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An Exploration of Medication Errors Generated by Baccalaureate Nursing Students Using Electronic Medication Administration Record (eMAR) Technology in Clinical Simulation

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ABSTRACT

Background: Medication errors continue to be a significant issue within both academic and clinical settings, posing substantial threats to the safety and well-being of patients. Through Bandura's theory of self-efficacy, nursing students' self-efficacy (confidence) and preparedness related to medication administration were examined to investigate their influence on the generation of medication errors in clinical simulation.

Research Questions: The research questions of this study aimed to examine the generation of medication errors and the differences that may exist based on nursing students' perceived confidence and preparedness.

Method: An exploratory secondary analysis of previously collected data that examined nursing students' generation of errors in clinical simulation was used. Descriptive statistics were completed, and inferential analyses were used to examine differences between variables of interest.

Results: A total of 178 medication errors were generated by the nursing students (N = 69) included in this analysis. Verification-related errors were the most frequently generated error during the medication administration process in clinical simulation. No statistically significant ($p < .05$) differences were found between nursing students' perceived confidence, preparedness, and the generation of medication errors with an exception noted for scanning-related errors ($p = .04$).

Conclusion: Based on the findings of this analysis, nursing students continue to generate medication errors within clinical simulation. Students' perceived confidence and preparedness did not produce statistically significant differences with the generation of medication errors. Further examinations of the variables and contextual factors related to safe medication administration practices is required to inform education and practice.

Keywords: Medication errors, nursing students, electronic medication administration

record, simulation, self-efficacy, confidence, preparedness, patient safety

CO-AUTHORSHIP STATEMENT

Ryan Chan completed the following thesis work under the supervision of Dr. Richard Booth and advisement of Dr. Gillian Strudwick who will be co-authors on publications resulting from this manuscript.

DEDICATION

I would like to dedicate this thesis to my mom, my dad, and my sister for their continuous support of all my personal and academic efforts.

I would also like to extend my dedication of this thesis to each and every patient whom I had the privilege to care for as your experiences and stories reinforced my aspiration, commitment, and determination to engage in efforts to further promote nursing education and enhance the quality of care.

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CHAPTER ONE

Background and Significance

Medication errors are defined as preventable events that can result in patient harm caused by personnel or process inappropriateness related to medications (i.e., from prescribing to monitoring the effects of the medication[s] after administration (Hughes & Ortiz, 2005). Any mistakes or issues generated by health care professionals related to the medication process are also considered to be medication errors (Health Canada, 2011). Examples of medication errors may include (but are not limited to) an inappropriate prescription/prescribing error; dispensing error; failing to verify patient identity; failing to calculate the appropriate dosage; failing to administer the medication via the appropriate route; and, failing to monitor the patient for potential side effects or complications after administering the medication (Aronson, 2009).

Given the complexities that may contribute to the generation of medication errors, medication errors are common within the healthcare system. The Institute of Medicine (2007) has indicated that hospitalized patients on average experience a minimum of one medication error per day. Further, medication errors are considered to be a medical error and may lead to both health and financial consequences (Samp, Touchette, Marinac, & Kuo, 2014). Physical illnesses or symptoms that may be experienced by patients as a result of medication errors can range from moderate (e.g., nausea and vomiting) to severe (e.g., allergic reactions and death). Financial consequences of medication errors can include costs related to the re-admission of patients to hospitals, additional treatments, and settlement compensation to patients harmed by errors. It has been estimated that medication errors contribute 1.3 million cases of patient harm and injury every year and

cost the health care system more the $21 billion USD on an annual basis in the United States (Agency for Healthcare Research and Quality, 2010, 2017; da Silva & Krishnamurthy, 2016; Lahue et al., 2012). Due to the significant risk of harm for patients related to medication errors, a greater examination of the potential influence and contributing factors associated with the generation of medication errors is therefore warranted.

