petrick, 2008; Henneman et al., 2010; Wolf, Hicks, & Serembus, 2006).

Nursing Students and Performance-Related Errors

Wolf et al. (2006) reported that medication administration errors among nursing students may occur more often than reported or estimated by research. Wolf et al. (2006), in association with the United States Pharmacopeia, conducted a descriptive study of medication errors (n = 1,305) involving nursing students. The study had two purposes: identify the characteristics of administration stage medication errors made by

nursing students; and match useful pedagogy to prevent the errors from reoccurring. Findings noted that one-third of the errors were omission and wrong dose errors; 32% of the errors were related nonadherence to protocol; 51% were related to performance deficit; and 20% were linked to distractions and interruptions (Wolf et al., 2006). Wolf et al. (2006) concluded that the major error-related contributory factors reported were inexperience and distractions.

Moreover, collective scholarship, spanning a decade and involving both nursing students and professional nurses, linked distractions to rule-based omission errors (Harding & Petrick, 2008; Marquard et al., 2011; Pape, 2003; Pape et al., 2005; Wolf et al., 2006; Wright, 2013). Potter et al. (2005) examined interruptions during medication administration and identified that nurses experienced many cognitive shifts that increased cognitive load. Reason (2000) stressed that organizations with unfailing safety reports (e.g. U.S. air traffic control centers) recognized that curtailing variability in human activity through utilization of standard protocol reduced errors. Treiber and Jones (2012) concluded that, to prevent medication errors and raise error awareness, (1) clinical nurses need to avoid complacency and utilize critical thinking with adherence to medication error reporting standards and (2) nursing researchers need to study the *mindset* of those who do not complete steps on a checklist that seem redundant.

Novices directed towards nonadherence to protocol. Pape (2003) and Pape et al. (2005) noted that nurses reported that checklist utilization improved focus and eased cognitive load with medication delivery. However, Gill et al. (2012) concluded that experienced nurses directed graduate nurses towards nonadherence to protocols. Similarly, cognitive psychologists, Kahneman (2013) and Reason (1990) identified that

the behavior of experienced coworkers often contradicted checklist usage, by defaulting to intuitive systems that eased cognitive load and saved time. As a result, the paradox was twofold because the experience level did not protect nurses from clinical or procedural errors (Westbrook et al., 2010) and the omission of standards and cues often led to errors among novices (Reason, 1997).

Furthermore, Reason (2013) suggested that error-prone healthcare professionals, often with little or no training in error recovery and reporting, would stigmatize those who made mistakes. Stigma and marginalization created obstacles for error disclosure and reporting (Reason, 2013). All points considered, human and system-related errors were expected (Kohn et al., 2000; IOM, 2006; Reason, 2013). Wittich et al. (2014) suggested that learning more about medication errors concurrent with the utilization of inexpensive and user-friendly strategies to facilitate medication administration may have the greatest effect on patient safety.

A Just Culture to improve error reporting. For decades, the airline industry has been upholding a Just Culture that encourages assertive communication from the crew to the pilot, to prevent errors and enhance passenger safety (Degani & Wiener, 1990). "Organizations with a Just Culture are as willing to expose areas of weakness as they are to display areas of excellence… They feel safe and emotionally comfortable while busily occupied in a work environment, able and expected to perform at peak capacity, but able at any moment to admit weakness, concern, or inability, and able to seek assistance when concerned that the quality and safety of the care being delivered is threatened" (Frankel, Leonard, & Denham, 2006, p.1692-1693). As a result, employees engaged in a Just Culture expose concerns, not only with their own actions, but also

with that of others, to ensure client safety (Frankel et al., 2006).

Benner (2001b) advised that a non-punitive and Just Culture in nursing education would better support quality care and patient safety. Likewise, Leufer and Cleary-Holdforth (2013) suggested that: (1) both flaws in nursing education programs and individual student errors jointly contribute to medication errors, and (2) a Just Culture was needed to identify the extent of the problem as well as remedy it. A Just Culture and medication error reporting could be practiced in a simulation environment (Degani & Wiener, 1990; Khairallah, Lehman, Arms, Turnbull, & Steenrod, 2012).

Aim of the Study

This study was aimed at the development of a quality standard to facilitate medication administration error detection, prevention, and reporting among pre-licensure nursing students. More specifically, the objective was to determine if pre-licensure nursing students' utilization of an original comprehensive inquiry-based medication administration paper checklist that paired clinical reasoning with rule adherence, reduced skill, rule, and knowledge-based errors of commission while increasing system-related medication error recovery and reporting. Sequential steps of the medication administration process were bundled and anchored in the mnemonic, C-MATCH-REASON, to form the new checklist for student use to prevent errors. The checklist was accompanied by an error tracking instrument for faculty to measure errors committed, recovered and reported.

This experimental study would be conducted in a simulation environment using a crossover design with two periods. There would be an experimental group (checklist

utilization) and a control condition (no-checklist utilization) who participate in medication administration. All participants would be randomly assigned to both groups to equalize learning experiences. Individual paired comparisons would be studied to assess learning from the repeated practice. Debriefing would be provided to elicit student reflection related to checklist utilization. The simulation environment would also be used to assess the reliability and validity of the error tracking instrument. This research was timely, as nursing education needs effective strategies for medication administration that enhance student learning and patient safety.

Study Hypotheses

The hypotheses for this study examining nursing students' processing of performance and system related errors included that:

1. *Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would report more medication errors in a simulated environment.*
2. *Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would demonstrate greater rule adherence in a simulated environment.*
3. *Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer skill-based errors in a simulated environment.*
4. *Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer knowledge-based errors in a simulated environment.*
5. *Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer knowledge-based confirmation bias errors in a simulated environment.*
6. *Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer errors in total in a simulated environment.*

Significance of the Study

Following an extensive review of the literature, gaps in error recovery (Bates & Slight, 2014) and error reporting (James, 2013) existed within the administration stage of the medication management process. Furthermore, the collective scholarship of Henneman et al. (2010), Keers, Williams, Cooke, Walsh, and Ashcroft (2014) and Manias, Aitken, and Dunning (2005) raised awareness to the continued need for standardized methods that were effective in the recovery and reporting of medication administration errors among both professional nurses and nursing students.

The AHRQ (June 2017) suggested that improving patient safety required the reduction of preventable harm errors from all causes. Research involving pre-licensure nursing students (Henneman et al., 2010; Wolf et al, 2006), both nursing and pharmacy students (Warholak, Queiruga, Roush, & Phan, 2010), and medical and nursing professionals (Nanji, Patel, Shaikh, Seger, & Bates, 2015; Nichols et al., 2008) identified limitations related to recognizing medication errors and a need to learn from errors. One solution was presented by van Klei et al. (2012) who reported that complete adherence to the WHO's *Surgical Safety Checklist*, was associated with a significantly decreased patient morbidity and mortality. However, prior nursing research that included the active examination of rule and/or knowledge-based medication errors with checklist utilization (Goodstone, 2013; White et al., 2010) and without checklist utilization (Henneman et al., 2010; Marquard et al., 2011) concluded that educational strategies were still needed in nursing to improve patient safety.

In addition, nursing research examining distractions and interruptions during the process of medication administration, with checklist utilization (Pape, 2003; Pape et al.,

2005) and without checklist utilization (Potter et al., 2005; Westbrook et al., 2010), further identified the need for error reducing safety interventions. Also, Cooper (2014), Harding and Petrick (2008), and Leufer and Cleary-Holdforth (2013) identified inconsistencies in error reporting systems within and between nursing academic institutions and healthcare agencies. Without question, further empirical research was needed in nursing education to identify: (1) effective learning strategies for medication administration that elicit error awareness and clinical reasoning (i.e. checklist utilization); (2) medication errors that students recover (close calls), commit, and report; as well as (3) root causes of student medication administration errors. These items were the primary focus of the present study.

Chapter Summary

Preventive efforts (e.g. quality standards) to facilitate accuracy with both error recovery and reporting yield to safer systems (Henneman, Tessier, Nathanson, & Plotkin, 2014; Kohn et al., 2000; Murphy, 2012; Reason, 2013). Medication administration requires clinical reasoning with adherence to safety standards to prevent fatal errors (Treiber & Jones, 2012), yet a standardized checklist that prompts error recovery and reporting was largely absent. The absence of a checklist was associated with rule-based omissions (Gawande & Weiser, 2008) and, at times of interruption in a busy setting, it was the most common cause of novice-level slips (Reason, 1997). Also, knowledge level error corrections were the least frequent (Reason, 1990). Checklists facilitated clinical reasoning with knowledge-based performance (Kahneman, 2013). Thus, a standardized medication administration checklist was posited to prevent errors as well as to improve patient safety. A literature review follows in Chapter Two.

Chapter II

Review of the Literature

This chapter was organized according to the research problem which comprised the examination of medication administration errors. The literature review and synthesis pertained to: (1) the complex interplay of medication management and error reporting; (2) Reason's error theory (1990; 2013) to measure medication errors; (3) the use of quality standards, implemented in a Just Culture, to facilitate medication error recovery, reporting, and patient safety; (4) medication errors among nurses and nursing students (5) the application of cognitive load, clinical reasoning, and novice to expert theories to the development of a checklist, to improve accuracy with learning the skill of medication administration; and (6) the utilization of a simulation environment to study medication errors among pre-licensure nursing students.

The collective scholarship was applied to the research problem: the need for development of a standardized medication administration checklist (anchored in a mnemonic) that prompts high order cognitive activity (clinical reasoning with rules and reflection on performance) to improve medication error recovery and reporting among pre-licensure nursing students. As a result, a new medication administration checklist (see Appendix D) designed for nursing student utilization and accompanied by an error tracking instrument for faculty (see Appendix E), was presented to: (1) track skill, rule, and knowledge-based medication errors recovered, committed and reported; and (2) discern human from system-related errors based on contributing factors documented on the data collection instruments.

The Interplay of Medication Management and Error Reporting

Medication management is a complex process comprised of stages and errors occur within all stages (Harding & Petrick, 2008; IOM, 2006; Wright, 2013). Furthermore, the stages that involve medication-use elicit individual clinical judgment and coordination with external sources to problem solve to prevent errors (Eisenhauer et al., 2007; Weant et al., 2014). For example, *drug ordering and delivery* may involve prescribing by physicians and nurse practitioners; transcribing by pharmacists and nurses; dispensing by pharmacists; administering by nurse; and monitoring by all involved with the patient (Weant et al., 2014). However, Curren (2010) and Reason (1990) noted that effective error prevention required that the recovery methods include the reporting of error feedback upon error detection (See figure 4.0).

Figure 4.0

Medication Management, the Medication-Use Stages, and Error Reporting (ER)

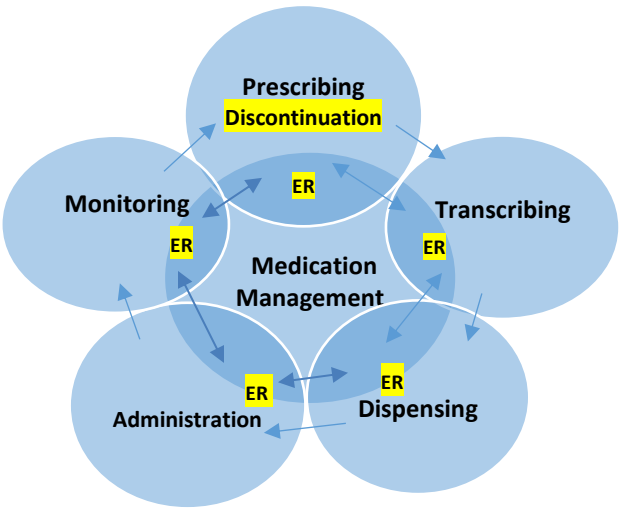


Figure 4.0. A modified illustration of Curren (2010) and Reason's (1990) representation of error reporting. The darker central areas that overlap demarcate where error reporting (ER) should occur as a central process (a wheel within the

wheel) threaded through each medication-use stage. The arrows are indicative of the non-linear aspect of the processes (Potter et al, 2005; Westbrook et al., 2010).

Specific to medication administration, Curren (2010) explained that after patient safety was established, if an error was not immediately reported then corrective and preventive actions would be compromised. Yet, Hughes and Blegen (2008) assigned medication error reporting to the monitoring stage, a conclusion that was inconsistent with Curren (2010). Cousins et al. (2012) identified that reports of medication errors resulting in patient harm were increasing, but close calls were not reported and actions to prevent recurrences were rarely included on error reports. Wright (2013) suggested that *not* reporting close call errors during the prescribing stage increased the likelihood of attributing patient harm errors to the administration stage. As noted in Chapter One, in hospitals, administration stage errors were not intercepted, whereas prescribing stage errors were recovered about half of the time, thereby reinforcing the need to enhance preventive measures within both stages (Bates et al., 2014).

Of relevance, *conservative prescribing principles* may be a strategy that reduces the overprescribing of opioids by physicians, thereby reducing ADEs (AHRQ, June 2017). Also, increasing the *discontinuation* of prescriptions associated with ADEs, polypharmacy and overuse through the preventive process of medication reconciliation reduced transitional care errors (AHRQ, June 2017; Fede et al., 2011; Pincus, 2013). Yet, a review of the literature pertaining to medication error prevention did not demarcate discontinuation with prescribing as stage one of the medication-use process. As a result, in Figure 4.0, stage one included discontinuing with prescribing to minimize medication errors and facilitate error recovery. If potential errors were not

reported upon detection, then it is also difficult to ascertain the correct stage in which an error occurred and the root cause (Curren, 2010; Wright, 2013).

In contrast, Jones (2009), Pape (2001), and Wright (2013) accurately identified root causes of medication errors, suggesting a theme: instead of placing the blame on one group (i.e. nursing), healthcare administrators need to broaden their focus. Medication management needed to be viewed in a larger context of the healthcare system. Additional researchers have identified root causes of medication errors that have been corrected (Bates et al., 1999; ISMP, 2016; & Poon et al., 2010). Examples include The Joint Commission (TJC, 2017) standards that support protocols (e.g. "do not use" list); Poon et al. (2010) technological stop gaps (e.g. bar-code scanning for patient ID verification); Bates et al. (1999) report on electronic orders that replace illegible handwriting; and ISMP's (2016) use of tall man lettering (to minimize look-alike drugs). While modifications were put into practice, medication errors continue to occur (ISMP, 2016; Poon et al., 2010).

Evermore, Wright (2013) suggested that it is crucial to question the role of nurses in medication errors since multiple definitions for medication errors exist and contingent on choice, error counts may be inflated. Wirtz, Taxis, and Barber (2003) identified that a nurse may be charged with a medication error when hospital policy was violated by having a window open while preparing medication. Wright (2013) and Sheu, Wei, Chen, Yu, and Tang (2009) noted that the development of medications (10,000+) over the past 40 years as well as the increases in continuous intravenous infusions prescribed in punitive environments, complicated administration stage responsibilities, contributed to errors, and jeopardized accuracy in error reporting.

Education-Practice Gap

Further, medication error reporting systems between academic institutions and healthcare agencies were inconsistent (Cooper, 2014; Harding & Petrick, 2008; Leufer & Cleary-Holdforth, 2013). Yet, joint initiatives among schools and clinical agencies for the development of a standardized error reporting system may elicit a safer patient care environment (Harding & Petrick, 2008). Gregory et al. (2007) and Murphy (2012) suggested that standardization of medication-use protocol between academic and clinical sites may enhance communication, resulting in error reduction. The American Association of Colleges of Nursing [AACN] (2019) stressed robust competency based education (CBE) and Cooper (2014), and Hughes and Blegen (2008) recommended policy changes in nursing education that stressed accuracy in tracking and reporting medication errors to improve patient safety.

Murphy (2012) reported that effective strategies to prevent errors and raise error awareness among nursing students included cues from expert nurse mentors, utilization of compliance aids for pharmacology and critical judgement, conjointly with, context-dependent adherence to standard protocol; suggestions that were congruent with Reason (1990, 2013). Reason's (1990) error theory identified that the recovery of errors, among novices to experts, resulted from reciprocity between self-monitoring and external sources to ensure that all steps related to problem solving were deliberated.

Conceptual Framework

Error Theory

As established in Chapter One, error theory was applied to measure medication

administration errors, among pre-licensure nursing students, utilizing James Reason's (1990) Generic Error-Modelling System [GEMS] (see Figure 3.0) and the basic error driven feedback loop (see Appendix B). Reason (1990) adapted GEMS from Rasmussen's (1983, 1986) skill-rule-knowledge classification of human performance. GEMS integrates skilled-based slip and lapse errors with rule and knowledge-based mistakes. The error driven feedback loop illustrates information processing and problem solving (error correction).

Human Performance Errors

Skill-based errors stem from an individual's saved patterns or habits that encourage automatic, fast thinking or intuitive behavior due to fatigue or a busy environment (Kahneman, 2013; Reason, 1990, 1997, 2002). Reason (1990) noted that in *the cognitive staging of errors*, skill-based lapses occurred in the storage stage (e.g. lack of knowledge/schema/expertise/ forgetting), whereas *slips* (attention failure) occurred in the execution stage (i.e. application) allowing for visibility. Skill-based errors differed from rule and knowledge-based errors as they often preceded detection of a problem, presenting as "the departure of action from current intention" (Reason, 1990, p. 157).

Rule-based errors were described as "inadequate habits" by both Henneman et al. (2010) and Reason (1990). For example, not following protocols, incorrect recollection of steps, and the misapplication of rules due to improper assessments. Additional research with nursing students (Dennison, 2007; Murphy, 2012) and professional nurses (Pape, 2003) suggested that not using a systematic process when administering medication was an inadequate habit. Rule-based mistakes were further

defined as errors that occurred in the drug administration process, including errors of commission (actual), omission (never administered) and close calls recovered before reaching the client (Bates et al., 1995; IOM, 2004, 2007).

Henneman et al. (2010) and Reason (1990) noted that error detection and recovery were performance processes that could be involved with near misses or close call errors. For example, a pharmacist dispensed the wrong drug, but the nurse identified the error before the drug was delivered to the patient. More specifically, Reason (1990) identified three modes of *error detection*: self-monitoring; environmental error cueing; and other people. For example, self-monitoring behavior may enable the detection of a skill-based slip related to attention failure; checklist review may prevent the omission of a rule; and collaborative efforts with checklist utilization may enhance the problem solving needed to interrupt and correct a knowledge-based error before it reaches a client (Mattox, 2012; Reason, 1990).

Reason (1990) and later Wright (2013) noted that knowledge-based mistakes occurred from the lack of understanding of a new situation that required troubleshooting. Wolf et al. (2006) and Wright (2013) proposed that student knowledge-based medication errors may occur due to limited time available for learning about 10,000+ medicines, the process of transcribing drug orders, the interplay with novel clients and situational circumstances.

Moreover, Reason (1990) suggested that novice to expert level knowledge-based mistakes involved “error prone *on-line* reasoning” (p. 61). Reason (1990) identified that knowledge-based mistakes occurred if accuracy in reasoning was hindered, for example, due to cognitive strain in the workplace, overconfidence,

selective attention, complex situations, over simplifying cause and effect, confirmation bias (the inclination to identify data that supports our prediction), and the availability heuristic. The availability heuristic, originally defined by Tversky and Kahneman (1973), was more recently described by Kahneman (2013) as "the reliance on the ease of memory search" (p.7). Kahneman (2013), Meehl (1986), and Reason (1990) noted that inconsistency with the use of formulas led to biases and poor judgment in complex situations, further suggesting that the memories of experts were inferior to checklists.

Reason (1990) also suggested that rule-based errors may result from failure to engage in metacognition. To explain, skill and rule-based errors may result from application of a "bad rule," whereas knowledge-based errors often result from lack of experience, foresight, and planning (Reason, 1990). Benner, Sutphen, Lenard, and Day (2010) defined *clinical reasoning* for nurses as "The ability to reason as a clinical situation changes, taking into account the context and concerns of the patient and family. When nurses use clinical reasoning, they capture a patient's trends and trajectories" (p. 85). Benner et al. (2013) suggested that identification of clinical issues, application of appropriate interventions, along with, self-monitoring behavior should improve clinical reasoning ability and engage metacognition, thereby limiting errors.

System-Related Errors

As described in Chapter One, Reason's (1990, 1997, 2000, 2013) error theory had widened in focus from error-prone people to error-prone systems. Reason (1997, 2000, 2013) categorized system-related errors as latent conditions (e.g. two medications with similar labels stored next to each other) and active failures (unsafe acts: choosing the wrong medication in a busy medication room). Latent conditions included

inexperience, lack of equipment, inadequate staffing, and unworkable procedures (Reason, 2000), which may include an agency not having a policy for the disposal of expired drugs resulting in unintended distribution. Latent conditions may exist for years before joining with active failures to cause an adverse event (Reason, 2013).

Root cause and situations of duality. A rule-based close call could be categorized as either a human performance or system-related error recovered before reaching the patient (Bates et al., 1995; IOM, 2004, 2007; ISMP, 2009). Identification of root cause may facilitate accuracy with sorting errors into categories for prevention measures (Harding & Petrick, 2008; Wright, 2013). Also, skill-based slips that involved distractions and interruptions in the hospital setting may be system-related errors (Pape, 2003; Pape et al., 2005). Reason (1990) explained that interruptions add to cognitive load and limit attention, thereby contributing to slips. Further, skill-based slips and lapses associated with interruptions that contributed to skipping protocol steps were also considered rule-based omissions (Biron, Lavoie-Tremblay, & Loiselle, 2009; Pape et al., 2005; Potter et al., 2005; Reason, 1990, 2002; Westbrook et al., 2010).

Standards to facilitate clinical reasoning, thereby reducing errors. What motivated the brain to skip procedural steps and/or jump to wrong conclusions instead of taking the time to engage in thoughtful reasoning? Herbert Simon (1992), a founding father of decision-making theory, defined intuition as "…nothing more and nothing less than recognition" (p 155). To develop further, Kahneman's (2003, 2013) [cognitive] *System 1* was a fast type of intuitive thinking that automatically searched the mind for answers with little effort. As cited in Kahneman (2013), Kahneman (2003) and Simon (1987) suggested that intuitions cued from memories of related experiences (i.e.

expertise) may lead to correct judgments whereas lack of proper habit formation may lead to hasty decisions. Benner et al. (2013) suggested that praxis was at the heart of nursing care since nurses must "think-in-action," as established in Chapter One.

Novice nurses do not practice at a level of intuitive thinking (Benner, 2001a; Benner et al., 2013). Although, experts (e.g. nursing educators) may effectively activate System 1 when clinical forethought was utilized to produce a quick intervention that prevented a novice-level student from making an error (Dreyfus, 1980; Stanovich & West, 2000; Benner, 2001a; Kahneman, 2003, 2013; Benner et al., 2013). Kahneman (2013) underscored that novices who were inadvertently taught to skip steps would most likely apply bias leading to errors.

In contrast, Kahneman's (2003, 2013) [cognitive] *System 2,* was slow but flexible thinking practiced by an individual (e.g. student) with a lack of experience, as evidenced by consciously applying reasoning to rules (cues) to problem solve. Kahneman (2013) suggested that awareness to the theory that the human brain thinks fast and slow facilitates the learning process. Dreyfus (1980), Benner (2001a), and Kahneman (2003, 2013) suggested that novice-level students engaged in safe practice when they utilized standard protocols to elicit clinical reasoning.

Likewise, Rycroft-Malone, Fontenla, Seers, and Bick (2009) suggested that the effective development of a nurse's decision-making processes was associated with protocol-based care that was applied within the context of a situation. Manias et al. (2005) suggested that nursing students would function more autonomously, learn from self-monitoring practices, and demonstrate greater accuracy with practical reasoning through the utilization of standard medication protocol that enabled error reporting.

Patient Safety

Quality Standards

The Joint Commission (TJC, 2016) described standards as "the basis of an objective evaluation process that can help healthcare organizations measure, assess and improve performance." The implementation of evidence-based standards in healthcare was essential to providing safe quality patient care (Hales et al., 2007; Pronovost et al., 2008; TJC, 2016). Cooper (2014), ISMP (2015), and Weant et al. (2014) noted that adherence to quality standards and an error reporting system with medication management enhanced patient safety and quality care. One example, developed by TJC (2013), included an extensive medication management quality standard in the form of a safety checklist for use by hospital administrators.

There continues to be widespread support for the development of standards in nursing education that facilitate coordinated teamwork, competency with critical judgment and clinical reasoning as well as accuracy with measuring outcomes (American Nurses Association [ANA], 2016; Cooper, 2014; IOM. 2010; TJC, 2016; Treiber & Jones, 2012). Valid and measurable standards, associated with patient safety, best practice, and ethics, still need to be developed from scientific literature and ongoing feedback from subject matter experts (ANA, 2016; CDC January 22, 2015; IOM, 2010; TJC, 2016; WHO, 2016).

Safety Checklists

Airline industry. As established in Chapter One, Gawande (2009), Hales et al. (2007), Hales and Pronovost (2006), and Pape (2003) borrowed safety data related to

checklist adherence from the airline industry and applied it to research in healthcare. Gawande (2009) noted "Pilots nonetheless turn to their checklists for two reasons. First, they are trained to do so. They learn from the beginning of flight school that their memory and judgment are unreliable and that lives depend on their recognizing that fact. Second, the checklists have proved their worth- they work" (p. 121).

Boehm-Davis and Remington (2009) reported that air traffic controllers have checklist procedures that shed tasks in situations of heavy traffic. However, checklists were not for every situation (Catchpole & Russ, 2015). For example, Henriqson, van Winsen, Saurin, and Dekker (2011) suggested that in response to pilot error, including calculation error, the creation of new airline safety procedures involving double, and cross-checks created redundancy between people and technology. Redundancy in practice may increase cognitive load and lead to errors with experts who apply intuitive thinking (Kalyuga, Ayres, Chandler, & Sweller, 2003; Reason, 1990). Yet, Kahneman (2013) and Mattox (2012) suggested that the checklists may aid individual reasoning and judgment, by interfering with lapsing into intuitive choices that eased cognitive load, thereby aiding problem solving and error reduction. Hence, Degani and Wiener (1990) suggested that when designing a checklist that may be used in tandem with technology, the steps need to flow logically to minimize cognitive shifts.

Checklists as scaffolding. Benner (2001a), Reason (1990) and Vygotsky (1962) suggested that scaffolding, from both an expert mentor and a structured protocol, facilitated accuracy among novices practicing a complex skill. Vygotsky (1962) explained that scaffolding (e.g. a checklist) was a support system that may be offered to students by a more knowledgeable other (e.g. mentor) to facilitate learning complex

skills. Likewise, Dewey (1966) upheld that learning by doing, with structured inquiry while engaging civil communication and reflection, advanced learning.

Henneman et al. (2014) concluded that utilization of a structured instrument (e.g. checklist) by nursing students, when interviewing patients about their medication history, led to greater accuracy with medication reconciliation as well as medication error reduction. Henneman et al. (2014) conducted a pilot study in a simulation environment and examined the use of a multidisciplinary standardized tool for *medication reconciliation* (the resolving of drug discrepancies to optimize therapeutic regimen). The tool was refined, and a study was implemented in the acute care setting. Results included a significant reduction of minor medication omission errors (1.10 versus post 0.60, $p = 0.003$) in a community hospital. Henneman et al. (2014) concluded that checklist utilization improved the accuracy of the admission medication list, thereby preventing error progression and resulted in error reduction.

Checklists and harm reduction. Depending on the study, findings also reflect that adherence to standardized checklists with medical and surgical procedures led to 18% - 47% decrease in mortality of hospitalized patients (Hales & Pronovost, 2006; Haynes, et al., 2009; van Klei et al., 2012; Wolff, Taylor, & McCabe, 2004). van Klei et al. (2012) concluded that complete adherence to the WHO's (2009) *Surgical Safety Checklist*, was associated with a significant decreased patient morbidity and mortality.

van Klei et al. (2012) conducted a retrospective cohort study involving 25,513 adult patients undergoing surgery in a tertiary university hospital. van Klei et al. (2012) examined the effectiveness of the WHO's surgical checklist on mortality and identified that crude mortality decreased from 3.13% to 2.85% (P = .19). Next, Odds Ratio was

used for analysis and it was noted that mortality was significantly lower in patients with completed checklists, 0.44 (95% CI, 0.28–0.70), as compared to those patients with partial 1.09 (95% CI, 0.78–1.52) or noncompleted checklists 1.16 (95% CI, 0.86–1.56) where the mortality rate remains unchanged. van Klei et al. (2012) concluded that the WHO Surgical Checklist intervention reduced in-hospital 30-day mortality. Also, van Klei et al. (2012) discussed limitations and noted that the Hawthorne effect increased awareness of safety issues, improved teamwork, and improved judgment. Therefore, a combination of several factors may have contributed to the crude mortality reduction.

Checklist utilization enhances teamwork. Reason (1990, 2013) suggested that collaborative problem solving enhanced by checklist utilization was more likely to prevent knowledge-based mistakes. Henneman et al. (2010) reported that coordination-related medical errors were associated with a lack of interdisciplinary communication of critical data. Benner (2001b), Gawande (2009), and Pape (2003) suggested that healthcare professionals may benefit from the airline industry's "team coordination concept" when using a standard protocol. Catchpole and Russ (2015) and Degani and Wiener (1990) suggested that team-based exercises, that stress communication and skill support, coincide in environments where checklists were effective.

Pronovost et al. (2008) evaluated team collaboration, adherence to ventilated patient protocol and infection control performance outcomes, among intensive care units (ICUs) within 77 US hospitals, by measuring improvements in safety culture scores from the *Teamwork Climate Scale of the Safety Attitudes Questionnaire* (SAQ). Data analysis (of a subset of 72 ICUs that participated in the teamwork climate assessment) using a 2-tailed paired samples *t* test, suggested statistical significance in

score improvement from year 2004 to 2005 ($p < .005$). Pronovost et al. (2008) concluded that protocol adherence for ventilated patients ranged from a mean of 25% (for sustaining blood glucose levels at or less than 110 mg/dL) to 89% (for stress ulcer prophylaxis). Regarding infection prevention, initial reports from the ICUs reflected that only 20% had chlorhexidine readily available. Within six weeks of alerting CEO's, 77% of the ICUs reported they had chlorhexidine in stock. In line, the ANA (2016), TJC (2016), and WHO (2016), also, suggested that implementation of quality standards improved patient safety.

Overall, Dreyfus (1980), Gawande (2009), Hales and Pronovost (2006), Hales et al. (2007), Kahneman (2013), Mattox (2012), Reason, (1990), and White et al. (2010) suggested that checklists promoted rule adherence, minimized the use of memory or heuristic-based thinking, and may be used as quality measurement tools. Moreover, Reason (1979) and White et al. (2010) suggested that checklist users may benefit from chunked protocol, with detailed descriptions, in busy settings. Collectively, nurses identified benefits with adherence to rule-based medication protocol including no extension of task time and improved focus on the task (Marquard et al., 2011; Pape, 2003; Pape et al., 2005). Nurses reported that checklists were valued as they cued steps, raised error awareness, impeded distraction, and improved ability to think more about the task on hand (Pape, 2003; Pape et al. 2005; White et al., 2010).

Threats to Patient Safety

Problems with Standardized Protocol

Mahajan (2011) suggested that, globally, the use of standardized checklists was

inconsistent. Gill et al. (2012) concluded that there were inconsistencies between nursing practice and adherence to medication administration protocol related to unclear protocol, insufficient mentoring, and inaccurate understanding of risks involved with nonadherence to protocol.

Hurdles

Catchpole and Russ (2015), Mahajan (2011), and van Klei, et al. (2012) suggested that resistance to the utilization of standardized reporting systems and protocols may be connected to hurdles, including proper-use training, relevance, duplication of work (redundancy), automaticity (protocol repeated without effort or intention) and interference with conceptual thinking. Degani and Wiener (1990) and Gawande (2009) noted that checklists needed to be scheduled for reviews to effectively update, maintain relevance, as well as, quality. Betancourt and Tan-McGrory (2014) underscored that to recover medication errors related to disparities in health, the following interventions needed to be integrated into quality standards: (1) the medication reconciliation process (a *high-risk* situation for those with Limited English Proficiency); (2) use of free live qualified interpreters; and (3) strategies to empower staff to report errors utilizing a system with items that prompt culture and language-related occurrence. As a result, the need to clarify the effectiveness of standard protocol and error reporting is underscored (Catchpole & Russ, 2015; Mahajan, 2011; van Klei, et al., 2012; White et al., 2010).

Non-adherence to medication error reporting systems. Covell and Ritchie (2009) noted that medication error reporting systems collect between 25% and 63% of all medication errors committed within U.S. hospitals. The U.S. Food and Drug

Administration Adverse Event Reporting System (FAERS) was standardized and accommodates users worldwide (ISMP, 2015). Standardization increased ADE trend reporting from 2006 and 2014, as shown on the table: *Reports Received and Reports Entered by Year* (U.S. FDA, 2015a). Notably, in 2013, FAERS received 1,170,104 ADE reports from healthcare personnel, consumers, and manufacturers combined. Of these ADE's, 707,593 were reported as serious harm and 116,388 as deaths, yet the amount that reflects medication errors remains unclear (U.S. FDA, 2015b).

The ISMP (2015) suggested that the inability to identify if a medication error was responsible for an ADE or a death reflected an outcome measuring process that threatened patient safety and quality care. Moore et al. (2015) and Makary and Daniel (2016) found that partially completed reports (including death certificates) submitted by healthcare professionals and drug manufacturers to FAERS, impeded accuracy with patient harm and mortality statistics specific to therapeutic drug use.

More specifically, the ISMP (2015) reported that serious ADE report submissions varied widely, with four drug manufacturers' submitting complete reports about 15% of the time. Of consequence, it was unclear if the increase in ADE reports was a result of a better reporting system, more error occurrences, or both (more submissions because of an improved reporting system as well as an increase in errors committed). FAERS plans to expand data collection involving pediatric drugs and birth defects along with updating the standardized system to reduce ADE report inconsistencies (ISMP, 2015).

Gaps specific to nursing. Moreover, a review of the literature identified the need to enhance strategies for nursing students who were learning how to administer

medication, detect medication errors and report errors (Gregory et al., 2007; Harding & Petrick, 2008, Henneman et al., 2010; Wright, 2013). Currently, the AACN (2019) is assisting nursing educators with competency development to facilitate the delivery of safe, high quality care by student and graduate nurses. The Nursing and Midwifery Council [NMC, 2010] (as cited in Murphy, 2012) reported that medication administration standards for nursing address knowledge, skills, safety, ethics and legal subject matter. Yet of interest, an extensive literature review did not identify a standard method to assure compliance with clinical reasoning with rule adherence when learning medication administration and error reporting. Instead, safety checks and skill checklists involving many permutations of the medication administration rights currently exist for nursing student utilization.

Permutations of the medication administration rights. The original five medication administration rights, regarded as a foundation for skill acquisition, were presented as inquiry-based safety checks: *Do I have the right patient, medication, time, dose, and route?* (Craven & Hirnle, 2009; Curren, 2010; White et al., 2010). Upon scrutiny, the five original medication administration rights were more applicable to the prevention of prescribing stage errors than administration stage errors. In line, a current literature review revealed that the original five medication administration rights, were informally and inconsistently modified by nurse and pharmacist researchers, resulting in combinations of *6-10* rights (see Appendix, Table C1). As a result, nursing textbook descriptions of medication administration processes and skills checklists vary. For instance, Craven and Hirnle (2009) cited five rights, whereas Berman, Snyder, and McKinney (2011) cited ten rights.

Also, varying numbers of administration rights were applied in studies focused on improving safety with medication administration. To illustrate, Pape (2003) cited seven *rights* (drug, patient, dose, time route, reason, documentation), whereas Pape et al. (2005) applied "5 Rights plus one" (drug, patient, dose, time, route, plus documentation) to a process improvement campaign. Each of these studies will be expanded on later in this chapter. Bourbonnais and Caswell (2014) noted that repeated attempts to modify the administration rights suggests greater complexity is involved with skill acquisition. Variations in protocol imposed challenges with learning the rule-based aspect of a skill (Degani & Wiener, 1990), limited success with medication management, prolonged the revision process and hindered standardization (Cooper, 2014; Wittich et al., 2014).

Moreover, Harding and Petrick (2008) suggested that nursing educators may be teaching the medication administration rights out of context, to students who do not have the schema needed to synthesize the complexities involved with administering medications. Murphy (2012) did not refer to the medication administration rights process, but instead stressed that mentors and their protégé needed to draw from a standardized medication management protocol to facilitate skill acquisition, error awareness, and patient safety.

Reason (1990) suggested that rule-based activities were learned actions that promote problem solving, but if rules were incomplete, then errors occurred. As previously discussed, Henneman et al. (2010) identified that verification of patient allergy information was not included in the medication administration rights check, but lack of allergy verification was a typical student error. Cooper (2014) and Henneman et

al. (2010) and Harding and Petrick (2008) suggested that nursing education needed to identify effective strategies to improve error recovery and reporting among nursing students. White et al. (2010) identified that "to think critically and remember the five rights of medication administration did not help with the abstract task" (p. 566).

Of relevance, Goodstone (2013) used a quasi-experimental design to test the use of a six-medication rights protocol cue card with the skill of medication administration in the clinical setting. The MASAT (medication administration safety assessment tool) and six-medication rights protocol cue (patient, medication, time, dose, route, and documentation) were developed to measure medication errors committed by nursing student subjects [n = 60] (Goodstone, 2013). The main hypothesis was that, upon comparison, the protocol cue card utilization group would commit fewer errors than the no-cue card control condition. Student medication errors scores were also sorted based on the number of semesters completed.

Goodstone (2013) conducted the pilot study in a simulation environment with a scenario embedded with medication errors. Nursing student subjects (n = 14) were split into experimental and control groups. An independent t-test of the mean MASAT scores was used for data analysis that suggested statistical significance: the experimental group identified more errors than the control condition. And yet, in the actual study, which took place in the clinical environment, Goodstone (2013) reported that the main hypothesis was not supported. The control group's score (7.85) was statistically significantly higher ($p = .000$) than the experimental group (7.39). In addition, pairwise comparisons identified six semester students scored lower than two ($p = .038$) or four semester students ($p = .001$).

Goodstone (2013) suggested that the students may have been less likely to adhere to the six-rights protocol in the human patient simulation setting and that a sample size of 60 subjects may not have generated enough power. Goodstone (2013) did not refer to a power analysis but reported that the target sample size (n= 60) was the size of the nursing class at the time of the study. Goodstone (2013) concluded that the absence of significant findings may have been related to limits with medication error occurrence in the hospital setting as well as a cluster of similar MASAT scores (dependent variable) creating a ceiling effect that reduced correlations between the group scores. Polit and Beck (2004) discussed how clusters of high or low scores restrict correlations that result in ceiling or floor effects that limit statistical analysis.

Goodstone's (2013) finding, that six semester students scored lower than two or four semester students, suggested that improvement in error awareness as well as reduction of rule-based errors, among pre-licensure nursing students, required consistent use of protocol cues (scaffolding) beyond fundamental coursework. In congruence, results from Henneman et al. (2010) and van Klei et al. (2012) suggested that poor adherence to rule-based protocol increased the risk of error and patient harm.

Cooper (2014) also utilized the medication administration rights to examine errors and error reporting at the University of San Francisco. Cooper (2014) developed a medication error reporting system that involved dividing errors into three categories: administration rights, system issues, and knowledge and understanding. Cooper (2014) acknowledged that the administration rights varied in type and number (5 to 9) from one author to the next, and yet, upholds seven administration rights as a medication error category. Cooper (2014) reviewed 26 medication error reports from the school of

nursing, collected over five semesters, with an estimated 610 students enrolled per semester. Cooper (2014) concluded that student medication error report submissions increased, and the most errors were administration rights-related (46%), followed by knowledge-based errors (39%), and finally, system-related omissions (15%).

In a retrospective study involving baccalaureate nursing students (n =77), Harding and Petrick (2008) applied seven medication administration rights (patient, medication, dose, time, route, reason, and documentation) to track rights violations. Harding and Petrick identified patterns in medication errors associated with contributing factors: rights violations; system factors; as well as, knowledge and understanding issues. System factors were described as environmental elements, in the setting where medications were administered, that contributed to errors. Harding and Petrick explained that system factors may not be routinely addressed by educators who teach medication management, yet the limited knowledge of pre-licensure nursing students often interplayed with system factors to contribute to medication errors. Harding and Petrick identified that omission errors among nursing student subjects were linked to distractions and interruptions.

More specifically, Harding and Petrick (2008) found that 66% of the student medication errors were commission errors (i.e. rights violation) and 34% were omission errors of which 27% interplayed with student reports of busyness and distractions. Furthermore, nursing students lacking in experience with reading and reasoning from the Medication Administration Record (MAR) were linked to 42% of omission type errors (Harding & Petrick, 2008). Harding and Petrick concluded that if nursing faculty tracked student errors, using a standard report that is familiar to clinical mentors, then a

communication bridge may be formed permitting joint efforts towards a safer system. The collective scholarship of Pape (2003), Wolf et al. (2006) and Wright (2013) also included results suggesting that medication rights violations as well as contributing factors (e.g. environmental distractions and interruptions) played major roles in the cause of medication errors.

Cooper's (2014) findings that almost half of nursing student's errors were related to violations of the seven administration rights; Goodstone's (2013) findings that the six rights protocol cue did not capture medication errors in the hospital; and Harding and Petrick's (2008) incident form not tracking close call errors, support the development of a comprehensive medication administration checklist that cues error recovery and reporting to improve skill acquisition as well as patient safety.

Nonadherence with patient verification. Gill et al. (2012) analyzed factors that swayed adherence from medication administration protocol and concluded that nurses most often verified the drug name, dose, route, and documentation whereas the least checked element was the patient identification (ID) band, results that were in congruence with Henneman et al. (2010). Gill et al. (2012) underscored that nurses who skip comparing the ID band to the chart may have the right patient but the wrong chart, a finding that was consistent with Goodstone (2013) and Henneman et al. (2010).