Medication Errors and Nursing Practice

Within the medication process chain, medication errors that are specifically generated in the *administration* process are the most common cause of patient harm in acute care and inpatient healthcare settings (Ofusu & Jarrett, 2015). The medication administration process involves the specific act in which the health care providers (i.e., registered nurse) physically administers medications to their patients. Medication administration is considered to be one of the most common clinical tasks for nurses given their scope of practice and responsibilities (Karabağ Aydin & Dinç, 2017). It has been reported that nurses can spend upwards of 40% of their work time administering medication, with the average medical-surgical unit patient receiving approximately 22 to 25 scheduled medications per day (Armitage & Knapman, 2003; Jennings, Sandelowski, & Mark, 2011). For instance, in a hospital environment where the nurse-to-patient ratio is commonly recommended to be 1:4 (British Columbia Nurses' Union, 2015), it is not unusual for an individual nurse to administer approximately 80 scheduled medications per 12-hour shift. Further, it is important to recognize that this quantity of medications does not include any unscheduled or 'as-needed' (prn) medications. Additional environmental factors including disruptions, unplanned emergencies, and nursing

interventions must also be accounted for when considering the actual amount of time nurses spend in the medication administration process (Relihan, O'Brien, O'Hara, Silke, 2010).

Medication Errors and Nursing Competency

Given the complexities related to the medication administration process, failing to engage in competent and safe medication administration practices may lead to severe consequences and harm to patients' safety and well-being. As part of the professional entry-to-practice requirements, nurses are expected to possess sufficient knowledge and competency related to medication administration (College of Nurses of Ontario [CNO], 2014). Pre-licensure nursing education has aimed to prepare nursing students to become competent practitioners with sound knowledge in both the theoretical and clinical components of nursing practice, including but not limited to medication administration (Bourbonnais & Caswell, 2014). It is an expectation that Canadian schools of nursing adequately prepare nursing students with the appropriate knowledge, skills, abilities, and competencies related to safe medication administration practices in order to promote safe clinical practice and ensure patient safety (Canadian Association of Schools of Nursing, 2014). Thus, nursing educators have recognized the need and importance of embedding medication administration education into the curriculum to prepare nursing students for safe clinical practice (Durham & Alden, 2008). However, the act of medication administration is complex and consists of many potential variations, which pose significant challenges to nursing educators (Latimer, Hewitt, Stanbrough, & McAndrew, 2017).

Medication Errors and Nursing Students

Despite receiving prior academic preparation involving both theoretical and clinical education, nursing students continue to generate medication errors in the clinical environment (Noland, 2014; Wolf, Hicks, & Serembus, 2006). Medication errors continue to be one of the most eminent sources of mistakes made by nursing students in the clinical setting (Zieber & Williams, 2015). In a study by Cebeci, Karazeybek, Sucu, and Kahveci (2015), findings indicated that 38% ($N = 324$) of nursing students generated medication errors with varying degrees of harm in the hospital environment during their clinical practicum. Furthermore, the Pennsylvania Patient Safety Authority (2016) examined medication errors generated in acute care settings by students enrolled in health professionals' education (i.e., nursing, pharmacy, medicine), and identified that 84 % ($N = 711$) of the medication errors involved nursing students.

However, it has been suggested that these statistics may not be an accurate reflection of the actual medication errors generated by nursing students as the underreporting of errors is common for students due to their fear of being reprimanded (Koohestani & Baghcheghi, 2009). Therefore, the actual cases of medication errors generated by nursing students may be even more concerning. Common factors that contribute to nursing students' generation of medication errors include insufficient knowledge and education, clinical skills (e.g., drug calculation), and the lack of supervision (Dolansky, Druschel, Helba, & Courtney, 2013; Gorgich, Barfroshan, Ghoreishi, & Yaghoobi, 2016; Reid-Searl, Moxham, & Happell, 2010). Given these potential influences, further research examining the relationships between nursing students and medication errors will be beneficial (Cooper, 2014).

Medication Error, Self-efficacy (Confidence), and Preparedness

In addition to insufficient knowledge and skills, Panduragan, Abdullah, Hassan, and Mat (2011) have suggested that the lack of confidence, knowledge, and competency can contribute to nursing students' generation of clinical errors. Within the nursing education literature, the concepts of confidence, knowledge, and competency have been explored in a multitude of fashions, commonly through the lens of self-efficacy (Akhu-Zaheya, Gharaibeh, & Alostaz, 2013; Park, Jeoung, Lee, & Sok, 2015; Van Horn, & Christman, 2017). Confidence is defined as a psychological construct that has been suggested to be a "colloquial" (Bandura, 1997, p.382) term used to denote elements of *self-efficacy*. Self-efficacy has often been used in combination with the construct of confidence to provide an overall measure of an individual's belief of success related to their participation in a specific activity or endeavor (Bandura, 2006; Lorig, Sobel, Ritter, Laurent, & Hobbs, 2001). Preparedness, or considered as the readiness to engage in certain behavior, has also been suggested to be an important indicator of students' success in the clinical setting (Banneheke et al., 2017; Lewallen & DeBrew, 2012). Nursing students' level of confidence and preparedness has been suggested to be an important factor that contributes to their development of competence, success, and ability to perform clinical tasks such as medication administration (Lewallen & DeBrew, 2012; Panduragan et al., 2011).

Given the significant responsibility and risk of harm related to the act of medication administration performed by nurses, it is important to examine the relationships between nursing students' perceptions of self-efficacy related to the medication administration process, and the generation of actual medication errors. In this

study, the differences between measures of nursing students' perceived self-efficacy (confidence), preparedness, and the generation of medication errors within clinical simulation will be examined.

Statement of Study Purpose

This study will examine the types of medication errors generated by nursing students in clinical simulation, and identify if there are differences in the generation of medication errors based on nursing students' self-perceived levels of self-efficacy (confidence) and preparedness. The theoretical underpinning of this study will be guided by Bandura's (1977) theory of self-efficacy as this framework may assist toward elucidating a greater understanding of nursing students' confidence, subsequent behaviors, and the related outcomes. The findings of this study will assist to expand the current body of research associated with the constructs of self-efficacy (confidence), preparedness, and educational practices related to medication administration within nursing education.

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CHAPTER TWO

Background

A medication error is defined as a preventable cause of patient harm within the clinical environment related to the various stages of the medication process (e.g., prescribing, dispensing, or administration) (Williams, 2007). It has been suggested that the actual prevalence of medication errors may vary given the different research and investigation approaches (Williams, 2007). However, a study that examined medication errors revealed that medication errors generated specifically within the *administration* process of the greater medication process accounted for up to 50% (N = 526 186) of the medication errors found in both acute and primary care environments (Cousins, Gerrett, & Warner, 2012). The medication administration process involves the act in which the healthcare provider physically administers the medication to their patients upon completing the necessary assessments and verification (i.e., drug name, dosage, etc.). Further, the Institute for Healthcare Improvement (2017) identified that 55% (N = 2 536) of adults reported that they have personally experienced a medication error in the past within the clinical environment including receiving the wrong dosage or wrong medication. Since nurses are the largest group of health care providers involved with the medication administration process, they carry a significant professional responsibility to promote safe medication practices and to ensure patient safety (Choo, Hutchinson, & Bucknall, 2010).

Given the potential risk of harm and consequences for patients as a result of medication errors, an examination of the potential influences that may contribute to the generation of such errors is needed. For instance, Cheraghi, Hassani, Yaghmaei, and

Alavi-Majed (2009) have suggested that it is important to explore nursing students' beliefs of self-efficacy as it may provide insight into their clinical performance. Nursing students' increased self-efficacy have been shown to enhance their academic success, motivation, competency, and independence to care for patients (Abdal, Masoudi Alavi, & Adib-Hajbaghery, 2015; McLaughlin, Moutray, & Muldoon, 2008). Conversely, nursing students with low levels of self-efficacy may not engage in or perform the necessary interventions for their patients (i.e., task avoidance) given their lack of confidence which may also subsequently result in potential harm for patients (Masoudi Alavi, 2014).