In addition, Gill et al. (2012) identified that pediatric intensive care unit (PICU) nurses skipped ID checks reasoning that they knew the patient and graduate nurses' skipped checks related to poor time management skills, raising caution to nursing students. Nurse clinicians and supervisors completed the most ID checks. Of relevance, Poon et al. (2010) noted that 20% of the medications ordered, on units with

bar-code technology, are administered skipping the e-Scan patient ID verification step, a step linked to error reduction. Moreover, use of bar-code technology at the time of medication administration reduced drug errors by 41.4% per Poon et al. (2010) and by 56% as noted by DeYoung, Vanderkooi and Barletta (2009). While, bar-code scanning alone was not a panacea, neither were checklists alone (Catchpole & Russ, 2015).

Performance and System-Related Medication Errors

Research, spanning several decades, involving medical errors that were rule-based errors (Henneman et al., 2010; Reason, 1990, 2013; White et al., 2010) and knowledge-based (Reason, 1990, 2013, White et al., 2010) suggested that these two types of performance errors were common. Harding and Petrick, (2008) and Wright (2013) suggested that researching the root cause and contributing factors, jointly, would lead to the development of a better system, resulting in a lower medication error rate.

Nursing student performance errors. To refine focus, Henneman et al. (2010) suggested that it was essential to determine the root cause of nursing student omission errors to prevent them. Cooper (2014), Harding and Petrick (2008), Henneman et al. (2010) as well as Wolf et al. (2006) identified that student medication administration errors frequently included non-adherence to the medication rights, lack of patient verification (e.g. allergy), lack of knowledge, and ineffective communication. Harding and Petrick (2008) found that causes of student errors were nonconforming medication schedule times, not understanding a drug label, attempting to prepare medication for more than one client at the same time, and allowing interruptions. Wolf et al. (2006) concluded that nursing educators need to increase rigor with skills practice.

Errors related to distractions and interruptions. Harding and Petrick (2008),

Pape (2003), Westbrook et al., 2010 and Wolf et al. (2006) noted that distractions and interruptions interfered with the cognitive work of nurses, contributing to medication errors that impede patient safety. A *distraction* may briefly interfere with one's ability to concentrate (a loud noise) whereas an *interruption* (answering a phone call) may prevent completion of the action (Reason, 1990). Pape (2003) and Pape et al. (2005) suggested that limiting distractions and interruptions reduced skill completion time.

Signage limits distractions; Checklists cue protocol. To study distractions and interruptions, Pape (2003) and Pape et al. (2005) applied safety interventions, borrowed from the airline industry and conducted quasi-experimental studies. Pape (2003) and Pape et al. (2005) each developed a safety checklist as well as "do not disturb" signage for use by nurses administering medication in the acute care setting. The checklists were designed to measure protocol adherence and distractions (Pape, 2003; Pape et al., 2005). Pape's (2003) medication administration checklist contained 12 sequential steps, including "Use 7 rights: right drug, patient, dose, time, route, reason, and documentation." Inconsistently, the checklist offered to subjects (n =78) by Pape et al. (2005) had 11 steps and applied "Five rights plus one." The steps resembled commands (e.g. DO NOT engage in conversation not pertaining to medication delivery).

Pape (2003) equally divided 24 nurse subjects into a control group or one of two distraction-intervention groups: a *focused protocol intervention*; and a *Medsafe vest with a focused protocol intervention*. The dependent variable was the change in number of distractions when administering medication. Pape (2003) analyzed data using one-way ANOVA which revealed statistical significance in the mean difference in total distractions between the experimental and control groups (p = .000). The control group

experienced 154 interruptions (58%); the focused protocol group (checklist utilization) experienced 84 (32%); and the Medsafe vest with a focused protocol group experienced 29 (11%).

Pape et al. (2005) used SPSS® V11.5 for analysis of data compliance scores collected from direct observation of checklist utilization among the subjects. Results identified that nurses' compliance with each checklist item varied: 80% checked the ID band; 77% checked allergy; 38% informed the patient of the name of the drug; 81% avoided distractions; and collectively, 30% of all nurses followed all steps. Both Pape (2003) and Pape et al. (2005) concluded that nurses appreciated: checklists to cue procedures, signage to reduce distractions, and interventions to raise error awareness.

Positive correlation between error rates and interruptions among experts. To further raise medication administration error awareness and support the hypothesis that medication error occurrence was increased by interruptions, Westbrook et al. (2010) conducted a quasi-experimental study in Sydney, Australia. Nurse volunteers (n = 98) were observed, on six wards at two separate teaching hospitals from September 2006 to March 2008, administering 4,271 medications to 720 patients over 505 hours. Westbrook et al. (2010) explained that observers were instructed to bring attention to the nurse only if they thought an error may lead to patient harm.

The observers used a handheld computerized observation tool to record details about medication administration procedures as well as interruptions that nurses experience while preparing or giving medications (Westbrook et al., 2010). Errors were classified by type and severity. Interruptions were defined as situations where the nurse must stop the process of medication administration to focus on an unexpected

occurrence. Total interruptions per administration was the independent variable, whereas total procedural failures and total clinical errors were the dependent variables. Logistic regression was used to link error with interruption.

Westbrook et al. (2010) findings revealed that the process of medication administration was not linear. Nurses shift between preparation, administration and patients. Westbrook et al. (2010) found that interruptions occurred in 53.1% of all administrations. Each interruption was associated with a 12.2% increase in procedural failure and a 12.7% increase in clinical errors. Procedural failures accounted for 74.4% (n= 3,177) of the errors among the total medications (n= 4,271) administered (95% CI, 73.1%-75.7%). The most common procedural lapses were not checking patient ID band with the MAR and wrong IV administration rate.

Of interest, Westbrook et al.' (2010) logistic regression equation outcome revealed that the projected risk of a severe error happening with a single medication pass doubled from 2.3% with zero (0) interruptions to 4.7% with four (4) interruptions (95% CI, 2.9%-7.4%; $P < .001$). The key findings were that experienced nurses were not immune to error, and when experienced nurses were linked with interruptions, they had higher procedural failure rate errors. Westbrook et al. (2010) concluded that "the lack of multisite and comprehensive data suggests that the full magnitude of the problem is still unknown" (p.683).

Interruptions and nurse's cognitive load. Potter et al. (2005) performed and ethnographic study and applied mixed methods to measure how interruptions during medication administration, in a tertiary care medical center, influenced nurses' cognitive load. Registered nurse (RN) subjects (n = 7) were observed working for a

total of 43 hours by an RN who is paired with a human factor's engineer (HFE). The RN-observer had a patient care focus, logging cognitive activities with respect to the nursing process. The HFE had a task focus (e.g. tracked tasks, timed interruptions).

Potter et al. (2005) noted that data tracked by the HFE is analyzed using a link analysis. The HFE transferred the data into a map of the nurses' motion and cognitive paths. The link joined tasks (the nurse preparing medication and then administering medication) and 86 cognitive shifts occurred over nine hours. An increase in the number of links, consistent with repetitive motion, was seen in all seven nurses and was described as multitasking (Potter et al., 2005).

Potter et al. (2005) used a second graph to record the interruptions and the cognitive shifts created by the interruptions. The HFE observed a total of 261 interruptions with 47% occurring while nurses were completing tasks and 24% occurring just before a cognitive shift. Many of the interruptions (22%) occurred during medication administration. However, the researchers were not able to link these interruptions with medication errors, but 21 omissions in care were observed.

Potter et al. (2005) identified that the nurses had high cognitive load and frequent cognitive shifts, which increased the risk for inattention, lending to omissions in care. The conclusions by Potter et al. (2005) were in congruence with suggestions by Marquard et al. (2011) and White et al. (2010) warranting further examination of errors related to interactions among systems, protocols, and nurses' cognitive shifts. In addition, Marquard et al. (2011) suggested that the system a nurse uses to detect potential medication errors is one that advances one step at a time using critical thinking instead of a multitasking method.

Multitasking. Marquard et al. (2011) used technology to monitor eye tracking of nurses (n = 20) during a simulated medication delivery. Marquard et al. (2011) noted "Error-identifying nurses tended to complete more process steps in a similar amount of time than non-error-identifying nurses and tended to scan information across artifacts (e.g. ID band, patient chart, medication label) rather than fixating on several pieces of information on a single artifact before fixating on another artifact (p. 247)." Also, the measurement of time, in seconds to complete the step, was recorded based on subjects who identified the error versus those who did not. ANOVA with repeated measures, suggested statistically significant results (p = .006).

Marquard et al. (2011) found that attempting to check both name and DOB at the same time (multitasking) increased the risk for rule-based types of errors. Of importance, Mattox (2012) stressed that checklists were useful with work that gave way to multitasking. Moreover, Marquard et al. (2011) findings were congruent with White et al. (2010) as both authors suggested that a checklist designed to guide a nursing student in the prevention of a patient identification error (a common rule-based error) would separate each directive (e.g. Read patient name on medication administration record [MAR]; Match patient name to ID band; Read patient date of birth [DOB] on MAR; and Match DOB to ID band).

As a result, the research by Marquard et al. (2011) on eye fixation and medication error identification had important implications for tool development and training: nursing students may be able to learn to follow a comprehensive medication protocol, step by step, and complete the medication process, accurately, without effects on task time. Likewise, Degani and Wiener (1990) suggested that a checklist may act

as a tripwire preventing a user (e.g. nursing student) from taking a dangerous shortcut.

The Need to Uphold a Just Culture

As established in Chapter One, *The Aviation Safety System[n.d.]* (as cited in Kohn et al., 2000) developed a culture of safety through teamwork that considered root causes of system errors, instead of blaming individuals. The airlines hired safety engineers to identify functions and situations that were linked to errors. The open communication that occurred between the engineers and the airline pilots as they worked to solve problems, created a culture of safety that encourages an ongoing process of identification and correction of errors. Kohn et al. (2000) (as cited in Benner, 2001b) stressed that adopting a cooperative team approach with patient care was needed to operationalize a Just Culture. Degani and Wiener (1990) noted that if an error occurs, then the team acknowledges joint responsibility.

Also, Benner (2001b) and Degani and Wiener (1990) suggested that limiting punitive action, when errors occurred, aided in preserving communication lines, further inhibiting error. Pape (2001) and Wright (2013) supported the shift to a system that is not punitive when an error was reported, because nurses feared retaliation. Therefore, open communication and feedback were essential for error prevention and reporting, whether professionals were airline pilots reviewing a safety checklist with crew members (Degani & Wiener, 1990) or nurse mentors adhering to a standard protocol with students (Murphy, 2012; Cooper, 2014).

Gregory et al. (2007) suggested that healthcare facilities have systems in place to mitigate errors, but the authors still wanted clarification of processes used by nursing

educators to safely manage medication errors. Questions included: How do nursing programs apply the concept of a Just Culture to improve patient safety? Are nursing faculty collecting data on the types of errors reported? If so, are error patterns decreasing or increasing?

Benner (2001b) and Gregory et al. (2007) considered system-related errors when attempting to create a culture shift toward safety. Collective scholarship suggested, instead of blaming a student for a performance-related error, look at the learning system and program processes to identify how they may jointly contribute to errors. For example, Polifroni, McNulty, and Allchin (2003) illustrated program inconsistency when reporting that nurse educators will not accept one medication error with patient care but will accept seventh grade level math calculation errors on a drug dosing exam. Polifroni et al. (2003) recommended 100% as passing scores on drug calculation exams.

Cooper (2013), a nursing quality of care and safety officer, focused on implementing and testing a medication error reporting system in a Just Culture at the University of San Francisco. The aim of Cooper's (2013) study was to explore if nursing student involvement with a blame-free error reporting system, initiated in the first semester of clinical practice, increased error awareness and patient safety. Cooper (2013) electronically distributed 669 surveys to students and 145 were returned. Survey findings included: 90% of the students were oriented to the reporting system; 83% of the students expressed support from clinical faculty upon commission of an error; errors perceived as unlikely to result in harm were reported less; and students expressed that there was general concern about errors among nurses and students.

Gregory et al. (2007), Harding and Petrick (2008) and Cooper (2014) suggested

that tracking student errors, over time, may aid in the detection of how academic and clinical systems contribute to student errors. Benner (2001b), Gregory et al. (2007), Pape (2001), Potter et al. (2005) and Wright (2013) stressed that to create a culture of safety, emphasis needs to be on finding the root causes of errors.

Research Methodology Influences Error Rates

Wright (2013) reported that error counts and the identification of root cause were influenced by the methodology chosen for error research (e.g. direct observation versus chart review and occurrence reports). Wright (2013) explained that a chart review usually identified prescribing stage errors committed by physicians, whereas direct observation included errors with the administration stage. Likewise, Westbrook et al. (2010) and Barker, Flynn, Pepper, Bates, and Mikeal (2002) suggested that direct observation facilitated error detection at higher rates than chart reviews or incident reports alone. Also, Wright (2013), Covell and Ritchie (2009), Harding and Petrick (2008), IOM (2006) and Moore et al. (2015) identified that retrospective incident analyses only included errors that were reported. Wright (2013) surmised that only errors observed were reported and that error data depended on comments documented.

To connect, in an active study involving human patient simulation, Henneman et al. (2010) effectively used observation as a method to measure rule-based error identification and recovery among senior nursing students (n=50). The senior nursing students reported experience with the use of simulation, but this was their first individual practice with human patient simulation and an acute illness scenario embedded with errors. Disconcertingly, the results indicated that 100% of the students committed rule-based errors, with the most common error being incomplete verification

of patient identification.

To expand, Henneman et al. (2010) used an adapted version of the Eindhoven *near-miss* model, developed by Henneman and Gawlinski (2004), to exhibit the nurse's role in detecting close call errors and preventing adverse patient outcomes. Henneman et al. (2010) noted that student error data (recovery and commission) were collected from the video recordings of the human patient simulation. Reason's (1990) error theory was applied and the data were coded into four rule-based error categories (coordination, verification, monitoring and intervention). Statistical analysis was conducted using Stat/SE 8.2 for Windows. Chi-square tests, with Alpha = 0.05, were used to identify statistical differences in proportions of senior nursing student errors sorted by category (e.g. lack of verification of patient ID and allergy). Fisher's Exact Test was used to determine *p* values for cell counts with low frequencies (≤ 5). The senior nursing students did not verify individual patient identification 84% and 88% of the time ($p < .001$) and allergies were missed 76% and 68% of the time ($p = .001$).

Nanji et al. (2015), in a study conducted in the United States of America, also used observation effectively to detect medication errors during 277 operations where 3,671 medications were administered. A total of 193 medication errors/ADEs were identified, of which 153 were reported as preventable. Grimly, Nanji et al. (2015) concluded that every other surgery had a medication error and/or an ADE with over one-third leading to patient harm.

Barker et al. (2002) used a mixed method design to observe the rate of medication errors in 36 health care facilities, including both acute care hospitals and skilled nursing facilities (SNFs). The results identified that one out of every five

medication doses were linked to an error among nurses (Barker et al., 2002). The study inclusion criteria specified current use of an incident reporting system. Extensive training of registered nurses and pharmacy technicians as subject matter experts (SMEs) was conducted and interrater reliability was established (p = .0541).

Barker et al. (2002) explained that the data collected by the SMEs from each medication pass dose was compared to the healthcare provider's prescription. Next, the data were submitted to a research pharmacist, who triangulated the data and validated errors by comparing observation records with prescription orders. In total, 3,216 medication doses were observed with 210 false negative and 87 false positive errors (Barker et al., 2002). The final analysis was derived from the research pharmacist's error conclusions that there were 605 errors out of 3,216 doses (Barker et al., 2002). A mean error rate of 19% suggested that medication errors were common. Seven percent of the medication errors were rated as potentially harmful and errors linked to faulty systems are prevalent in all observation areas, with the most frequent being wrong time (43%) followed by omissions [30%] (Barker et al., 2002).

Of interest, Barker et al. (2002) were pharmacists and physicians who defined medication errors by using eight "wrong" categories that resemble the discipline of nursing's medication administration rights (e.g. the right… patient, medication, time, drug, route, and documentation). The eight "wrong" categories include: unauthorized drug, extra dose, wrong dose, omission, wrong route, wrong form, wrong technique, and wrong time (Barker et al., 2002). Notably, neither "documentation" nor "response" were included among the wrong categories. Later research conducted by Henneman et al. (2010) and Poon et al. (2010) identified that incomplete documentation and lack of

verification of allergy are common medication errors. As a result, Barker and colleagues (2002) category oversight may have interfered with the detection of additional errors and adverse drug reactions.

Mattox (2012) and Wright, (2013) suggested that without inclusive documentation when reporting contributing factors, it would remain unclear if a skill-based omission error was linked to an environmental failure (e.g. interruption) rather than a human performance error. Wright (2013) concluded that further examination of the interplay among error producing factors within the context of a setting (e.g. interruptions merging with protocol violations and limited knowledge of medications) was needed to improve accuracy in error reporting. Therefore, when educating nurses on medication administration, practice should include a range of observable skills to facilitate error awareness (Wright, 2013). Cooper (2014) suggested that error reporting be threaded throughout nursing curriculum to improve reporting accuracy.

Facilitating Learning

Hsieh, Hsu, and Huang (2016) suggested that the accurate shaping of nursing students' behavior, needed for learning the skill of medication administration as an evidence-based standard practice, may be facilitated by minimizing cognitive load. Pape et al. (2005) and Potter et al. (2005) suggested that nursing educators need to promote critical thinking, while exploring strategies that reduce extraneous cognitive load, when administering medication in the acute care setting.

Benner et al. (2010; 2013) suggested that to understand errors, from the perspective of learners, we need to understand the process of thinking related to a skill

within the praxis of nursing. Kahneman (2003, 2013) noted that heuristics may limit cognitive load by bringing quick reasoning to solve a problem but accuracy with heuristics is often questioned. Contrary to heuristics, checklists were safety enhancing interventions that limit automaticity as well as cognitive load (Dreyfus, 1980; Gawande, 2009; Kahneman, 2013; Reason, 1990). Of relevance, *Best Practices for Simulation* included the application of cognitive load theory (Lioce et al., 2015). As a result, checklists, simulation, and cognitive load theory would be utilized in this study to facilitate learning.

Cognitive Load Theory

How an educator organizes subject matter (e.g. multimodal, chunking, sequencing) enhances transfer of data to long term memory, facilitating learning (Kalyuga, Chandler, & Sweller, 2000; van Merrienboer & Sweller, 2005). To understand cognitive load theory, it is useful to understand its relationship with working memory (WM).

Bruning, Schraw, and Norby (2011) noted that the concept of WM was described as a function that the brain performs to determine meaning of current ideas being held by conscious thought. Miller (1956) concluded that working memory can hold seven items (plus or minus two). As a result, the WM of human beings is not able to process many elements (van Merrienboer & Sweller, 2005). Although, van Merrienboer and Sweller (2005) noted that, over time, we can combine simple elements (e.g. chunking) to form complex ideas (e.g. mnemonics) that lend to the development of new or revised versions of data or skills (e.g. safety checklists). As cited in Tuovinen and Sweller (1999), with specific design of the learning environment (e.g. sequencing,

cuing), educators can maximize student processing of new data from a limited working memory (Miller, 1956) to long-term memory (Simon & Gilmartin, 1973).

The model of WM has three parts and the master part is the *executive control system* (Baddeley, 1986, 2001, 2007; Baddeley & Hitch, 1974). Linked to the master part are two *slave subsystems*: the *articulatory loop* and the *visual-spatial sketchpad* (Baddeley, 1986, 2001, 2007; Baddeley & Hitch, 1974; Bruning, et al, 2011; Reason 1990). The articulatory loop oversees auditory rehearsal and oral communication and gives the learner the ability to hold up to nine elements of rehearsed sounds, briefly in thought (Miller, 1956; Bruning et al., 2011). The second subsystem oversees visual rehearsal and spatial comparisons (Bruning et al., 2011). To illustrate, this visual subsystem allows a nursing student to consciously *match* a prescription label on a bottle, to a patient's medication administration record (MAR) and *reason*. The application of the types of cognitive load, when learning a complex skill that requires clinical reasoning to reduce errors, will be discussed next.

Leppink, Paas, Van der Vleuten, Van Gog, and Van Merrienboer (2013) along with Tuovinen and Sweller (1999) and Henriqson et al. (2011), sorted cognitive load into three types: intrinsic (prior knowledge interplayed with complexity of the task); extraneous (instruction that does not benefit learning – redundant); and germane (instruction that benefits learning). Of interest, extraneous cognitive load is not needed for learning, but it can be manipulated by instructional design. For example, withholding versus offering information needed for a complex task (van Merrienboer & Sweller, 2005).

To expand, Sweller (1988) noted an increase in cognitive load when students

attempted to solve math problems without any assistance or cues. In subsequent research by van Merrienboer and Sweller (2005) students were provided with prompts or partial solutions to problems (cues with limited redundancy) and findings suggested a reduction in extraneous cognitive load, thereby facilitating the ability to problem solve. Therefore, as tasks become more complex, encouraging regular use of cues may be helpful. The application of cognitive load theory to facilitate learning how to apply the new checklist to medication administration, which includes calculating drug doses, reaffirms the purpose of this study: medication error prevention.

Rationale for Multimodal Learning

Consistent with Bloom's Taxonomy, analyzing, reasoning, and evaluating were thinking processes that required high levels of cognitive functioning (Anderson et al., 2001). Pointedly, Pesut, and Herman (1992) and Kautz, Kuiper, Pesut, Knight-Brown, and Daneker (2005) suggested that structured teaching-learning strategies (e.g. cues, checklists); periodic student written reflection (without rating or evaluating student journals); and self-regulation decreased cognitive demand and improved clinical reasoning ability among nursing students.

Murphy (2012) suggested that prelicensure nursing students, working with a mentor, needed to learn to integrate theoretical knowledge of medication administration into the context of each patient's current health situation and the clinical environment. Benner et al. (2010) stressed that theory alone made it difficult to learn to "think or reason like a nurse." Benner et al. (2013) suggested that when practicing a complex skill, for example, medication administration, the clinical reasoning processes included analyzing, reasoning, and evaluating.

Developing safe practice habits. Benner, Hughes and Sutphen (2008) noted "If nothing is routinized as a habitual response pattern, then practitioners will not function effectively in emergencies" (p 18). However, Benner et al. (2008), also noted "If expectations are held rigidly, then subtle changes from the usual will be missed, and habitual, rote responses will inappropriately rule" (p. 18). To enhance safety and quality care, nurses must be able to transition in and out of habits and practices depending on both the situation and the guidelines at hand (Benner et al., 2008; 2013). Curren (2010) made it clear that "routine medication administration must never be routine" (p. 83), findings that were congruent with Treiber and Jones (2012). Dennison (2007), Gregory et al. (2007) and Murphy (2012) suggested that leaders were essential players in the creation and maintenance of safe practice habits.

***e*Learning improves knowledge, not habits**. Dennison (2007) conducted a quasi-experimental study, with a pretest-posttest design, to evaluate the effect of a computer based educational program to facilitate medication safety in a U.S. hospital. Nurses (n = 20) on a 12-bed coronary care unit, completed an *electronic learning* (eLearning) program. Paired *t* tests were used to complete data analyses of an original 18-item Medication Safety Knowledge Assessment Tool. Dennison (2007) reported statistical significance ($p < 0.001$) with changes in knowledge upon completion of eLearning modules. Next, Dennison (2007) used four items to analyze nurse behavior with medication infusions before and after the eLearning program.

Dennison (2007) rated individual nurse behavior by using the Chi-square test, and statistical significance was noted with the behavior of labeling the infusion bag ($p = 0.033$) but not with the labeling of the tubing. The author concluded, "…a change in

knowledge does not necessarily produce a change in practice" (p. 179). In line, Ferrell (1998) noted "for continuing education to change the behavior of participants, they must have the desire and ability to learn and the right job climate to transfer the new knowledge and skills into the new practice" (p. 181). Ford et al. (2010) suggested that an effective method for shaping safe behavior and reducing error rates was lecture combined with simulation practice.

Simulation

The International Nursing Association for Clinical Simulation and Learning (INACSL) identified that best practices for simulation include standardized programming, student debriefing, methods for evaluation, and application of educational theory, for example, cognitive load theory (Lioce et al., 2015). Benner, Tanner, and Chelsa (2009) recommended that, when introducing abstract concepts, educators assist learning among nursing students by using simulation exercises that place theory in context of patient care situations.

Simulation environments contribute to patient safety. Nursing educators may utilize simulation to facilitate the development of safe practice habits (Schlairet & Fenster, 2012). Henneman et al. (2010) noted that rule-based medication errors are observable making them likely to be captured in a simulation environment without actual patient harm. Furthermore, if errors go unreported, then finding the safest method to administer medications will be impossible (Harding & Petrick, 2008; Pape, 2001; Wolf et al., 2006; Wright, 2013). Dreyfus and Dreyfus (1979, 1980) and Henriqson et al. (2011) noted that the airline industry also included the application of a Just Culture to situational activities practiced in simulation environments to improve

error reporting.

Lecture combined with simulation. Ford et al. (2010) compared medication error rates of intensive care unit (ICU) nurses (n = 24) before and after educational interventions. Twelve nurses on the medical intensive care unit (MICU) were offered remediation for medication errors that involved traditional lecture, whereas twelve nurses on the coronary care unit (CCU) participated in a human patient simulation session. Each intervention was followed by a quiz. Ford et al. (2010) used a quasi-experimental mixed method design that included: real-time observation that was prospective (three phases spanning three months) and single-centered (one trauma center) with parallel groups (comparison of well-matched ICU nurse groups to prevent same unit nurses from knowledge sharing).

Ford et al.'s (2010) small sample size (n = 24) did not reduce statistical power, since the data collection involved pharmacist observation of the nurse subjects delivering 880 doses of medication to 76 patients over 48 hours, post educational intervention. The pharmacists recorded each step of the six rights for medication administration. Ford et al.'s (2010) findings demonstrated that the pre-post written quiz scores increased in both groups due to the educational interventions, but the group that received the simulation-based intervention (CCU nurses) had a significantly lower error rate (4.0%) than the traditional lecture group (MICU nurses) error rate (30.8%) as observed by the SME's. The statistical significance was noted as $p < 0.001$. Ford et al. (2010) also reported that reduced error rates remained with the CCU nurses.

Simulation for measuring clinical judgment. Schlairet and Fenster (2012) concluded that student learning of reasoning was built on knowledge linked to prior

experience, results that were in congruence with Thiele, Baldwin, Hyde, Sloan, and Strandquist (1986). Schlairet and Fenster (2012) focused on developing clinical reasoning ability by analyzing the effects of sequencing on cognitive learning with the use of simulation. A mixed method design was used to explore the use of simulation as an effective substitute for direct care clinical experience, with respect to learning clinical judgment and critical thinking skills (CTS) among 78 undergraduate nursing students. Jeffries' (2005) Nursing Education Simulation Framework was applied to the study, which included pre-and post-testing of students CTS as well as accumulating knowledge over six weeks with interleaved sequencing of simulation alternated with direct care practice.

To measure change in CTS, the students were given a post-test that measures six cognitive skills after their last day of clinical (Schlairet & Fenster, 2012). Faculty rated clinical judgment by using the Lasater Clinical Judgment Rubric [LCJR] (Lasater, 2007) which was based on observation during both simulation and direct care experiences. Analysis of variance (ANOVA) was used to estimate differences among variables and correlation data was used to explore relationships. Ordinary Least-Squares Regression was used to explain the LCJR Total Score by Design Schema and Ethnicity. Statistical significance was noted with clinical judgment ($p = 0.000$) when using the 50% interleaved design of alternating simulation with direct care experience (*SDSDSD*) every other week (Schlairet & Fenster, 2012).

Simulation to teach cue recognition to aid problem solving. From another perspective, Carnevali, Mitchell, Woods, and Tanner (1984) as well as Thiele et al. (1986) suggested that clinical decision theory started with cue recognition or the

identification of relevant data (cues) which were joined to form a pattern which triggered diagnostic reasoning to interpret the pattern and translate it into action. Thiele et al. (1986) noted that accuracy with pattern formation was what facilitated accuracy in decision-making. Subsequent research published by Kahneman (2013) as well as Simon (1992) noted that recognition (intuition) may be used interchangeably when describing the thought processes associated with increased expertise. While novice nurses respond less accurately to cues than expert nurses, clinical reasoning needed to be learned (Benner, 2001a; Benner et al., 2013; del Bueno, 1983; Thiele, et al., 1986). Thiele et al. (1986) concluded that when pre-licensure nursing students were given multiple opportunities to develop cue recognition, in association with sorting and linking of data, they demonstrated accuracy with decision-making.

To explain, Thiele et al. (1986) identified the effects of teaching cue recognition by using three successive computer-assisted instruction (CAI) programs with baccalaureate nursing students to aid in decision-making and skill acquisition. An experimental design was used to compare three sets of pre-and posttest scores that measured the change in junior (n = 43) and senior (n = 37) students' ability to recognize and sort relevant from non-relevant cues as well as link choices to make accurate clinical decisions. Feedback was given for incorrect responses. Thiele et al.'s (1986) first program, using a clinical case study titled "Cues, Chunks, and Clinical Inferences," taught steps to diagnostic reasoning linked with cues. Subjects were presented several cues, of which they choose to view separately, leading them to incorrect judgments. The remaining two sessions, with content relative to junior or senior coursework, focused on recognizing, sorting and linking cues. By the third CAI simulation, accurate

linking of cues provided evidence of student progress in clinical decision-making.

For analysis, Thiele et al. (1986) sorted data into intervention groups (juniors and seniors) by cue recognition and decision-making, and then by program measures. Data analysis included using paired t-tests. For cue recognition, statistically significant findings ($p < 0.05$) were noted among the juniors (with respect to repeated teaching of cue recognition) in two of three programs (cues and aged) and among the seniors in the last two program measures (community and leadership). For decision-making, statistical significance ($p < 0.05$) was noted with the juniors with the last two measures (child and aged) and for the seniors all measures were significant ($p < 0.05$). Thiele et al.'s (1986) findings suggested that students who had multiple chances (three computer case studies) to develop cue recognition and to sort (determine what is relevant) and link cues (chunk into groups), showed improvement with clinical decision-making as evidenced by posttest scores increasing with more attempts.

Checklists as Cues to Reduce Clinical Errors

A Checklist designed to engage problem solving. To transform sequential protocol steps into effective critical thinking habits, Hales et al. (2007) suggested consideration of clinical judgement within the content design of a checklist. Degani and Wiener (1990), Hales and Pronovost (2006), and Pronovost et al. (2008) suggested that checklists, sequentially bundled and anchored in the form of an acronym, may further facilitate rule adherence, communication, and team coordination for problem solving. Catchpole and Russ (2015) reported that checklists were tools that can slow us down, for careful review of problems and ease communication allowing for an increase in accuracy among teamwork. Harding and Petrick (2008) and Wright (2013)

suggested that the data entered on a checklist, delineating error-related contributing factors, was feedback that may be used to identify root cause.

A checklist designed to elicit error feedback and reflection. Dewey (1966) and van Merrienboer and Sweller (2005), researchers in both education and psychology, identified that feedback from error examination and reflection were fundamental to learning, particularly from the perspective of the student. Moreover, learning became evident in the reflection period which occurred in the debriefing session after use of a procedural cue (Dewey, 1966). Hogarth (2001) and Kahneman (2013) suggested that accurate and relevant error feedback, obtained from the use of an algorithm, may enhance a student's decision-making ability, whether it evolved from deliberate or intuitive thinking. To expand, Boehm and Remington, (2009) suggested that disengaging from one task to switch to another often resulted in a slip or lapse with remembering to finish the initial task. Once disengaged, those at the expert level may intuitively find where they left off, but this was not usually the case for all others (Boehm & Remington, 2009; Dreyfus & Dreyfus, 1980). A checklist can be used to mark a point in step completion (Degani & Wiener, 1990; Hales et al., 2007).

A checklist redesigned. White et al. (2010) suggested that, regardless of expertise, nurses who check high-risk drug orders by reading data from a patient's drug infusion pump, without referencing an associated checklist, may contribute to *confirmation bias* (knowledge-based error). Confirmation bias may be defined as "a deliberate search for confirming evidence…, people (and scientists, quite often) seek data that are likely to be compatible with the beliefs they currently hold" (p. 81, Kahneman, 2013). Therefore, an infusion pump directive may lead a nurse to default

to selectively retrieving evidence, instead of engaging in reasoning (Easty, 2017; White et al., 2010). White et al. (2010) identified that a well-designed checklist can facilitate the independent process of double-checking medication doses among nurses. Additional research is needed to identify strategies that reduce confirmation bias associated with data verification.

To expand, White et al. (2010) examined the independent double-checking process between two nurses to prevent medication errors related to confirmation bias as evidenced by the phenomena of detecting errors from checklist comparisons (new versus old) in a simulation environment. Errors identified from a checklist used on an oncology unit were grouped into four categories: pump-programming error; patient ID error; mismatch between drug and label and order; and clinical decision error (White et al., 2010). From these observations, a new checklist was developed. Next, White et al. (2010) observed professional nurses (n= 10) delivering medication using, first, the old and then the new checklist to identify what parts of a double check system (performed by a second nurse) assisted with detection of medication errors.

White et al. (2010) identified seven steps for developing a checklist that detects errors including "Develop specific checklist instructions for each predictable error. Include details of what information to check…" (p. 566). Findings suggested that detailed instructions on high-risk items increased error identification rates 80-90%. Data analysis of error detection rates were completed by "using a 2 (checklist type; old vs. new) x 4 (error type: pump programming vs. mismatch vs. patient ID vs. clinical decision) repeated-measures analysis of variance (ANOVA) with a *p* level of 0.05" (White et al., 2010, p. 563). More errors of any type were detected by using the new

versus the old checklist (55%; 71/130 vs. 38%; 49/130, $p < 0.01$).

White et al. (2010) concluded that further research was needed to identify how checklist utilization can facilitate the shifting of a nurse's cognitive processes, between mechanistic tasks and deliberate reasoning, to solve abstract clinical problems. In addition, White et al. (2010) identified that a checklist reminder to *stop and think critically* did not influence detection of medication errors. The findings of White et al. (2010) research with checklist development were congruent with Hales et al. (2007) suggesting that a more complete set of checklist rules, applied in context with systemic factors, may support identification of omission errors.

Overall, this extensive review of research has shown that use of standardized checklists (Reason, 1990; Hales et al., 2007; Mattox, 2012; Kahneman, 2013) along with multiple sessions in a simulation environment facilitate reasoning (Schlairet & Fenster, 2012) and decision-making (Thiele et al.,1986) regardless of experience level. This review also found that experienced nurses were observed directing graduate nurses towards nonadherence to protocols (Gill et al., 2012). The omission of standards often leads to errors among novices (Reason, 1997).

A Standardized Safety Checklist for Medication Administration

Peer-reviewed research from nursing, the airline industry, medicine, and cognitive psychology, along with feedback from expert nurses, was applied by this researcher to design a medication administration checklist for nursing students. References for each checklist item were listed in Table F1, *Evidence-based Checklist Items* (see Appendix F*),* and references for design suggestions were listed in Table G3,

Evidence-based Guidelines for Checklist Design and Usage (see Appendix G).

A shortcoming identified was that the number of medication administration rights varied in the literature creating challenges for standardization (see Table C1, Appendix C). As a result, 11 medication administration rights were identified. The new rights were organized sequentially and anchored in the mnemonic: C-MATCH-REASON. The mnemonic was anchored into the new checklist: *C-MATCH-REASON Oral Medication Administration Checklist* for student utilization (see Appendix D). This new checklist would be accompanied by the *C-MATCH-REASON Medication Error Tracking Instrument* for faculty utilization (see Appendix E). These instruments would be referred to as the *C-MATCH-REASON Checklist* and the *Observation Form*.

User orientation would involve a C-MATCH-REASON Lesson Plan based on cognitive load theory to facilitate learning (see Appendix H). The lesson plan would be joined with Standard Operating Procedures for nursing faculty. The goals for learning would emphasize that medication administration is a rule-based procedure that requires both clinical reasoning and error awareness for the recovery and reporting of medication errors. Chunking the checklist data would reduce extraneous cognitive load and facilitate procedural learning (Bruning et al., 2011; van Merrienboer & Sweller, 2005). Procedural learning may lead to skill acquisition, expertise, and know-how (Bruning et al., 2011). Know-how further reduces cognitive load which frees space in working memory for error identification (Bruning et al., 2011). Thus, the mnemonic, C-MATCH-REASON, reads as a directive to cue rule adherence.

Of importance, the checklist does not rely on memorization which is described as inferior to algorithms (Kahneman, 2003, 2013; Meehl, 1986). Kahneman (2013)

explained that checklists "are more likely than human judges to detect weakly valid cues and much more likely to maintain a modest level of accuracy by using such cues consistently" (p. 241). Reading the C-MATCH-REASON checklist with each client's medication administration may slow nursing students down, pairing clinical reasoning with rule adherence, to facilitate error awareness, recovery, and reporting.

Error tracking and reporting. The C-MATCH-REASON checklist also cues students to document errors found (F) and errors reported (R) in the appropriate boxes in columns three (preparing) and four (administering). As established earlier, errors in judgment and reasoning may be associated with the *availability heuristic* (Tversky & Kahneman1973; Reason, 1990). Therefore, nursing students applying the availability heuristic would judge errors as more or less likely to occur based on the number of errors that come to mind, which may be influenced by errors reported. Kahneman (2013) reported that the more instances of an occurrence that an individual was asked to list and reflect upon, the lower they would rate themselves. For example, if nursing students were asked to list medication errors committed and they list none, then they may judge themselves to be competent.

On the other hand, if students utilized a standardized checklist to facilitate the detection of errors seeded in a simulation scenario and document errors found or receive error feedback noting incomplete step completion, then the students would more accurately judge their competence level. At the same time, nursing faculty observing the administration process could utilize the accompanying error tracking instrument (Observation Form) to measure student errors. These instruments and the methods used to test their effects would be described, in detail, in Chapter Three.

Chapter Summary

This chapter offered a comprehensive literature review by focusing on specific areas pertaining to the complexities of medication management and gaps in standards for medication administration, error recovery, and error reporting. Research associated with nursing education advocates for the development of standard protocols that promote both clinical reasoning and error awareness (AACN, 2019; Hales et al, 2007; Henneman et al., 2010; IOM, 2010; Mattox, 2012). Included in the review were: (1) that quality standards, implemented within a Just Culture, facilitate error recovery, reporting, and patient safety; (2) challenges related to standards; (3) Reason's (1990) error theory for measuring medication administration errors; (4) medication errors in nursing; (5) cognitive load, clinical reasoning, and novice to expert theories to facilitate learning; and (6) that simulation was safe and effective for studying medication errors. Chapter Three describes the methodology that would be utilized to conduct this study.

Chapter III

Methodology

This was an experimental study. Included in this chapter were the description of the human subject protection, study aim and implementation steps, conceptual framework and hypotheses, research design, sample, recruitment strategies, Training PowerPoints, pilot studies, simulation practice, measurement materials, data collection procedures, data analyses, and study limitations. A crossover design with a checklist intervention and a control condition were used. A pre-pilot assessment was proposed to assess the study's implementation and procedures. If the pre-pilot assessment

results indicated the need for modifications of the procedures and the measurements, then these were completed and followed by a pilot study.

Protection of Human Subjects (Participants)

The population of interest in this study, pre-licensure nursing students, was determined to be low risk for vulnerability to harm or exploitation. There were no ethical barriers foreseen. Institutional Review Board (IRB) approval to conduct this study would be obtained from The Sage Colleges IRB and the Department of Nursing. Also, a letter from the Chair of the Department of Nursing to conduct this study within the nursing department at The Sage Colleges (see Appendix I) and the Introduction Letter inviting Nursing Faculty to participate (see Appendix J) and the Invitation Letter to nursing students (see Appendix K) would be included in the IRB application. Both letters explain that the study would occur outside of scheduled classes and clinicals.

After IRB approval (see Appendix L), students would be informed about the purpose of the study, as well as its procedures, and invited to participate. Consent and participation would be voluntary. Confidentiality of the student participants' personal information, testing and survey responses would be maintained by utilizing (1) a Moodle course shell; (2) a numerical coding system; (3) a password encrypted private server protected with antiviral software; and (4) a virus-free flash drive secured by the researcher. Relevant details involving the steps to maintain confidentiality during data collection would be described later in this chapter.

Study Aim and Implementation Steps

This aim of this study was to develop a quality standard to facilitate medication

administration error detection, prevention, and reporting among pre-licensure nursing students. Implementation of this study required several steps: (1) development of an appropriate, reliable and valid medication administration checklist for student utilization; (2) development of a reliable and valid error-tracking instrument for faculty utilization; (3) development of reliable and valid Training PowerPoints for the use of the checklist and the error tracking instrument; (4) design and implementation of a pre-pilot assessment to assess the proposed methods; and (5) modification of the proposed methods based on the pre-pilot assessment results and implementation of the pilot study to assess nursing students' use of the medication administration checklist.

Conceptual Framework and Hypotheses

According to the hypotheses for this study, pre-licensure nursing students would, individually and collectively, commit fewer medication administration errors utilizing the checklist compared to not utilizing the checklist. Reason's (1990) Generic Error Modelling System (GEMS) integrates skilled, rule and knowledge-based errors and illustrates that error recovery may result from self-monitoring, consulting with others, and/or an external cue (see Chapter One, Figure 3.0). Therefore, to measure errors it was appropriate to integrate GEMS with both utilization of the C-MATCH-REASON checklist by pre-licensure nursing students and utilization of the Observation Form by nursing faculty. Reason's (1990) error theory would be the foundation for measuring error outcomes as evidenced by the number of: (1) errors reported (procedural learning); (2) rules correctly adhered to (procedural learning); (3) skill-based slips related to an embedded interruption (system-related active failure); (4) knowledge-based mistakes (clinical reasoning with external cue); and (5) confirmation

bias errors (clinical reasoning with external cue). For further illustration of errors measured see Table M (Appendix M).