Like self-efficacy, nursing students' confidence and knowledge have also been positively related to their skills and abilities related to the medication administration process (Andrew, Salamonson, & Halcomb, 2009). In a nursing student population, Woods et al. (2015) found that although nearly 90% ($N = 113$) of students felt ready and prepared for clinical practice, the students continued to lack confidence with certain aspects of care, thus limiting their abilities to engage in practice as independent practitioners. Given the variability of findings related to self-efficacy (confidence), preparedness, and the performance of clinical tasks, a study was undertaken to better ascertain the influences between these variables. The purpose of the study was to examine the potential differences found in the generation of medication errors by nursing students within clinical simulation based on their self-perceived levels of confidence and preparedness.

Theoretical framework

The theoretical framework for this study is based on Bandura's (1977) theory of self-efficacy. *Self-efficacy* refers to an individual's psychological conviction that he or she can successfully execute the behaviour required to produce the desired outcome (Bandura, 1977). The concept and definition of self-efficacy shares much similarity with *confidence*, and confidence has been suggested to be the more common term used to describe self-efficacy (Bandura, 1997). Based on this understanding, the term confidence will be used interchangeably with self-efficacy in this present study. In order for an individual to develop self-efficacy or the conviction of success, four sources of *efficacy expectations* have been proposed as essential: (a) *performance accomplishments;* (b) *vicarious experience;* (c) *verbal persuasion*; and, (d) *emotional arousal* (Bandura, 1977). These four sources of efficacy expectations contribute to the development of an individual's self-efficacy or conviction of success, and simultaneously generate a strong psychological influence towards behavioral change (Bandura, 1977).

Performance accomplishments. Considered as one of the most important and influential source of efficacy expectation, performance accomplishments refers to an individual's past personal mastery experience and performance with a particular behaviour and whether it resulted in success or failure (Bandura, 1977). Successful experiences in the past not only offer individuals with the opportunity to further develop their skills and contribute to successful performance, but also reinforce their level of self-efficacy (Bandura, 1977).

Vicarious experience. Another source of efficacy expectation is vicarious experience which refers to the experiences and opportunities for individuals to observe others performing the behaviour (e.g., role modelling) (Bandura, 1977). For example, observing other individuals performing a specific task that results in success will produce greater self-efficacy for the observer (Bandura, 1977).

Verbal persuasion. Verbal persuasion refers to the positive verbal suggestions, recommendations, and/or encouragement provided by others to an individual in an effort to enhance their self-efficacy towards performing a certain task or behaviour (Bandura, 1977). Although a widely integrated source of efficacy expectations, verbal persuasion presents unique challenges (e.g., perceived credibility of the encouragement) towards fostering an actual and stronger sense of self-efficacy, and warrants further experimental considerations (Bandura, 1977).

Emotional arousal. Emotional arousal refers to an individual's emotional and psychological state of mind towards engaging in a certain behaviour or experience (Bandura, 1977). High emotional arousal resulting from stressful and intensive situations may negatively impact their behaviour; therefore, a reduction of stress during tasks or behaviors has been suggested to enable and foster a greater self-expectation of success (Bandura, 1977).

In this present study, the following sources of efficacy expectations were identified and considered based on individual student's prior preparation related to medication administration: (a) formal exposure and practice in the simulated setting; (b) viewing video demonstrations; and, (c) receiving clinical instructors' feedback regarding

their performance. As a result of this process, certain efficacy expectations were more prominent and extensively examined than others. For example, performance accomplishments may be a limited source of efficacy expectations for students given their lack of experience with medication administration. In contrast, *vicarious experience* may be a more significant and influential source of efficacy expectations given students' previous opportunities to observe others engaging in medication administration (e.g., both in-person within clinical simulation and through video demonstrations included as part of their preparatory material). However, all sources of efficacy expectations outlined in Bandura's (1977) theory were simultaneously considered when examining students' self-efficacy in this present study.