Research Design

The quantitative methods to test the hypotheses included direct observation of pre-licensure nursing students by nursing faculty in a simulation environment using a 2x2 crossover design with two experimental groups (intervention and control) and two periods for both the pre-pilot assessment and the pilot study (see Figure 5.0). The

Figure 5.0

2x2 Crossover Design for Simulation Practice

	Period One - Scenario 1	**Period Two - Scenario 2**
Sequence AB	A (Checklist)	B (No Checklist)
Sequence BA	B (No Checklist)	A (Checklist)

crossover design would produce efficient comparisons because the same participants (subjects) would practice both conditions (Polit & Beck, 2004). Simulation is safe and appropriate to use for observation of the skill of medication administration (Henneman et al., 2010). The participants would be assigned to either crossover sequence, AB (checklist/no-checklist) or BA (no-checklist/checklist), for the simulation practice (see Figure 5.0). The two periods of the crossover design would be spaced about two weeks apart to allow for a washout period because a treatment carry-over effect may occur if intervention *A* (checklist) leads to more learning than control condition *B* [no-checklist] (Polit & Beck, 2004). However, learning would be a desired effect.

Therefore, data from the second period would be aggregated with data from the first period to enhance statistical power.

Pre-Pilot Assessment and Pilot Study

Pre-Pilot testing would help identify: (1) student acceptance (i.e. ease of use, readability, understanding) of the C-MATCH-REASON checklist intervention; (2) faculty acceptance (i.e. ease of use, readability, understanding) of the Observation Form; (3) potential implementation problems; and (4) assessment of validity and reliability of the instruments to detect errors. Thus, two essential purposes of the pre-pilot assessment would be: (1) for students to use the C-MATCH-REASON checklist and faculty to use the Observation Form to test the administration of medications as part of the simulation scenarios, and (2) to identify if the pre-pilot assessment demonstrated a need for study modification, otherwise the same procedures would be done in the pilot study. Recruitment for a pilot study would begin after the pre-pilot assessment was completed, data were analyzed, and study modifications were completed.

Study Population and Sample

The target population would include pre-licensure baccalaureate student nurses enrolled in selected 300 level and 400 level nursing courses in the Department of Nursing at The Sage Colleges, upstate New York. This population would be best fit to confirm the hypotheses based on their novice experience with oral medication administration (Benner, 2001a).

Sample Recruitment

Pre-licensure baccalaureate nursing students who: (1) practiced in a simulated

patient care environment; and (2) completed pharmacology content and concepts in nursing coursework (including previous demonstration of competency in the skill of medication administration) would be recruited for this study. This would be a convenient and voluntary invitation to participate. Exclusion criteria would include students enrolled in coursework taught by this researcher to prevent testing bias with the pre-pilot assessment, the pilot study, and the participants. Also, if significant modifications were necessary, then participants in the pre-pilot assessment would be excluded from the pilot study.

Cohen's (1988) power analysis method was used to determine the requisite size of the sample. The criteria for establishing the smallest number of participants included an effect size of 0.5; an Alpha significance level of 0.05; a paired sample type (two periods); and a two-sided alternative test. A power calculator, for paired samples t-test with the above values, identified desired power values of 0.80 for a paired sample size of 34 students, 0.86 for a sample of 40 students, and 0.93 for a paired sample size of 50 students (ANZMTG Statistical Decision Tree, 2018). About 180 nursing students, who met the recruitment criteria were enrolled in 300 level and 400 level courses for the 2018-2019 academic year. The goal would be to recruit about eight students for a pre-pilot assessment and about 40 students (20 participants in each sequence of AB and BA) for the pilot study. Paired data and repeated practice from the two periods of the crossover design would be used to test the hypotheses.

Study Implementation

For consistency, the same recruitment procedure was expected to be used for the pre-pilot assessment and the pilot study. After IRB approval was obtained, permission

to access nursing student and nursing faculty email addresses would be obtained from the Director of Nursing of The Sage Colleges. The goal would be to conduct the pre-pilot assessment during the fall of 2018 and the pilot study in the spring of 2019.

Student participants (subjects). Letters of introduction and invitation (see Appendix K) would be emailed to students in either 300 or 400 level courses who fit the inclusion criteria. The email would contain a *Recruitment PowerPoint* (see Appendix N) and a link to the Moodle course shell prepared for this study: *Dissertation Project-Medication Safety*. The online recruitment process for students to review the PowerPoint and submit a signed consent form was estimated to be ten-minutes. The recruitment presentation directed to potential student participants would include: (1) the study aim (as previously discussed in this proposal); (2) the voluntary nature of student participation, including the right to withdraw at any time without penalty; (3) an estimated two-hour and 10 minute commitment time that involves simulation practice; (4) permission to video record students participants during the simulation practice; (5) protection of confidentiality of students according to IRB standards. Study commitment time for students is explained, in detail, later in this chapter.

Students interested in enrolling would reply to the researcher via the Moodle page which would include the Informed Consent form, Demographic Data Survey (see Appendix O), the C-MATCH-REASON checklist, and the Training PowerPoint-SV. Students would utilize this Moodle page to: (1) submit any questions to the researcher privately before the onset of the study; (2) submit signed informed consent forms and completed demographic data surveys via a drop box; (3) view the Training PowerPoint and submit a post-training test; and (4) provide best contact information.

Also, the recruitment email would include a date and time for attending an (optional) in-person meeting with the researcher. The meeting would be held at the library on The Sage College Campus (Troy, NY) and would include a five-minute presentation of the Recruitment PowerPoint by the researcher followed by a period for answering questions (up to 10 minutes). Following the discussion, the researcher would leave the room. Students interested in participating in the study would sign an informed consent form (see Appendix K) and provide the best contact information on a separate form. A student volunteer would return the signed consent forms to the researcher who would be waiting in an adjacent classroom.

Nursing faculty raters. Nursing faculty (hereafter called raters) would volunteer to conduct simulation exercises which would involve the observation of student participants administering medication (with and without checklist utilization) along with tracking and tallying student error data by utilizing the Observation Form. A letter of introduction (see Appendix J), to encourage participation in this study, would be emailed to Nursing Faculty. Total study commitment time for faculty is explained later in this chapter.

Training PowerPoints

Student and faculty orientation, to the pilot study and the instrumentation, would be conducted using parallel versions of a Training PowerPoint to provide consistent education on application of the C-MATCH-REASON protocol. The students who submitted signed informed consent forms, via a drop box on the Moodle page, would be directed to complete Training PowerPoint-SV (see Appendix P). Also, a Moodle page would be created for training the raters. Upon agreement to participate in this study, a

link to the faculty Moodle page would be emailed to the raters. The Training PowerPoint-FV (Faculty Version) would be posted on this page (see Appendix Q).

Each slide of the Training PowerPoint would be narrated by this researcher and include discussion regarding patient safety; medication error awareness; safety checklists and error reduction; utilization of the C-MATCH-REASON checklist; and orientation to the simulation practice. The purpose of the Training PowerPoint-FV, developed from the student version, would be to orient nursing faculty on the use of both the C-MATCH-REASON checklist and the Observation Form. Therefore, the faculty version would include instructive slides for use of the Observation Form and a C-MATCH-REASON Lesson Plan (see Appendix H). Also, it was suggested in both Training PowerPoints that students and faculty take about 10-minutes to review earlier learned theory specific to each scenario (e.g. Lyme disease) and related medications (e.g. doxycycline) before the simulation practice. Finally, participants and nursing faculty would be asked to complete the same post-training test, described below.

Post-training test. The electronic submission of a single version of a five-question multiple-choice test would be used as evidence of the successful completion of both versions of the Training PowerPoint. Moodle would be used to create and deliver the post-training test. The results would be privacy protected by a password encrypted scoring system. Unlimited attempts would be permitted to obtain the minimum passing score of 80%. Completion time for the post-test was estimated to be three minutes. Total completion time for both the training and post-test was estimated to be 20-minutes. Upon completion of the pre-pilot assessment, the Training PowerPoints would be revised, as needed, before use with the pilot study.

Simulation Practice

Overview. Both the pre-pilot assessment and the pilot study would be conducted in a simulation environment. The Pre-Pilot would be comprised of an assessment of all aspects of the study implementation, including student debriefing and faculty feedback, to identify any potential areas that may need refinement, before conducting the pilot study. The participants would be randomly assigned to one of two crossover group sequences (AB or BA) and two 45-minutes appointments (periods one and two). As a result, every student participant would have an opportunity to utilize the checklist with medication administration.

Moreover, best practice standards for simulation include reflection and debriefing, methods that raise error awareness (Lioce et al., 2015). Therefore, as a part of the 45-minute simulation practice, for both periods, students would be allotted a minimum of 10-minutes to complete a ***Debriefing Questionnaire*** (see Appendix R). The rater and two members of the research team (dissertation committee members) would complete the ***Faculty Feedback Survey*** (see Appendix S). The primary focus of the feedback from this survey would be to identify any potential areas that may need refinement, before conducting the pilot study. The raters would complete the survey on the day of the simulation practice and the research team members would complete the survey after using the Observation Form with the video recorded data.

An ***Assistant/Greeter*** would be secured to assist with the simulation practice. The assistant/greeter would be scheduled, for each simulation practice, to facilitate the directional flow of the participants through the simulation environment, and to provide participants with their coded packets. A ***Videographer*** would record the participants.

In addition, a display monitor would be set up, in an adjacent room, for the researcher to remotely observe the live simulation practice. Participant roles as well as study commitment time are further described later in this chapter.

Pre-Pilot Assessment - Period One (proposed). Student participants (n = 8) and a rater (n = 1) would be scheduled to participate in simulation exercises that would be planned on two separate days (periods one and two). The simulation practice would be scheduled for 6.5 hours and Scenario One was utilized. The rater would observe each student participant administer medications and utilize the Observation Form to track error data. Each participant would be scheduled for a 45-minute simulation appointment which involves a faculty-student pre-briefing (five-minutes); medication administration (30-minutes); and student completion of the Debriefing Questionnaire (10-minutes). The participants randomly assigned to sequence AB (n = 4) would utilize the checklist with medication administration and those randomly assigned to sequence BA (n = 4) would administer medication without the checklist.

The videographer would record the medication administration practice of the student participants randomly assigned to both the first four appointments and sequence AB. Two members of the research team would be oriented to utilize the Observation Form to tally error data via the Training PowerPoint-FV and the accompanying instructions (see Appendix E). Next, the two research team members would utilize the Observation Form paired with the video recordings from the pre-pilot assessment to establish interrater reliability. The faculty instrument scores would replicate the degree to which protocol steps and the embedded errors were correctly addressed during the practice of medication administration to a simulation patient.

Changes, if needed, would be made to the C-MATCH-REASON checklist and the Observation Form immediately following the pre-pilot assessment.

Pre-pilot assessment - Period Two. Period Two would follow within two weeks of Period One. Only the participants assigned to sequence BA would utilize the checklist with medication administration. The process, as stated above, would be repeated except Scenario Two would be utilized and the participants would not be video recorded, unless recording issues arose in Period One. The role of the rater would be consistent with Period One.

From pre-pilot assessment to pilot study. Based on the findings from the pre-pilot assessment, refinements of the study design, including the scenarios, would be completed prior to conducting the pilot study. The raters (n = 6) would need to establish interrater reliability before participation in the simulation practice for the pilot study. The six raters would view the pre-pilot assessment video recordings to collect data on the Observation Form to establish interrater reliability among the group. Next, the simulation schedule would be adjusted to accommodate an estimated sample of 40 subjects and six raters. Also, for the pilot study, it was expected that the primary focus for both debriefing and feedback would be to identify student and faculty perspectives on the use of the measurement instruments and suggestions for refinement prior to further research.

Pilot study- Period One. It was expected that the simulation practice for the pilot study would be repeated, as stated above. With a sample of 40 participants (20 per sequence), every 45-minutes, four of the six raters would each be assigned to one of four simulated patient rooms to conduct Scenario One and observe a participant.

Also, based on feedback from the pre-pilot assessment, if more video data were needed, then the first four participants assigned to both sequence AB and the simulation room prepared by the videographer, would be recorded.

Pilot study- Period Two. Only the participants assigned to sequence BA would utilize the checklist. The process, as stated above, would be repeated except Scenario Two would be utilized.

Measurement Materials

Demographic Data Survey

A Demographic Data Survey (see Appendix Q) would be distributed to students along with the informed consent form. On a voluntary basis, demographic information would be gathered from participants including age, gender, race, primary language, current overall cumulative GPA, highest academic degree completed, current employment status (hours per week), and history of work experience with patient medication administration. These data would be summarized (see Table 4.2, Chapter Four) and used to compare participant groups in the crossover design.

C-MATCH-REASON Checklist and Observation Form

As described in chapter two, the C-MATCH-REASON checklist and the Observation Form were designed to detect medication administration errors. These instruments were developed based on an extensive literature review. Chunking and sequencing were used to organize subject matter. Both instruments contain 11 administration rights anchored in the mnemonic C-MATCH-REASON. The rights were further divided by steps to prompt clinical reasoning and error reporting.

Configuration of the C-MATCH-REASON checklist. The C-MATCH-REASON checklist, for student utilization, comprises four-columns (see Appendix D). The first column contains the 11 administration rights. The second column consists of bundles of sequential procedural steps listed next to the corresponding administration right. Reason (1990) suggested that error recovery may result from consulting with others and Murphy (2012) stressed that mentors run interference with student inexperience to prevent medication errors. Therefore, the C-MATCH-REASON checklist steps that involve problem-solving with an expert (knowledge-based procedure) were identified with asterisks. The asterisks serve as cues for the student to alert an expert (e.g. instructor, RN, PCP, pharmacist) of abnormal data/errors found and to prompt coordinated problem-solving in the form of clinical reasoning.

Columns three and four sorted the procedural steps related to preparing (column three) and administering (column four) medications (Potter et al., 2005; Westbrook et al., 2010). Both columns were configured with boxes for students to track errors found (F) and reported (R). Many of the procedural steps in column three were repeated in column four. The repetition was to prevent confirmation bias errors (White et al., 2010).

In addition, columns three and four were subdivided based on five *physical-cognitive* shifts that were rooted in the non-linear medication administration process (Potter et al., 2005). The five physical-cognitive shifts were illustrated in the checklist using the colors yellow (client area), green (medication area), and red a stop sign that would cue the user to shift to the Administer Column for step completion (see Appendix D). The stop sign was presented at the end of column three with the message, “After preparing all medications, continue at the top of the next column

(Client-Chart).” This message would facilitate the physical-cognitive shift. The section “Notation for Error Reporting,” located at the end of the checklist, would be utilized to clarify error occurrence, reporting, contributing factors, and patient harms.

C-MATCH-REASON Checklist instructions. The process of medication administration would involve the nursing student matching the MAR to the patient ID band and to the drug label, while questioning one checklist step at a time (clinical reasoning). Instructions for use of the C-MATCH-REASON checklist include:

1. Start at the top of the checklist where it states: **Obtain MAR**. Access the MAR in the **client area** to collect patient verification/assessment data. Complete the steps in the section “Client-Chart?” If an error is found, then report the error and mark the corresponding box in the Prepare 1st column with the letters F and R.
2. Move to the **medication area** with the MAR. Preparing one medication at a time, complete each step all the way through the “Amount?” section, unless an error is found. If an error is found, then report the error and mark the corresponding box in the Prepare 1st Column with the letters F and R, otherwise continue preparing the medication.
3. At the end of the “Amount?” section, a STOP sign will be reached. STOP. If there are more medications, then prepare each medication as instructed above in step two. If there are no other medications, then proceed to step four listed below.
4. When all medications are prepared to the point of the STOP sign, then follow the message, “Go to the top of the next column, Client-Chart Administer.”
5. At the **client area**, with the prepared medication and the MAR, start at the top of Column Four (Administer 2nd). Use the checklist to facilitate patient verification.
6. Shift back to the **medication area** and complete each checklist step in the Administer 2nd column, checking one prepared medication at a time. If an error is found, then report the error and mark the appropriate box with letters F and R.
7. If no errors are found, shift back to the **client area** and follow the remaining steps to safely administer the medication. Monitor the patient. Report and document outcomes and error occurrences.

Configuration of the Observation Form. The C-MATCH-REASON Error Tracking Instrument (Observation Form) was designed to accompany the C-MATCH-

REASON checklist. The Observation Form would be used by raters and the research team to track rule adherence, errors found, and errors reported among students.

The left half of the Observation Form is identical to the first two columns of the Checklist (e.g. the 11 rights and the bundled steps). The right half of the Observation Form contains seven columns for error tracking. These seven columns were divided among five categories: reasoning with rule adherence (columns one and two), errors found (column three), errors reported (columns four and five), skill-based errors (column six), and knowledge-based errors [column seven] (see Appendix E). Columns one through five would be utilized by the raters and the research team to track and tally error data related to student performance during the administration of medication. Column six (skill-based errors) and column seven (knowledge-based errors) would be for *Research Use Only* and would be explained below.

Observation Form Instructions. This form was designed to be used by both raters and the researcher. Instructions, with a completed example, accompany the form (see Appendix E). The raters would be trained to tally rule adherence, errors found, and errors reported as follows:

- The rule adherence score would be the sum of the tallies entered in columns one and two.
- If a step was partially completed, then circle the part of the step ***NOT*** completed if relevant to the scenario (e.g. adjust bed height), but do not enter a tally.
- Do not tally "rule adherence" for any medications that were administered in error.
- The errors found score would be the sum of the tallies entered in column three.
- The total close call errors reported would be the sum of tallies in column four
- The actual errors committed score would be the sum of tallies in column five.

Finally, the researcher would tally commission errors. Skill-based errors would

be tallied in column six. Knowledge-based errors would be tallied in column seven. The researcher would use the data entered on the Observation Form by the raters, to distinguish knowledge-based errors (e.g. clinical reasoning, confirmation bias) from rule-based errors (Kahneman, 2013; Mattox, 2012; Reason, 1990; 2002). The researcher would tally commission errors from the comments entered in the section "Notation for Error Reporting" on both the C-MATCH-REASON checklist and the Observation Form. The knowledge-based errors would be tallied if a step marked with an asterisk was not completed. Confirmation bias (identified as "CB") would be tallied in column seven, if one of the corresponding items in either column one or column two were skipped (e.g. not completing a repeated step or a "double check"). A rubric, discussed later in this chapter, would assist with establishing validity of faculty scores.

Establishing Validity and Reliability of the Instrumentation

Both the C-MATCH-REASON checklist and the Observation Form were proposed as evidence-based standards to facilitate medication error management. Specifically, the C-MATCH-REASON checklist and the Observation Form were designed to (1) track skill, rule, and knowledge-based medication administration errors by type (see Table M1, Appendix M); and (2) differentiate human errors from systemic failures, based on contributory factors documented on the instrumentation. Therefore, validity and reliability of the instruments needs to be established.

Content validity. A content validity survey was used to measure which elements of an instrument aptly represent knowledge of the content (Haynes, Richard, & Kubany, 1995). First, early in the research process, "The Content Validity Survey for MATCH and READ (Nine Rights for Medication Administration)" was developed

(see Appendix T). Next, registered nurses with five or more years of expertise with medication administration, were identified as subject matter experts (SMEs). The SMEs were asked to examine the proposed checklist for content validity and judge how well it could be operationalized to measure errors (Knapp, 1998). The survey was reviewed by nine SMEs with undergraduate and graduate level degrees in nursing and currently working in both the academic and clinical settings. Revisions were made based on the feedback and an outcome was the mnemonic C-MATCH-REASON with 11 administration rights. Two additional nurse experts, a pediatrician, a psychologist, a patient advocate, and research team members offered feedback, and the C-MATCH-REASON checklist and Observation Form were further revised (see Appendix T).

Interrater agreement. A finely produced video recording would be a highly regarded external instrument for measuring errors (Polit & Beck, 2004). Therefore, video recordings of the checklist group from the pre-pilot assessment would be used to test the accuracy and consistency of the research team and nursing faculty rater with the instruments and, subsequently, to train additional nursing faculty for the pilot study (Knapp, 1998). The scores would be compared to identify the degree of consistency between the recorded measurements and the simulation scenarios (Appendix U) accompanied by answer keys [see Appendix V] (Knapp, 1998). Also, two members of the research team would view video recorded data from the pilot study to further compare the degree of consistency between the recorded measurements.

Simulation Scenarios

Three novice-level acute care scenarios embedded with three medication errors were developed for this study (see Appendix U). Scenario One and Scenario Two

would be utilized. Scenario Three would be available as an alternative as needed. The scenarios were peer-reviewed. The scenarios were consistent with standards for medication administration (Lioce et al., 2015; Polit & Beck, 2004) and correspond to medication administration procedure taught to The Sage Colleges undergraduate nursing students.

To ensure consistency, the scenarios were accompanied by *Faculty Response Guidelines* (see Appendix W). Included in the guidelines was that the participants would be permitted to ask nursing faculty questions during the simulation practice. Next, both scenarios would require the recovery and reporting of three medication errors and the administration of two medications. Scenario answer keys were developed to facilitate scoring consistency and establishing interrater reliability. Each scenario answer key noted a *perfect score*. Perfect scores for medication administration for Scenario One (n = 78 steps) and Scenario Two (n = 73 steps) were close in range.

Scenario One involved a patient diagnosed with Lyme disease, dehydration, and atrial fibrillation. Scenario Two involved a patient diagnosed with pneumonia, hypertension, and pain. Both scenarios would include an embedded interruption in the form of a telephone ring sound. If the participant answered the phone, the rater would state, “it’s a wrong number.” The ring sound would occur after the participant obtained the first drug listed on the MAR.

Scoring Rubric

Using a scoring rubric, the data from each scenario would be totaled, resulting in a Global Medication Administration Total Error Score (see Appendix X). The rubric

would sort data into categories (skill, rule, knowledge, errors found, errors reported). Also, the rubric would differentiate positive tallies (points desired), based on accuracy with the delivery of one medication (37), from negative tallies (points not desired) based on errors (-38). Each additional medication delivered correctly would add only 20 more points because step redundancy would be minimized. Also, if errors embedded in the scenario were found, then less than 20 points would be added because the participants would be instructed to follow the checklist steps and stop the checking process at the point of error identification.

Debriefing Questionnaire

The four-question Debriefing Questionnaire (see Appendix R) was developed as a method to facilitate student reflection and obtain feedback related to the use of the C-MATCH-REASON checklist. The expectation was that the standardized checklist would provide scaffolding that would enhance development of clinical reasoning with protocol adherence. To explain, Dewey's (1966) inquiry-based learning (e.g. Do I have the right…?) was embedded in the checklist. Pre-licensure nursing students would need to apply reasoning to each of the checklist's 11 administration rights to manage errors (Marquard et al, 2011). As a result, clinical reasoning themes and student perception of the usefulness and effectiveness of the C-MATCH-REASON checklist (face validity) would be identified from the student responses to the Debriefing Questionnaire administered in the debriefing periods. The student responses would be used to assess the effectiveness of the checklist in medication error prevention and reporting and to confirm the validity of the Observation Form to measure errors consistently.

Procedures for Data Collection

Included within the Informed Consent would be an attestation that the student participants would maintain the confidentiality of the C-MATCH-REASON strategy, the simulation scenarios, and any outcomes by not sharing the study content information with other nursing students. After IRB approval and upon submitting the signed informed consent, participants would complete the Demographic Data Survey (see Appendix O). Completed surveys would be accepted via a drop box in the Moodle page or at the recruitment informational. The data would be summarized and used to compare the participant groups. The survey would take about two minutes to complete.

Random Assignment and Scheduling

Students (n = 8) who submitted signed informed consent forms, provided contact information, and completed the Training PowerPoint-SV post-test would be randomly selected to participate in the pre-pilot assessment. Using a random code generator, identification (ID) codes and a crossover sequence (AB or BA) would be assigned to student participants. For example, a student who returned a signed informed consent would be randomly assigned the ID code 291BA. Upon reaching the targeted sample size, the assigning of codes would stop. The student participants would receive their ID code and via Moodle messaging.

Prior to data collection, participant ID codes would be entered onto the following data collection documents: C-MATCH-REASON checklist, Observation Form, and the Debriefing Questionnaire. The coded documents would be assembled into packets to maintain confidentiality and accuracy when linking participants with

responses. Thus, maintenance of a single master tracking list would be needed due to the crossover design and data analysis involving same subject simulation error score comparisons over an extended period.

The researcher would coordinate the scheduling for the simulation activities by creating a schedule for both raters and participants (see Appendix Y). The raters would register for simulation practice via email. To ensure the integrity of the testing protocol, the researcher would schedule each student participant for an individual simulation practice appointment for each testing period. Participant ID codes would be used to schedule the appointments. The participants would receive simulation practice appointments via Moodle messaging.

Simulation

Flow of participants. For both studies, flow charts would be developed to communicate information regarding the expected flow of the participants (and the data collection forms) through this randomized experiment with a crossover design (see Figure Z1, Appendix Z) in a simulation environment (see Figures AA1 and AA2, Appendix AA). For the pre-pilot assessment, when a participant arrives at the simulation lab, the assistant/greeter would direct the student to sign-in using their pre-assigned ID code. Next, the assistant/greeter would match pre-coded data collection packets with each participant's ID code; distribute packets to the participants; and escort the participants to the waiting area.

The rater would ensure that the packet matches the participant ID code and then escort the participant from the waiting area to a simulated patient room. Each

appointment would involve a rater pre-briefing with a student participant (5-minutes); a student administering medication and the rater using the Observation Form to observe and score the error data (30-minutes). After a student participant completed the medication administration process, the rater would inform them of any error-related data. Next, the rater would collect the forms containing data (e.g. C-MATCH-REASON checklist, Observation Form, and the medication sheet); bring the forms to the assistant/greeter; and escort the participant to the debriefing room for completion of the Debriefing Questionnaire (see Appendix R). At this point, the rater would prepare for the next participant (5-minutes) and would have time for a break (5-minutes).

Poster boards would be available to create privacy areas in the debriefing room. The participants would submit the completed Debriefing Questionnaire to the assistant/greeter and use the ID code to sign-out. The assistant/greeter would attach each Debriefing Questionnaire to the data packet with a matching ID code and place each packet in a nearby locked box. The researcher would collect the contents of the locked box. Upon completion of the pre-pilot assessment, this process and the sample flow chart, may be revised, as needed for the pilot study.

Data Storage

Storage of hard copies. The master tracking list with student signatures and ID codes as well as study material containing ID codes and error data (e.g. Observation Form and the Debriefing Questionnaire) would be maintained in a locked cabinet, in the home of the researcher, when not in use by the research team. The researcher would have sole access to this cabinet. The master list and data maintained on hard copies would be destroyed with a crosscut paper shredder at the end of the study.

Storage of electronic data. Error data obtained from hard copies would be scored/stored using SPSS® software, error data obtained from digital video recordings would be stored on a flash drive, and post-training test scores, copies of the informed consents, and the demographic data surveys would be contained in the Moodle course shell. Therefore, to maintain confidentiality of all electronic data, a password encrypted private server protected with anti-viral software along with a virus free flash drive would be utilized. The flash drive would be secured in a locked file cabinet as stated above. In addition, a videographer who utilized encrypted equipment would be hired and sign a confidentiality statement according to current IRB protocol (see Appendix BB). Upon completion of the study, the *Office of Online Educational Support* at The Sage Colleges would be instructed to delete the Moodle page.

Study Commitment Time

Commitment time varies for the assistant/greeter, videographer, research team, student participants, and raters. The study commitment time is explained below.

Assistant/greeter. The assistant/greeter would attend every simulation practice day. Study commitment time for the for the pre-pilot assessment would be 6.5 hours per period or 13-hours for both periods. For the pilot study, commitment time would be about eight-hours per period or 16 hours for both periods. Total study commitment time for the assistant/greeter would be 29-hours.

Videographer. The study commitment time for the videographer would be about eight-hours for Period Two of the pre-pilot assessment. The estimate included set-up (two-hours), recording four participants (three-hours), clean-up (one-hour), and

editing (two-hours). Also, based on the findings of the pre-pilot assessment, the first four participants in Period One of the pilot study assigned to the checklist condition and the simulation room with video recording capability, may be recorded. As a result, a total study commitment time for the videographer would range from eight to 16 hours.

Student participants. It was estimated that participants would take 20-minutes to complete the Training PowerPoint-SV and 10-minutes to review theory prior to each simulation practice. Next, each student participant would complete the first-order medication administration and then would be reassigned to the opposite condition in Period Two. Each simulation appointment was set for 45-minute. The total commitment time would be about two-hours and 10-minutes per student (see Table 1).

Table 1

Study Commitment Time for Student Participants

	#	Training PowerPoint	Review Theory Scenario 1	Simulation Period 1	Review Theory Scenario 2	Simulation Period 2	Total
Student Participants	8	20 minutes	10 minutes	45 minutes	10 minutes	45 minutes	2 hours & 10 minutes per student

Research team, pre-pilot assessment. Upon completion of the video recording, two members of the research team would view about two-hours of the recorded data paired with the Observation Form to establish interrater reliability.

Rater, pre-pilot assessment. It was estimated that the rater (n = 1) for the pre-pilot assessment would take 20-minutes to complete the Training PowerPoint-FV and 10-minutes to review theory prior to each simulation practice. Next, the rater would be

scheduled for a 6.5-hour simulation period, twice, to observe eight student participants, each with a 45-minute appointment. As a result, the total pre-pilot assessment commitment time for one rater would be 13-hours and 40-minutes (see Table 2).

Table 2

Commitment Time for One Nursing Faculty Rater (Pre-Pilot Assessment)

	#	Training PowerPoint	Review Theory Scenario 1	Simulation Period 1	Review Theory Scenario 2	Simulation Period 2	Total
Nursing Faculty Rater	1	20 minutes	10 minutes	6.5 hours (includes 30-minute lunch)	10 minutes	6.5 hours (includes 30-minute lunch)	13 hours & 40 minutes

Raters-pilot study. It was expected that six nursing faculty would be scheduled to view video recordings from the pre-pilot assessment to establish interrater reliability and become raters for the pilot study (about two-hours). Next, the sample size of 40 students would require an estimated eight-hours of simulation time per period for two raters and about 3.75 hours of simulation time per period for the remaining four raters. At a given time, four raters would each be assigned to a simulation room and would test one participant at a time (45 minutes each) for a total of either five or ten student participants in Period One. For Period Two, the raters would follow the same process with the exception that they test different students and adhere to the AB and BA sequences to complete the crossover. Also, reflected in the total commitment time was 10 minutes to review the scenario. Therefore, depending on the schedule of each rater, the total commitment time would be either 10 hours (n = 4) or 18.75 hours [n = 2] (see Table 3). The combined time for six raters would be about 80 hours.

Table 3

Commitment Time for Six Nursing Faculty Raters (Pilot Study)

	#	Interrater Reliability	Training Power Point	Review Theory Scenario 1	Simulation Period 1	Review Theory Scenario 2	Simulation Period 2	Total
Nursing Faculty Raters	Six (6) faculty with a sample size of 40	2 hours	20 minutes	10 minutes	One day 8.0 hours (10 students/ faculty) or 3.75 hours (5 students/ faculty)	10 minutes	One day 8.0 hours (10 students/ faculty) or 3.75 hours (5 students/ faculty)	**80 hours for six Faculty:** ~18.75 hours each for two faculty; ~10 hours each for 4 faculty

Data Analysis

Variables of Interest

The aim of this study included determination of the extent to which medication administration errors would decrease with the use of the C-MATCH-REASON checklist, designed by this researcher. The independent variable was the utilization of the C-MATCH-REASON checklist. The dependent variable was medication administration errors. The errors would be sorted by type: errors committed (skill, rule, knowledge-based), recovered (close calls), and reported (close calls and commission errors).

Statistical Testing

The simulation practice would involve a crossover design with two periods to collect quantitative data, therefore the same students would be tested twice. Data from the pilot study would be analyzed for statistical significance. Rule-based adherence, errors found, and errors reported would be tracked and tallied on the Observation Form by nursing faculty. Upon completion, the researcher would review each Observation

Form, in conjunction with the Scenario Answer Keys and the Scoring Rubric and subsequently double check the tally summations. Next, the researcher would tally knowledge-based errors. The researcher would review the protocol steps and any incomplete double checks or incomplete steps marked with an asterisk would be scored as knowledge-based errors. Subsequently, the researcher would tally skill-based errors by reviewing comments related to the embedded interruption on both the Observation Form and the C-MATCH-REASON checklist. If the faculty and/or the student participant document that the interruption led to an error, then the researcher would tally a skill-based error. Lastly, the researcher would tally error reporting by reviewing the documentation on each Observation Form and Checklist.

The Observation Form data would be transferred to SPSS software V25.0 for cumulative scoring on an individual student basis. Next, medication administration errors committed, recovered, and reported based on the Observation Form, would be reported for a broad comparison of the means and medians of the experimental conditions. Since this is a pilot study, a small sample size is expected. Small samples often have population data without normal distribution. Therefore, a nonparametric rank sum test would be used, and data would be transferred to an ordinal scale. The rank sum test has several equivalent forms (Kachigan, 1986). For example, the Kruskal-Wallis test would be generated for independent samples (Breslow, 1970) and the Wilcoxin matched-pairs signed rank test would be used to compare data between periods [see Table 4] (Kachigan, 1986). Specifically, due to the crossover

Table 4

Hypotheses with Statistical Testing Techniques for Data Analysis

Hypothesis	Statistical Analysis	Statistical Hypothesis
Pre-licensure nursing students who utilize the C-MATCH-REASON checklist would report more medication errors in a simulated environment.	Comparison of the average number of *errors reported* between the two groups in Period One, using Independent Samples Kruskal-Wallis test.	H_0: $ErrorsReported_{Control} = ErrorsReported_{Checklist}$ H_A: $ErrorsReported_{Control} \neq Errors\ Reported_{Checklist}$
Pre-licensure nursing students who utilize the C-MATCH-REASON checklist would demonstrate greater rule adherence in a simulated environment.	Comparison of the average number of checklist *rules adhered to* between the two groups in Period One, using Independent Samples Kruskal-Wallis test.	H_0: $RuleAdherence_{Control} = RuleAdherence_{Checklist}$ H_A: $RuleAdherence_{Control} \neq RuleAdherence_{Checklist}$
Pre-licensure nursing students who utilize the C-MATCH-REASON checklist would commit fewer skill-based errors in a simulated environment.	No data to compare.	H_0: $SkillBasedErrors_{Control} = Errors\ SkillBasedErrors_{Checklist}$ H_A: $SkillBasedErrors_{Control} \neq Errors\ SkillBasedErrors_{Checklist}$
Pre-licensure nursing students who utilize the C-MATCH-REASON checklist would commit fewer knowledge-based errors in a simulated environment.	Comparison of the average number of *knowledge-based errors* between the two groups in Period One, using Independent Samples Kruskal-Wallis test.	H_0: $KnowledgeBasedErrors_{Control} = KnowledgeBasedErrors_{Checklist}$ H_A: $KnowledgeBasedErrors_{Control} \neq KnowledgeBasedErrors_{Checklist}$
Pre-licensure nursing students who utilize the C-MATCH-REASON checklist would commit fewer knowledge-based confirmation bias errors in a simulated environment.	Comparison of the average number of *confirmation bias errors* between the two groups in Period One, using Independent Samples Kruskal-Wallis test.	H_0: $ConfirmationBias_{Control} = ConfirmationBias_{Checklist}$ H_A: $ConfirmationBias_{Control} \neq ConfirmationBias_{Checklist}$
Pre-licensure nursing students who utilize the C-MATCH-REASON checklist would commit fewer errors in total in a simulated environment.	Comparison of the total number of skill, rule, and knowledge errors between/within the groups in both periods using both Independent Samples Kruskal-Wallis test and the Wilcoxin matched-pairs signed rank test.	H_0: $TotalErrors_{Control} = TotalErrors_{Checklist}$ H_A: $TotalErrors_{Control} \neq TotalErrors_{Checklist}$

NOTE: Frequencies, range of scores, medians, and means will be reported.

design, a treatment carry-over effect was expected (Lui, 2016). Thus, for hypotheses one through five, statistical analysis between the experimental groups (A: B) would be conducted, only, for Period One.

To test hypothesis six, Total Error data from Period One and Period Two would be paired for analysis. For example, the Wilcoxin matched-pairs signed rank test would be utilized for statistical comparison of the Total Errors of the checklist groups [A+A] (both periods combined) to the no-checklist groups [B+B] (both periods combined). The prediction being that the Total Errors would be lower in the checklist intervention (see Chapter Four, Figure 10 and Table 18). Next, the Kruskal-Wallis test would be generated for hypothesis six for statistical comparison of error data within the **no-checklist conditions** (B: B) to identify treatment carry-over effect (i.e. learning from the repeated simulation practice). The prediction being that the no-checklist condition (B) in Period Two would commit fewer errors than the no-checklist group (B) in Period One (see Chapter Four, Figure 11 and Table 19).

Moreover, SPSS ® V25.0 would be utilized to produce descriptive statistics that summarize data related to the identified demographic variables. Additional errors may be identified that this researcher did not foresee, and they would be considered. The administration rights category errors (11) would be sorted by frequency of occurrence from most to least. Validity and reliability testing of the measurement instrumentation would be assessed. Finally, themes identified from the students' reflective data would be noted on the Debriefing Questionnaire and would be analyzed and compared to the statistical findings to confirm validity of the instrumentation to consistently measure errors. Feedback themes would be discussed in further detail, in chapter five.

Study Limitations

The experimental design may hasten a Hawthorne effect because students received attention from being observed (Knapp, 1998). Therefore, faculty would be

discreet with scoring. The Sage Colleges Nursing Program is not large, so it may be difficult to maintain confidentiality of the subject matter. Also, the number of voluntary research participants recruited from this single program is limited; all participants would be nursing students which may limit generalizability of the method to transfer to licensed nurses; and simulation is great for control but not for generalizability (Knapp, 1998). In addition, there could be the possibility of instructor bias. Hence the importance of establishing the reliability of the faculty observations and coding. Although both raters have expertise with simulation utilization and both would be trained by the researcher, there may be unknown systematic bias that occurs when scoring observations. As a result, there could be recording errors.

Chapter Summary

The literature demonstrated that checklists are products of scientific study that enhance medical care by reducing errors (Gawande, 2009; Hales et al., 2007; Kahneman, 2013; White et al., 2010). Standardized protocols that demonstrate error reduction and error reporting with medication administration are needed in nursing (Henneman et al., 2014; Keers et al., 2014; Manias et al., 2005; Murphy, 2012; White et al., 2010). After using the new instrumentation (independent variable), the methods used to research the hypotheses addressing medication error identification (dependent variable) would include quantitative statistical analysis with a crossover design using simulation and two practice periods to enhance rigor, validity and reliability of data collection along with patient safety. Medication administration errors would be grouped and measured: rule-based errors; skill-based slips related to an embedded interruption (Reason, 1990); knowledge-based mistakes (Reason, 1990); knowledge-

based confirmation bias (Kahneman, 2013) and errors reported [close calls recovered and commission errors] (Henneman et al., 2010).

Statistical analysis of the independent, dependent, and demographic variables may provide significance for the use of a standardized medication administration checklist as a clinical reasoning cue to reduce medication administration errors as well as improve error recovery and reporting among nursing students. Clinical reasoning themes reported on the student reflection sheet that are consistent with notations on the checklists and error tracking instruments may reinforce the validity and reliability of both instruments to accurately track and report errors. Chapter four reports data identified from statistical analysis of the variables. The identified research hypotheses provide the guidance for quantitative analysis.

Chapter IV

The purpose of this experimental study was to investigate the use of a new checklist (i.e. the C-MATCH-REASON checklist) to reduce medication administration errors among pre-licensure baccalaureate nursing students. A 2x2 crossover design (see Figure 5.0, Chapter Three) within a simulated environment was utilized. Following informed consent, participants were randomly assigned to either crossover sequence, AB (checklist/no-checklist) or BA (no-checklist/checklist). A pre-pilot assessment was conducted first, and then followed by the Pilot Study. Reason's (1990) error theory (GEMS) was utilized for the conceptual framework and medication administration errors recovered, committed and reported were measured.

Implementation Overview

Presented first in this chapter were the study implementation steps and descriptions of the pre-pilot assessment and the pilot study with an explanation of how the data were collected. Next, the study results were reported with description of the variables and the statistical tests applied; each variable was detailed in a data dictionary (see appendix CC). Characteristics of the final sample population, the undergraduate nursing program associated with this study (The Sage Colleges), were illustrated. Each hypothesis was presented with an explanation of the statistical results.

Pre-Assessment Implementation: Validity of the Instruments

Content validity of the checklist. First, following an extensive literature review, the C-MATCH-REASON checklist was devised. Final items were included subsequent to a survey of professional colleagues to establish content validity (see Appendix T). In addition, the researcher's experience with practicing and teaching the skill of medication administration informed this process. Further, feedback was obtained from the Debriefing Questionnaire related to the use of the C-MATCH-REASON checklist among student participants. Clinical reasoning themes and student perception of the usefulness and effectiveness of the C-MATCH-REASON checklist (face validity) were identified from the responses and are detailed in Chapter Five.

Content validity of the simulation scenarios. Based on peer review, content validity of the scenarios was established, and the scenarios were judged to be of equal difficulty. A planned interruption was not included in either scenario for both the pre-pilot assessment and pilot study. Yet, most of the participants noted on the Debriefing

Questionnaire that the scenarios were realistic with the acute care hospital setting. The raters offered similar feedback, all of which, is presented in Chapter Five. Also, quantitative statistical analysis was conducted to evaluate whether scenario synthesis performance differed based on scenario (easiness) regardless of order. These results are presented later in this chapter as a part of the findings related to hypothesis six.