Literature Review

In order to gain a greater understanding of the concepts and variables presented in this present study, a search of the literature was conducted in the following databases: The Cumulative Index of Nursing and Allied Health Literature (CINAHL), PubMed, PsychINFO, and Scopus. The following key words and terms were used as search terms in various combinations: *self-efficacy, confidence, preparedness, nursing students,* and *medication errors*. Boolean operators such as "AND" and truncation symbols such as an asterisk "*" were also used in conjunction with the search terms (Polit & Beck, 2017). Additional literature search strategies were also used including the analysis of reference lists of retrieved literature (Jadad, Moher, & Klassen, 1998). Peer-reviewed articles published within the past ten years (2007-2017) and those published in English were included for review. Unpublished manuscripts such as abstracts, theses, and dissertations were excluded.

Upon title and abstract screening, 89 articles were deemed relevant to the purpose and scope of this review, and were selected for further analysis. Subsequently, 45 articles were then selected for a deeper examination and included in this review. The findings were summarized, organized, and presented thematically based on the sources of efficacy expectations outlined by Bandura's (1977) theory of self-efficacy. Past literature that examined nursing students' experience with medication administration processes and sources of efficacy expectations related to specific nursing clinical tasks and interventions (including medication errors) are also presented.

Self-efficacy and Confidence

Bandura's (1977) theory identified four sources of efficacy expectations that contribute to an individual's level of self-efficacy, which may promote positive behavioural and/or psychological changes. *Performance accomplishments, vicarious experience, verbal persuasion*, and *emotional arousal* have been suggested to assist and influence an individual's personal conviction of success in accomplishing a specific behaviour (Bandura, 1977). These sources of efficacy expectations can be identified and gained through previous positive learning experiences and exposures, and will also strengthen an individual's level of self-efficacy, confidence, persistence, and motivation towards accomplishing specific behaviours (Bandura, 1993; Lauder et al., 2008; McMullan, Jones, & Lea, 2012). Given the potential impact of self-efficacy and its contribution towards influencing individual behaviour, Bandura's (1977) theory has been extensively used in the nursing literature to examine the relationship and effects of self-efficacy on nursing students' learning and development, including clinical skills such as medication administration (Campbell, 2013; Mackie & Bruce, 2016; Soulosaari, Kajander, Hupli, Huupponen, & Leino-Kilpi, 2012).

Personal Mastery Experiences and Self-efficacy

Performance accomplishments or personal mastery experience has been considered to be a significant and influential source of efficacy expectation (Bandura, 1977). It has been suggested that earlier successes from an individual's past personal experiences improves their self-efficacy (Bandura, 1977). Baillie, Merritt, Cox, and Crichton (2015) found that nursing students' pre-course contact and previous experience in caring for dementia patients prior to their formative education had the most significant influence on their self-perceived level of confidence when compared to other factors such as age, academic year, and personal expectations. Nursing students who had previous exposure caring for patients with dementia had significantly greater confidence than those who lacked such experience (Baillie et al., 2015). Similarly, nursing students who had pre-course exposure and experience with conducting certain clinical tasks (such as measuring blood pressure) also demonstrated greater self-efficacy than their peers who had no previous experience (Baillie & Curzio, 2009).

In an examination exploring the relationship of self-efficacy and demographic factors of nurse anesthesia students, Imus, Burns, and Weglarz (2017) found that years of academic learning (i.e., years of formative nursing education) was negatively correlated with students' self-efficacy and confidence. It was suggested that although students may gain valuable knowledge and skills during their formative education, they lacked the opportunity to fully develop their personal mastery experiences. It was proposed that personal mastery experiences gained from intensive exposures were superior in contributing to nursing students' confidence as opposed to sporadic, infrequent experiences (Imus et al., 2017). The specific, intensive, and repetitive nature gained from

personal mastery experiences have been proposed to demonstrate greater influence on an individual's confidence (Bandura, 1977).

In a study examining nursing students' participation in an integrated clinical and simulation learning program, Pauly-O'Neill and Prion (2013) found that students who were exposed to an intensive training program involving exposure to both actual clinical practice and clinical simulation reported increased self-efficacy, confidence, knowledge, and skills in caring for the pediatric population. Specifically, nursing students demonstrated greater knowledge and reported greater confidence with their skills including administering medications to pediatric patients after the training program (Pauly-O'Neill & Prion, 2013).

Raica (2009) explored the effectiveness of a researcher-led communication training program and its influence on nurses' confidence to communicate other members of the health care team. Raica (2009) determined that nurses' confidence was enhanced after being exposed to the training program for five weeks. The training program consisted of elements where nurses were to actively utilize and engage in meaningful communication with other members of the health care team using a standardized communication tool, while observing others and providing input and feedback. Raica (2009) indicated that the enhanced level of confidence was influenced by both the training process and personal mastery experiences derived from the training. In addition, the opportunity to observe others performing a specific behavior (e.g., peer communication) described this study also served as a source of efficacy expectation (vicarious experience), and promoted an individual's level of self-efficacy (Bandura, 1977; Raica, 2009).

Vicarious Experience and Self-efficacy

The opportunity to observe others performing and engaging in specific activities has the ability to influence an individual's determination to attempt such behaviour (Bandura, 1977). For example, the opportunity for a student to observe other students engaging in a similar behavior (i.e., *vicarious experience*) within clinical simulation have been suggested to affirm nursing students' perception of self-efficacy (Sinclair & Ferguson, 2009). It has been reported that nursing students who took part in clinical simulation that involved the opportunity to observe other students providing care to patients reported greater self-efficacy with their own abilities to provide nursing care (Sinclair & Ferguson, 2009). Furthermore, Hayes, Jackson, Davidson, Daly, and Power (2017) examined the use of role-play within nursing clinical simulation related to students' abilities to manage interruptions during the medication administration process. It was found that the role-play experience involving students observing each other and switching roles improved their knowledge, skills, and abilities in managing unexpected interruptions (such as demands from a confused patient) during the medication administration process (Hayes et al., 2017).

In addition to managing interruptions related to medication administration, the opportunities to observe modelled behaviors by other nurses may also contribute to nursing students' confidence related to their clinical decision-making abilities (Brown, Kim, Stichler, & Fields, 2010). In a cross-sectional study by Brown et al., (2010), nursing students who reported greater confidence with their decision-making also resulted in more positive behaviors such as engaging in evidence-based practice and to provide greater quality of care (Brown et al., 2010).

Verbal Encouragement and Self-efficacy

Verbal persuasion refers to the act when an individual is provided with suggestions and affirmations by others in an attempt to positively influence an individual's self-efficacy and their behaviour (Bandura, 1977). Verbal persuasion has been suggested to contribute to an individual's success with managing or mastering behaviors or situations (Bandura, 1977). Specific acts of verbal persuasion that involve an interactive and social component (such as interpersonal communication), may be of greater value and influence when compared to generalized and unspecific sources of verbal support (Bandura, 1977). For example, the process of debriefing provides opportunities for nursing students to receive direct and specific feedback on their performance from their clinical instructor. Furthermore, a debriefing process that occurs after students' completion of a simulated scenario has been found to promote greater critical reflection and self-efficacy for nursing students (Tutticci, Coyer, Lewis, & Ryan, 2017).

In addition to the debriefing process, other forms of verbal encouragement that may support the development of nursing students' self-efficacy have also been examined. Fiske (2017) examined the relationship between verbal persuasion and nursing students' self-efficacy with their licensure examination. Nursing students who engaged in a faculty-led contemplative practices session and received verbal encouragement reported greater self-efficacy with passing their licensure examination (Fiske, 2017). Furthermore, verbal reinforcements, encouragement, and a mentoring relationship supported by clinical instructors that assured nursing students of their knowledge, skills, and behaviour with

caring for their clients have also been suggested to increase nursing students' self-efficacy, independence, and competence (Jordan & Church, 2013; Molloy, 2017).