Validity of the Training PowerPoint via post-test. Second, the Training PowerPoints were posted on secure Moodle pages that were developed for this study. For both the pre-pilot assessment and the pilot study, student participants viewed the Training PowerPoint-SV to learn about the study and how to utilize the C-MATCH-REASON checklist. The raters viewed the Training PowerPoint-FV to learn about the study and how to utilize the Observation Form. The student participants and raters completed the same electronic post-test via a password encrypted Moodle page. All student participants and raters obtained the minimum passing score of 80% or higher, suggesting effectiveness of the Training PowerPoint's content.

Pre-pilot assessment with training video production. Third, upon completion of the Training PowerPoint, six nursing students were recruited for a pre-pilot assessment. Three of the six students participated (response rate is addressed later in this chapter). The three students agreed to be video recorded administering medication with and without the checklist in the simulation environment as one rater utilized the Observation Form to tally error data. As a result, a Training Video, comprised of six medication administration practice sessions was produced for use by the raters to establish interrater agreement among the raters.

Interrater agreement for the Observation Form. Fourth, the Observation

Form further applied Reason's (1990) error theory by containing columns for the raters to track errors by type. In the course of conducting the pre-pilot assessment it became evident that the participants, who were nursing students, could complete the medication administration without completing all 78 expected steps. As a result, interrater reliability formulas were not applicable. Instead, percent agreement was measured (McHugh, 2012). Interrater agreement, akin to reliability, was promoted using the specially produced training video whereby the study's raters practiced using the Observation Form after viewing the same video clip.

The process of establishing interrater agreement involved training each rater in the use of the protocol, the Observation Form, and the checklist. The first rater (rater one) was trained during pre-pilot assessment and was video recorded utilizing the Observation Form. The video recordings were utilized for training the second rater (rater two). The Observation Form scores were then compared to identify the degree of consistency between the recorded measurements and the simulation scenarios (Appendix U) accompanied by answer keys [see Appendix V] (Knapp, 1998).

Problematic items were identified (e.g. not checking the client's name independent of checking the DOB), further training was completed, and the percent of agreement between each rater and the trainer (the researcher) was computed. Interrater agreement was computed at 96.2% between the researcher and rater one following three training iterations. Interrater agreement was initially 44.40% between the researcher and rater two. Further training ensued and after four iterations the interrater agreement rose to 96.2%; and thus, rater two participated in the pilot study.

Finally, it was decided that before the pre-pilot assessment, if there was no

significant change to the instruments and/or the protocol, then data collected from the pre-pilot assessment could be aggregated with the data from the pilot study for final analysis. The pre-pilot assessment suggested minimal need to modify procedures and measurements, as outlined in Table 5.

Table 5

Checklist Items and Revisions based on the Pre-Pilot Assessment

Item October 2018	Revised December 2019	Rationale
Confirm medication reconciliation (MAR/client/family/interpreter): clarify drug duplication, omission, and need for discontinuation*	Medication reconciliation (MAR/client/family/interpreter): Clarify Adverse Drug Reactions. Check for drug duplication, omission, and need for discontinuation*	*Clarify Adverse Drug Reactions* was added to the *Client-Chart* section for greater accuracy with medication reconciliation.
Calculate right Amount/Rate (Pediatric doses mg/kg)	Calculate right amount and/or rate (pediatric doses mg/kg) * Calculate right amount and/or rate (calculate pediatric doses mg/kg) *	More concise wording More concise reminder to use mg/kg for pediatrics
Did an error lead to patient harm? Yes/No/Unknown. If an error occurred, then list the contributing factors:	List actual errors committed and contributing factors. Did error lead to patient harm? Yes/No/Unknown.	Delineate an area of the checklist for tracking errors of commission.

Subsequent research methods and data collection steps for the pre-pilot assessment and the pilot study are sequentially described below. Finally, the results of a single open-ended question that the raters addressed upon completion of the data collection will be reviewed at the end of this chapter.

Pre-Pilot Assessment

Rater Recruitment

First, a letter of invitation to participate in this study, the link to the Moodle page, and an incentive (entry into raffle) created for this study were distributed to nursing faculty via the college email system. In addition, announcements regarding study participation were made at faculty meetings. One nursing faculty member responded to the researcher, via email, and agreed to participate in the pre-pilot assessment. It was decided that if minimal changes were made to the procedures and protocol, this rater (rater one) would participate in the pilot study.

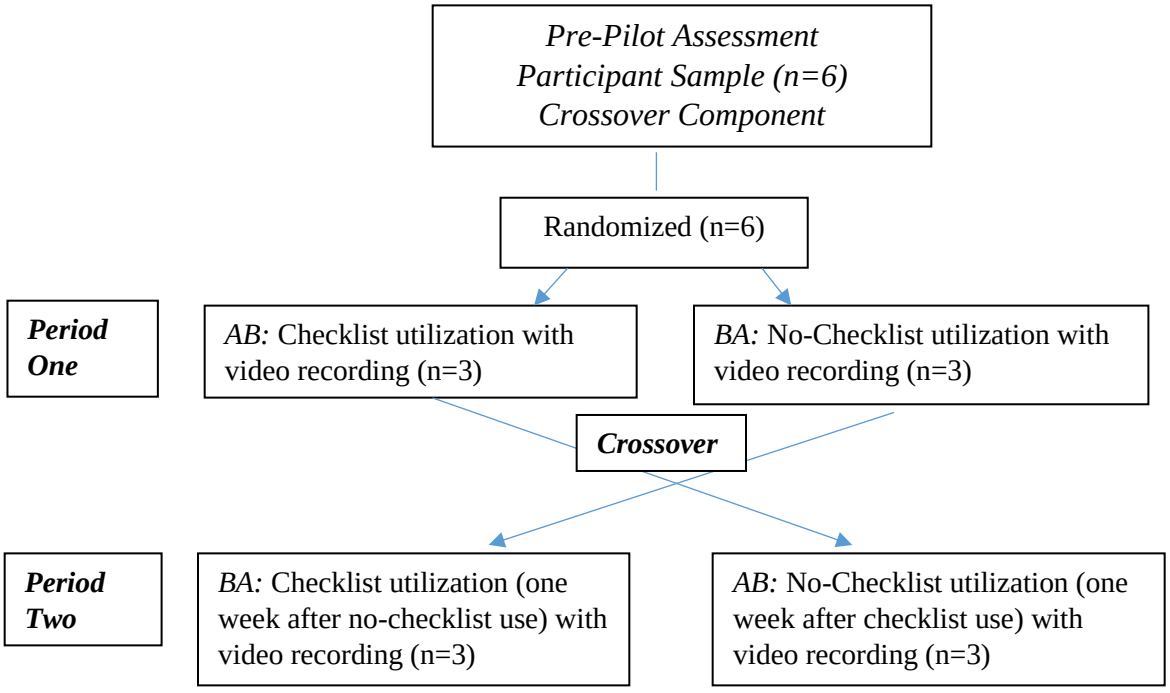
Study Sample

Participant recruitment. Three proposed methods were used to recruit nursing student participants: email, library informationals, and classroom visitations. A letter of introduction and the informed consent form were utilized as a script. Also, included in the email was the IRB approved incentive ($15 gift card) for participating. For the pre-pilot assessment, the participants were nursing students, enrolled as juniors or seniors in the baccalaureate level nursing program at The Sage Colleges, who met the inclusion criteria. An email was sent to about 100 junior and senior level nursing students and classes were visited by the researcher. Six students enrolled via a link (embedded in the email) to the study's Moodle page. No one attended the library informational.

Flow of participants. Next, the researcher organized the simulation environment with video recording. The flow of participants through the randomized experimental pre-pilot assessment with a crossover design is illustrated in Figure 6.0.

Figure 6.0

Sampling and Flow of Enrollees Through a Randomized Experimental Pre-Pilot Assessment with a 2x2 Crossover Design



Random assignment and coding. Prior to data collection, a random code generator was used to produce codes for establishing and maintaining participant anonymity. A crossover sequence (AB or BA) was applied to the generated code to form identification (ID) codes (e.g. JMSZ-76-AB). The first letter of each crossover sequence was coded for Period One and the second letter was coded for Period Two. The letter A indicated checklist utilization and B indicated no-checklist.

ID codes were entered onto the following data collection documents: C-MATCH-REASON checklist, Observation Form, MAR, and the Debriefing Questionnaire. The coded documents were assembled into a coded packet to maintain

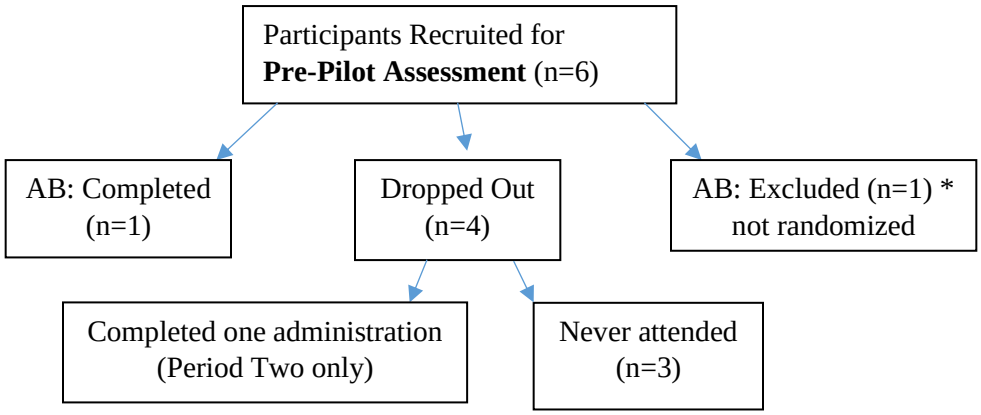
confidentiality and accuracy when linking participants with their responses. An ID Code was emailed to each participant upon scheduling their simulation session.

Scheduling. The researcher coordinated the scheduling for the simulation activities for both the participants and the rater (see Appendix Y). Email was utilized to identify availability dates for the rater, assistant/greeter, videographer and the simulation practice area. Next, to ensure the integrity of the testing protocol, the researcher used Moodle messaging to assist student participants with scheduling individual practice appointments for each testing period. Participants were offered dates/times and the schedule was created.

Response rate. Six students enrolled and three participated. Due to inclement weather, the simulation appointments fell on a Saturday and The Sage College is mostly a commuter college. These factors further contributed to the low response rate. After completion of the pre-pilot assessment, a decision was made by the researcher and members of the dissertation committee to exclude first semester juniors from participating in the pilot study due to limited practice with medication administration. Also, students actively being taught by the researcher were excluded from enrolling (n = 8). Further, it was established that if a participant only completed Period Two, then the data would be confounded by the crossover design. Consequently, a participant was excluded from the final analysis due to absence of data from Period One. A second participant was excluded due to checklist use in both periods to obtain additional video-recorded data [see * in Figure 7.0] (Gupta, 2011). The third participant met the inclusion criteria and these data were utilized in the final analysis of the pilot study. Figure 7.0 illustrates the actual crossover response for the pre-pilot assessment.

Figure 7.0

Actual Crossover Response - Pre-Pilot Assessment



Data Collection

Period One. The simulation practice was scheduled for 6.5 hours and Scenario One was utilized. Due to unforeseen circumstances (e.g. death in family, personal illness, dates changed due to inclement weather, and work-related conflict) only two of six enrollees participated in the simulation exercises for Period One. Neither participant remembered their ID Code, therefore, the Master List was utilized.

Each participant completed a 45 minute simulation appointment which involved a faculty-student pre-briefing (5 minutes); medication administration while being video recorded (25 minutes); and debriefing (5 minutes). Next, the rater inserted the coded forms containing data (e.g. Checklist, Observation Form, and MAR) back into the packet; brought the packet to the assistant/greeter; and escorted the participant to the debriefing room for completion of the Debriefing Questionnaire [10 minutes] (see Appendix R). While the participant completed the Debriefing Questionnaire, the rater prepared the simulation room for the next participant (5 minutes). Each participant

submitted the completed Debriefing Questionnaire to the assistant/greeter, who then inserted the form into the data packet with a matching ID code and placed each packet in a nearby locked box. Considering there was only one rater scheduled on a given day, there was no overlap of participants in the debriefing area. Following completion of the simulation, each participant received a $15 Amazon.com gift card.

Also, while the rater tracked error data, the researcher remotely observed the medication administration and completed the Observation Form to track error data. The completed forms were compared, item scoring was clarified, and interrater agreement was computed after each medication administration as discussed earlier in this chapter.

Of importance, the first participant in Period One of the pre-pilot assessment was randomly assigned to sequence AB and checklist utilization (A). However, the second participant was also assigned to sequence AB due to the need for more video recorded data with checklist utilization. Since validity and reliability of the instrument were being determined, the rater prompted each participant to utilize the checklist. Even so, the second participant stopped using the checklist during the simulation practice. The second participant agreed to be video recorded for a second time and the checklist was utilized throughout the medication administration. As a result, three video recordings were created during Period One.

Period Two. Period Two took place one week later with three participants. Video recording of the participants was conducted due to the need for more training material. The first participant, randomly assigned to sequence AB from Period One, crossed over to the no-checklist group. The second and third participant were assigned by the researcher in Period Two to utilize the checklist to obtain more video recorded

data. Collectively, the pre-pilot assessment produced a total of six training videos.

Standard Operating Procedures

Based on the findings from the pre-pilot assessment, refinements to the study design, including the scenarios, were completed prior to conducting the pilot study. Standard operating procedures were fine-tuned (see Appendix H) based on the feedback obtained from the rater, the participants, and the assistant/greeter. First, the need for greater consistency with tallying error data from one participant to the next was identified and minor revisions were made to the standard operating procedures (see Appendix H). Next, the standard operating procedures were edited to more clearly note that raters may prompt participants assigned to the checklist to use the checklist. Also, based on Sage's nursing curriculum, all participants were prompted to complete three checks for each administration right (i.e. preparing check, post-preparation check, and an administering check). Further, the need for detailed instructions to achieve consistency with conducting the simulation scenarios was noted. Thus, scenario guidelines for the raters were fine-tuned to assure consistent and valid participation with checklist use to limit confounding during the pilot study. Lastly, the assistant/greeter reported that the participants did not remember their study ID code. The coding system was modified for the pilot study and the revisions are explained later in this chapter.

Study Commitment Time (Pre-Pilot Assessment)

Commitment time varied for the assistant/greeter, videographer, research team, student participants, and raters as described below.

Assistant/greeter and videographer. The assistant/greeter attended both

simulation practices for the pre-pilot assessment, resulting in a study commitment time of 6.5 hours per period or 13 hours for both periods. The study commitment time for the videographer was ten-hours for Period One of the pre-pilot assessment. This included set-up (three-hours), recording two participants (three-hours), clean-up (two-hours), and editing (two-hours). Also, based on the Pre-Pilot findings from Period One, three participants in Period Two were video recorded. Fewer cameras were utilized. As a result, a total study commitment time for the videographer was eighteen hours.

Student participants. As projected in Chapter Three (see Table 2, p. 96), the total commitment time was about two-hours and 10 minutes per student participant. There was no mention of inaccuracies with the commitment time as projected on the participant Moodle page. As proposed, each simulation appointment was 45 minutes.

Rater (pre-pilot assessment). The rater (n = 1) completed the Training PowerPoint-FV in 20 minutes and spent 10 minutes reviewing theory prior to each simulation practice as proposed. Next, the rater was scheduled for a 6.5 hour simulation practice, twice, to observe participants with individual appointments. However, collaboration with the videographer added two hours to Period One. The total pre-pilot assessment commitment time for one rater was 15 hours and 40 minutes (see Table 6).

Table 6

Pre-Pilot Assessment Commitment Time for One Rater

	#	Training PowerPoint	Review Theory Scenario 1	Simulation Period 1	Review Theory Scenario 2	Simulation Period 2	Total
Nursing Faculty Rater	1	20 minutes	10 minutes	8.5 hours (includes ½ hr lunch, videography)	10 minutes	6.5 hours (includes ½ hr lunch, videography)	15 hours & 40 minutes

Upon completion of the pre-pilot assessment, modifications were completed, and the revised checklist was added to the Training PowerPoints, before use in the pilot study. The results of the pilot study relative to the six hypotheses will now be presented.

Pilot Study

Rater Recruitment

As previously discussed, minimal changes were made to the procedures and protocol therefore, the rater from the pre-pilot assessment (referred to as rater One) participated in the pilot study. Upon completion of the pre-pilot assessment, a second rater (rater Two) was recruited for the pilot study utilizing the same methods as stated above. Next, the simulation environment was modified to accommodate two raters, one assistant greeter, 18 participants, and two scenarios.

Study Sample

Recruitment. As discussed, the recruitment methods for the pre-pilot assessment did not produce a desired sample size. Thus, a request was sent to the IRB for an added incentive to increase participation in the pilot study. The IRB approved incentive was participant entry into a raffle to win a $100 Amazon.com gift card.

Next, at the start of the spring semester 2019, a letter of invitation (see Appendix K) was emailed to nursing students (n=178) in 300 or 400 level courses who fit the inclusion criteria for the pilot study. The email also included a date and time for attending an (optional) in-person meeting with the researcher. The informational was held in the library on The Sage Campus (Troy, NY). Six students responded to the email, but unfortunately, no one attended the meeting. Thus, the added incentive was

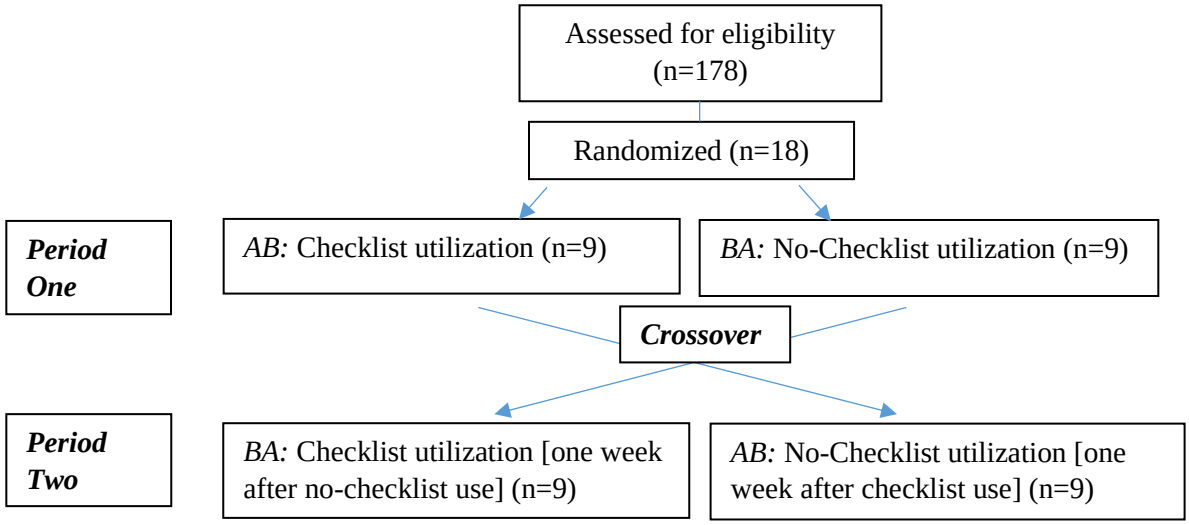
not strong enough to recruit 36 to 40 students to attend two simulation practice periods.

After discussing recruitment concerns with members of both the dissertation committee and The Sage Colleges undergraduate nursing faculty administrators, a new plan was agreed upon. Second semester seniors who participated in this study would fulfill an eight-hour professional day requirement. Despite a second email, study enrollment remained low. Thus, the IRB approved the distribution of two $15 gift cards to participants, one card for each practice period completed. Two weeks prior to spring break a third email was delivered and the researcher visited classrooms attended by second semester juniors. At the poster sessions during a specific class, the researcher met with about 60 junior-level nursing students in groups of six. The researcher distributed copies of the invitation letter, highlighted the new participation incentives, and answered student questions. Citrus fruit and chocolate candy were offered to students at this time. Interested students utilized the Moodle page to submit signed informed consent forms, complete demographic data surveys, post-training tests, and share their best contact information.

Flow of participants. The potential respondents (n=178) invited to participate in the study included second semester juniors (n=84), first semester seniors (n=18), and second semester seniors (n=76). Following the recruitment efforts, 18 students actually participated in the pilot study. Figure 8.0 illustrates the flow of the participants (n=18) through the study using a 2x2 crossover design with two experimental groups (AB and BA) and two practice periods (one and two).

Figure 8.0

Sampling and Participant Flow Through a Randomized Crossover Design Pilot Study



Response rate. Of 178 potential respondents, 18 nursing students who met the inclusion criteria participated in the pilot study. The response rate was 10.11%. The respondents (n =18) included second semester juniors (n =9) and second semester seniors (n =9). Every participant was randomly assigned to either crossover sequence (AB = 9; BA = 9) and completed two medication administrations. Also, one participant from the pre-pilot assessment was included in the final analysis. As a result, the final sample size was 19 participants with 10 for sequence AB and nine for sequence BA.

Scheduling. The pre-pilot assessment processes for reserving the simulation practice area and for scheduling the raters for the simulation observations were repeated, except each rater had several observation dates per period. Therefore, the participants had greater flexibility in scheduling practice appointments. Moreover, participant ability to reschedule appointments greatly improved the participant response rate. As a result, there were no participants lost to follow up for the pilot study.

Random assignment and coding. Next, instead of emailing ID Codes, the pilot study participants (n = 18) were randomly assigned coded packets (e.g. 075-AB or 051-BA) upon arrival to the simulation practice appointment. The assistant/greeter distributed the packets which were stacked by alternating the crossover sequences. The first participant who arrived for simulation practice received a packed coded AB from the top of the stack and then initialed an individualized coding form. Participants retained the ID code for both periods to ensure completion of the crossover design.

For Period Two, a second set of packets were prepared specific to Scenario Two. The new packets were a different color, but they were marked with ID codes that were identical to Period One. Each individual coding form was transferred to the new packet with the matching ID code. Furthermore, to ensure accuracy with packet return, each participant initialed the coding form upon leaving. This approach assured consistency with simulation error score comparisons over an extended period of time.

Data Collection

Period One. The simulation practice for the pilot study was repeated, as stated for the pre-pilot assessment, except with a larger sample size, two raters, and the intentional absence of videography. Simulation practice appointments spanned about two weeks to maximize participation. On a given day, a single rater conducted Scenario One and observed one participant at a time. Only the participants assigned to sequence AB used the checklist. Each participant was allotted 45 minutes to complete the simulation practice and the debriefing period. Also, it was expected that the primary focus of debriefing and feedback was to identify student and faculty perspectives on the use of the measurement instruments and suggestions for refinement

prior to further research.

Period Two. Period Two was initiated nine days after the first appointment in Period One, resulting in appointments being spaced seven to nine days apart. Period Two appointments with two raters spanned 11 days, maximizing participation. Only the participants assigned to sequence BA utilized the checklist. The process, as stated above, was repeated except Scenario Two was utilized with a different simulation room.

Scoring rubric. Scenario answer keys and the scoring rubric were used as a reference for consistency with error tallying. First, rule-based adherence, errors found, and errors reported were tracked and tallied on the Observation Form by the raters. Next, the researcher reviewed each Observation Form to total the errors. Counted among the knowledge-based error total score were protocol steps marked with an asterisk that were omitted, incomplete double checks (confirmation bias errors), and errors not reported. Skill-based errors were not observed. Validity and reliability testing of the measurement instrumentation were assessed. The scores were not prorated if a shortcut was applied (e.g. an error was found before expected based on the answer key). The researcher transferred the Observation Form data to SPSS® software V25.0 for cumulative scoring on an individual student basis.

Study Commitment Time (Pilot Study)

Assistant/greeter. The assistant/greeter attended every simulation practice day. For the pilot study, which spanned 2.5 weeks, the total study commitment time for the assistant/greeter was 34.5 hours.

Participants. The total commitment time for each participant in the pilot study

was two-hours and 10 minutes. None of the participants discussed inaccuracies with the commitment time as projected on the Moodle page and in Chapter Three.

Raters. The commitment hours for the two raters in the pilot study were consistent with the hours proposed in Chapter Three. The video recordings from the pre-pilot assessment were used for training the second rater and to establish interrater agreement. The sample size required 17 hours of simulation practice time, per period. On a given day, a single rater tested one participant at a time (45 minutes each). For Period One, rater one tested 10 participants and rater two tested eight participants. For Period Two, rater one tested 17 participants and rater two tested one (1) participant.

The same process was to be conducted for both periods with the exception that each rater observed different participants in Period Two as compared to Period One. However, rater one completed most of the testing. As a result, rater one observed bot same and different subjects across the periods. Of relevance, rater one tested the same subjects for both periods in the pre-pilot assessment and no issues were identified. The AB and BA sequences were followed to complete the crossover. The total commitment time was 27 hours for rater one and 9.5 hours for rater two (see Table 7).

Table 7

Pilot Study Commitment Time for Raters

	#	Interrater Reliability	Training Power Point	Review Theory Scenario 1	Simulation Period 1	Review Theory Scenario 2	Simulation Period 2	Total
Nursing Faculty Raters	Two faculty for Sample of 18	2 hours	20 minutes	10 minutes	5 half-days for a total of 17 hours	10 minutes	3 full days for a total of 17-hours	34-hours (plus 2 hours, 40 minutes training rater two)

Study Results

Data Analysis

SPSS ® V25.0 was utilized for all analyses related to the study. Non-parametric tests were conducted due to the small sample size (n = 19). First, demographic data and descriptive statistics are presented. The Chi square test was utilized to analyze the relationships between the nominal variables. Next, the study's findings are presented. GEMS (Reason, 1990) served as the conceptual framework and medication errors recovered, committed, and reported were measured. The median test, the Kruskal-Wallis test for independent samples, and the Wilcoxin matched-pairs signed ranks test were conducted with continuous outcome variables. To reduce the likelihood of Type I errors, the significance level was set where Alpha = 0.05. The Confidence Interval (CI) = 95%. The crossover groups were AB: BA (A = checklist; B = no-checklist).

Demographic Data Characteristics

This section describes the demographic data reported by the participants (n = 19). Included are employment experiences outside of nursing classes related to both the acute care clinical setting and medication administration. First, all participants (n = 19) identified English as their primary language, while 21% (n = 4) reported being born outside of the US. Regarding age, 79% (n = 15) were between the ages of 20 to 29 years old (AB = 80%; BA = 77.8%); 16% (n = 3) were between the ages of 30 to 39 years old (AB = 10%; BA = 22.2%); and 5.0% (n = 1) were between the ages of 40 to 49 years old (AB = 10%; BA = 0). Table 8 demonstrates these characteristics were comparably distributed between the two groups.

Table 8

Demographic Data for the Experimental Groups (AB: BA), N = 19

	Group AB		Group BA		Overall	
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**
Age						
20 to 29	8	80%	7	77.8%	15	79%
30 to 39	1	10%	2	22.2%	3	16%
40 to 49	1	10%	0	0%	1	5.0%
Overall GPA*						
A range (3.7 – 4.0)	2	20%	5	55.5%	7	37%
B range (3.2 – 3.69)	8	80%	4	44.4%	12	63%
Race{%}						
African American, Asian, Black	3	30%	2	22.2%	5	26%
Caucasian	7	70%	7	77.8%	14	74%
Country Origin{%}**						
USA	8	80%	7	77.8%	15	79%
Other	2	20%	2	22.2%	4	21%
Gender{1}						
Male	0	0%	1	11.1%	1	5.0%
Female	10	100%	8	88.9%	18	95%
Degree{%}						
High School	4	40%	6	66.7%	10	53%
Associate	1	10%	0	0%	1	5.0%
Baccalaureate	5	50%	3	33.3%	8	42%
NursingED{%}						
Jr2ndSemester	5	50%	6	66.7%	11	58%
Sr1stSemester	1	10%	0	0%	1	5.0%
Sr2ndSemester	4	40%	3	33.3%	7	37%
PHARM{%}						
Enrolled	1	10%	1	11.1%	2	11%
3 credits	6	60%	6	66.7%	12	63%
4+ credits	1	10%	0	0%	1	5.0%
Integrated	2	20%	2	22.2%	4	21%
WKHRS{%}						
None	3	30%	1	11.1%	4	21%
PT	6	60%	7	77.8%	13	68%
FT	1	10%	1	11.1%	2	11.%
HealthcareAcute{%}						
Yes	4	40%	5	55.6%	9	47%
None	6	60%	4	44.4%	10	53%
HealthcareMedicationAdmin{%}						
Yes	3	30%	3	33.3%	6	32%
No	7	70%	6	66.7%	13	68%

Note 1: Chi-square tests generated for nominal characteristics suggest that groups were similar.
Note 2: *Kruskal-Wallis test generated for overall GPA suggested that groups were similar.
Note 3: **All participants identified English as their primary language.

Education

Table 8 also demonstrates about half (53%) of all participants (AB = 40%; BA = 66.7%) reported that the highest degree held was a high school diploma; 42% held a baccalaureate degree (AB = 50%; BA = 33.3%); and one participant (AB) held an associate degree. The mean overall grade point average (GPA) for the sample (n= 19) was 3.573 (AB = 3.564; BA = 3.582). The Kruskal-Wallis test did not identify a relationship (p = 0.838) between the sequence groups (AB: BA) and overall GPA.

Regarding nursing program semesters completed, 58% (n = 11) of the participants were second semester juniors (AB = 5 or 50%; BA = 6 or 66.7%); 5.0% of the participants (n=1) were first semester seniors; and 37% (n = 7) of the participants were second semester seniors (AB = 4 or 40%; BA = 3 or 33.3%). The Pearson's Chi-Square test was conducted and differences between the sequence groups (AB: BA) and semesters completed were not suggested (p =.553).

Next, more than half (63%) of the participants for both groups (AB = 60%; BA = 66.7%) earned three credits in pharmacology. Of the remaining participants, 11% were enrolled in a pharmacology course (AB = 10%; BA = 11.1%); 5.0% had 4 or more credits (AB = 1); and 21% were seniors (n = 4) who had pharmacology integrated into nursing courses (AB = 20%; BA = 22.2%). The four seniors did not have the option to take pharmacology course NSG 345, but they satisfied this study's pharmacology requirement via a curriculum with pharmacology content integrated within courses.

Work Experience in Healthcare

Work experience was approximately distributed between the groups. Most

(79%) of the participants (AB = 70%; BA = 89%) worked outside of class. More specifically, 15 participants reported work experience in healthcare and nine (9) or 47% (AB = 40%; BA = 55.6%) reported working in the acute care setting of a hospital. Two participants reported working in both the acute and non-acute healthcare settings. Acute Care was defined as employment in a hospital including certified nurse's aide [C.N.A] (n = 4); patient care technician [PCT](n = 2); emergency department technician who doubled as an emergency medical technician-paramedic [EMT-P] (n = 1); and patient care assistant (PCA) on an intensive care unit (n = 1).

Clinical experience (community). Eight (8) participants reported employment with patients in the community. Participants who reported administering medications included: EMT-P (n = 1); EMT-Basic (n = 1); licensed practical nurse-homecare (LPN) (n = 1); caretaker of the intellectually disabled (n = 1); employee at a group home (n = 2); and Resident Assistant (RA) in a geriatric center (n = 2). As a result, one third of the participants (AB = 30%; BA = 33.3%) reported work experience with medication administration. Noteworthy, one EMT noted experience only with injectable vaccines. The homecare LPN reported administering medications orally and through a gastrostomy tube.

Summary of Respondent Characteristics

Most (79%) participants were in the age range of 20 to 29. Almost all participants (95%) reported being female gender and 100% reported English as their primary language. Statistical analyses among the variables identified above, suggested both the categorical and continuous variables were comparably distributed between the two groups.

Statistical Testing

The data from the current pilot study were analyzed for statistical significance in the manner mentioned above for all six hypotheses. First, the data collected from the Observation Forms were analyzed for broad comparison of the means and medians of the experimental conditions. Due to a small sample size (n = 19) and the data not being normally distributed, the nonparametric rank sum test was used following transformation to an ordinal scale. More specifically, the Kruskal-Wallis test was generated for independent samples (Breslow, 1970) within Period One, whereas the Wilcoxin matched-pairs signed rank test was used to compare aggregated data from both periods (Kachigan, 1986). Paired data and repeated practice from the two crossover periods were only used to test hypothesis six. Subsequently, analysis was conducted to identify a treatment carry-over effect (e.g. learning) with the results presented in hypothesis six.

Hypothesis One Results

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would report more medication errors in a simulated environment.

For Period One, *error reporting* was composed of four analyses which included comparing the checklist intervention (A) to the no-checklist control condition (B) for (1) embedded errors found; (2) embedded errors committed; (3) embedded errors found/reported; and (4) Total Errors Reported (found/reported + committed/reported). Scenario One contained three embedded errors for each participant to recover and

report. Thus, in Period One, the maximum scores for embedded errors found for each experimental group were: 30 for AB (n = 10); and 27 for BA (n = 9). Likewise, the maximum scores for embedded errors committed for each group were: 30 for AB (n = 10); and 27 for BA (n = 9). However, the maximum scores for embedded errors reported for each group were dependent upon the number of errors found: 23 for AB; and 12 for BA. Table 9 (embedded errors found), Table 10 (embedded errors committed), and Table 11 (embedded errors found/reported) each illustrate the number of participants (n), the frequency of errors (0, 1, 2, 3) per the number of participant errors within each group, and each groups' total error score.

For the first two analyses, from within sequences (AB: BA), the mean and median of the checklist (A) and no-checklist (B) groups were compared to identify differences in embedded errors found (see Table 9) and embedded errors committed (see Table 10). The Kruskal-Wallis Test for independent samples failed to reject the null hypothesis ($p > .05$) for both embedded errors found ($p = 0.061$) and embedded errors committed ($p = 0.061$). As a result, for Period One, there was neither a relationship with embedded errors found nor embedded errors committed between the checklist intervention and the no-checklist control condition. Also, the identical findings ($p = 0.061$) suggest that embedded errors found, and embedded errors committed were reciprocal (i.e. if an error was found, then it was not committed) which is consistent with the scoring rubric (see Appendix X).

Table 9

Frequency, Mean, and Median of Number of Embedded Errors Found (EEF) by Experimental Group (A: B) for Period One

Experimental Group	n	Number of EEF Per Participant (0 - 3)				Group Total	Mean	Median
		0	1	2	3			
A	10	0	3	1	6	23 of 30	2.3	3
B	9	2	4	1	2	12 of 27	1.33	1

Table 10

Frequency, Mean, and Median of Number of Embedded Errors Committed (EEC) by Experimental Group (A: B) for Period One

Experimental Group	n	Number of EEC Per Participant (0 - 3)				Group Total	Mean	Median
		0	1	2	3			
A	10	6	1	3	0	7 of 30	0.7	0
B	9	2	1	4	2	15 of 27	1.67	2

For the third analysis, embedded errors found were combined with embedded errors reported within each experimental group to identify differences in error reporting between the checklist group and the no-checklist group. For Period One, the checklist group (A) found/reported 18 of the 23 embedded errors found. The no-checklist group (B) found/reported 11 of 12 embedded errors found (see Table 11). Thus, error reporting was not reciprocal with error recovery. Means and medians were compared (see Table 11). Finally, the Kruskal-Wallis Test (two-sided) for independent samples failed to reject the null hypothesis where $p = 0.144$. The checklist group did not find/report more errors than the no-checklist group.

Table 11

Frequency, Mean, and Median of Number of Embedded Errors Found/Reported by Experimental Group (A: B) for Period One

Experimental Group	n	Number of Embedded Errors Found/Reported				Group Total	Mean	Median
		0	1	2	3			
A	10	1	3	3	3	18 of 23	1.8	2
B	9	2	3	1	2	11 of 12	1.38	1

Next, Table 12 illustrates the findings for embedded errors committed/reported. While there were eight participants who did not have errors to report because they did not commit errors, neither group reported embedded errors committed. Table 12 includes the number of participants per group (n), the frequency of errors committed/reported (0/0, 1/1, 2/2, 3/3) per the number of participant errors within each group; and each groups' total error reporting score. The frequencies for embedded errors committed and embedded errors reported were presented side-by-side to detail: (1) incidences in which errors were not committed (e.g. **6**/0); and (2) that none of the commission errors were reported (e.g. 4/**0**).

Table 12

Frequency and Median of Number of Embedded Errors Committed/Reported by Experimental Group (A: B) for Period One

Experimental Group	n	Number of Embedded Errors Committed/Reported				Total Errors Reported	Median
		0/0	1/1	2/2	3/3		
A	10	6/0	1/0	3/0	0/0	0 out of 7	0
B	9	2/0	1/0	4/0	2/0	0 out of 15	0

For the fourth analysis, the data from each experimental group for errors found/reported were combined with the data for errors committed/reported. The medians were compared to identify statistical differences in Total Error Reporting (see Tables 11, 12). The Kruskal-Wallis Test (two-sided) did not suggest a relationship between checklist use and Total Error Reporting ($p = 0.254$) for Period One.

Hypothesis Two Results

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would demonstrate greater rule adherence in a simulated environment.

Medication administration is a rule-based process (Henneman, et al 2010). As noted in the data dictionary (see Appendix CC), *rule adherence* was defined as rule-based steps + knowledge-based steps + confirmation bias steps + embedded errors found + embedded errors reported. For Period One, Scenario One was applied and the maximum score for rule adherence was 78 (see Appendix X). More specifically, Scenario One contained 78 steps (rules) for completion by one participant, totaling 1,482 steps (rules) for the entire sample (n = 19). Participant scores ranged from 10 to 76 (see Table 13). The median and mean of the experimental groups (A: B) were compared to detect differences in rule adherence. Table 13 details that the checklist group (n = 10) completed 605 of 780 steps (mean = 60.5), whereas the no-checklist group (n = 9) completed 356 of 702 steps (mean = 39.5).

Next, statistical significance was suggested with both the Fisher Exact Test (2-sided) where $p = 0.005$ ($p < 0.05$) and the Kruskal-Wallis Test for independent samples

(2-sided) where $p = 0.005$ ($p < 0.05$). Both findings reject the null hypothesis and suggest that, in Period One, the participants who utilized the checklist (A) demonstrated greater rule adherence than those who didn't utilize the checklist (B). The findings were consistent with Gawande (2009), Hales and Pronovost (2006), Henneman et al. (2014), van Klei et al. (2012), and White et al. (2010) whose research, involving patient safety in the acute care setting, suggested that checklists promote rule adherence.

Table 13

Frequency, Range of Scores, Mean and Median for Rule Adherence by Experimental Group (A: B) for Period One

Experimental Group	n	Range of Scores for Rule Adherence			Total	Mean	Median
		10 - 35	36 - 56	57 -76			
A	10	1	2	7	605	60.5	62
B	9	2	6	1	356	39.5	46

Hypothesis Three Results

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer skill-based errors in a simulated environment.

While originally planned for inclusion, due to the complexity of the pre-assessment and video recording processes, no distraction was embedded in the scenarios. As a result, there was no data to assess this hypothesis, but should be included in future simulations.

Hypothesis Four Results

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer knowledge-based errors in a simulated environment.

Total Knowledge-based Errors were comprised of four parts: (1) knowledge-based errors involving the checklist steps identified with an asterisk that were omitted or completed incorrectly; (2) confirmation bias errors which included checklist steps that needed to be double checked but were not (errors were tallied if one of the corresponding checklist steps in, either, the prepare or administer columns were skipped); (3) embedded errors committed, and (4) embedded errors not reported. As a result, *Hypothesis Four* included a two-part statistical analysis: (1) knowledge-based errors and (2) Total Knowledge Errors (the errors from the four parts combined).

Scenario One contained 22 knowledge-based steps for completion by one participant, totaling 418 steps for the entire sample (n = 19). The mean and median of the experimental groups (A: B) were compared (pairwise) to identify differences in knowledge-based errors for Period One. Table 14 illustrates that the checklist group (n = 10) incorrectly completed or omitted 69 of 229 knowledge-based steps (mean = 6.9), whereas the no-checklist group (n = 9) incorrectly completed or omitted 128 of 198 knowledge-based steps (mean = 14.2). Statistical significance was detected for knowledge-based errors with the Fisher Exact Test (two-sided) where $p = 0.005$ ($p < .05$) and the Kruskal-Wallis Test for independent samples (2-sided) where $p = 0.010$. The data supported the rejection of the null hypothesis. Thus, in Period One, the participants who utilized the checklist (A) committed fewer knowledge-based errors

than those who did not utilize the checklist (B).

Table 14

Frequency, Range of Scores, Mean and Median for Knowledge-based Errors by Experimental Group (A: B) for Period One

Experimental Group	n	Range of Scores for knowledge-based errors			Total Errors	Mean	Median
		0 - 6	7 - 14	15 - 25			
A	10	5	4	1	69	6.9	7
B	9	1	5	3	128	14.2	13

Second, the mean and median of the experimental groups (A: B) were compared (pairwise) to identify differences in the Total Knowledge Error score for Period One (see Table 15). Statistical significance was identified with both the Fisher Exact Test (two-sided) where $p = 0.001$ ($p < .05$) and the Kruskal-Wallis Test for independent samples (two-sided) where $p = 0.011$ ($p < .05$). The data supported the rejection of the null hypothesis. Thus, in Period One, the participants who used the checklist (A) committed fewer Total Knowledge Errors than those who did not use the checklist (B).

Table 15

Frequency, Range of Scores, Mean and Median for Total Knowledge Errors by Experimental Group (A: B) for Period One

Experimental Group	n	Range of Scores for Total Knowledge Errors			Total Errors	Mean	Median
		0 - 10	11 - 26	27 - 41			
A	10	5	4	1	131	13.1	11
B	9	1	2	6	247	27.4	28

Hypothesis Five Results

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer knowledge-based confirmation bias errors in a simulated environment.

Confirmation bias errors were tallied if one of the corresponding checklist steps in either the prepare or administer columns were skipped (i.e. not completing a repeated checklist step or a "double check"). For Period One, Scenario One was applied and the rubric (see Appendix X) identified 16 steps per participant that could be tallied as confirmation bias errors, totaling 304 steps for the entire sample (n = 19). The mean and median of the two experimental groups (A: B) were compared (pairwise) to identify differences (see Table 16). The results included that the checklist group (n = 10) skipped 51 of 160 double checks (mean = 5.1). The no-checklist group (n = 9) skipped 103 of 144 double checks (mean = 11.4).

Next, statistical significance was detected with both the Fisher Exact Test (two-sided) where $p = 0.005$ and the Kruskal-Wallis Test (two-sided) for independent samples where $p = 0.014$. The findings reject the null hypothesis and suggest that checklist utilization facilitated the double checking of steps, limiting confirmation bias errors with medication administration. For Period One, the participants who utilized the checklist (A) committed fewer knowledge-based confirmation bias errors than those who did not utilize the checklist (B).

Table 16

Frequency, Range of Scores, Mean, and Median for Confirmation Bias Errors by Experimental Group (A: B) for Period One

Experimental Group	n	Range of Scores for Confirmation Bias Errors			Total	Mean	Median
		1 - 5	6 to 11	12 - 16			
A	10	6	3	1	51	5.1	3
B	9	2	1	6	103	11.4	13

Hypothesis Six Results

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer errors in total in a simulated environment.

For hypothesis six, Total Errors for both crossover sequence groups (AB: BA) were analyzed between and within the two periods. Total Errors were defined as: Embedded Errors Committed + Embedded Errors Not Reported + Rule-based Errors + Knowledge-based Errors + Confirmation Bias Errors (see Appendix CC).

Statistical analyses were organized into four separate analyses for Total Errors committed: (1) compare the checklist group (A) to the no-checklist group (B) for Period One only; (2) compare the combined checklist groups from Period One and Period Two (A + A) to the combined no-checklist groups from Period One and Period Two (B + B); (3) compare the no-checklist control condition in Period One (B) to the no-checklist control condition in Period Two (B); and (4) compare the combined experimental groups in Period One (A + B) to the combined experimental groups in Period Two (A +

B). Each analysis is illustrated (see Figures 9 – 12) and nonparametric statistical tests were generated because the data were not normally distributed. Of importance, for a sample size of 19, Scenario One contained 1,501 potential errors whereas, Scenario Two contained 1,406 potential errors. While, Scenario One contained 95 more potential errors in total, it was established that the scenarios were of equal difficulty.

Analysis one. For the first analysis, statistical tests were conducted to detect differences in Total Errors for Period One only (see Figure 9.0). Scenario One was utilized. The mean and median of the experimental groups (A: B) were compared (see Table 17). The results identified that the checklist group (n = 10) incorrectly completed or omitted 200 of 790 steps (mean = 20; median 18), whereas the no-checklist group (n = 9) incorrectly completed or omitted 379 of 711 steps (mean = 42.1; median 40). Statistical significance was noted ($p < .05$) with the Fisher Exact Test (2-sided) where $p = 0.023$ and the Kruskal-Wallis Test for independent samples (2-sided) where $p = 0.010$. Both findings reject the null hypothesis and suggest that, in Period One, the participants who utilized the checklist (A) committed fewer errors in total than those who did not use the checklist (B).

Figure 9.0

Comparison of Total Errors by Experimental Group (A: B) in Period One Only [*p*=.010]

	Sequence AB	Sequence BA
Period One (A, B)	Group A (Checklist) 200/1,501 Total Errors	Group B (No-Checklist) 379/1,501 Total Errors

Table 17

Frequency, Range of Scores, Mean, and Median of Total Errors by Experimental Group (A: B) Period One

Experimental Group	n	Range of Scores for Total Errors				Total	Mean	Median
		0 - 18	19 - 38	39 - 58	59 - 77			
A	10	5	4	1	0	200	20	18
B	9	1	3	3	2	379	42.1	40

Analysis two. For the second analysis, error data from both Scenario One and Scenario Two were combined and resulted in a maximum Total Error Score of 2,907 (see Appendix X). Next, the Total Error data from the Period One and Period Two checklist groups (A + A) were combined and compared to the combined Total Error data from the Period One and Period Two no-checklist groups [B + B] (see Figure 10.0). The medians of the crossover sequence data (A + A: B + B) were compared to detect differences in Total Errors. Table 18 identifies that the checklist group (A + A) incorrectly completed or omitted 359 of 2,907 steps (mean = 18.9; median = 16), whereas the no-checklist control condition (B + B) incorrectly completed or omitted 570 of 2907 steps (mean = 30; median = 26.5). The Wilcoxin matched-pairs signed rank test was conducted and statistical significance (2-tailed) was suggested where p = 0.023. The data supported the rejection of the null hypothesis. Thus, the participants who utilized the checklist (A = 19) committed fewer errors in total than those who did not utilize the checklist (B = 19).

Figure 10.0

Comparison of Total Errors by Experimental Group (A+A: B+B) Periods Combined [*p* = 0.23]

	Sequence AB	Sequence BA
Period One (A, B)	**Group A (Checklist) 200 Total Errors**	Group B (No-Checklist) 379 Total Errors
Period Two (B, A)	Group B (No-Checklist) 191 Total Errors	**Group A (Checklist) 159 Total Errors**

Table 18

Frequency, Range of Scores, Mean, and Median of Total Errors by Experimental Group Periods Combined (A+A: B+B)

Periods Combined	n	Range of Scores for Total Errors				Total	Mean	Median
		0 - 18	19 - 38	39 - 58	59 - 77			
A Groups	19	12	5	2	0	359	18.9	16
B Groups	19	6	8	3	2	570	30	26.5

Analysis three. The third analysis involved comparing the control groups (B:B) for Total Errors from (see Figure 11.0) and was conducted to identify a treatment Carry-over effect (i.e. learning) due to the crossover design. From within the crossover sequences (A**B**: **B**A), the medians of the no-checklist control groups were compared (pairwise) to identify differences in Total Errors from Period One to Period Two (see Table 19). The results suggested that, in Period One, the no-checklist group (n = 9) committed 379 out of 1501 Total Errors (mean = 42.1; median = 40), whereas, in Period Two, the no-checklist group (n= 10) committed 191 out of 1,406 Total Errors (mean = 19.1; median = 19).

Statistical significance was identified with both the Fisher Exact Test (2-sided) where $p = 0.023$ and the Kruskal-Wallis Test for independent samples (2-sided) where $p = .007$. The data supported the rejection of the null hypothesis. Thus, the no-checklist group in Period Two committed fewer errors in total than the no-checklist group in Period One. The outcomes also suggest that learning occurred from the repeated practice.

Figure 11.0

Total Errors Experimental Group B (No-Checklist) Periods One: Two [*p* = .007]

	Sequence AB	**Sequence BA**
Period One (A, **B)**	*Group A*	**Group B** (No-Checklist) 379 Total Errors
Period Two (B, A**)**	**Group B** (No-Checklist) 191 Total Errors	*Group A*

Table 19

Frequency, Range of Scores, Mean, and Median of Total Errors by the No-Checklist Groups (B) Period One: Period Two

Group B	**n**	**Range of Scores for Total Errors**				**Total**	**Mean**	**Median**
		0 - 18	19 - 38	39 - 58	59 - 77			
Period One (Group B)	9	1	3	3	2	379	42.1	40
Period Two (Group B)	10	5	5	0	0	191	19.1	19

Analysis four. For the fourth analysis, Figure 12.0 shows how the Total Error data from both experimental groups were combined (200 + 379 = 579) and then

compared to the Total Error data from both Period Two experimental groups (191 + 159 = 350). Aggregating the experimental groups to compare periods increased the size of each group to 19 and increased the overall sample size (n = 38).

Figure 12.0

Total Errors Period One: Period Two (*p* = .021)

	Sequence AB	Sequence BA
Period One (A, B)	**Group A (Checklist) 200 Total Errors**	**Group B (No-Checklist) 379 Total Errors**
Period Two (B, A)	Group B (No-Checklist) 191 Total Errors	Group A (Checklist) 159 Total Errors

The means and medians were compared (see Table 20). The Wilcoxin matched-pairs signed rank test (two-tailed) was conducted and statistically significant differences were detected in Total Errors between periods ($p = 0.021$). The results indicated that *fewer* Total Errors were committed in Period Two (350 out of 1406) as compared to Period One (579 out of 1501).

Moreover, Table 20 demonstrates that Total Errors were similar for crossover sequence AB from Period One (checklist) to Period Two (no-checklist). However, Total Errors decreased by more than 50% for crossover sequence BA from Period One (no-checklist) to Period Two (checklist). Error reduction offers evidence that: (1) practice across two time periods produced a desired carry-over effect, learning; and (2) as both scenarios were of equal difficulty, their sequence did not bias the participant's performance. Feedback from both participants and raters supports the above findings. Further discussion follows in Chapter Five.

Table 20

Frequencies, Range of Scores, Mean, and Median of Total Errors Period One (A+B): Period Two (A+B)

Group, Period, Scenario	n	Range of Scores for Total Errors				Total	Mean	Median
		0 - 18	19 - 38	39 - 58	59 -77			
AB (checklist) Period One Scenario One	10	5	4	1	0	200	20	18
BA(no checklist) Period One Scenario One	9	1	3	3	2	379	42.1	40
A**B(**no checklist) Period Two Scenario Two	10	5	5	0	0	191	19.1	19
B**A** (checklist) Period Two Scenario Two	9	7	1	1	0	159	17.6	16

Summary

The results obtained from conducting this pilot study were presented in Chapter Four. The procedure for obtaining the final sample population was defined. Demographic data for the sample population was described. None of the hypotheses tested included data with a normal distribution, most likely due to the small sample size which consisted of novice-level nursing students. Nonparametric tests were utilized for statistical analysis, and the results were reported on each hypothesis tested.

The findings did not suggest a significant relationship between checklist utilization and error recovery (p = .061), nor errors found/reported (p = 0.144).

However, a *p* value close to 0.05 in a pilot study proposes the need for study replication with a larger sample. Moreover, failing to reject the null hypothesis for embedded errors found and errors reported may be the result of a Type II error. Factors increasing the likelihood of a Type II error included: (1) both embedded errors found and embedded errors reported were limited to three per scenario; and (2) limited power from the small sample size restricted the ability to detect potential differences (Cohen, 1988; Kachigan, 1986; Polit & Beck, 2004).

Next, statistical analysis identified significant relationships with checklist utilization and the remaining hypotheses that were tested. In Period One, the participants who utilized the checklist demonstrated greater rule adherence ($p < 0.05$); committed fewer knowledge-based errors ($p < 0.05$); fewer confirmation bias errors ($p < 0.05$); and fewer errors in total ($p < 0.05$) than the no-checklist control condition.

Moreover, when the data from both periods were combined (n = 38), fewer errors in total were committed ($p < 0.05$) by the checklist intervention (A = 19) as compared to the no-checklist control (B = 19). Also, fewer errors in total were committed ($p < .05$) in the no-checklist group in Period Two (B = 10) than the no-checklist group in Period One (B = 9). Given that the crossover sequence groups were balanced, and the two scenarios were of equal difficulty, the above findings also suggest that learning occurred.

Chapter Five will discuss how the findings from each hypothesis tested mirror and differ from the literature review. Pedagogical implications, limitations, and recommendations for future research will be also addressed.

Chapter V

Discussion, Implications, and Recommendations

This chapter provides a discussion of the research findings as they relate to the hypotheses and limitations, as well as the implications for nursing education, nursing practice, patient safety, policy changes, and further research. The findings are discussed in the context of the literature review presented in Chapter Two.

Hypothesis One in Relation to Prior Research

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would report more medication errors in a simulated environment.

As discussed in Chapter Two, error reporting is complex and involves activity synthesis (ISMP, 2017a), suggesting it is a knowledge-based process involving high-level cognitive function (Anderson et al., 2001). Specifically, error reporting includes planning (e.g. how to report the error), analyzing (e.g. finding the error), collaborating with experts to problem-solve (i.e. clinical reasoning), along with monitoring, evaluating, and documenting adverse reactions (ISMP, 2017a) in a Just Culture (Degani & Wiener, 1990; Frankel et al., 2006). Further, Curren (2010) noted that if error reporting was not immediate, then corrective and preventive actions would be diminished. For this pilot study, error reporting was integrated within the practice of medication administration via prompts on the C-MATCH-REASON checklist.

Next, Armitage and Knapman (2003) found that the nursing profession was often identified with administration stage errors; Bates and Slight (2014) detected that

patient harms were not being recovered during the administration stage of the medication process; and James (2013) and Nichols et al., (2008) noted that medication errors not recovered went unreported. Thus, to examine medication administration error recovery and reporting, three errors were embedded in each scenario. Data were organized as follows: (1) embedded errors found/reported; (2) embedded errors committed/reported; and (3) Total Errors Reported.

Error Recovery-Reporting Gap. Subsequently, statistical analysis for Total Errors Reported did not identify a difference between checklist use and no-checklist use among novice-level nursing students. For Period One, the study findings identified that error reporting was dependent upon error recovery. However, the participants may or may not have found the embedded errors and they may or may not have reported the errors found. Specifically, the results for embedded errors found/reported identified that the checklist group did not report five (5) of the 23 errors found, whereas the no-checklist group did not report one (1) of the 12 errors found. These findings were consistent with Bates and Slight (2014) and Nichols, et al. (2008) who identified discrepancies in error recovery and reporting. While the researcher for the current study did not survey the participants for their not reporting every error found, it became evident that most participants did not follow the Training PowerPoint instructions for documenting errors reported on the checklist. Likewise, Cooper (2013) trained nursing students on the use of a blame-free error reporting system and identified that not every error found was reported.

Commission error-reporting gap. Next, for both experimental groups, none (0) of the embedded errors committed were reported in Period One. The participants

were not surveyed regarding unreported commission errors. It is possible that the participants did not realize that errors were committed, which would be consistent with the findings reported by Nichols et al. (2008). Noteworthy, commission errors were reported in Period Two, suggesting that learning occurred from completing more than one simulation practice session. Still, there was not a statistically significant difference in the high-level cognitive process of error reporting between checklist use and no-checklist use among novice-level nursing students. These findings were consistent with Benner (2001a), Benner et al. (2013), del Bueno (1983) and Schlairet and Fenster (2012) who suggested that novice-level nursing students need to learn clinical reasoning and, therefore, respond less accurately to cues (i.e. checklists) than experts. Likewise, Dreyfus and Dreyfus (1979, 1980) explain that novice and advanced beginner pilots rely heavily on rules bundled in checklists to accurately complete skills, but when distracted, steps are often skipped, whereas experts use intuition to complete the procedure accurately (Boehm & Remington, 2009; Dreyfus & Dreyfus, 1980). Thus, a third simulation practice session may be warranted to shift study findings towards support of checklist use for error reporting.

In pursuit of a Just Culture. Moreover, it is unlikely that two practice sessions in a simulation environment would instill a non-punitive and Just Culture. Benner (2001b) and Kohn et al. (2000) suggested that a Just Culture is created through team collaboration. Even though feedback on the Debriefing Questionnaire did not suggest that a Just Culture was lacking during the simulation practice, greater emphasis on its application would be advised for further research. For example, the Training PowerPoints included a reference in support of the practice of a Just Culture to facilitate

error reporting (Degani & Wiener, 1990; Henriqson et al., 2011), however, a Just Culture was not defined. Minimal training combined with a need for time to develop a sense for a Just Culture may have limited participant's awareness of the Just Culture until Period Two, resulting in self-serving bias in Period One. These results were in congruence with Cooper (2013).

Lastly, the researcher did not survey the participants about prior work experience within a Just Culture. For this pilot study's novice-level participants to grasp the complexities of error reporting, they may have needed: (1) prior practice in a Just Culture; (2) greater emphasis on the Just Culture; (2) enhanced error reporting training; (3) a review on how to report errors as a part of debriefing; and (4) added training on checklist utilization. The need to enhance student training further supports exploring checklist utilization for the complex processes of medication error recovery and reporting with competent to expert level registered nurses practicing in the acute care setting. White et al. (2010) concluded that further research was needed with nurses to identify how checklist use can enable the shifting of a registered nurse's cognitive processes (completing tasks while thinking-in-action) to solve complex problems.

Hypothesis Two in Relation to Prior Research

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would demonstrate greater rule adherence in a simulated environment.

As discussed in Chapter Two, prior research reported that utilization of standardized checklists improved performance by facilitating both rule adherence and

error reduction (Dreyfus & Dreyfus, 1979, 1980; Gawande, 2009; Hales & Pronovost, 2006; Hales et al., 2007; Henneman et al., 2014; Kahneman, 2013; Mattox 2012; Reason, 1990; van Klei et al., 2012; and White et al.,2010). Hypothesis Two investigated if the new checklist would result in similar findings. Analysis of the data from Period One revealed that the participants (n = 10) who utilized the C-MATCH-REASON checklist demonstrated greater rule adherence than the participants (n= 9) in the no-checklist control condition ($p = 0.005$). As described in Chapter Four, the results regarding Rule Adherence included that the checklist group (n = 10) completed 605 of 780 steps, whereas the no-checklist group (n = 9) completed 356 of 702 steps. Significantly fewer steps without checklist use indicates that *shortcuts* were taken.

Shortcuts. Of importance, in the course of completing the simulation practice, the raters observed the tendency for some participants to complete the skill using fewer steps because an embedded error was discovered sooner than expected based on the answer key. The scores were not prorated. The participants, who were novice nursing students, strayed from the instructions and took shortcuts. A shortcut does not always get one to where they need to go and can be dangerous (Degani & Wiener, 1990).

Further, novices are prone to errors when standards are omitted (Reason, 1997), and the inadvertent teaching of shortcuts will likely contribute to bias and lead to errors (Kahneman, 2013). Related research reported that poor adherence to rule-based protocol increased the risk of medical error and patient harm (Henneman et al., 2010; van Klei et al., 2012). Checklist utilization limits shortcuts by facilitating slow, deliberate clinical reasoning (Kahneman, 2013). Likewise, the AACN (2019) goals include curtailing time-based training while increasing competency-based education

(CBE). CBE is learner centered and promotes accountability. Further, competencies are derived from both patient and societal needs. Consistent with the AACN (2019) movement toward CBE, nursing education needs to examine the use of standardized checklists for complex skills. This study has built a case for utilization of the C-MATCH-REASON checklist with medication administration to facilitate teaching as well as clinical reasoning with procedural learning, and patient safety.

Rule adherence and memory. In Chapter Two, it was noted that Miller (1956) identified that working memory can hold up to nine items. The C-MATCH-REASON checklist contains 11 items (11 medication administration rights) and each item contains a bundle of steps. Of relevance to this study, a participant in the no-checklist control group noted on the Debriefing Questionnaire "I had the [Training] PowerPoint and 11 med [sic] administration steps in the back of my mind. The hard part is remembering all eleven!" This comment is in congruence with Miller's (1956) findings regarding limitations of working memory. Likewise, feedback from participants in the checklist group also reflected limits to working memory, but because they had the checklist, they referred to it as a means to extend their working memory. Therefore, rule adherence is dependent upon consistent use of the checklist with each medication administration. Of consequence, the checklist will need to be reviewed regularly and updated as needed.

Qualitative feedback. Themes extracted from feedback on the Debriefing Questionnaire specific to rule adherence and memory from both the checklist group and the no-checklist group are discussed next as they relate to Chapter Two. Comments from both Period One and Period Two are included.

Checklist intervention. Consistent with Pape 2003 and Pape et al., 2005, many participants reported that the checklist was helpful as it reminded them of the steps needed to safely complete medication administration. Moreover, one participant included that her confidence rose when administering medication using the checklist: "Having the checklist handy gave me more confidence in my ability to safely administer meds [sic] without wondering if I forgot something." The C-MATCH-REASON checklist may have facilitated a reduction in extraneous cognitive load resulting in increased rule adherence (i.e. procedural learning) for this participant (Bruning et al., 2011; van Merrienboer & Sweller, 2005). Pointedly, procedural learning leads to skill acquisition (Bruning et al., 2011).

Noteworthy, two participants in the checklist group noted that they forgot steps: "I still forgot to state what type of med it was (liquid/ enteric coated, etc.)…" and "I forgot to bring the medication packaging to the bedside to do the final check." The current quantitative findings further corroborated by participant reflection suggesting that both rule adherence and procedural learning occurred with checklist use, further supports nursing education's need to support policy change for the standardization of complex skills with evidence-based checklists.

No-checklist. Gawande and Weiser (2008) noted that the absence of a checklist was associated with rule-based omissions. Themes that emerged from the no-checklist group included not remembering to check: (1) expiration dates; (2) forms of drugs; (3) name as well as DOB for a second time; and (4) steps in general. Themes that emerged from comparing practice with the checklist to without the checklist included: (1) the importance of slowing down; and (2) trying to remember the steps to prevent errors.

Consistent with prior research, the feedback suggested that checklists promote rule adherence and minimize the use of memory and/or heuristic-based thinking (Dreyfus & Dreyfus, 1979, 1980; Gawande, 2009; Hales & Pronovost, 2006; Hales et al., 2007; Kahneman, 2013; Mattox, 2012; Reason, 1990; White et al., 2010).

Steps skipped. The participants (n = 19), generally adhered to the six rights of medication administration. However, the steps on the C-MATCH-REASON checklist, that go beyond the six rights and were most frequently skipped by both experimental groups included (starting with the highest number): (1) *double check high-risk drug dosage with RN* (coumadin); (2) *identify form of drug* and *independent check for patient name and independent check for DOB;* (3) *errors reported*; (4*) monitor patient* and *documentation*; (5) *screen health data, link to shifts in care, and to drug contraindications*; (6) *expiration date* and *match allergy list on MAR to drug label;* and (7) *match ADRs on MAR to drug label* and *calculating safe dose range*.

Based on feedback from the Debriefing Questionnaire, rationales for skipping steps included: (1) checking safe dose range, allergy, and ADR's were not among the six rights, so they were forgotten; (2) checking correct form and the expiration date were not stressed by nurses in the clinical setting; (3) never being taught to check the patient's name independent from DOB (participants were more familiar with e-scanning ID bands); and (4) no experience with documenting on a paper MAR. Of relevance to this study, participant training and course curriculum needed to correspond.

In Period Two, fewer steps were skipped, evidently procedural learning occurred (Bruning et al., 2011). Improved areas included: (1) screening health data; (2) documentation; and (3) checking both expiration date and ADR's. However, there was

no data to compare double checking a high-risk drug dose with an RN between periods, because a drug requiring a double check was not included in Scenario Two. As a result, participant feedback included requests for additional training to be in sync with the evaluation process. For study replication, student training would need to emphasize: (1) how to document on a paper MAR; (2) how to record errors found and errors reported on the checklist; (3) that patient name is checked separately from DOB; and (4) that high-risk drug doses need to be double checked with an RN.

In Period Two, 100% of the participants received a tally for completing medication reconciliation. However, 10 of the 18 embedded errors associated with medication reconciliation were not recovered in relation to the sequence of the checklist. These errors were found subsequent to checking other steps. Thus, the checklist reminder for medication reconciliation did not solely facilitate accuracy with this process. This point is consistent with Henneman et al. (2014) who developed a collaborative protocol to enhance accuracy with medication history for medication reconciliation. When the collaborative protocol was utilized by nursing students in a hospital setting, accuracy with medication reconciliation resulted, along with, error reduction (Henneman et al., 2014). While the C-MATCH-REASON checklist does not list protocol steps specific to medication reconciliation, the checklist does suggest collaboration with an expert when completing knowledge-based steps. Therefore, both above mentioned checklists are necessary for rule adherence and error reduction.

Hypothesis Three in Relation to Prior Research

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit

fewer skill-based errors in a simulated environment.

As discussed in Chapter Two, skill-based errors (i.e. slips) may stem from habits that encourage fast thinking often due to a busy environment (Kahneman, 2013; Reason, 1990, 1997, 2002). In relation, Pape (2003) and Pape et al. (2005) applied a medication administration checklist to the acute care setting and studied distractions and interruptions among nurses using the checklist. However, for this pilot study, neither a planned interruption nor a distraction were actualized in the simulation environment. As a result, skill-based errors were not observed, and data were not collected. The planned distraction needed to: (1) be consistent for each participant; and (2) occur independent of the rater and the greeter/assistant.

For study replication, one solution would be to assign a volunteer to the role of distractor. During the medication process, the distractor would perform the same disturbance (e.g. cell phone ring sound) for each participant and both periods. A planned distraction would not be needed for the hospital setting as they occur on a regular basis (Pape et al., 2005); and interruptions occur in 53.1% of all medication administrations (Westbrook et al., 2010).

Hypothesis Four in Relation to Prior Research

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer knowledge-based errors in a simulated environment.

As discussed in Chapter Two, Reason (1990) identified that effective error corrections are lowest at the knowledge-based level. Cognitive processes involved with

knowledge-based step completion include analysis, diagnosis, evaluation, and coordination with external resources [i.e. checklists and/or experts] (Reason, 1990). The C-MATCH-REASON checklist is inquiry-based, and the knowledge-based steps on the checklist (identified with an asterisk) cue the user to collaborate with an expert (e.g. nursing instructor, pharmacist). Therefore, during the simulation practice the participants were encouraged to ask the rater questions. Also, a telephone was utilized as a prop to cue participants to contact experts (e.g. pharmacist).

Analysis of the data revealed, in Period One, that the participants (n = 10) who utilized the C-MATCH-REASON checklist demonstrated fewer knowledge-based errors than the participants (n = 9) in the no-checklist control group ($p = 0.010$). These findings were consistent with research published by Benner (2001a), Reason (1990, 1997), and Vygotsky (1962) suggesting that scaffolding from both an expert mentor and a structured protocol facilitate accuracy among novices practicing a complex skill; as well as Henneman et al. (2014) who concluded that if nursing students applied a collaborative protocol when interviewing patients, the process was completed with greater accuracy and patient safety was enhanced. Increased collaboration with practice is among the AACN's (2019) goals for academic nursing.

Hardcopies, software, and critical thinking. Further, Reason (1990) suggested that knowledge-based errors often result from lack of experience, foresight, and planning. In congruence, feedback on the Debriefing Questionnaire from the no-checklist group included "It wasn't easy to plan without the list." This comment reflects support of checklist utilization for learning a skill that involves higher level cognitive activities. Of relevance, the EMAR is not equivalent to a standardized

checklist for learning the skill of medication administration. Easty (2017) suggested that the use of electronic medical records (EMR) and/or the eMAR are documentation systems that are not conducive to learning because users tend to *check the boxes* without critical thinking. On the contrary, the C-MATCH-REASON checklist is an inquiry-based tool that facilitates clinical reasoning as it cues collaboration for the complex processes involved with administering medication.

Thinking-in-action and checklists. Nursing research suggested that deliberate practice with a checklist improved ability to think more about the task on hand (Marquard et al., 2011; Pape, 2003; Pape et al., 2005; White et al., 2010). Knowledge-based steps require deliberate reasoning (Reason, 1990; Kahneman, 2013). Likewise, responses from the checklist group to the Debriefing Questionnaire question "How did this simulation experience impact how you administered medication today?" included: "It helped me to stop and think about what I was doing and to make sure everything was correct;" "It taught me to pay attention to drugs that can't be given together;" "I was able to focus on the things I needed to verify and check because of the checklist I had with me;" and "Being able to see the checklist really helped me to see all of the errors that can be made, but with the checklist it helps you think of everything." The feedback suggested that use of the C-MATCH-REASON checklist was conducive to thinking-in-action, a form of clinical reasoning (Benner et al., 2013). Still, solutions are needed to reduce the gap in the knowledge-based process of error reporting (Cooper, 2014).

Hypothesis Five in Relation to Prior Research

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit

fewer knowledge-based confirmation bias errors in a simulated environment.

Reason (1990) and Kahneman (2013) suggested that confirmation bias involved the inclination to identify data that supports our prediction. Kahneman (2013) and Mattox (2012) suggested that a checklist may interfere with lapsing into intuitive choices. Hence, steps that required double checks were embedded into the C-MATCH-REASON checklist to prevent confirmation bias errors. Participants completed the first check when preparing a medication. The double check was completed upon administering the medication to the patient. Analysis of the Period One data revealed that the checklist group completed twice as many double checks than the no-checklist group. Statistical significance was detected with both the Fisher Exact Test (two-sided) where $p = 0.005$ and the Kruskal-Wallis Test (two-sided) for independent samples where $p = 0.014$. The results suggested that checklist use facilitated the double checking of steps, limiting confirmation bias errors with medication administration.

In relation to nursing practice, Cooper (2014), Harding and Petrick (2008), Henneman et al. (2010) and Wolf et al. (2006) identified that nursing student medication errors frequently involved non-adherence to procedure, inexperience, and ineffective communication. In this study, participants who utilized the C-MATCH-REASON checklist, complete with double checks and prompts to collaborate with an expert, committed fewer of the types of errors listed above. Implications for patient safety include double checks that could prevent both: (1) delivery of medication to the wrong patient; and (2) administering errors related to the drug, time, route, and/or dose.

On the contrary, the C-MATCH-REASON checklist step that was skipped the most by the participants in Period One was the double checking of a high-risk drug dose

with an RN. These results were not consistent with White et al. (2010) who found that a well-designed checklist can improve accuracy with the independent process of double-checking medication dosages between two registered nurses, thereby preventing confirmation bias errors. It is possible that the student participants were not taught to double-check oral coumadin with an RN, but coumadin is reported as a high-risk drug (Vallerand, 2018). Also, the researcher did not survey study participants regarding prior experience with completing double-checks for high-risk drugs. Consistent with findings reported by Wolf et al. (2006), nursing student errors are frequently related to inexperience. Therefore, further research investigating use of the C-MATCH-REASON checklist in the acute care setting with registered nurses is strengthened.

Hypothesis Six in Relation to Prior Research

Pre-licensure nursing students who utilized the C-MATCH-REASON checklist compared to not utilizing the checklist, individually and collectively, would commit fewer errors in total in a simulated environment.

Hypothesis Six was analyzed between/within the experimental groups across both periods. As a result, a four-part statistical analysis was conducted to examine Total Errors. "Total Errors" was defined as Rule-based Errors + Knowledge-based Errors + Skill-based Errors + Confirmation Bias Errors + Embedded Errors Committed + Errors Not Reported. Findings from all four parts were statistically significant in support of checklist use for medication error reduction among nursing students. These findings were consistent with checklist use and medical error reduction results published by Gawande (2009), Hales et al. (2007), Haynes, et al., (2009), Pronovost et al. (2008), van Klei et al. (2012); and White et al. (2010).

Analysis one. The first analysis of Total Errors was between the two experimental groups (A: B) within Period One only. The null hypothesis was rejected ($p = 0.010$). The participants who utilized the C-MATCH-REASON checklist ($n = 10$) gave evidence to nearly 50% fewer Total Errors than the participants who did not use the C-MATCH-REASON checklist ($n = 9$). This finding was encouraging, and strongly supported study replication with a larger sample size.

The remaining analyses for Hypothesis Six involved data collected from both periods. As discussed in Chapter Two, knowledge linked from prior experience facilitates learning (Schlairet & Fenster, 2012; Thiele et al. 1986). Therefore, Period Two appointments were scheduled one week after Period One appointments to allow for a washout period. Still, learning was examined as it was a desired treatment carry-over effect of the crossover design. A detailed discussion regarding the carry-over effect is presented later in this chapter.

Analysis two. A second analysis of Total Errors involved the aggregation of the participant data ($n = 38$) from each experimental group across both periods (A+A: B+B). The findings were statistically significant ($p = 0.023$). Aggregating data from both periods did not enhance the findings upon comparison to the Period One ($n = 19$) findings ($p = 0.010$). This may have been due to a carry-over effect (learning) which resulted in fewer errors for Period Two. Overall, the checklist group (A + A) completed 211 more steps than the no-checklist group (B + B). Implications for further research include a study design with only one period to avoid both the carry-over effect and challenges related to follow-up (Liu, 2016).

Analysis three. The third analysis of Total Errors involved comparing data

from the no-checklist control conditions between Period One and Period Two (B: B). This analysis was conducted specifically to identify a treatment carry-over effect from the 2x2 crossover design. As discussed in Chapter Two, Dewey (1966) identified that hands on experience and reflection advanced learning. Nursing research identified that, regardless of experience level, repeated practice sessions facilitated both decision-making (Thiele et al., 1986) and clinical reasoning (Schlairet & Fenster, 2012) among nursing students in a simulation environment. Consistent with Dewey (1966), Thiele et al., (1986) and Schlairet and Fenster (2012) the current pilot study results suggest that the participants in the no-checklist group (B) in Period One gave evidence to nearly twice as many Total Errors as compared the no-checklist group (B) in Period Two (p = 0.007). Implications for nursing education include the use of two or more simulation practice periods with reflection to facilitate clinical reasoning and learning, regardless of experience level, in the simulation environment.

Analysis four. The fourth statistical analysis of Total Errors involved paired samples (n = 38). The Total Error data from both experimental groups in Period One were combined (A + B) and compared to the combined Total Error data from both groups in Period Two (A + B). The null hypothesis was rejected (p = 0.021). Implications for nursing education and further research include that both checklist utilization and practice across two time periods facilitate error reduction as well as clinical reasoning (Schlairet & Fenster, 2012).

Relevance to Conceptual Framework

This pilot study investigated the utilization of the C-MATCH REASON checklist to reduce medication administration errors among pre-licensure baccalaureate

nursing students. Reason's (1990) error theory (GEMS) was utilized as the conceptual framework. The medication administration errors that were identified were grouped into rule-based errors (Reason, 1990); knowledge-based mistakes (Reason, 1990); knowledge-based confirmation bias errors (Reason, 1990; Kahneman, 2013); and errors recovered (Henneman et al., 2010; Reason, 1990, 2013) that were not reported. The errors were tracked and measured by raters utilizing the Observation Form.

As a result, the study findings support the central tenets of the literature review: (1) medication errors are common (Wittich et al., 2014); (2) accuracy is needed with medication administration to prevent errors (Curren, 2010; Kohn et al., 2000); (3) the landmark report, *To Err is Human* (Kohn et al., 2000), remains relevant 19 years later regarding the need to improve error awareness and error reporting (Bates & Slight, 2014; Cooper, 2014; James, 2013); (4) the omission of standards and cues often leads to errors among novices (Reason, 1997); (5) collaborative problem-solving with checklist utilization prevents knowledge-based errors (Reason, 2013); and (6) checklists facilitate clinical reasoning with knowledge-based performance (Kahneman, 2013).

This pilot study, which involved original research, expanded on the work of those mentioned above by offering a new and comprehensive evidence-based standard for medication administration in the form of a checklist with 11 medication administration rights. Subsequently, when pre-licensure nursing students administered medication in a simulation environment with the new C-MATCH-REASON checklist, they demonstrated greater rule adherence as well as fewer knowledge-based errors, fewer confirmation bias errors, and fewer errors in total when compared to the no-checklist control condition. While statistical analysis did not identify a relationship

between checklist use and error reporting, this pilot study identified that nursing students need repeated training to grasp the complex skill of error reporting. For example, in Period One none (0) of the commission errors were reported whereas, in Period Two commission errors were reported. Evidently, debriefing and reflection from Period One raised awareness to the need to report errors in the simulation environment. Lastly, qualitative feedback identified that 100% of the participants and the raters supported continued use of the C-MATCH-REASON checklist.

Limitations

This pilot study had several limitations. First, generalizability was a limitation because: (1) the study was conducted in a nursing school simulation lab; and (2) the population consisted of students from one nursing program in New York State. According to the website for the Office of the Professions at the New York State Department of Education, as of October 20, 2015, there were 60 pre-licensure baccalaureate level nursing programs in New York State (http://www.op.nysed.gov/prof/nurse/nurseprogs-bacc.htm). Conducting a study with a broader group of participants who, in turn, offer even more qualitative feedback involving themes that are similar (e.g. raised error awareness, clinical reasoning, and procedural learning) as well as different from the current sample, would have strengthened generalizability. Therefore, the findings would be more reflective of the real world and the broader practice of nursing.

Further, the population was limited to pre-licensure baccalaureate nursing students enrolled at The Sage Colleges who were either second semester juniors or seniors (n = 178). A low response rate (10.11%) resulted in a final small sample of 19

participants with limited power (Cohen, 1988; Polit & Beck, 2004). Factors that may have had a negative effect on the response rate included: (1) the seniors were not scheduled for classes during the recruitment period, nor were they on campus when the study was conducted due to clinical rotations; (2) the participants were required to attend both periods; and (3) a perceived bias of the raters who were the students' faculty members in some cases.

There were limits to comparisons. The current pilot study involved 19 participants and was scenario-based making use of answer keys and a scoring rubric. For each scenario, there were a fixed number (three) of embedded errors that could be recovered and reported by each participant for a total of 57 errors recovered with a sample size of 19. Of relevance, in a study with 60 participants 180 errors could be found, thus providing more data for comparison. By combining a small sample size (n = 19) with a significance criterion set at 0.05, the study power was lower and the probability of committing a Type II error rose (Kachigan, 1986).

The current pilot study was conducted for the first time in a learning environment and the 2x2 crossover design added several challenges. First, the need to return for a second simulation practice limited overall student enrollment. The sample size was further reduced when one participant was excluded for only completing Period Two. Moreover, the design complicated commitment time for both raters and student participants because the study spanned over several weeks and overlapped with exam periods and personal plans. Consistent with crossover design limitations reported by Lui (2016), extra effort was needed to ensure that the participants not only returned, but closely followed the simulation practice guidelines in period two, as well.

Specific to Hypothesis Six, to further identify the treatment carry-over effect (learning), the Total Error data from periods one and two from each no-checklist group (B) were compared for statistical analysis. Comparing Total Error data between periods risked a Type I error. For example, in clinical trials with pharmaceuticals, a crossover design with a drug washout period is necessary because a drug carry-over effect can lead to bias in the interpretation of a treatment effect (Lui, 2016). However, we cannot be sure that treatment carry-over effects are prevented by washout periods (Lui, 2016).

In the current pilot study, the original design included a two-week washout interval to limit treatment carry-over effect from Period One to Period Two. However, Period One of the pre-pilot assessment was pushed back one week due to the college closing for inclement weather. Participant feedback on the Debriefing Questionnaire indicated that learning occurred. The one-week washout period was repeated for the pilot study because both the treatment effect (medication error reduction) and the treatment carry-over effect (learning) were desired. However, several participants in the no-checklist group in Period Two of the Pilot Study commented on the Debriefing Questionnaire that they applied memory from checklist use in Period One to administering medications in Period Two. Thus, for study replication, a two-week wash-out period may be preferred. Noteworthy, for actual clinical settings, Lui (2016) suggested that using a *parallel* design to limit bias from both treatment-by-period (participant responses that vary between periods) and carry-over effects. Future investigation of the use of the C-MATCH-REASON checklist would include a parallel design in the acute care setting.

Close monitoring in a simulation environment facilitates formative feedback *in*

vivo but monitoring also facilitates the Hawthorne effect. At the time of study conduction, the simulation lab at The Sage Colleges did not have a two-way mirror. Thus, the raters were utilizing the Observation Form alongside the student as medication was administered. Since the participants knew they were being observed, they may not have behaved in the simulation environment as they would in clinical practice in a hospital setting. To the point, feedback on the Debriefing Questionnaire included "Being watched so closely made me overthink things too much." Future study conduction would involve the use of a two-way mirror. The rater would track error data from behind the mirror. An audio system with microphones would be utilized for student-rater communication. These suggested methods are intended to offset the undesirable aspects of the Hawthorne effect.

Of importance**,** debriefing would still occur as the role of the multidisciplinary team involves promoting and teaching about a Just Culture and medication safety. Moreover, in the clinical setting teams now collaboratively review medication errors and system processes to reduce errors.

Implications for Nursing Education

As this was a pilot study, paying attention to customer satisfaction comments (i.e. written feedback from raters and participants) was an important factor since the instrument was utilized for the first time. Themes noted by both raters and participants were that the simulation experience was well organized, and the scenarios were realistic with the hospital setting. Themes specific to practice with the instrumentation included critical thinking, procedural learning across two periods, and increased error awareness linked to checklist utilization. The themes associated with use of an evidence-based

standard for medication error reduction among nursing students were consistent with the findings from Treiber and Jones' (2012) study involving professional nurses in the acute care setting. Further, the above study themes were consistent with the AACN's (2019) goals for nursing education related to the development of robust *transition to practice models* (to generate graduates from nursing programs matched to deliver services). In general, the AACN (2019) goals address skills, knowledge, and attitude, but the focus narrows to evidence-based practice to elicit critical thinking among pre-licensure baccalaureate nursing students. For the current pilot study, feedback themes linking nursing education to evidence-based practice are presented below.

Rater Feedback

Themes from the rater feedback included (1) learning; (2) ease/difficulty of use of the Observation Form; and (3) a strong desire to transition the instrumentation into practice in the educational setting. First, the raters noted that using the Observation Form in tandem with participants using the C-MATCH-REASON checklist facilitated learning for the rater as well as for the participant. Further, the parallel use of the instruments enabled a more transparent observation process for the rater. Rater comments included "The checklist is a great tool to slow the student down and make them think to prevent medication errors. One point they [participants] all miss with the checklist is checking the patient name and date of birth separately. Part of that is because we have been teaching them to do both at the same time" and "I learned from this experience." These comments suggest that participation in the simulation practice raised error awareness among the raters.

Second, regarding the use of the instrument, one rater noted **"**The Observation

Form took me a little bit to get used to as I was observing the student and trying to follow. Also, when students jump around, maybe checking all medications at the same time with the MAR, and then going back individually, it would get a little confusing." Both comments are worthwhile and speak to the complexity of the process.

Third, transition to practice was underscored. Both raters agreed that, as nursing educators, they would use the instruments with students practicing the skill of medication administration. For example, "Overall, I think this is a much-needed study, and checklist, to help prevent medication errors for our patient safety. I cannot wait to use the form [checklist] with students in the lab and in the clinical setting."

Participant Feedback Themes (Nursing Students)

Most of the feedback written on the Debriefing Questionnaire was positive and in favor of checklist utilization. In Period One, 90% of the participants in the checklist group (sequence AB) offered positive feedback regarding the C-MATCH-REASON checklist. Feedback included that the checklist was helpful, easy to use, and a strength of the simulation practice. Constructive criticism from Period One included "I believe the checklist makes medication administration a little more difficult than it actually is. Having to stop and reference the checklist makes the process very clunky."

The three overarching themes from participant feedback were: (1) error awareness; (2) clinical reasoning; and (3) learning. These themes are discussed below.

(1) Error awareness with checklist utilization

Consistent with nursing research involving checklist utilization by Pape (2003), Pape et al. (2005), and White et al. (2010), in the current pilot study, participant

feedback suggested increased error awareness with checklist use. A comment from Period One included, "[I] was more aware of the possibilities of problems that may occur [with the checklist], anxious that a step would be missed."

No-checklist to checklist period comparison. In Period Two, enhanced error awareness with checklist utilization emerged as a theme among 89% of the checklist group upon comparison to Period One. For example, "I realized there are so many things that I forgot to do when I gave meds. At the last simulation [without the checklist] I didn't think to put the patient in a better position for swallowing or to educate on side effects"; "It really opened my eyes to a lot of aspects of how easily a mistake can happen if you don't pay attention to what you are doing. I was more equipped to point out errors;" and "I was a bit slower and it was hard for me to break old habits. Didn't miss anything though."

While 89% of the comments in Period Two were supportive of checklist utilization, the mixed review was insightful. For example, "[The] checklist is hard to follow… it needs bold lines between each step in the Medication Area Section. I think with more practice I would become more efficient at the checklist. I think checking drug adverse reaction are very important. Observing someone perform the C-MATCH-REASON checks would benefit [sic] because I wasn't sure what to expect"

Checklist to no-checklist period comparison. Participants in the no-checklist group in Period Two offered feedback when comparing the two practice periods that ranged from: "I think it was a great simulation experience testing my knowledge. It is harder without the list ensuring I am not missing steps" to "It

was easier to follow the guidelines today because I looked over the checklist on my own time, again, after my first session. I think today was easier without having to physically stop and reference the checklist every time I made a move." The participant feedback suggests that the introduction of the C-MATCH-REASON checklist narrowed the nursing education gap related to the need for strategies that raise medication error awareness to enhance patient safety and quality care (Henneman et al., 2010; Henneman et al., 2014; Murphy, 2012).

(2) Clinical Reasoning

As discussed in Chapter Two, Kahneman (2013) suggested that clinical reasoning involved slow, deliberate thinking whereas intuitive thinking was fast. The use of standard protocol elicits clinical reasoning. Consistent with Kahneman (2013), the feedback from one participant in the checklist group in Period Two summed up the effect of *thinking fast and slow* with utilization of the C-MATCH-REASON checklist: "I liked having the checklist to ensure that I didn't forget anything. At some points I found it hard to follow just because I would start doing things automatically. I caught all three errors." In effect, the checklist slowed the participant down, facilitating the recovery of all three embedded errors. Another noted, "[The checklist] helped me to remember all of the parts of a med admin [sic] that get rushed in a real hospital experience."

Next, clinical reasoning was sorted on the Debriefing Questionnaire into eight categories: interpreting, comparing, analyzing, planning, coordinating, monitoring, evaluating and reporting. Similar feedback was offered in each category in Period One by both experimental groups. Of interest, for the category of coordination, a participant from the no-checklist group noted that they practiced the six rights: "reviewing six rights

and planning what needed to be given at that time." However, another participant commented, "I became more aware because if I just used the six rights, I may not have caught the drug allergy that could have occurred from the medications ordered." The comments suggest that shortcuts were applied when the checklist was not utilized.

Compared to the no-checklist group, the participants in the checklist intervention in Period One offered a greater number of examples on the Debriefing Questionnaire for applying the following clinical reasoning categories: comparing, analyzing, planning, and monitoring. Both groups applied an equal number of examples regarding evaluating and reporting. In Period Two, the checklist intervention offered a greater number of examples for applying clinical reasoning in seven of the eight categories when compared to the no-checklist group. For both periods, *interpreting* was the only category that the no-checklist group offered a greater number of application examples. Of interest, in Period Two, feedback from the no-checklist group included "It wasn't easy to plan without the checklist" and "Having the list made me more aware the first time of checking the other documents, so I was able to recall that from the first time."

(3) Learning

Feedback noted on the Debriefing Questionnaire from both periods and experimental groups combined suggested that learning occurred. Greater than 75% of the participant feedback suggested that the checklist facilitated learning. Examples include, "I learned to ask the patient their name and DOB separately and to tell [sic] patient that I will be coming back to check on them," and "It gave me insight to look for allergies in med [sic] administration." Greater than 50% of the participants suggested that they learned from the repeated practice over two periods. For example: "Built on experience from last

time;" "I had learned from mistakes that I made last time. I made sure to check with [the] provider about allergies, etc.;" and "Compared to last time [no-checklist], I felt like I picked up on more of the important details [checklist intervention]."

As discussed in Chapter Two, Kahneman (2013) reported that the learning process is facilitated by an awareness to the theory that the human brain thinks fast and slow. Feedback from the checklist group in Period Two included a need to slow down to prevent medication errors: "This simulation helped me realize I need to slow down when administering medication and do all the checks in the patient's room" and "This simulation experience impacted the speed at which I do things as well as my need to be more mindful of what I'm doing." Lastly, feedback from 100% of the participants and raters endorsed the continued use of the instruments (with relevant revisions).

Additional Participant Feedback

Technology, checklists, and learning. Participant feedback on the Debriefing Questionnaire also included reference to technology. For example, one participant requested access to technology during the simulation to hasten the medication practice. Another participant questioned its use: "In the clinical setting everything is now so technologically based. It is so easy to walk into a patient room, scan their wrist band and medications and then just administer them without truly evaluating a patient's need or the medications. As nurses it is important that we evaluate our patients need for medications not just administering them because the physician says so." Students need to learn how to detect errors and report errors to prevent patient harms. Overreliance on the use of technology in healthcare may be prompting students and professionals to take shortcuts. Further, electronic systems could be the root cause of errors. Easty (2017)

reported that the eMAR does not facilitate critical thinking and learning. Healthcare professionals generally access the eMAR, but a best practice hurdle exists in that the eMAR is not standardized from facility to facility. This is particularly of concern because students learn medication administration in multiple settings.

Consistent with cockpit research for safety in the airline industry (Degani & Wiener, 1990), this researcher posited that an evidence-based paper checklist for medication administration would flow logically with the eMAR and thus reduce cognitive load. The findings of this pilot study suggested that medication errors were reduced when novice-level nursing students used a hard copy of an evidence-based checklist paired with the eMAR (Degani & Wiener, 1990) instead of relying on memory alone (Miller, 1956) or incomplete protocol (Reason, 1990).

Collaboration. Subsequently, Reason (2013) reported that collaborative problem-solving with checklist utilization prevents knowledge-based errors. Consistent with findings from the current pilot study, feedback from participants (novice nursing students) in Period Two, suggested that there was greater engagement with clinical reasoning when administering medication with the C-MATCH-REASON checklist (which includes prompts to collaborate with experts) as compared to not using the checklist. Finding and reporting errors also demonstrates social responsibility and accountability. The above findings are in line with the AACN's (2019) goal to increase collaboration between academic and clinical settings to both improve public health and optimize students' transitioning to professional practice.

To facilitate learning the skill of medication administration, nursing educators could create a more realistic simulation environment by: (1) embedding up to three

medication errors in a simulation scenario; (2) permitting students to practice with an evidence-based medication checklist paired with the eMAR to find the errors; and (3) permitting students to collaborate with an expert during the simulated practice to engage clinical reasoning. Subsequently, nursing educators could repeat the above steps each semester for competency testing that involves medication practice and recall.

Implications for Nursing Practice

Checklist Utilization

As discussed in Chapter Four, feedback from 100% of the participants and both raters supported use of the C-MATCH-REASON checklist for medication administration (with relevant revisions). Moreover, this pilot study corroborated White et al. (2010) who previously reported a relationship between checklist utilization, rule adherence, and medication error reduction. Thus, the ongoing gaps in nursing practice standards related to medication administration include: (1) the administration rights; (2) a medication error reporting system; and (3) an education-practice partnership for error reporting. The identified gaps are discussed below.

Ongoing Gaps

Administration rights gap. As discussed in Chapter Two, complexity with medication administration was reflected by the many attempts to increase the number of medication administration rights from the traditional five rights (Bourbonnais & Caswell, 2014). This study built a case for increasing the medication administration rights to the 11 included in the C-MATCH-REASON checklist. As noted in Chapter Four, when the researcher sorted and ranked the medication error data based on 11

administration rights, it was identified that the five new rights (ADRs, Current Health, Expiration, Site-Safety, and Outcomes) were less frequently adhered to than the standard six rights (Patient, Medication, Time, Route, Dose, and Documentation) taught in most nursing programs, including The Sage Colleges. This suggests that students demonstrate what they are taught. However, clinical reasoning surfaced in a participant's reflection after utilizing the C-MATCH-REASON checklist: "I became more aware because if I just used the six rights, I may not have caught the drug allergy that could have occurred from the medications ordered." To facilitate learning, standardizing protocol to reflect practice that includes checking 11 medication administration rights would involve effort from nursing educators in both healthcare facilities and academia. This effort would be consistent with the AACN's (2019) goals.

Medication error reporting system gap. Next, a standardized system for the complex process of medication error reporting would reduce reporting discrepancies among healthcare workers in the hospital setting (Weant et al., 2014). The standardized error reporting system would include the standard practice of a Just Culture (Degani & Wiener, 1990; Frankel et al., 2006; Leufer & Cleary-Holdforth, 2013). Furthermore, the demands of a complex skill joined with the use of a standardized system would facilitate clinical reasoning (Kahneman, 2013). As discussed in Chapter Two, competent to expert level nurses have established clinical reasoning skills (Benner, 2001a; Benner et al., 2013). However, Kahneman (2013) suggested that people were not as good at reasoning as they believe and advised that all professionals (i.e. from novice to expert) use standard protocol to elicit clinical reasoning and enhance safe practice. Thus, to address the gap in medication error reporting, future studies would

include investigating the use of the C-MATCH-REASON checklist with nurses practicing at the competent level or higher.

Education-practice partnership gap. Finally, the discipline of nursing does not have a standardized, non-punitive error reporting system that connects healthcare agencies with academic institutions (Cooper, 2014; Leufer & Cleary-Holdforth, 2013). The AACN (2019) goals include expanding academic practice partnerships. More specifically, the goals include threading competencies through diverse settings to improve public health. Therefore, to ensure adherence to best practice for medication administration, this researcher recommends that nursing programs: (1) practice a Just Culture to enable error reporting; and (2) coordinate with clinical sites and require that mentors and students jointly refer to an evidence-based medication administration checklist (i.e. the C-MATCH-REASON checklist) for clinical practice (Murphy, 2012).

Further, tracking error data over time may aid in detection on how both academic and clinical systems contribute to student errors (Gregory et al., 2007; Harding & Petrick, 2008; Cooper, 2014). It is imperative that nursing educators research methods that facilitate error reporting among students to further improve patient safety and quality care (Cooper, 2013; Leufer & Cleary-Holdforth, 2013).

Implications for Quality Care, Patient Safety, and Leadership

As discussed in Chapter One, it was estimated that 100,000 hospitalizations (AHRQ, June 2017) to 280,000 hospitalizations (HHS, 2014), annually, were attributed to adverse drug events, half of which may be preventable medication errors. Moreover, the human costs were compounded by financial costs. The WHO (March 2017)

reported that medication errors, annually, cost $42 billion worldwide. The quandary would be that to reduce human and financial costs, medication errors need to be realized (Moore et al., 2015; James, 2013; Kohn et al., 2000; WHO March 2017).

As discussed in Chapter Two, Reason (2000) identified that most adverse events involved the interplay of active failures (unsafe acts committed by people) with latent conditions (system-related errors). Reason (1990) also reported that knowledge-based errors often occurred from a lack of experience and planning. Consistently, Wolf et al. (2006) concluded that inexperience was a major contributing factor of medication errors among nursing students. Subsequently, Reason (2013) reported that when collaborative problem-solving included reference to a standard protocol, knowledge errors were prevented. Added research noted that a Just Culture (Degani & Wiener, 1990; Khairallah, et al. 2012; Leufer & Cleary Holdforth, 2013; Reason, 2013) and transparency (Cooper, 2014; James, 2013) facilitated error reporting and supported quality care and patient safety.

Nursing leadership (AACN, 2019) is developing competencies that promote both clinical reasoning and error awareness to facilitate the delivery of safe, high quality care by nursing students. Competencies are tools utilized for evaluation. An evidence-based checklist for medication administration could be included as part of competency-based education. Yet, a standardized checklist for medication administration that includes error reporting still needs to be actualized.

As discussed in Chapter Two, evidence-based standards were essential to providing safe quality patient care (Hales et al., 2007; Pronovost et al., 2008; TJC, 2016; van Klei et al., 2012). Leaders were key players in creating and maintaining

safe practice habits (AACN, 2019, Dennison, 2007; Gregory et al., 2007; Murphy, 2012). In the current pilot study, the C-MATCH-REASON checklist was developed and investigated to determine if medication errors were reduced among pre-licensure nursing students. A significant finding in this study, consistent with research reported by Hales (2007), Kahneman (2013), Mattox (2012), and Reason (1990, 2013), was that the participants who utilized the C-MATCH-REASON checklist demonstrated greater rule adherence and committed fewer knowledge-based errors than the no-checklist control condition. Also, feedback on the Debriefing Questionnaire indicated that use of the C-MATCH-REASON checklist engaged clinical reasoning and increased error awareness as compared to the no-checklist group. Consistent with Henneman et al. (2014), Murphy (2012), and White et al. (2010), improving a system with a standardized medication administration checklist that included prompts to collaborate with an expert, improved human performance [i.e. fewer errors].

Lastly, research from both the airline industry (Degani & Wiener,1990) and cognitive psychology (Reason 1990, 2013) suggested that checklists can function as quality measurement tools for error reporting. However, consistent with findings from prior research involving pre-licensure baccalaureate nursing students and error reporting (Cooper, 2014), discrepancies in error reporting were detected in this current pilot study. Therefore, in addition to supporting research investigating error recovery and reporting, nursing education has a social responsibility to advocate for policies that emphasize accuracy in tracking and reporting of medication errors for the improvement of patient safety (Cooper, 2014; Hughes & Blegen, 2008).

Implications for Policy Change

Policy Change is Process Oriented

One way to reduce errors and raise error awareness is through instituting policy change that stipulates the utilization of evidence-based safety checklists every time procedures are performed (Degani & Wiener, 1990; Gawande, 2009; Gawande & Weiser, 2008). Longest (2016) identified four activities that need to be completed before policy is implemented: designing, rulemaking, operating and evaluating. Regarding this pilot study involving nursing education, all four activities were completed. First, the instrumentation was designed based on a literature review. Next, content validity, of both the instrumentation and the simulation scenarios, was obtained through peer-review. Training PowerPoints were created and utilized by the participants and raters. Training Videos were created and utilized by raters and interrater agreement was established for reliability of testing among the raters. The simulation practice was operationalized: the raters conducted the scenarios and collected the data; the researcher analyzed and reported the data.

Just Culture as Standard Practice

As noted in Chapter Four, the checklist group demonstrated greater rule adherence and committed fewer errors in total than the no-checklist group. However, not every medication error recovered was reported. Nor was every error committed reported. Consistent with the findings from Cooper (2013), it remains unclear if the participants in this pilot study, chose not to report (e.g. no harm to patient/save face), or if the complexities of the skill interfered with the completion of error reporting. The

outcomes from this pilot study have important implications if attempts were to be made to standardize policy with a dual purpose: reduce medication errors and improve error reporting. Thus, to promote error reporting without penalty, this researcher further recommends policy development for the standard practice of a Just Culture (Benner, 2001b; Frankel et al., 2006) to be practiced in both the simulation and clinical settings (Degani & Wiener, 1990; Henriqson et al., 2011; Khairallah, et al., 2012). Increased collaboration between educators and practicing professionals would advance desired nursing education pathways (AACN, 2019).

Of interest, in current times, computer-assisted delivery of drugs from dispensers (that do not involve nurses) exist in hospitals to improve administration accuracy (Lohman, 2017). However, Lohman did not discuss how the system would recover and report errors. Even airline crew members still, jointly, refer to a paper checklist every time, preflight to reduce pilot error and enhance safety with air travel. Also, finding the safest method to administer medications would be impossible without error reports (Harding & Petrick, 2008; Pape, 2001; Wolf et al., 2006; Wright, 2013).

New settings. Finally, to implement an evidence-based medication administration protocol in a new setting (academic and/or clinical) certain policy changes would need to be operationalized with respect to the organizational processes particular to the new setting (Longest, 2016). This researcher suggests that the ideal venue to operationalize a new policy would be a teaching hospital where a Just Culture is standard practice and academics and professionals collaborate to heal patients. Within this environment where a Just Culture is the norm for error reporting, the new medication administration protocol would be implemented. Next, data would be

collected and evaluated to identify effectiveness of the protocol.

Implications for Further Research

Checklist Revisions

The C-MATCH-REASON checklist was developed to be an evidence-based standard. In general, future research would involve making relevant revisions to the C-MATCH-REASON checklist and then retesting whether utilization of the checklist results in medication error reduction. This pilot study, as written, was dependent on the raters to conduct a rigorous protocol in a simulation environment. The C-MATCH-REASON checklist has many steps which produced a noisy instrument making it difficult to compute interrater reliability. However, interrater agreement was attained among the raters. Next, given the tendency that people want to complete tasks in as few steps as possible (Kahneman, 2013), further optimizing the number of steps for both the trainer and trainee (while maintaining standardization) is suggested. Albert Einstein was credited for stating that "Everything should be as simple as possible, but not simpler" (Prausnitz, 2002, p. 230). Further research may find that a reduction of the steps bundled on the C-MATCH-REASON checklist results in greater accuracy in the measurement of errors.

In the hospital setting error data would be collected *in vivo*. However, in the simulation environment, error data could be collected, either *in vivo* or from video recordings of study participants. Tracking and tallying error data from well produced video recordings would improve accuracy with the data collection process (Polit & Beck, 2004). Also, converting the Observation Form to an electronic form may

facilitate ease of use and greater accuracy when tallying and reporting error data *in vivo* or from video recordings. An electronic Observation Form with video recorded data may facilitate accuracy with establishing interrater reliability.

Study Replication and Transition to Practice

The addition of a paper checklist to nursing curriculum is not likely to influence a program budget. However, the costs for study replication and/or transitioning the new checklist into practice include time (for both training and practice) and material. Since the checklist and study methodology have been designed, the activities that would be repeated are rulemaking, operationalizing, and evaluation (Longest, 2016).

After obtaining IRB approval and recruiting student participants, rulemaking activities would involve the researcher updating the Training PowerPoints and then training both nursing faculty (raters) and participants on the use of the instrumentation. As previously mentioned, greater emphasis would be put on both the Just Culture and how to use the checklist to track errors reported. Also, the Debriefing Questionnaire would be revised to include a question specific to error reporting. Next, the raters would utilize the Observation Form while viewing the Training Videos to track errors and to establish interrater agreement. *Operationalizing* would involve identifying and securing a practice environment, conducting the study, and collecting data. The data collected would be *evaluated* to identify effectiveness of the protocol.

Study population considerations. As discussed earlier in this chapter, a population consisting of novice-level nursing students who were learning from participating in this pilot (Dewey, 1966) may not have been ideal for testing a new

instrument for medication administration and error reporting. Nurses practicing with a higher level of expertise (e.g. competent, proficient, expert) may have been more suitable for participation in this study (Benner, 2001a). Even so, a need continues for standardized methods that are effective in the recovery and reporting of medication errors among both professional nurses and nursing students (Henneman et al., 2010; Keers, et al., 2014; Leufer & Cleary-Holdforth, 2013; Murphy, 2012). As a result, future studies conducted by this researcher-post doctoral, would examine error recovery and reporting with utilization of the C-MATCH-REASON checklist among both, highly experienced RNs in the clinical setting as well as nursing students. The findings from professional nurses would be compared to those of novice-level students.

Sample size. It is highly likely that, due to the small sample size, a Type II error occurred with respect to error reporting (hypothesis one). For study replication, if *t*-tests (two-sided) were used, significance level was set at 0.05 and effect size was 0.5, then the recommended sample size would be 65 to obtain a power level of 0.80 (ANZMTG Statistical Decision Tree, 2018; Cohen, 1988). The results from this pilot study (n=19) could be included in a meta-analysis examining similar research questions.

Additional questions related to checklist utilization research may include: *Do participants who apply checklist steps in sequential order detect more errors? Are participants finding errors because they are using the checklist? Are participants who use a checklist more consistent upon completion of multiple practice sessions (i.e. was there a treatment-by-period interaction)? What are the barriers to error reporting? What are the barriers to double-checking high-risk drugs?*

Conclusion

Findings from this pilot study were consistent with the findings of Reason (1990, 1997) and Kahneman (2013) regarding the use of evidence-based checklists to reduce errors. Utilization of the C-MATCH-REASON checklist with medication administration facilitated rule adherence and reduced knowledge-based errors, confirmation bias errors, and Total Errors among novices as compared to a no-checklist control condition. The findings were statistically significant, noteworthy, and encouraging. Moreover, feedback from 100% of the faculty and participants expressed interest in the continued use of the C-MATCH-REASON checklist. Themes included that checklist utilization facilitated clinical reasoning and raised error awareness.

However, the pilot study did not find that utilization of the C-MATCH-REASON checklist improved medication administration error recovery ($p = 0.061$) and error reporting among pre-licensure baccalaureate nursing students. Two factors that may have contributed to not finding a relationship with error reporting and checklist use included: (1) a small sample size (n = 19) that lacked power (type II error); and (2) a fixed number of embedded errors to recover and report. Therefore, gaps in research remain related to the use of an evidence-based medication administration checklist to facilitate error recovery and reporting. It is recommended that elements of the current study be revised and then a similar study could be conducted with a larger sample.

Patient harms related to medication administration errors are serious and widespread. Based on the preliminary findings from this pilot study, further investigation of the use of the C-MATCH-REASON checklist for error recovery and error reporting appears warranted.

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Appendix A

Permission to use
James Reason's Error Theory

The Sage Colleges

Mary Agoglia <agoglm@sage.edu>

FW: Permission Request

2 messages

Georgia Stratton <gstratton@cambridge.org> Fri, Jun 23, 2017 at 9:50 AM
To: "agoglm@sage.edu" <agoglm@sage.edu>

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From: Permissions request [mailto:noreply@cambridge.org]
Sent: 23 June 2017 13:05
To: Permissions Sales UK <Rights@cambridge.org>
Subject: Permission Request

date = June 23, 2017

name = Mary Agoglia

email = agoglm@sage.edu

address1 = 2622 State Rte 295

address2 = PO box 56

address3 =

town = Canaan

state_province = New York

postcode = 12029

country = US

tel = 518-781-0572

ourTitle = book

bookTitle = Human Error

authorType = author

bookauthor = James T. Reason

isbn = 978-0-521-31419-0

journalvol =

pubyear = 1990

details = Author and Title: Reason, J. T. 1990. Human Error. I am requesting the use of two illustrations from Human Error. The first is on page 64: Figure 3.1. Outlining the dynamics of the generic error-modelling system GEMS. The second is on page 150: Figure 6.1. A basic feed-back loop in which the output signal is compared to a reference input signal.

request = reprint

publicationBy = author

authorname = Mary Agoglia

workingtitle = Effect of a New Checklist on Medication Error Types and Error Recovery among Nursing Students in a Simulation Environment

publisher = Sage Graduate School, ProQuest Disseration Publishing

market = other

other = Dissertation for Academics

format = parallel

extract = 0

printrun = 10

sellprice = $00.00

Mary Agoglia <agoglm@sage.edu> Fri, Jun 23, 2017 at 5:11 PM
To: Georgia Stratton <gstratton@cambridge.org>, Kathleen Kelly <kellyk5@sage.edu>

Dear Georgia Stratton,

Thank you. I will abide to your terms and conditions.

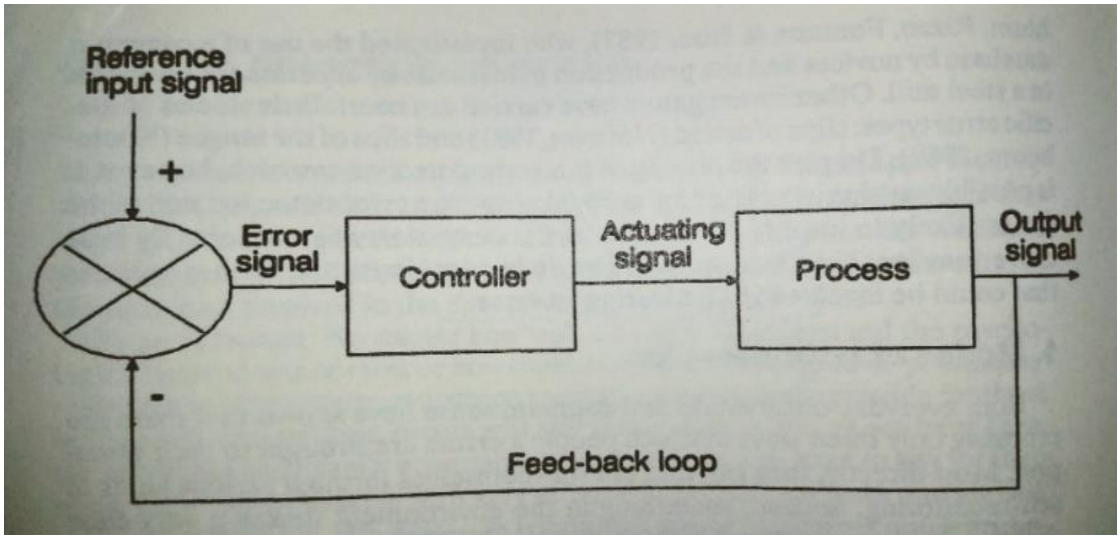
Respectfully,

Mary Agoglia
[Quoted text hidden]

Appendix B

Basic Feedback Loop

Basic Feedback Loop



Note. Reprinted with permission from Reason, J. (1990). Human error (1st ed., p. 150). New York, NY: Cambridge University Press. "A basic feedback loop in which the output signal is compared to a reference input signal. The difference between the output and input signals (the error signal) constitutes input to the controller, which then acts to minimize the discrepancy. The system is thus error driven" (Reason, 1990, p. 150).

Appendix C

Permutations of the Medication Administration Rights

Table C1. Permutations of the Medication Administration Rights

Author	Number	Description
Craven and Hirnle, 2009 White et al., 2010	5	patient, medication, time, dose, route
Pape et al., 2005	*Five plus one**	drug, patient, dose, time, route, plus documentation
Gill et al., 2012	6	patient, medication, time, dose, route, and documentation
Wilson and DiVitio-Thomas, 2004	6	patient, medication, time, dose, route, and response
Burton and Ludwig, 2014	6 or 7**	patient, medication, time/date, dose, route, and documentation
Curren, 2010	7	patient, medication, time, dose, route, recording, and partnering with the patient
Cooper, 2014; Harding and Petrick, 2008; Pape, 2003	7	drug, patient, dose, time route, reason (action), and documentation
College of Nurses of Ontario (2014) (as cited in Bourbonnais and Caswell, 2014)	8	client, medication, dose, time, frequency, route, reason, and site
Elliot and Liu, 2010	9	patient, medication, time, dose, route, documentation, action, form, response
Berman, Snyder, and McKinney (2011)	10	medication, dose, time, route, client, client education, documentation, refuse, assessment, evaluation

***** Pape et al. (2005) explain that *Five plus one* is a process improvement campaign.
** Burton and Ludwig (2014) suggest designating *date* as a seventh right.

Appendix D

C-MATCH-REASON Oral Medication Administration Checklist with Instructions

(C-MATCH-REASON Checklist)

C-MATCH-REASON-Checklist Instructions

1. **Column One: The items that comprise the mnemonic C-MATCH-REASON.**
    - **C-MATCH-REASON translates to 11 medication administration rights:** Client-chart?; Medication?; Adverse drug reactions?; Time?; Current Health?; Route?; Expiration date?; Amount?; Site-safety?; Outcomes?; Notation?
2. **Column Two: Procedural Steps for Medication Administration**.
    - The steps in Column Two are bundled next to the corresponding right.
3. **Column Three: Prepare 1st.**
    - Column Three is comprised of the steps involved with preparing medication.
    - If an error is found (F) and/or an error is reported (R) during preparation, then enter the letters F and/or R in the corresponding box in Column Three.
4. **Column Four: Administer 2nd.**
    - Column Four is comprised of the steps involved with administering medication.
    - There are steps from the preparing stage that are not repeated in the administering phase, therefore directional arrows connect the gaps.
    - If an error is found and/or an error is reported during preparation, then enter the letters F and/or R in the corresponding box in Column Four.
5. **The asterisk** (*) indicates that the student needs to reason & alert the instructor, RN, PCP, pharmacist, etc. of error/abnormal data to correct it.

Procedural Steps

1. Start at the top of the checklist: **Obtain MAR**. Take the MAR to the **client area** and complete the steps in the section "Client-Chart?" If an error is found, then report the error and mark the corresponding box in the Prepare 1st Column with the letters F and R, otherwise continue preparing the medication.
2. Move to the **medication area** with the MAR. Preparing one medication at a time, complete each step all the way through the "Amount?" section, unless an error is found. If an error is found, then report the error and mark the corresponding box in the Prepare 1st Column with the letters F and R.
3. At the end of the "Amount?" section, a STOP sign will be reached. STOP. If there are more medications, then prepare the next medication as instructed above in step two. If there are no other medications to prepare, then proceed to step four listed below.
4. When all medications are prepared to the point of the Stop sign, then follow the message, "After preparing all medications, continue at the top of the next column (Client-Chart)"
5. At the **client area**, with the prepared medication and the MAR, start at the top of Column Four (Administer 2nd). Use the checklist to facilitate patient verification.
6. Shift back to the **medication area** and complete each checklist step, checking one prepared medication at a time, unless an error is found. If an error is found, then report the error and mark the appropriate box with the letters F and R.
7. If no errors are found, shift back to the **client area** and follow the remaining steps to safely administer the medication to the patient. Monitor the patient and report and document outcomes and error occurrences.

C-MATCH-REASON Oral Medication Administration Checklist **(C-MATCH-REASON-Checklist)** ***Use boxes in the Prepare and Administer columns to note error found (F) and/or error reported (R)***		**Prepare 1st**	**Administer 2nd**
Did I identify the right…	**Obtain MAR**. Read client name and DOB	(1)	(3)
Client-Chart?	**Client Area**: Ask client/family/interpreter to state client name/DOB		
	Match name on ID band to MAR		
	Match DOB on ID band to MAR		
	E-scan client's ID band bar-code		
	Medication reconciliation (MAR/client/family/interpreter): Clarify Adverse Drug Reactions. Check for drug duplication, omission, and need for discontinuation*		
	Collect assessment data and compare data to parameters in MAR*		
Medication?	**Medication Area**: Wash hands. Read client name, DOB from MAR	(2)	
	Read & clarify reason for order; "Read Back" verbal order*		
	Clarify safe dose range*		
	Obtain drug (prepare 1 at a time); inspect storage, sign out narcotic		
	Match (and/or E-scan) drug label to MAR		(4)
	Follow instructions on drug label and MAR; Keep drug in sight		
Adverse Drug Reactions?	Match allergy list on MAR to drug label		
	Match adverse drug reactions on MAR to drug label		
Time?	Match time/date/frequency on MAR to drug label		
Current Health?	Screen health data (e.g. lab results, pregnancy status), link to shifts in care (e.g. procedures, surgery) and to drug contraindications*		
Route?	Match route on MAR to drug label		
	Identify form of drug*		
Expiration?	Clarify expiration date of medication*		
Amount?	Match amount ordered on MAR to amount on drug label		
	Calculate Amount and/or Rate (calculate pediatric doses in mg/kg)		
	Keep unit dose in package; pour liquid at eye level into medicine cup on level surface; follow aspiration precautions;		
	Double check the amount prepared of *high-risk drugs* with RN*		
STOP	After preparing all medications, continue at the top of the next column (Client-Chart) STOP		
Site Safety?	**Client Area:** Educate on drug use/effect; position client; administer drug with a suitable beverage; readjust bed height, call bell in reach; proper disposal of waste*		(5)
Outcomes?	Anticipate problems: monitor/evaluate patient's response to the medications*		
Notation?	Document: drug effect, assessment, teaching, if drug was held, etc.		

Notation for Error Reporting	**List actual errors committed and contributing factors. Did error lead to patient harm? Yes/ No/ Unknown.**

Legend: Medication Administration Record (MAR); Date of birth (DOB); Identification (ID); Vital Signs (VS); Registered Nurse (RN); *Reason & alert Instructor, RN, PCP, Pharmacist, etc. of error/abnormal data.

Appendix E

C-MATCH-REASON Medication Error Tracking Instrument with Instructions

(Observation Form)

Instructions for the C-MATCH-REASON Medication Error Tracking Instrument

(Observation Form)

Nursing faculty will utilize the Observation Form to track medication error data as they observe students administer medications.

1. **Columns One and Two: Reasoning with Rule Adherence**

   Column One. As students prepare one medication at a time:
   - Enter a tally (/) in Column One for each step that a student completes when preparing each medication that is to be administered. **Don't score tallies for medications prepared in error (e.g. expired drug).**
   - If a step is partially completed, then circle the part of the step ***NOT*** completed, if it is relevant to the scenario (e.g. adjust bed height), but do not enter a tally.
   - A step ***NOT*** completed may need to be circled more than one time if more than one medication is being prepared and administered.

   Column Two. As students check one medication at a time with administering:
   - Enter a tally (/) in Column Two for each step that a student completes correctly. **Don't score tallies for medications administered in error**.
   - Repeat the above process for partially completed steps.
2. **Column Three: Error Found**
   - Enter a tally (/) in the corresponding box in Column Three for an error found.
3. **Columns Four and Five: Errors Reported**
   - Enter a tally (/) in the corresponding box in Column Four for student reporting of a close call (e.g. an error found before reaching the patient).
   - Enter a tally (/) in the corresponding box in Column Five for student reporting of an error of commission (an actual error).
   - If a student **states** that they will fill out an occurrence report for any close call errors found as well as any actual errors committed, then mark a tally for error reporting.
4. **Columns Six and Seven: RESEARCH USE ONLY**
   - This section is for the researcher. **Do Not** enter data in these columns.
5. **Notation for Error Reporting**: List errors committed by the student.
6. **Legend:** The asterisk (*) indicates: The student needs to reason & alert instructor, RN, PCP, pharmacist, etc. of error/abnormal data to correct it. Medication Administration Record (MAR);Date of birth (DOB);Vital Signs (VS); Confirmation bias (CB); Adverse Drug Reaction (ADR); Registered Nurse (RN)

Additional Guidelines for Tallying Errors

- The student needs to check the Name on the ID band and compare it to the Name on the MAR. Next, the student must check the DOB on the ID band and compare it to the DOB on the MAR. These are two separate steps. **If the student combines the two steps then the student doesn't get a tally for either step.**
- Tallies are tracked and counted to the point where an error is first evident (e.g. close call).
- If a student gave an expired medication and the rater marked tallies for each step, then the error-linked tallies must not be included when totaling tallies for rule adherence.

C-MATCH-REASON Medication Error Tracking Instrument (Observation Form) ***Did the student identify the right…***		Reasoning with Rule Adherence		Error found **(close calls)**	Errors Reported		Skill based errors	Know ledge based errors
		1 Prepare	2 Admin -ister	3	4 **Close Calls**	5 **Actual Errors**	6 **RESEARCH USE ONLY**	7
Client-Chart?	**Obtained MAR**; Read client name and DOB							CB
	Client Area: Asked client/family/interpreter to state client name and DOB							CB
	Matched client name on ID band to MAR							CB
	Matched DOB on ID band to MAR							CB
	E-scanned client's ID band bar-code							CB
	Medication reconciliation (MAR/client/family/interpreter). Clarified Adverse Drug Reactions. Checked for drug duplication, omission, and need to discontinue drug*		n/a					
	Collected assessments; compared data to parameters-MAR*		n/a					
Medication?	**Medication Area**: Washed hands. Read name, DOB on MAR		n/a					n/a
	Read & clarified reason of order; "Read Back" verbal order*****		n/a					
	Clarified safe dose range*		n/a					
	Obtained drug (prepared 1 medication at a time), inspected storage, signed out narcotic		n/a					n/a
	Matched (E-scan) drug label to MAR							CB
	Followed instructions on label and MAR; Kept drug in sight							CB
Adverse Drug Reactions?	Matched allergy list on MAR to drug label		n/a					n/a
	Matched ADR's on MAR to drug label		n/a					n/a
Time?	Matched time/date/frequency on MAR to drug label							CB
Current Health?	Screened health data (e.g. lab results, pregnancy status) linked to shifts in care (e.g. procedures, surgery) & drug contraindications*****		n/a					
Route?	Matched route on MAR to drug label							CB
	Identified form (enteric coated, liquid, capsule, etc.) *****		n/a					
Expiration?	Clarified expiration date of medication		n/a					
Amount?	Matched amount ordered on MAR to amount on drug label		n/a					n/a
	Calculated right amount and/or rate (pediatric doses mg/kg)*							CB
	Kept unit dose in package; poured liquid at eye level into medicine cup on level surface; aspiration precautions		n/a					n/a
	Double checked amount prepared of *high-risk drugs* with RN		n/a					CB
Site-Safety?	**Client Area:** Educated client: drug use/effect; positioned client; offered suitable beverage; administered drug; adjusts bed height, call bell in reach; proper disposal drug waste*	n/a						
Outcomes?	Anticipated problems: monitored and evaluated drug effect*	n/a						
Notation?	Documented: drug effect, assessments, teaching, drug held*	n/a						
TOTAL							-	-
Notation for Error reporting	**List actual errors committed and contributing factors. Did an error lead to patient harm? Yes / No / Unknown.**							

C-MATCH-REASON Medication Error Tracking Instrument (Observation Form) *Did the student identify the right…*		Reasoning with Rule Adherence		Error found (close calls)	Errors Reported		Skill based errors	Know ledge based errors
		1 Prepare	2 Admin -ister	3	4 Close Calls	5 Actual Errors	6 RESEARCH USE ONLY	7
Client-Chart?	**Obtained MAR**; Read client name and DOB	/	/					CB
	Client Area: Asked client/family/interpreter to state client name and DOB	/	/					CB
	Matched client name on ID band to MAR							CB
	Matched DOB on ID band to MAR							CB
	E-scanned client's ID band bar-code	/	/					CB
	Medication reconciliation (MAR/client/family/interpreter). Clarified Adverse Drug Reactions. Checked for drug duplication, omission, and need to discontinue drug*	/	n/a	/				
	Collected assessments; compared data to parameters-MAR*	/	n/a					
Medication?	**Medication Area**: Washed hands. Read name, DOB on MAR	/	n/a					n/a
	Read & clarified reason of order; "Read Back" verbal order*	///	n/a					
	Clarified safe dose range*	/	n/a					
	Obtained drug (prepared 1 medication at a time), inspected storage, signed out narcotic	///	n/a					n/a
	Matched (E-scan) drug label to MAR	///						CB
	Followed instructions on label and MAR; Kept drug in sight	/						CB
Adverse Drug Reactions?	Matched allergy list on MAR to drug label	///	n/a					n/a
	Matched ADR's on MAR to drug label	/	n/a					n/a
Time?	Matched time/date/frequency on MAR to drug label	///						CB
Current Health?	Screened health data (e.g. lab results, pregnancy status) linked to shifts in care (e.g. procedures, surgery) & drug contraindications*	///	n/a					
Route?	Matched route on MAR to drug label	///						CB
	Identified form (enteric coated, liquid, capsule, etc.) *	///	n/a					
Expiration?	Clarified expiration date of medication	///	n/a	/	/			
Amount?	Matched amount ordered on MAR to amount on drug label	//	n/a					n/a
	Calculated right amount and/or rate (pediatric doses mg/kg)*	//						CB
	Kept unit dose in package; poured liquid at eye level into medicine cup on level surface; aspiration precautions		n/a					n/a
	Double checked amount prepared of *high-risk drugs* with RN	/	n/a					CB
Site-Safety?	**Client Area:** Educated client: drug use/effect; positioned client; offered suitable beverage; administered drug; adjusts bed height, call bell in reach; proper disposal drug waste*	n/a	//					
Outcomes?	Anticipated problems: monitored and evaluated drug effect*	n/a	//					
Notation?	Documented: drug effect, assessments, teaching, drug held*	n/a	//					
TOTAL	**Scenario #1 Score = 53 out of 78**	41	9	2	1		-	-
Notation for Error reporting	**List actual errors committed and contributing factors. Did an error lead to patient harm? Yes / No / Unknown. Error- Vitamin D3 given on wrong date. Turned back on 2 drugs to answer phone. Identified ibuprofen shouldn't be given didn't call the HCP to D/C it. Didn't report this as a close call error. Meds taken out of packages were not rechecked**							

Appendix F

Evidence-Based Checklist Items

Table F1.

Evidence-Based Checklist Items

Performance Category	Associated Checklist Items	Author(s)
Ruled-based	Verify Client Name separately from DOB when comparing data on ID band to the chart	Henneman et al., 2010
	Allergy/ADR Verification	
	Medication reconciliation	Henneman et al., 2014
	Partnering with the patient	Curren, 2010
	Involve interpreter	Betancourt and Tan-McGrory (2014)
	Reason for the medication,	Bourbonnais and Caswell, 2014; Cooper, 2014
	Amount (dose) verification	Harding and Petrick, 2008; Pape, 2003
	Time, Date verification	Burton & Ludwig, 2014;
	Frequency verification	Bourbonnais and Caswell, 2014
	Route and Form verification	Elliot and Liu, 2010
	Current Health data and	Burton & Ludwig, 2014
	Expiration date verification	
	Site verification	Bourbonnais and Caswell, 2014
	Proper disposal of drug waste	Kinrys, Gold, Worthington, and Nierenberg, 2018
	Observations-outcomes	Wilson and Divitio-Thomas, 2004
	Teach Proper-Use	FDA, 2017; NSPA, 2015
	Error Reporting	Curren, 2010; James, 2013
Rule-based Close-calls	Error Found Column	Henneman et al., 2010; Reason, 1990
Knowledge-based	Engage metacognition	Curren, 2010
	*Alert and coordinate with professionals and patient to problem solve.	Mattox, 2012 Reason, 1990 Vygotsky, 1962
Knowledge-Confirmation bias	Double check selected steps (e.g. high-risk drugs with second RN)	Kahneman, 2013; Mattox, 2012; White et al., 2010
Skill-based Slips: System or human (e.g. root cause)	Students are asked if they permitted interruptions/ distractions. If yes, explain.	Kahneman, 2013; Mattox, 2012; Pape, 2003; Pape et al., 2005; Reason 1990, 2013; Wright, 2013
Skill-based Lapses	Promote use of resources (e.g. checklist)	Mattox, 2012 Reason, 1990

Appendix G

Evidence-Based Guidelines for Checklist Design & Use

Table G1.

Evidence-Based Guidelines for Checklist Design and Use

Author	Evidence-based Guidelines for Checklist Design and Use
Betancourt and Tan-McGrory (2014)	**Use:** Cultural Competence- error reporting systems need to prompt high-risk situations (e.g. medication reconciliation) and access to interpreters to identify and prevent LEP errors
Catchpole and Russ (2015)	**Use**: Improve communication (briefing and debriefing).
Degani and Wiener (1990)	**Design**: Sequential steps; duplication of highly critical items (pilots call them "killer items"); divide long checklist into chunks (group corresponding items) and flow logically if used with technology (minimizing non-linear processes); improve supervision, communication and act as a quality control tool.
Fede et al., (2011); Pincus (2013)	**Use:** Reduce transitional care errors by increasing the *discontinuing* of prescriptions related to ADEs, polypharmacy and overuse by medication reconciliation.
Hales and Pronovost (2006)	**Design:** Chunk and bundle data to minimize cognitive load **Use:** Prompt memory.
Hales, et al., (2007)	**Design:** Sequential steps to obtain a valid outcome; "logical and functional order that reflect the sequence or flow of real-time clinician activities…" (p. 25). **Design for Academia:** "strong, external review of format, content, design; expert consensus; testing, rigorous validation process" (p. 26).
Mattox (2012)	**Use:** "Ensure that all factors in the problem space are adequately assessed and integrated into the final understanding" (Mattox, 2012, p. 58).
Kahneman (2013)	**Use:** Cognitive cuing with checklists to promote rule adherence and reasoning (Kahneman, 2013; Mattox, 2012) **Design:** "Well designed checklists… include the critical steps susceptible to skill-based errors (e.g. hand hygiene) as well as rule-based mistakes [e.g. verification of the presence of contraindications]" (Mattox, 2012, p. 56)
White et al. (2010)	**Design:** "step-by-step instructions… for detecting specific errors when a care provider is… to perform a long series of mechanistic tasks under a high cognitive load" (p. 562)
Potter et al. (2005); West-brook et al. (2010)	**Design:** distinguish shifts from preparing to administering to prevent multitasking

Appendix H

C-MATCH-REASON Lesson Plan Standard Operating Procedures

Lesson Plan: C-MATCH-REASON - A Process to Enhance Safety with Medication Administration

Goal: Pre-licensure nursing students will participate in two Simulation Practices with two different novice-level scenarios and learn that medication administration is a rule-based procedure that requires clinical reasoning as well as error awareness for the recovery and reporting of medication errors. Methods to facilitate learning: sequencing lecture content from simple to complex; chunking; multimodal effect; and two simulation practice sessions.

Objectives: The student will

- Identify and list the rights to medication administration
- Review medication administration skills checklist that includes the medication rights.
- Describe the meaning of each medication administration right.
- Demonstrate matching the MAR to medication labels and to the client's ID band.
- Practice the use of inquiry (Do I have the right…?) to prompt clinical reasoning.
- Follow the non-linear sequence on the checklist to prepare and administer the medication.
- Utilize external resources (e.g. expert staff, drug guide) to facilitate clinical reasoning to problem solve to detect, interrupt and correct errors
- Report errors

Learner Activities/Course Expectation

- All participants will receive via email a Training PowerPoint presentation and complete an electronic post-test. Estimated time: 20 minutes.
- All participants will participate in two simulation practices involving novice-level scenarios, each embedded with three medication errors.

Evaluation

- Post-test scores via an online Learning Management System. The Observation Form will be used to track rule adherence and errors. Debriefing with faculty and written reflection.

Learning Outcome

- The predicted learning outcome is that the participants using the C-MATCH-REASON checklist will (1) report more errors; (2) adhere to more checklist rules; (3) commit fewer knowledge-based mistakes; (3) commit fewer confirmation bias errors; (4) commit fewer skill-based slips; and (5) report more errors, as compared to the control condition.

Participant Description

- Inclusion criteria: pre-licensure nursing students who completed pharmacology and fundamentals of nursing coursework in addition to having prior experience with simulation practice will administer medications in a simulation environment.

Standard Operating Procedures

Participant Selection and Informed Consent

Full-time and adjunct clinical faculty, who teach in BSN programs, will be recruited to assist with using the C-MATCH-REASON learning strategy. Student nurse volunteers will be recruited to participate as part of their clinical training. The researcher will obtain informed consent. Also, the researcher will describe the study, answer questions and witness the participants sign the informed consent. The participants will receive a copy and the researcher will retain the original copy in a secure location. Participating faculty will receive an orientation to the C-MATCH-REASON method for oral medication administration via a Training PowerPoint-FV (Faculty Version).

Curriculum Intervention

Curriculum Guidelines for Study Conduction and Replication

An outcome of the student's clinical education practice will be to improve safety with medication administration through utilization of a standardized checklist and as evidenced by the number of medication administration errors committed, recovered, and reported when compared to a control condition. A crossover design will be used so all students will participate in both groups. The C-MATCH-REASON checklist and Observation Form were developed by this researcher. The content and design of the checklist were developed from a literature review that focused on medication administration, checklist utilization, the examination of errors and error reporting (Barker et al., 2002; Goodstone, 2013; Henneman et al., 2010; Pape, 2003; Cooper, 2013; White et al., 2010).

Cognitive load theory. The medication administration lesson is sequenced from simple to complex. Novice nursing students who previously studied pharmacology will be the targeted population to learn the proposed *11 Rights* for safe medication administration. The first part of the lesson comprises a 20-minute-long PowerPoint presented by this researcher who explains the C-MATCH-REASON system for medication administration. This multimodal effect is designed to maximize the capacity of working memory and to shape habit that will enhance student training.

Chunking. To further stretch working memory, the proposed 11 rights are chunked into the mnemonic and directive C-MATCH-REASON. Chunking processes information more efficiently (Bruning et al., 2011). The students are expected to spend 15 minutes rehearsing the administration of oral medication using the C-MATCH-READ Oral Medication Checklist for Students (van Merrienboer & Sweller, 2005). Students apply visual and psychomotor rehearsal when comparing a drug label to the MAR and practice the skill referring to the Checklist. Students in the no-checklist control condition will follow traditional coursework as taught in the syllabus during the simulation exercise.

Course Description and Learning Environment

Lesson Design: Utilization of scaffolding, sequencing, and an external cue in the form of a skills checklist for the practice of oral medication administration and error reporting in a simulation environment.

Purpose: To minimize the extraneous cognitive load on nursing students by cuing existing schemata (e.g. pharmacology coursework; knowledge of medication

administration) with new information (simulation scenario; standardized skills checklist anchored with a mnemonic) to improve safety with medication management.

Rationale: Medication administration is a complex rule-based process that is difficult to learn (Henneman et al., 2010). A literature review does not identify a standard protocol nor a standard number of medication administration rights to facilitate skill acquisition. To enhance both learning and patient safety, this proposed instruction design includes the utilization of a skills checklist comprised of eleven rights anchored in the mnemonic C-MATCH-REASON. The mnemonic also reads as a directive. Checklists can assist users with procedural learning that involves both clinical reasoning and rule adherence (Mattox, 2012). Also, minimizing cognitive load with utilization of procedural cues facilitates learning (van Merrienboer & Sweller, 2005). Procedural learning may lead to skill acquisition, expertise and know-how (Bruning et al., 2011). Know-how further reduces cognitive load which frees space in working memory for error identification (Bruning et al., 2011).

Confirming the proposed 11 rights occurs primarily in the administration stage of the medication-use process. Outcomes are identified during the monitoring stage. To illustrate use of the C-MATCH-REASON checklist, with every medication pass, the nurse needs to match the MAR to the drug label while questioning:

Do I have the right: client-chart?; medication?; Adverse Drug Reactions?; time; current health?; route?; expiration?; amount?; site-safety?; outcomes?; notation?

This medication administration lesson plan has been developed based on cognitive load theory to facilitate learning. The goals for student learning emphasize

that medication administration is a rule-based procedure that requires clinical reasoning as well as error awareness for the recovery and reporting of medication administration errors. The predicted learning outcome is that the student participants using the C-MATCH-REASON checklist will (1) report more errors as compared to the control condition; (2) adhere to more protocol rules; (3) commit fewer knowledge-based mistakes; (4) commit fewer knowledge-based confirmation bias errors; (5) commit fewer skill-based slips related to an embedded interruption.

Randomization, Course Delivery, and Data Collection

After completion of the C-MATCH-REASON Training PowerPoint presentation-SV (Student Version), student participants will be randomly assigned to either the checklist/no-checklist group or the no-checklist/checklist group and administer medication in a simulation environment. Based on assignment, participants will be instructed to place the C-MATCH-REASON checklist in a visible location for use with medication administration. Students will be instructed to refer to the checklist for each step of the medication administration process and use it to track errors found and errors reported. Nursing faculty will also instruct students on specifics of the scenario: (1) faculty read the scenario with the student; (2) students can seek clarification; (3) the time is 9 am; (4) the vital signs are current and to be utilized; (5) faculty is the voice of the patient; (6) students may utilize the drug guide; and (7) there is a phone (prop) to call the HCP (faculty role-plays the HCP). As the student prepares and administers medication, the faculty will input data onto the Observation Form. The faculty will tally the error data entered on the Observation Form upon completion of the simulation experience.

Method of Evaluation

Nursing faculty will utilize the Observation Form to track medication error data as they observe students administer medications.

1. **Columns One and Two: Reasoning with Rule Adherence**

Column One. As students prepare one medication at a time:

- Enter a tally (/) in Column One for each step that a student completes when preparing each medication that is to be administered. **Don't score tallies for medications prepared in error (e.g. expired drug).**
- If a step is partially completed, then circle the part of the step ***NOT*** completed, if it is relevant to the scenario (e.g. adjust bed height), but do not enter a tally.
- A step ***NOT*** completed may need to be circled more than one time if more than one medication is being prepared and administered.

Column Two. As students check one medication at a time with administering:

- Enter a tally (/) in Column Two for each step that a student completes correctly. **Don't score tallies for medications administered in error**.
- Repeat the above process for partially completed steps.

2. **Column Three: Error Found**
   - Enter a tally (/) in the corresponding box in Column Three for an error found.
3. **Columns Four and Five: Errors Reported**
   - Enter a tally (/) in the corresponding box in Column Four for student reporting of a close call (e.g. an error found before reaching the patient).
   - Enter a tally (/) in the corresponding box in Column Five for student reporting of an error of commission (an actual error).
   - If a student **states** that they will fill out an occurrence report for any close call errors found as well as any actual errors committed, then mark a tally for error reporting.
4. **Columns Six and Seven: RESEARCH USE ONLY**
   - This section is for the researcher. **Do Not** enter data in these columns.
5. **Notation for Error Reporting**: List errors committed by the student.
6. **Legend**
   - The asterisk (*) indicates: The student needs to reason & alert instructor, RN, PCP, pharmacist, etc. of error/abnormal data to correct it.
   - Medication Administration Record (MAR); Date of birth (DOB);Vital Signs (VS); Confirmation bias (CB); Adverse Drug Reaction (ADR); Registered Nurse (RN)

Additional Guidelines for Tallying Errors

- The student needs to check the Name on the ID band and compare it to the Name on the MAR. Next, the student must check the DOB on the ID band and compare it to the DOB on the MAR. These are two separate steps. **If the student combines the two steps then the student doesn't get a tally for either step.**
- Tallies are tracked and counted to the point where an error is first evident (e.g. close call).
- If a student gave an expired medication and the rater marked tallies for each step, then the error-linked tallies must not be included when totaling tallies for rule adherence.

Faculty Instructions for Consistency with the Sim Lab Practice

1. The faculty are encouraged to cue or gently remind the students assigned to the checklist intervention to read from the checklist throughout the scenario. If the nursing curriculum includes the practice of three checks with medication administration, then students in both groups complete these checks (i.e. preparing check, post-preparation check, and an administering check).
2. The faculty will read the scenario out loud to the student.
3. The current time for both Scenario One and Scenario Two is 9 am.
4. The students are to be informed that the vital signs in the scenario were just taken by them. They are to use these vital signs to complete the medication administration.
5. The students can ask the faculty questions to seek clarification (e.g. If the student asks, "Can I just say that I am washing my hands" Faculty can say yes and give them credit).
6. The faculty speaks for the patient (mannikin).
7. The MAR is a loose-leaf notebook that contains forms that the student must review: the medication record (students need to sign off medications); a current Lab Report (e.g. Coumadin and Vitamin D3 levels); a current Medication Reconciliation Sheet (e.g. indicating Vitamin D3 dose was taken); and a blank Medication Occurrence Report.
8. There will be a drug guide for students to look up drug action, ADR's, doses, etc.
9. There is a phone (prop) to cue students to call the MD or the Pharmacy.
10. If the student makes or finds and error, the student needs to state that they will complete a medication occurrence report, but they do not actually fill out the form.

Appendix I

Letter from Department of Nursing Chair

October 29, 2018

The Sage Colleges
Troy, NY 12180
Department of Nursing

Colleagues,

Good morning. Mary Agoglia is a Sage DNS student and has received IRB approval to conduct her study. She is asking to post this letter to a 300 and 400 level course to invite students.

I will be glad to post tonight to the 400 level. Could Arlene and Victoria forward to the one or two faculty in the 300 level that are not in 408 or 425. I will ask Nancy or Melissa to post the letter today for those two courses.

Please confirm who the other faculty contacted are for Mary Agoglia.

Mary, Good Luck with your study.

Regards,

Glenda B. Kelman Ph.D., ACNP-BC
Chair & Professor, Nursing
The Sage Colleges
Troy, New York 12180
(518) 365-3546
kelmag@sage.edu

Appendix J

Letter of Introduction to Nursing Faculty

The Sage Colleges

Troy, New York

Dear Nursing Faculty,

My name is Mary Agoglia, I am a student in the Doctor of Nursing Science Program at The Sage Colleges. I am working on my dissertation project, currently: Investigation of a Checklist to Reduce Medication Errors among Pre-Licensure Baccalaureate Nursing Students. My research method includes a crossover design and the use of a simulation environment with two testing periods. Nursing students will be asked to administer medication at Sage's Troy Campus simulation lab. Half of the volunteer student participants will utilize an original checklist and the other half will be in a no-checklist control condition. In the second period the volunteer student participants will crossover to the opposite group. My hypotheses include that students who utilize the checklist will commit less errors as well as find and report more errors.

If you are interested in volunteering to participate in this study, as nursing faculty observing student participants administer medication in the simulation environment and offering feedback on the experience, please let me know as soon as possible. I will send a Training PowerPoint Presentation to faculty who agree to participate. The pre-pilot assessment will be conducted in the fall of 2018 and the pilot study will take place in the spring of 2019 and both will occur outside of scheduled classes and clinicals.

Thank you and Kind Regards,

Mary Agoglia, MA, RN-BC
DNS Student, The Sage Colleges
Contact Information: agoglm@sage.edu

Appendix K

Informed Consent Forms for the Pilot Studies
(with Study Introduction and Invitation Letters)

Dear Nursing Students,

I am a student in the Doctor of Nursing Science Program at The Sage Colleges. I would greatly appreciate your assistance with my doctoral research project titled: Investigation of a Checklist to Reduce Medication Errors among Pre-Licensure Baccalaureate Nursing Students.

In my study, I am interested in learning more about the use of safety checklists to prevent medication errors. This study involves an estimated 2-hour and 10-minute commitment time and is divided into two parts: (1) completion of a Training PowerPoint and (2) participation in two simulation practice sessions involving medication administration at Sage's Troy Campus simulation lab. A pre-pilot assessment will be conducted the fall of 2018 and the pilot study will take place in the spring of 2019 and both will occur outside of scheduled classes and clinicals.

If you are interested in participating, then click the link to the Moodle course shell, *Dissertation Project-Medication Administration*, and follow the instructions for enrollment.

https://moodle.sage.edu/course/view.php?id=13552#section-0

Thank you and Kind Regards,

Mary Agoglia, MA, RN-BC
DNS Student, The Sage Colleges
Contact Information: agoglm@sage.edu

INFORMED CONSENT FORM

To: _____

You are being asked to participate in a research project entitled**:** Investigation of a Checklist to Reduce Medication Errors among Pre-Licensure Baccalaureate Nursing Students.

This research is being conducted by Mary Agoglia, DNS (c), MA, RN-BC, a student in the Doctor of Nursing Sciences Program at The Sage Colleges.

The purpose of this study is to evaluate the effectiveness of a learning strategy, in the form of an original checklist, to promote acquisition of the skill of medication administration. The study will take place in the nursing simulation lab at The Sage Colleges (Troy, NY). The study will be conducted in two phases: a pre-pilot assessment followed by a pilot study. Students will be asked to participate in either the pre-pilot assessment or the pilot study.

Role of the Student Subject. You will be given two appointments (spaced two to three weeks apart) to participate in two medication administration practice sessions (about 45-minutes each) as part of simulation at The Sage Colleges (Troy, NY). You may be video recorded. A nursing instructor will document your performance on the task of medication administration. Private debriefing with the nursing instructor along with completion of four reflective questions will immediately follow the simulation practice. Confidentiality will be maintained: instruments used with simulation testing and reflection responses have been coded. Student identification information will be deleted from the forms and a master tracking list with student names/codes will be maintained by the researcher to prevent others from linking students to performance.

If you decide to participate in the research, you will be asked to complete, via email, a Training PowerPoint Presentation on how to utilize a new medication administration checklist and participate in two simulation exercises. The estimated total study participation time is about

two-hours and 10-minutes. A direct benefit from participation is that the experiential and theoretical knowledge gained will lead to a stronger grasp of the medication administration skill.

There are no physical or emotional risks associated with this study.

I give permission to the researcher to play the audio or video recording of me in the places described above. Put your initials here to indicate your permission. _____

In the event that I am harmed by participation in this study, I understand that compensation and/or medical treatment is not available from The Sage Colleges. However, compensation and/or medical costs might be recovered by legal action.

Participation is voluntary, I understand that I may at any time during the course of this study revoke my consent and withdraw from the study without any penalty.

I understand that if I agree to participate it is expected that I will maintain confidentiality of the Checklist and the learning strategy, the simulation scenario content, and any outcomes.

I have been given an opportunity to read and keep a copy of this Agreement and to ask questions concerning the study. Any such questions have been answered to my full and complete satisfaction. I am at least 18 years of age.

I, _____, having full capacity to consent, do hereby volunteer to participate in this research study

Signed: _____ Date: _____

Research participant

This is a student conducted study. If you have any concerns, please contact Mary Agoglia at agoglm@sage.edu

This research has received the approval of The Sage Colleges Institutional Review Board, which functions to insure the protection of the rights of human participants. If you, as a participant, have any complaints about this study, please contact:

Dr. Theresa Hand
Associate Provost
The Sage Colleges
65 1st Street
Troy, New York 12180
518-244-2069
handt@sage.edu

Dear Nursing Students,

I am a student in the Doctor of Nursing Science Program at The Sage Colleges. I would greatly appreciate your assistance with my doctoral research project titled: Investigation of a Checklist to Reduce Medication Errors among Pre-Licensure Baccalaureate Nursing Students. All students who participate will be entered in a lottery and the winner will receive an Amazon gift card valued at $100 (one-hundred dollars). All students who enroll will receive a $15 Amazon Gift Card for each simulation practice completed. **For capstone students: participation in this study will fulfill the professional day requirement.**

In my study, I am interested in learning more about the use of safety checklists to prevent medication errors. This study involves an estimated 2-hour and 10-minute commitment time and is divided into two parts: (1) completion of a Training PowerPoint and then (2) participation in two simulation practice sessions involving medication administration at Sage's Troy Campus simulation lab. You will be given a private appointment for the sim practice. This study will be conducted March 22nd and March 29th and will occur outside of scheduled classes and clinicals. If your schedule conflicts with the above dates, please inform the researcher for additional dates.

If you are interested in participating in this study, then click the link below. The link will take you to the Moodle course shell, *Dissertation Project-Medication Administration*, where you will find enrollment instructions. https://moodle.sage.edu/course/view.php?id=13552#section-0

Thank you and kind regards,

Mary Agoglia, DNS (c), MA, RN-BC
DNS Student, The Sage Colleges
Contact Information: agoglm@sage.edu

INFORMED CONSENT FORM

To: _____

You are being asked to participate in a research project entitled**:** Investigation of a Checklist to Reduce Medication Errors among Pre-Licensure Baccalaureate Nursing Students.

This research is being conducted by Mary Agoglia, DNS (c), MA, RN-BC, a student in the Doctor of Nursing Sciences Program at The Sage Colleges.

The purpose of this study is to evaluate the effectiveness of a learning strategy, in the form of an original checklist, to promote acquisition of the skill of medication administration. The study will take place in the nursing simulation lab at The Sage Colleges (Troy, NY). The study will be conducted in two phases: a pre-pilot assessment followed by a pilot study. Students will be asked to participate in either the pre-pilot assessment or the pilot study.

Role of the Student Subject. You will be given two appointments (spaced one to two weeks apart) to participate in two medication administration practice sessions (about 45-minutes each) as part of simulation at The Sage Colleges (Troy, NY). A nursing instructor will document your performance on the task of medication administration. Private debriefing with the nursing instructor along with completion of four reflective questions will immediately follow the simulation practice. Confidentiality will be maintained: instruments used with simulation testing and reflection responses have been coded. Student identification information will be deleted from the forms and a master tracking list with student names/codes will be maintained by the researcher to prevent others from linking students to performance.

If you decide to participate in the research, you will be asked to complete, via Moodle, a Training PowerPoint Presentation on how to utilize a new medication administration checklist and to participate in two simulation exercises. The estimated total study participation time is about two-hours and 10-minutes. A direct benefit from participation is that the experiential and

theoretical knowledge gained will lead to a stronger grasp of the medication administration skill.

There are no physical or emotional risks associated with this study.

In the event that I am harmed by participation in this study, I understand that compensation and/or medical treatment is not available from The Sage Colleges. However, compensation and/or medical costs might be recovered by legal action.

Participation is voluntary, I understand that I may at any time during the course of this study revoke my consent and withdraw from the study without any penalty.

All students who participate will receive a $15 Amazon Gift Card upon completion of each simulation practice appointment. All student participants will be entered in a lottery and the winner will receive an Amazon gift card valued at $100 (one-hundred dollars). **For capstone students: participation in this study will fulfill the professional day requirement.**

I understand that if I agree to participate it is expected that I will maintain confidentiality of the checklist and the learning strategy, the simulation scenario content, and any outcomes.

I have been given an opportunity to read and keep a copy of this Agreement and to ask questions concerning the study. Any such questions have been answered to my full and complete satisfaction. I am at least 18 years of age.

I, _____, having full capacity to consent, do hereby volunteer to participate in this research study

Signed: _____ Date: _____

Research participant

This is a student conducted study. If you have any concerns, please contact Mary Agoglia at agoglm@sage.edu

This research has received the approval of The Sage Colleges Institutional Review Board, which functions to insure the protection of the rights of human participants. If you, as a participant, have any complaints about this study, please contact:

Dr. Theresa Hand
Associate Provost
The Sage Colleges
65 1st Street
Troy, New York 12180
518-244-2069
handt@sage.edu

Revised March 2019

Appendix L

IRB Approval Letter*

October 23, 2018

Mary Agoglia
Student, Nursing, The Sage Colleges

***IRB PROPOSAL #707 – Letter on record- not included here**

Appendix M

Medication Administration Error Types & Measurement Methods

Table M1.

Medication Administration Error Types (Reason, 1990) and Measurement Methods

Student Role in Prevention of Error	Error Measurement	How Measured
Skill-based		
Student averts/minimizes an (embedded) interruption while performing the skill of medication administration	Interruption associated with skipping protocol step: 0 to 1 (Yes/No)	Observation Form Video recording
Rule-based		
Student completion of checklist steps for the skill of medication administration Close-Calls (see System-based)	Number of checklist steps completed/not completed (tallies)	Observation Form
Knowledge-based		
Student coordinates with an expert (e.g. instructor, preceptor, pharmacist) to correct any detected errors	Lack of coordination results in error: # error tallies-steps with asterisks	Observation Form
Student monitors patient for outcomes	Lack of monitoring results in error: # tallies	Observation Form
Confirmation Bias: student completes all double checks	Number of double checks not completed: # tallies	Observation Form
System-based Errors Recovered (Rule-based Close Calls)		
Errors embedded in the scenario (3). Students find errors and collaborate to correct system-related errors.	Number of embedded errors (0 to 3) found/ corrected – tallied on Observation Form	Observation Form Video recording
Interruptions- Students minimize interruptions	Error related to an interruption: Yes or No	Feedback from students in debriefing period
Workability of the new checklist – Students and Faculty receive instruction on checklist procedure before utilization	Errors linked to unpredicted flaws with new checklist: Yes or No	(responses to questions)
Reporting Errors (Rule-based)		
If the student finds & reports error(s), faculty enters tallies on the Observation Form for each error report submission	Number of errors found-reported: 0 to 3 tallies	Observation Form

Appendix N

Recruitment PowerPoint

Click Here

Recruitment PP Aug 21 2018.pptx

Appendix O

Demographic Data Survey

Demographic Data Survey

Name: _____

Age: _____ Gender: Male Female Other: _____

Marital Status: _____

Race: _____

Primary Language: _____

Country of Origin: _____

Current highest academic degree completed: _____

Current level of nursing education: (e.g. senior-2nd semester) _____

Current overall cumulative GPA: _____

Have you taken pharmacology coursework? Yes / No. If ***yes*** how many credits?

Choose one: 3 credits; 4 to 6 credits; 7 to 9 credits; 10 or more credits

Current employment status.

Not including school, how many hours do you work per week? _____

List any work experience with acute care patients (other than student nurse practice):

_____

_____

List any work experience with medication administration (other than student nurse supervised clinical):_____

APPENDIX P

Training PowerPoint-SV
(Student Version) with Instructions

Instructions for Use of the Training PowerPoint - Student Version

The Training PowerPoint includes an audio narration by the researcher. Student participants are asked to listen while viewing the presentation which involves: (1) discussion regarding patient safety, medication error awareness, checklist utilization and error reduction; (2) orientation to the C-MATCH-REASON checklist; (3) orientation to the simulation practice; and (4) successful completion of an electronic post training-test. The electronic post training-test will be scored immediately following submission. Student participants who agree to participate will be scheduled for simulation practice that involves medication administration.

APPENDIX Q

Training PowerPoint-FV
(Faculty Version) with Instructions

Instructions for Use of the Training PowerPoint - Faculty Version

The Training PowerPoint- Faculty Version includes an audio narration by the researcher. Nursing faculty are asked to listen while viewing the presentation which involves: (1) discussion regarding patient safety, medication error awareness, checklist utilization and error reduction; (2) orientation to the C-MATCH-REASON checklist; (3) instructional slides on how to score error data on the Observation Form; (4) orientation to the simulation practice; and (5) successful completion of an electronic post training-test. Nursing faculty who completed the Training PowerPoint (faculty version), post training-test, and established interrater reliability with use of the Observation Form, will be scheduled to conduct the simulation exercises.

Appendix R

Debriefing Questionnaire

Debriefing Questionnaire

Participant I.D. __ __ __ __

1. How did this simulation experience impact how you administered medication today?

   _____

   _____

2. List strengths and weaknesses of today's simulation experience:

   _____

   _____

3. What form of clinical reasoning (thinking-in-action) did you apply to the medication administration process today (choose all that apply and offer an example):

   a. Interpreting:

   b. Comparing:

   c. Analyzing:

   d. Planning:

   e. Coordinating:

   f. Monitoring:

   g. Evaluating:

   h. Reporting:

   i. Other _____

4. When I think about the patient's outcome from today's simulation practice scenario, I become aware of protocol steps omitted. Yes / No.

   If yes, explain.

Appendix S

Faculty Feedback Survey

Faculty Feedback Survey

List strengths and weaknesses of today's simulation experience with utilization of the Observation Form:

APPENDIX T

Content Validity Survey and Survey Responses

Content Validity Survey for

MATCH and READ (Nine Rights of Medication Administration)

Background: This is a behavioral observation checklist for the nursing instructor to use during the simulation lab scenario. The instructor will use the checklist to record student adherence to nine rights with medication administration.

Instructions:

1. Read the MATCH and READ Instrument for Adherence to Medication Administration Rights.
2. Complete the questionnaire to assist with defining face validity of the instrument.
3. Review each checklist behavioral observation that the instructor is expected to record (numbered 0-25).
4. Rate each item using the rating scale provided: How characteristic is the corresponding right of medication administration to the behavior specified by the checklist item.

		How Characteristic?				
"Right"	*Checklist Item*	*Not*	*Very Little*	*Somewhat*	*Considerably*	*Very*
Right Medication	1. Student observed matching drug label to order on MAR 2. Student heard reading right client name from MAR 3. Student heard reading right DOB from MAR 4. Student heard reading right name of drug on label 5. Student heard reading right name of drug on MAR					
Right Allergy	6. Student heard reading allergy(s) from MAR					
Right Time	7. Student observed matching time/frequency on drug label to MAR 8. Student heard stating the right time drug is due 9. Student heard reading time last dose was given per MAR					

Right Client	10. Student observed matching client ID band to client name on MAR 11. Student heard reading correct client name from ID band 12. Student heard reading correct client name from MAR 13. Student heard reading correct DOB from ID band 14. Student heard reading correct DOB from MAR					
Right Health	15. Student observed measuring and reviewing client's current health assessment data & any new orders before medicating					
Right Route	16. Student observed matching route on drug label to MAR. 17. Student heard reading correct route from drug label 18. Student heard reading correct route from MAR					
Right Expiration	19. Student observed reading expiration/ bottle open dates					
Right Amount	20. Student observed matching drug label to MAR. 21. Student heard reading correct dose from drug label 22. Student heard reading correct dose from MAR 23. Student observed identifying safe dose range 24. Student observed calculating correct dose					
Right Documentation	25. Evidence of student notes with evaluation & teaching					

Rate the ability of the checklist to sufficiently present face validity to 25 behaviors of the rights for medication administration. Please circle rating below:

1. Not at all
2. Very Little
3. Somewhat
4. Considerably
5. Very close to entire

Table T1.

Content Validity Survey Responses

Subject Matter Expert	Suggested Revision
1. RN, PhD	• Add a safety section (e.g. adjust bed height, handwashing). • Add an outcomes section (e.g. monitor client and evaluate drug effect)
2. RN, PhD	• Include "clarify safe dose range, call bell within reach, adjust bed height, position patient to prevent aspiration"
3. NP, PhD	• Include "proper disposal of drug waste"
4. NP, PhD	• Change "student heard" to "student stated"
5. NP	• Steps need to be sequential
6. RN	• Steps need to be sequential (medication section)
7. RN	• Include "sign out narcotic and keep drug in sight"
8. RN	• Include "ask client to state name and DOB"
9. RN, New Graduate	• Include adverse drug reactions in addition to allergies
10. Patient Advocate (Hospital in NYC)	• Include medication reconciliation with access to an interpreter
11. MD, Pediatrician	• Grammar corrections
12. PhD, Psychologist	• Design the acronym to read as a directive that cues the student to follow the checklist
13. Dissertation Committee	• Consult with graphic artist to improve the checklist design related to (1) the format of the preparing and administering columns and (2) the color scheme.

Appendix U

Simulation Scenarios

Simulation Scenario 1 - Oral Medication Administration

The student reads a report on the simulation patient and then greets the patient in the Sim hospital room. Next, the student enters the medication preparation area and follows the healthcare provider's orders as noted on the MAR and prepares the patient medication. Lastly, the student administers the medication to the client.

Client Name: Mrs. Linda Smith **Admission Date**: (current date)

Date of Birth: 12/16/1944 **Allergies**: NKDA

Admitting Diagnoses: Atrial fibrillation; Dehydration; Lyme Disease

Activity: OOB ad lib; **Diet**: regular

REPORT. Nursing Assessment: Client is alert and oriented x3. Complains of fatigue and pain in knees but can ambulate. Bull's eye rash on left upper arm. Breath sounds clear bilaterally. Abdomen soft, slight tenderness, active bowel sounds. Voiding clear yellow urine. Dry mucous membranes. Appetite poor.

Vital Signs: Temp. 102, Pulse 98, RR 18, BP 144/90, Pulse Oximetry 98%

Medications: **Standing Orders**.

Coumadin (warfarin) 5 mg p.o. once a day

Doxycycline 100mg p.o. every 12 hours for a total of 21 days

Vitamin D3 50,000 units PO once a week for four weeks

IV D5 1/2 Normal saline at 100mL/hour.

PRN Orders.

Acetaminophen 650mg p.o. for fever equal to or greater than 101F every 4 hours PRN (do not exceed 4,000mg of acetaminophen in a 24-hour period)

Ibuprofen 200mg p.o. for knee pain every 6 hours PRN

Simulation Scenario 2 - Oral Medication Administration

The student reads a report on the simulation patient and then greets the patient in the Sim hospital room. Next, the student enters the medication preparation area and follows the healthcare provider's orders as noted on the MAR and prepares the patient medication. Lastly, the student administers the medication to the client.

Client Name: Mrs. Elizabeth Harris **Admission Date**: (current date)

Date of Birth: 09/15/1964 **Allergies**: Penicillin

Admitting Diagnosis: Community Acquired Pneumonia (CAP)

Past Medical History: Hypertension; Smokes 10 cigarettes/day- trying to quit.

Activity: Ambulate with pulse oximetry. Oxygen 2 L via Nasal Cannula if O2 Saturation is below 94% - notify M.D. **Diet**: Regular

REPORT. Nursing Assessment: Client is alert and oriented x3; C/O urticaria from new onset of hives, C/O fatigue with limited ability to ambulate, and sinus-headache (pain 4 out of 10). Breath sounds clear. Abdomen soft with bowel sounds in all quadrants. Voiding. Moist mucous membranes. Tolerating diet. Saline well in left hand. Vital Signs: T 98.6, P 98 regular, RR 28, BP 154/88, Pulse Oximetry 95%

Medications: **Standing Orders**

Prednisone 10mg P.O. once a day

Augmentin (amoxicillin/clavulanic acid) P.O. 1,000mg/ 62.5mg every 6 hours

Vitamin D3 50,000 units PO once a week for four weeks

Lopressor (metoprolol) 100mg PO every 12 hrs, hold if apical pulse less than 60

PRN Orders

Xopenex 0.63mg/3ml vial via Nebulizer for wheezing or cough PRN

Tylenol 650mg P.O. PRN for fever equal or greater than 101F for pain every 6hrs (do not exceed 4,000mg of acetaminophen in a 24-hour period)

Simulation Scenario 3 - Oral Medication Administration

The student reads a report on the simulation client and then greets the client in the Sim hospital room with the MAR. Next, the student enters the medication preparation area and follows the healthcare provider's orders as noted on the MAR and prepares the client medication. Lastly, the student administers the medication to the client.

Client Name: Mr. Jack Phillips **Admission Date: (current date)**

Date of Birth: January 15, 1954 **Allergies: NKDA**

Admitting Diagnoses: Fall injury: Left radial head fracture

Secondary diagnosis: Bipolar Disorder Type 1

Activity: OOB with assistance; Diet: regular

REPORT: Client was smoking a cigarette and carrying an antenna up a ladder to his roof during a lightning storm to connect with aliens. He lost balance and fell from the third step of the ladder, resulting in a radial fracture-left arm.

Nursing Assessment: Client is alert and aware that he is in the hospital. He is biting his lower lip and grimacing. He speaks fast with pressured speech and complains of lack of sleep due to "mild to moderate" pain at the site of the fracture. He also states, "I must stay awake to watch for UFOs." Splint to left arm intact. Circulation to left arm good: pulses equal, strong, symmetrical; full ROM to fingers pink with capillary refill less than two seconds. Denies numbness/tingling sensation in affected arm. Breath sounds clear bilaterally. Abdomen soft, slight tenderness, active bowel sounds and bowel movement this morning. Voiding clear yellow urine; moist mucous membranes. Appetite good.

Vital Signs: Temp. 98.6, Pulse 98, RR 18, BP 128/86, Pulse Oximetry 98%

Labs/Bloodwork: Lithium levels, Chem profile, Renal and Thyroid Function

Medications

Standing Orders: Lithium 600mg p.o. twice daily

PRN Orders.

Acetaminophen 650 mg p.o. for fever equal to or greater than 101F every 4 hours PRN (do not exceed 4,000mg of acetaminophen in a 24-hour period). Notify HCP for fever greater than 101F.

Acetaminophen 650mg p.o. for mild to moderate pain in left arm every 4 hours (do not exceed 4,000mg of acetaminophen in a 24-hour period). PRN

Ultram 50 mg p.o. for severe pain in left arm every 6 hours PRN

Colace 50 mg p.o. for constipation PRN once a day

Appendix V

Answer Keys for Scenarios

C-MATCH-REASON Medication Error Tracking Instrument (Observation Form) *Did the student identify the right…*		Reasoning with Rule Adherence		Error found (close calls)	Errors Reported		Skill based errors	Know ledge based errors
		1 Prepare	2 Admin -ister	3	4 Close Calls	5 Actual Errors	6 **RESEARCH USE ONLY**	7
Client-Chart?	**Obtained MAR**; Read client name and DOB	/	/					CB
	Client Area: Asked client/family/interpreter to state client name and DOB	/	/					CB
	Matched client name on ID band to MAR	/	/					CB
	Matched DOB on ID band to MAR	/	/					CB
	E-scanned client's ID band bar-code	/	/					CB
	Medication reconciliation with client/family/interpreter. Clarified Adverse Drug Reactions. Checked for drug duplication, omission, and need to discontinue drug*	/	n/a	//	//			
	Collected assessments; compared data to parameters-MAR*	/	n/a					
Medication?	**Medication Area**: Washed hands. Read name, DOB on MAR	/	n/a					n/a
	Read & clarified reason of order; "Read Back" verbal order*	///	n/a					
	Clarified safe dose range*	///	n/a					
	Obtained drug (prepared 1 medication at a time), inspected storage, signed out narcotic	///	n/a					n/a
	Matched (E-scan) drug label to MAR	///	//					CB
	Followed instructions on label and MAR; Kept drug in sight	///	//					CB
Adverse Drug Reactions?	Matched allergy list on MAR to drug label	///	n/a					n/a
	Matched ADR's on MAR to drug label	///	n/a					n/a
Time?	Matched time/date/frequency on MAR to drug label	///	//					CB
Current Health?	Screened health data (e.g. lab results, pregnancy status) linked to shifts in care (e.g. procedures, surgery) & drug contraindications*	///	n/a					
Route?	Matched route on MAR to drug label	///	//					CB
	Identified form (enteric coated, liquid, capsule, etc.) *	///	n/a					
Expiration?	Clarified expiration date of medication	///	n/a	/	/			
Amount?	Matched amount ordered on MAR to amount on drug label	//	n/a					n/a
	Calculated right amount and/or rate (pediatric doses mg/kg) *	//	//					CB
	Kept unit dose in package; poured liquid at eye level into medicine cup on level surface; aspiration precautions	//	n/a					n/a
	Double checked amount prepared of *high-risk drugs* with RN	/	n/a					CB
Site-Safety?	**Client Area:** Educated client: drug use/effect; positioned client; administered drug with a suitable beverage; adjusts bed height; call bell in reach; proper disposal drug waste*	n/a	//					
Outcomes?	Anticipated problems: monitored and evaluated drug effect*	n/a	//					
Notation?	Documented: drug effect, assessments, teaching, drug held*	n/a	//					
	Scenario #1 Perfect Score = 78	51	21	3	3		-	-
Notation for Error Reporting?	**List actual errors committed and contributing factors. Did an error lead to patient harm? Yes / No / Unknown.**							

C-MATCH-REASON Medication Error Tracking Instrument (Observation Form)		Reasoning with Rule Adherence		Error found (close calls)	Errors Reported		Skill based errors	Know ledge based errors
Did the student identify the right…		1 Prepare	2 Admin -ister	3	4 Close Calls	5 Actual Errors	6 **RESEARCH USE ONLY**	7
Client-Chart?	**Obtained MAR**; Read client name and DOB	/	/					CB
	Client Area: Asked client/family/interpreter to state client name and DOB	/	/					CB
	Matched client name on ID band to MAR	/	/					CB
	Matched DOB on ID band to MAR	/	/					CB
	E-scanned client's ID band bar-code	/	/					CB
	Medication reconciliation with client/family/interpreter. Clarified Adverse Drug Reactions. Checked for drug duplication, omission, and need to discontinue drug*	/	n/a	//	//			
	Collected assessments; compared data to parameters-MAR*	/	n/a					
Medication?	**Medication Area**: Washed hands. Read name, DOB on MAR	/	n/a					n/a
	Read & clarified reason of order; "Read Back" verbal order*	///	n/a					
	Clarified safe dose range*	///	n/a					
	Obtained drug (prepared 1 medication at a time), inspected storage, signed out narcotic	///	n/a					n/a
	Matched (E-scan) drug label to MAR	///	//					CB
	Followed instructions on label and MAR; Kept drug in sight	///	//					CB
Adverse Drug Reactions?	Matched allergy list on MAR to drug label	///	n/a					n/a
	Matched ADR's on MAR to drug label	///	n/a					n/a
Time?	Matched time/date/frequency on MAR to drug label	///	//	/	/			CB
Current Health?	Screened health data (e.g. lab results, pregnancy status) linked to shifts in care (e.g. procedures, surgery) & drug contraindications*	//	n/a					
Route?	Matched route on MAR to drug label	//	//					n/a
	Identified form (enteric coated, liquid, capsule, etc.) *	//	n/a					
Expiration?	Clarified expiration date of medication	//	n/a					
Amount?	Matched amount ordered on MAR to amount on drug label	//	n/a					n/a
	Calculated right amount and/or rate (pediatric doses mg/kg) *	//	//					CB
	Kept unit dose in package; poured liquid at eye level into medicine cup on level surface; aspiration precautions	//	n/a					n/a
	Double checked amount prepared of *high-risk drugs* with RN	-	n/a					CB
Site-Safety?	**Client Area:** Educated client: drug use/effect; positioned client; administered drug with a suitable beverage; adjusts bed height, call bell in reach; proper disposal drug waste*	n/a	//					
Outcomes?	Anticipated problems: monitored and evaluated drug effect*	n/a	//					
Notation?	Documented: drug effect, assessments, teaching, drug held*	n/a	//					
TOTAL	**Scenario #2 Perfect Score = 73**	46	21	3	3		-	-
Notation for Error Reporting?	**List actual errors committed and contributing factors. Did an error lead to patient harm? Yes / No / Unknown.**							

C-MATCH-REASON Medication Error Tracking Instrument (Observation Form) ***Did the student identify the right…***		Reasoning with Rule Adherence		Error found (close calls)	Errors Reported		Skill based errors	Know ledge based errors
		1 Prepare	2 Admin -ister	3	4 Close Calls	5 Actual Errors	6 **RESEARCH USE ONLY**	7
Client-Chart?	**Obtained MAR**; Read client name and DOB	//	/					CB
	Client Area: Asked client/family/interpreter to state client name and DOB	//	/					CB
	Matched client name on ID band to MAR	//	/					CB
	Matched DOB on ID band to MAR	//	/	/	/			CB
	E-scanned client's ID band bar-code	/	/					CB
	Medication reconciliation with client/family/interpreter. Clarified Adverse Drug Reactions. Checked for drug duplication, omission, and need to discontinue drug*	/	n/a					
	Collected assessments; compared data to parameters-MAR*	/	n/a	/	/			
Medication?	**Medication Area**: Washed hands. Read name, DOB on MAR	/	n/a					n/a
	Read & clarified reason of order; "Read Back" verbal order*	//	n/a					
	Clarified safe dose range*	//	n/a					
	Obtained drug (prepared 1 medication at a time), inspected storage, signed out narcotic	//	n/a					n/a
	Matched (E-scan) drug label to MAR	//	//					CB
	Followed instructions on label and MAR; Kept drug in sight	//	//					CB
Adverse Drug Reactions?	Matched allergy list on MAR to drug label	//	n/a					n/a
	Matched ADR's on MAR to drug label	//	n/a					n/a
Time?	Matched time/date/frequency on MAR to drug label	//	//	/	/			CB
Current Health?	Screened health data (e.g. lab results, pregnancy status) linked to shifts in care (e.g. procedures, surgery) & drug contraindications*	//	n/a					
Route?	Matched route on MAR to drug label	//	//					CB
	Identified form (enteric coated, liquid, capsule, etc.) *	//	n/a					
Expiration?	Clarified expiration date of medication	//	n/a					
Amount?	Matched amount ordered on MAR to amount on drug label	//	n/a					n/a
	Calculated right amount and/or rate (pediatric doses mg/kg) *	//	//					CB
	Kept unit dose in package; poured liquid at eye level into medicine cup on level surface; aspiration precautions	//	n/a					n/a
	Double checked amount prepared of *high-risk drugs* with RN		n/a					CB
Site-Safety?	**Client Area:** Educated client: drug use/effect; positioned client; administered drug with a suitable beverage; adjusts bed height; call bell in reach; proper disposal drug waste*	n/a	//					
Outcomes?	Anticipated problems: monitored and evaluated drug effect*	n/a	//					
Notation?	Documented: drug effect, assessments, teaching, drug held*	n/a	//					
Scenario #3 Perfect Score = 69		42	21	3	3		-	-
Notation for Error Reporting?	**List actual errors committed and contributing factors. Did an error lead to patient harm? Yes / No / Unknown.**							

Appendix W

Faculty Response Guidelines: Scenarios 1- 3

Faculty Response Guidelines - Scenario 1

Scenario Situation	Related to the right...	Student Action	Faculty Action
1. Is the right DOB on the patient's ID Band? (Rule-based patient-verification) 2. ***Embedded Error #1*** *– As per the Medication Reconciliation form the Vitamin D3 was already given (Knowledge-based)*	Client	Match name on MAR to ID band Match DOB on MAR to ID band *The student reviews Med-Rec form with the client; identifies that the last dose of Vit D3 was given a few days ago, so they don't give it. Student reports a close call error.*	Faculty reviews scenario with the student, states it's 9am, VS are current, is the voice of patient. *Faculty agrees don't give Vit D3, close call.*
3. ***Embedded Error #2*** *The wrong pain med was prescribed: Ibuprofen is contraindicated with Coumadin;* ***medication reconciliation****: partner with patient & knowledge-based analysis with expert-PCP*	Client Medication	*The student (1) informs patient that the drugs interact, states Ibuprofen may cause a GI bleed r/to Coumadin intake; (2) applies clinical reasoning with HCP/ patient to select a suitable pain med.*	Faculty is the voice of the patient & HCP (phone prop) *Tylenol order changed: give for fever and/or pain, assess pain*
4. The client has a fever	Time	*Student checks MAR for last time Tylenol given & gives it.*	Correct
5. ***Embedded Error #3*** *Expired medication (doxycycline)(rule & knowledge-based error)*	Expiration date	*If a student finds an expired drug, then they state: "I will not administer it. I will notify pharmacy & get a new dose."*	Faculty agrees
6. Coumadin lab results need to be checked (INR/PT) (rule-based-interpret/reason) 7. If student gives wrong dose: patient antidote-Vit K (knowledge-based monitoring/planning)	Current Health Amount	• checks/interprets lab value, notes result is WNL, give Coumadin; • monitors outcomes • states they were prepared to give Vit K	Faculty states agrees
8. High-risk drug dosages need to be double checked by second RN (rule-based-coordination/ knowledge-based confirmation bias)	Amount	• The student needs to ask the faculty to double check the Coumadin dose.	Correct
9. Rule-based monitoring	Outcomes	Student reassess pain & fever	
1. Embedded Interruption (skill-based slip/system)		The student uses the checklist & doesn't miss a step	Correct

Note 1: The areas in italics indicate errors that will be embedded in the scenario. *Note 2*: Rule-based errors and subcategories are based on research by Henneman et al. (2010) and Reason's (1990) error theory; Knowledge and skill-based performance errors are based on Reason's (1990) error theory. System-related errors are based on Reason (1997, 2013). Note 3: Drug references: Vallerand, A. H. (2018). *Davis's drug guide for nurses*. FA Davis; Kennel, K. A., Drake, M. T., and Hurley, D. L. (2010). Vitamin D deficiency in adults: when to test and how to treat. Mayo Clinic proceedings, 85(8), 752-7; quiz 757-8.

Faculty Response Guidelines - Scenario 2

Scenario Situation	Related to the right…	Student Action	Faculty Action
1. Is the right DOB on the patient's ID Band? (Rule-based patient-verification)	Client	Matches Name on MAR to ID band. Matches DOB on MAR to ID band.	Faculty: reviews scenario, states it's 9am & VS current; is the voice of patient & HCP, answers questions
2. ***Embedded Error #1*** *Vitamin D3 is due only once a week. The last dose was consumed at home. Medication reconciliation reveals that it is not due (Knowledge-based)*	Time (date)	*The student reviews the medication reconciliation form with the client; identifies that the last dose of Vit D3 was given a few days ago and they don't give it and report a close call error.*	*Faculty agrees that the medication reconciliation list needs to be reviewed, Vit D3 not given and close call reported*
3. ***Embedded Error #2*** *The patient is allergic to a prescribed drug. The RN on the prior shift administered it (knowledge-based).* 4. The patient is having a mild allergic reaction [hives, no wheezing, O2 sat 95%] (knowledge-based clinical reasoning-analysis/synthesis 5. The HCP needs to be called to assess the patient/write treatment order that includes new Antibiotic (knowledge clinical reasoning/planning	Allergy Allergy	Identify that (1) *the patient is allergic to penicillin; (2) an RN on the last shift administered the PCN; (3) the patient's O2 sat is stable at 95%; (4) the breath sounds are clear; (5) and states: I will notify pharmacy and ask the HCP to assess the patient and f/u on a RX for a different anti-infective drug*. Caution: *Benadryl may increase the blood level of the metoprolol further reducing BP.*	*Faculty agrees that the student should not give the Augmentin due to allergic reaction and to ask PCP to assess patient and for a prescription for a different anti-infective drug*
6. Embedded Error #3 *Patient requests Tylenol for pain (4 out of 10) but PRN sheet notes it was given at 6 am (knowledge-based error)*	Time	*Student informs patient it is too soon for Tylenol. Student informs HCP that Tylenol is not relieving patient's pain.*	*Faculty agrees that it is too soon to give Tylenol & need to call HCP*
7. Check apical pulse before giving Metoprolol, hold dose if AP< 60 (Rule-based) 8. Outcomes – Monitor pain	Current Health	Check pulse and identify that it is above 60BPM and then administer the Metoprolol Student reassesses pain	Correct… Correct
1. Embedded Interruption (skill or system error)		The student uses checklist & doesn't miss a step	Correct

Note 1: The areas in italics indicate errors that will be embedded in the scenario. *Note 2*: Rule-based errors and subcategories are based on research by Henneman et al. (2010) and Reason's (1990) error theory; Knowledge and skill-based performance errors are based on Reason's (1990) error theory. System-related errors are based on Reason (1997, 2013). Note 3: Drug references: Vallerand, A. H. (2018). *Davis's drug guide for nurses*. FA Davis; Kennel, K. A., Drake, M. T., and Hurley, D. L. (2010). Vitamin D deficiency in adults: when to test and how to treat. Mayo Clinic proceedings, 85(8), 752-7; quiz 757-8.

Faculty Response Guidelines - Scenario 3

Scenario Situation	Related to the right…	Student Action	Faculty Action
Faculty reads the scenario to the student, states it's 9am, VS are current, and answers questions.			Faculty is the voice of the client & the PCP.
1. ***Embedded error #1****: The DOB on the client's ID Band is incorrect (Rule-based client-verification)*	*Client*	*The student needs to state "I will get a new ID band"*	*Faculty hands student new ID & OK's med pass*
1. **Embedded error #2**: *The client states he has mild to moderate pain in his elbow area and would like Tylenol, but he rates his pain as 8 and his nonverbal cues suggest severe pain (Rule-based verification)*	*Current Health*	*The student assesses the pain on a scale of 0 to 10. The student identifies that a pain rating of "8"and nonverbal cues suggests severe pain and further assesses the client's pain*.	*Faculty states: the client rates his pain as 8 out of 10.* *Faculty agrees, his pain is severe.*
2. **Embedded error #3**: *Tylenol PRN was given by night nurse 2.5 hours ago. (Rule-based verification and knowledge-based)*	*Time* *Medication*	*The student identifies from the PRN sheet that (1) it is too soon to administer more Tylenol; (2) that the Ultram is ordered for severe pain. Options are discussed with the client: Ultram is chosen.* Student informs client (1)	*Faculty agrees*
3. Client teaching to prevent injury (knowledge-based)	Safety 1	Ultram may cause dizziness, drowsiness, and orthostatic changes;(2) change positions slowly and to use call bell to ask for assistance with ambulation.	
	Safety 2	Student asks client to open mouth and stick out tongue to be sure the patient swallowed the Lithium tablet	
4. Evaluate effect of Ultram w/client (knowledge-based)	Outcomes	Student states pain level will be reassessed in 30-minutes.	Faculty states his pain level is a "2"
5. Embedded Interruption (system related skill-based slip)		Student identifies place by referring to the checklist and does not skip a step	Correct

Note 1: The areas in italics indicate errors that will be embedded in the scenario. *Note 2*: Rule-based errors and subcategories are based on research by Henneman et al. (2010) and Reason's (1990) error theory; Knowledge and skill-based performance errors are based on Reason's (1990) error theory. System-related errors are based on Reason (1997, 2013). Note 3: Drug references: Vallerand, A. H. (2018). *Davis's drug guide for nurses*. FA Davis.

Appendix X

Scoring Rubric

Rubric for Medication Administration -Total Error Score (Scenario-Based)

Category	**Observ -ation Form Scoring**	**Points if *one* drug is prescribed**	**Points for each added drug**	**Total No-Scenario 20 subjects *0 embedded errors, 3 meds***	**Total Scenario # 1: 19 subjects *3 embedded errors, 3 meds***	**Total Scenario #2: 19 subjects *3 embedded errors, 3 meds***
1. Skill-based slip related to interruption: Yes/No	negative tallies	-1 to **0**	n/a	-20 to 0	-19 to 0	-19 to 0
2. ***Rule Adherence (RA) Total*** – rules correctly adhered to	positive tallies	0 to 37	0 to 23	37+ 23+23= 83 83x20 = 1,660	37+23+12 + 6 (EEF+ER) =78 78x19= 1,482	36+23+ 8 + 6 (EEF+ER) =73 73x19= 1,387
3. Rule-based errors (RB): step non-adherence	negative tallies	-16 to 0	-10 to 0	-36x20 = -720	16+10+8= - 34 34x19= - 646	16+10+6 = -32 -32x19 = -608
4. Knowledge errors (Kn) a. General knowledge steps coded using an asterisk * b. Confirmation bias coded as CB	 negative tallies negative CB tally	 -10 to 0 -11 to 0	 -8 to 0 -5 to 0	 -26x20 = -520 -21x20 = -420	 10+8+4= -22 -22x19= -418 11+5+0= -16 -16x19= -304	 10+8+2 = - 20 -20x19= -380 10+5+0 = -15 -15 x19= -285
5. Embedded errors found, EEF (rule-based)	positive tallies	Scenario-based	n/a	Scenario-based	n = 0 to 3 3 x 19 = +57	n = 0 to 3 19 x 3= +57
6. Embedded errors committed, EEC	negative tally	Scenario-based	n/a	Scenario-based	n = 0 to 3 3 x 19 = - 57	n = 0 to 3 19 x 3 = -57
7. Embedded Errors Reported, EER (RB) *I. Errors Found:* Were EEF reported? a. found/reported (1) b. found/not reported (0) c. neither found nor reported (0) d. not found/cued report (1) *II. Actual errors: Did the student (self) report errors committed*? a. notified/ reported (1) b. notified/not reported (0) c. not notified/not reported (0) d. self-corrected/ self-reported (1)	 positive tallies positive tallies	 Scenario-based Scenario-based Verbalized completion of occurrence report	 n/a n/a	 Scenario-based Scenario-based	 I (EEF) and II (EEC) are reciprocal Scenario #1 n= 0 to 3 19 subjects n = 0 to 57	 I (EEF) and II (EEC) are reciprocal Scenario #2 n = 0 to 3 19 subjects n = 0 to 57
<u>Global Medication Administration Total Error Score</u> **Points Desired = RA +EEF + EER (**See scenario key)	37+ EEF + EER		+23	1,660 +EEF + EER	1,482	1,387
Error Points Not Desired = skill, rule, knowledge errors + EEC +EENRep	(-1) +(-16) + (-10) + (-11) + EEC + EENRep		-23	-1,680+(-EEC) + (-EENRep)	**-1,501**	**-1,406**

Appendix Y

Simulation Practice Appointment Schedules for Participants and Raters

Simulation Practice Schedules for Participants and Raters

Table Y1. Simulation Practice Schedule for the Pre-Pilot Assessment (both periods)

Nursing Student Participants (n = 8)	Shift for Rater (n = 1)
1	9:00 am
2	9:45 am
3	10:30 am
4	11:15 am
Lunch break	12 noon to 12:30
5	12:30 pm
6	1:15 pm
7	2:00 pm
8	2:45 pm
Completion Time	3:30 pm

Table Y2. Simulation Practice Schedule for the Pilot Study (both periods and with a proposed sample size of 40 participants).

Nursing Student Participant (n = 40)	Shift hours for Six Raters Arrive at 8:15 am or 12:30 pm depending on assignment
1	8:30 am
2	9:15 am
3	10:00 am
4	10:45 am
5	11:30 am
Lunch Break	12:15 – 12:45 pm
6	12:45 pm
7	1:30 pm
8	2:15 pm
9	3:00 pm
10	3:45 pm
Completion Time	End at 4:30

For the pilot study, six raters are suggested to conduct the simulation practice for either a full shift or a half-shift for a sample with 40 participants. Two of the six raters volunteer from 8:15am to 4:30pm for both periods. Of the remaining four, two raters volunteer from 8:15 am to 12:15 pm and two from 12:30pm to 4:30 pm for both periods. The raters can be assigned to different students for each period.

Appendix Z

Proposed Sampling and Flow of Participants through a Randomized Experiment with a Crossover Design

Figure Z1.

Proposed Sampling and Flow of Participants Through a Randomized Experiment with a 2x2 Crossover Design

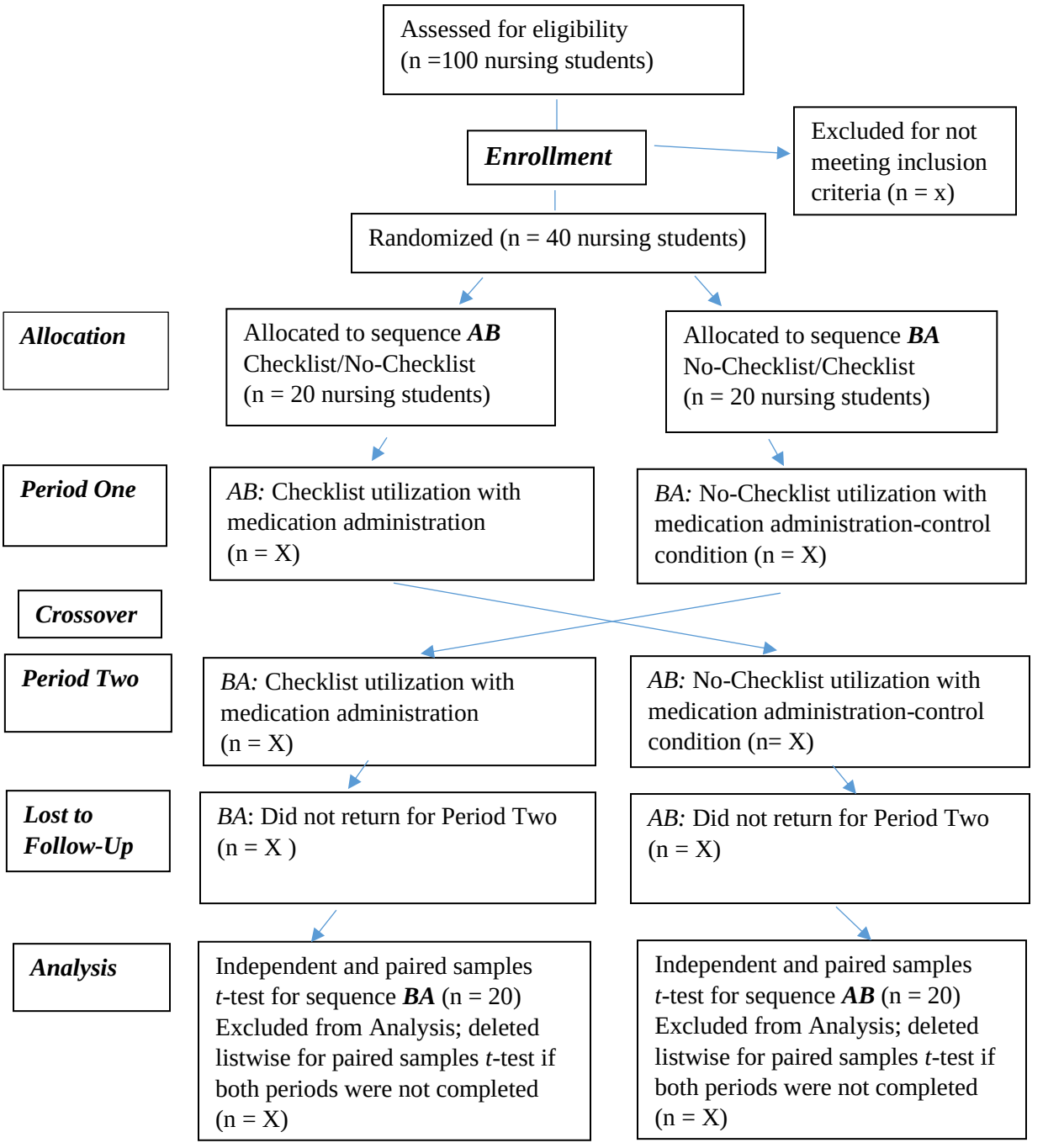


Figure Z1. Proposed student participant flow chart for a 2x2 crossover design with two groups and two periods in a simulation environment involving medication administration. Adapted from Figure 5.3 of the sixth edition of *The Publication Manual of the American Psychological Association* (2010, p. 154).

Appendix AA

Flow Charts for Participants
through a Simulation Environment
(Pre-Pilot Assessment and Pilot Study)

Figure AA1.
Flow of Participants Through a Randomized Experiment in a Simulation Environment: Pilot-Phase One

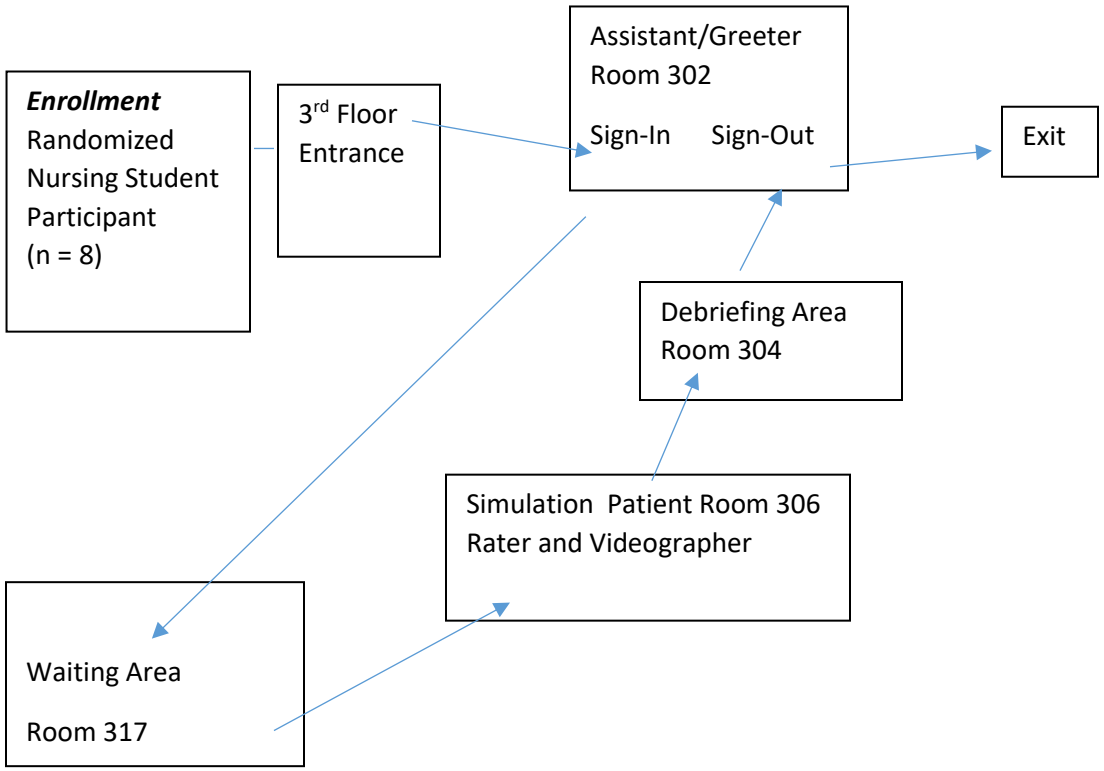


Figure AA1. Flow chart for a pre-pilot assessment involving nursing student participant (n= 8), with individual appointments, participating in a randomized experiment in a simulation environment. An assistant/greeter will direct each student participant to sign-in and then escort each participant to the waiting area. The nursing faculty rater will escort the student participant to the simulation practice area. Participants will be video recorded utilizing the checklist with medication administration by a videographer. Upon completion of the simulated medication administration, the faculty will escort the participant to the debriefing area. Upon completion of the debriefing questionnaire (about 10 minutes), the assistant/greeter will direct the participant to sign-out and exit via the entrance via either the stairs or the elevator.

Figure AA2.

Flow of Participants Through a Randomized Experiment in a Simulation Environment: Pilot Study

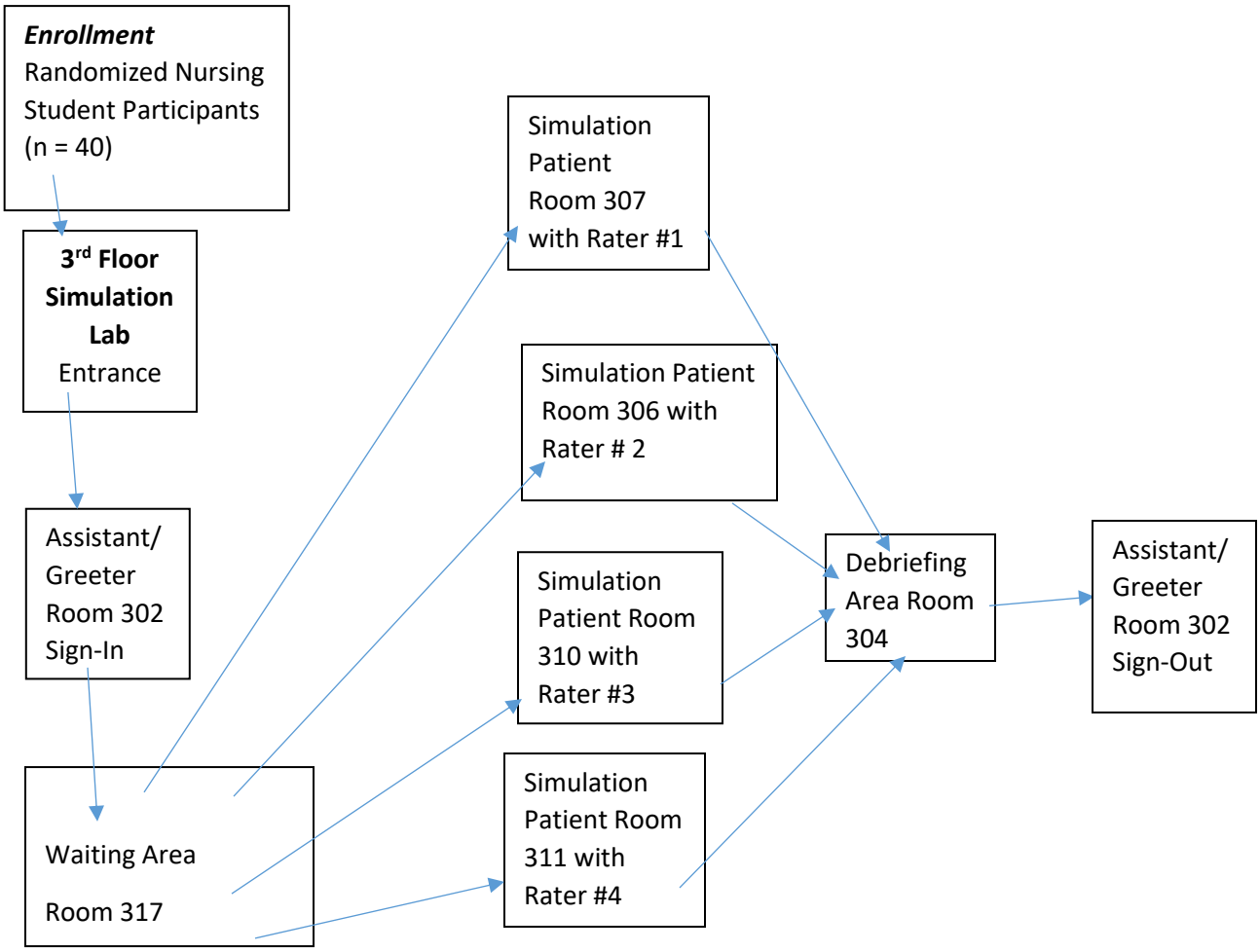


Figure AA2. Flow chart for the pilot study in a simulation environment involving randomized nursing student participants (n = 40); raters (n = 4). The participants will have individual appointments. An assistant/greeter will direct each student participant to sign-in using their pre-assigned study Identification (ID) Code, and then escort each participant to the waiting area (poster boards will be utilized to create privacy booths). The rater will escort the participant to the simulation practice area. Upon completion of each simulated medication administration, the rater will escort the participant to the debriefing area (poster boards will be used to create privacy booths). Upon completion of the debriefing questionnaire (about 10 minutes), the assistant/greeter will direct the student to sign-out using their study ID Code and exit via either the stairs or the elevator.

APPENDIX BB

Confidentiality Statement

Confidentiality Agreement

I, Thomas Ervin, individually and/or on behalf of The Sage Colleges, School of Nursing, Troy, New York, do agree to maintain full confidentiality in regard to any and all audiotapes, videotapes, and/or oral or written documentation created for Mary Agoglia related to the research project titled *Investigation of a Checklist to Reduce Medication Errors among Pre-Licensure Baccalaureate Nursing Students.*

The information in the video recordings and/or documentation has been revealed by those who participated in this research project with the understanding that their information would remain strictly confidential. I understand I have the responsibility to honor this confidentiality agreement.

Furthermore:

1. I will follow the established protocol for my role in the project.
2. I will not share any information in these tapes and/or documents with anyone except the researchers listed on this form.
3. I will hold in strictest confidence the identification of any individual who may be revealed in these tapes and/or documents.
4. I will not disclose any of the information created for profit, gain or otherwise.
5. I will not make copies of the audiotapes, videotapes, and/or oral or written documentation, unless specifically requested to do so by Mary Agoglia
6. I will store audiotapes, videotapes, and/or oral or written documentation in a safe, secure location as long as they are in my possession.
7. I will return all materials; including audiotapes, videotapes, and/or oral or written documentation; to Mary Agoglia within the mutually agreed upon time frame.
8. I will return all electronic computer devices to the researchers at the end of the project. I will not save any data provided to me in any format, electronic or otherwise.

Any violation of this agreement would constitute a serious breach of ethical standards and I pledge not to do so. I am also aware I am legally liable for any breach of confidentiality agreement, and for any harm incurred by individuals if I disclose identifiable information contained in the videotapes and/or oral or written documentation to which I have access.

Printed name _____

Signature _____ Date: _____

Affiliation with the researchers: Video Consultant, Director and Producer

APPENDIX CC

Data Dictionary

Table CC.

Data Dictionary: Variables of Interest

Variable	Description	Format	Value
Group	Experimental group	Char (2)	AB = Experimental group using Checklist in first time period BA = Experimental group using checklist in second time period
UID	Unique identifier	Char (3)	Three-digit identification number: character format
Age	Participant age	Numeric	1 = 20 to 29 years 2 = 30 to 39 years 3 = 40 to 49 years
Gender	Gender of study participant	Char (2)	F = Female M = Male
RACE	Self-identified race of study participant	Char (2)	W = White B-A = Black or Asian
ELL	English Language Learner Question: What is the primary language spoken?	Char (8)	English
CoOrig	Country of Origin	Char (2)	1 = USA 2 = Nigeria 3 = India 4 = Guyana
DEGREE	Highest academic degree completed	Numeric	1 = High School 2 = Associate Degree 3 = Baccalaureate Degree
NSGED	Nursing Education: Current level of coursework completed in nursing school	Numeric	1 = Junior 2nd Semester 2 = Senior 1st Semester 3 = Senior 2nd Semester
OGPA	Overall Grade Point Average at start of intervention	Numeric	2.00 to 4.00
PHARM	Pharmacology coursework Questions: Have you taken pharmacology coursework? Yes/No If yes, how many credits?	Char (2)	1 = Enrolled 2 = 3 Credits 3 = 4 or more credits 4 = Integrated through curriculum
WKHRS	Work Hours - Current Employment Status Question: How many hours do you work?	Numeric	0 = None 1 = PT 24 hours or less 2 = FT 37 to 40 hours
HCAcute	Healthcare -Acute Care Experience Question: List any work experience with acute care patients (other than student nurse practice).	Char (2)	Y = Yes N = No
HCMeds	Healthcare -Medication Administration Experience Question: List work experience with medication administration (other than student nurse supervised clinical).	Char (2)	Y = Yes N = No
P1RA_TOT	Period One Rule Adherence Total Steps = Rule-base + Knowledge + Confirmation bias + EEF + EERep	Numeric	0 to 78
P2RA_TOT	Period Two Rule Adherence Total Steps =Rule-base + Knowledge + Confirmation bias + EEF + EERep	Numeric	0 to 73
P1RAPrep	Period One Rule Adherence Prepare Column	Numeric	0 to 51
P2RAPrep	Period Two Rule Adherence Prepare Column	Numeric	0 to 46

P1RAPrpT	Period One Rule Adherence Prepare Total = P1RAPrep + P1_EEF + P1_EERep	Numeric	0 to 57
P2RAPrpT	Period Two Prepare Rule Adherence = P2RAPrep + P2_EEF + P2_EERep	Numeric	0 to 52
P1_AdmRA	Period One Administer Column Rule Adherence (does not include errors found or error reporting)	Numeric	0 to 21
P2_AdmRA	Period Two Administer Column Rule Adherence (does not include errors found or error reporting)	Numeric	0 to 21
P1_EEF	Period One Embedded Error Found (close calls).	Numeric	0 to 3
P2_EEF	Period Two Embedded Error Found (close calls).	Numeric	0 to 3
P1_EERep	Period One Embedded Errors Reported. Question: How many close call errors were reported?	Numeric	0 to 3
P2_EERep	Period Two Embedded Errors Reported. Question: How many close call errors were reported?	Numeric	0 to 3
P1FdNRep	P1_EEF - P1_EERep	Numeric	0 to 3
P2FdNRep	P2_EEF - P2_EERep	Numeric	0 to 3
P1NotReT	P1FdNRep + P1EECNRe	Numeric	0 to 3
P1EEC	Period One Embedded Errors Committed	Numeric	0 to 3
P2EEC	Period Two Embedded Errors Committed	Numeric	0 to 3
P1EECRep	P1Embedded Errors Committed Reported	Numeric	0 to 3
P1EECNRe	P1EEC – P1EECRep	Numeric	0 to 3
P1_RBErr	Period One Rule-based errors: checklist steps completed incorrectly or omitted that are not tallied as knowledge errors or confirmation bias errors.	Numeric	0 to 33
P2_RBErr	Period Two Rule-based errors: checklist steps completed incorrectly or omitted that are not tallied as knowledge errors or confirmation bias errors.	Numeric	0 to 32
P1KnErr	Period One Knowledge errors: steps identified on the checklist with an asterisk that are completed incorrectly or omitted (excludes CB errors). Final tally includes P1EEC (0 to 3) + P1NotReT (0 to 3)	Numeric	0 to 29
P2KnErr	Period Two Knowledge errors: steps identified on the checklist with an asterisk that are completed incorrectly or omitted (excludes CB errors). Final tally includes P2EEC (0 to 3) + P2NotReT (0 to 3)	Numeric	0 to 26
P1_CBErr	Period One Confirmation Bias Errors were tallied if one of the corresponding checklist steps in either the prepare or administer columns were skipped (i.e. not completing a repeated step or a “double check”).	Numeric	0 to 16
P2_CBErr	Period Two Confirmation Bias Errors were tallied if one of the corresponding checklist steps in either the prepare or administer columns were skipped (i.e. not completing a repeated step or a “double check”).	Numeric	0 to 15
P1KNErrT	P1KnErr +P1_CBErr	Numeric	0 to 45
P2KNErrT	P2KnErr + P2_CBErr	Numeric	0 to 41
P1KTENRT	P1KnErr +P1_CBErr + P1NotReT	Numeric	0 to 48
P1ErrTSc	P1EEC + P1KnErr + P1_CBErr +P1_RBErr + Skill-based Errors +P1NotReT (Total Score)	Numeric	0 to 78
P2ErrTSc	P2EEC + P2KnErr + P2_CBErr +P2_RBErr + Skill-based Errors + P2NotReT (Total Score)	Numeric	0 to 73
Include	Participants meeting inclusion criteria.	Char (2)	Y = Yes N = No

Note:

APPENDIX DD

Hypotheses Test Summaries
Generated from SPSS® V25.0

Hypotheses Test Summary for Period One (generated with SPSS® V25.0): 1- 8 Hypothesis #1 - errors found/reported, committed/reported and Error Reporting Total; 9-10 Hypothesis #2 - Rule Adherence; 11-12 Hypothesis #4 - Knowledge errors; 13-14 Total Knowledge errors; 15-16 Hypothesis #5 -Confirmation bias errors; 17-18 Hypothesis #6 -Total Errors.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The medians of P1 Embedded Errors Found are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.170[1,2]	Retain the null hypothesis.
2	The distribution of P1 Embedded Errors Found is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.061	Retain the null hypothesis.
3	The medians of P1Embedded Errors Committed are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.179[1,2]	Retain the null hypothesis.
4	The distribution of P1Embedded Errors Committed is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.061	Retain the null hypothesis.
5	The medians of P1_EEF + P1EERep = TOTAL FDREP are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.350[1,2]	Retain the null hypothesis.
6	The distribution of P1_EEF + P1EERep = TOTAL FDREP is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.144	Retain the null hypothesis.
7	The medians of P1FdNRep + P1EECNRe =NotRepTOT are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.303[1,2]	Retain the null hypothesis.
8	The distribution of P1FdNRep + P1EECNRe =NotRepTOT is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.254	Retain the null hypothesis.
9	The medians of P1RA_TOT=RB+Kn+CB+EEF+ER are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.005[1,2]	Reject the null hypothesis.
10	The distribution of P1RA_TOT=RB+Kn+CB+EEF+ER is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.005	Reject the null hypothesis.
11	The medians of P1Kn Errors in steps with asterisks are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.005[1,2]	Reject the null hypothesis.
12	The distribution of P1Kn Errors in steps with asterisks is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.010	Reject the null hypothesis.
13	The medians of P1KnErr +P1_CBErr + P1NotReT are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.001[1,2]	Reject the null hypothesis.
14	The distribution of P1KnErr +P1_CBErr + P1NotReT is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.011	Reject the null hypothesis.
15	The medians of P1CB errors skipping double checks are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.005[1,2]	Reject the null hypothesis.
16	The distribution of P1CB errors skipping double checks is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.014	Reject the null hypothesis.
17	The medians of P1RBKnCB + P1NotReT are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.023[1,2]	Reject the null hypothesis.
18	The distribution of P1RBKnCB + P1NotReT is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.010	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1] Exact significance is displayed for this test.

[2] Fisher Exact Sig.

Hypotheses Test Summary involving Total Error data and both periods (SPSS® V25.0):

1. Comparison of the Period One and Period Two combined Total Error data from the checklist groups (A+A) to the no-checklist groups (B+B).

Test Statistics[a]

	B (no checklist) total errors Pd1Pd2 - A (checklist) total errors Pd1Pd2
Z	-2.276[b]
Asymp. Sig. (2-tailed)	.023

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

2. Comparison of the Total Error data from Period One to Period Two (A+B: B+A).

Test Statistics[a]

	P2RBKnCB + P2NotReT - P1RBKnCB + P1NotReT
Z	-2.316[b]
Asymp. Sig. (2-tailed)	.021

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

3. Comparison of the Total Error data from the no-checklist group in Period One to the no-checklist group in Period Two (B: B)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The medians of B (no checklist) total errors Pd1vsPd2 are the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Median Test	.023[1,2]	Reject the null hypothesis.
2	The distribution of B (no checklist) total errors Pd1vsPd2 is the same across categories of PD1 AB-Checklist PD2 BA-Checklist.	Independent-Samples Kruskal-Wallis Test	.007	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1]Exact significance is displayed for this test.

[2]Fisher Exact Sig.