Personal Emotions, State of Mind, and Self-efficacy

An individual's psychological state of mind or emotions, while conducting a certain behaviour or attempting a certain task, has been suggested to influence their self-efficacy (Bandura, 1977). Insomuch, individuals who experienced a more positive and calm state of mind while engaging in certain behaviors were suggested to be more likely to develop greater self-efficacy and their subsequent conviction of success (Bandura, 1977). For instance, clinical simulation is a well-established pedagogical strategy within nursing education which attempts to provide a safe and positive experience for nursing students to assist with their learning and development (Berragan, 2011). Within clinical simulation, nursing students are given the opportunity to develop their skills in a safe and risk-free environment. The risk-free environment generated by clinical simulation helps to improve nursing students' emotions and provide an engaging learning experience that may foster greater skills development and self-efficacy (Pauly-O'Neill & Prion, 2013). Simulated learning has also been suggested to positively contribute to nursing students' emotional state of mind and enhance greater knowledge transfer (Pawar, Jacques, Deshpande, Pusapati, & Meguerdichian, 2017). Aggar and Dawson (2014) suggested that nursing students' exposure and experience with high-fidelity simulated learning environments also supported students' preparedness, confidence, and knowledge development in various aspects of care, including medication administration.

Khalaila (2015) suggested that a conducive learning environment including simulation has been reported to decrease nursing student's anxiety while increasing their confidence and caring abilities. This study noted that caring efficacy was negatively predicted by anxiety, indicating that students who reported high levels of anxiety had reduced levels of efficacy (Khalaila, 2014). This finding suggested that an individual's emotional arousal or state of mind, despite of the environment, also plays a significant role in contributing to one's efficacy. It has also been suggested that a positive and calm learning environment not only promotes nursing students' self-efficacy, but also serve as a positive influence on their medication administration skills and abilities including problem solving, dosage calculations, and critical thinking, (Zahara-Such, 2013).

Self-efficacy, Preparedness, and Medication Errors

Medication errors have been defined as any mistake(s) made during the medication administration process, including the prescribing, transcribing, dispensing, administering, and monitoring of medications (Harding & Petrick, 2008). Examples of medication errors include administering the wrong medication to the wrong patient and/or at the wrong time, the incorrect handling of medications (i.e., medication re-constitution, aseptic techniques), or failing to appropriately monitor patients after administering their medications (Tzeng, Yin, & Schneider, 2013). Within the context of medication errors, nurses are often responsible for errors that occur during administration phase of the medication process, given their scope of practice as a registered nurse (College of Nurses of Ontario [CNO], 2017).

Leufer and Cleary-Holdforth (2013) outlined that medication management including medication administration is one of the most labor intensive and high-risk activities associated with nursing practice. Nurses bear a significant responsibility to engage in safe medication practices and to ensure the safety and well-being of all patients in their care (Meechan, Valler-Jones, & Jones, 2011). While all medication errors are *theoretically* preventable (Ben Natan, Sharon, Mahajna, & Mahajna, 2017), given the complexity of the medication process, errors continue to occur despite significant advances and developments in preventative strategies, interventions, and best practices (Pitkanen, Teuho, Uusitalo, & Kaunonen, 2016).

Nursing students are particularly at high risk for generating medication errors in the clinical setting given their lack of experience (Koohestani & Baghcheghi, 2009). Saintsing, Gibson, and Pennington (2011) have indicated that medications errors are likely the primary source of clinical error for new graduate nurses with less than one year of practice experience. While there are a range of factors that contribute to the development of medication errors made by both students and practicing nurses, past research has suggested that errors commonly originate from two different dimensions: (a) systemic factors; and, (b) human factors (Durham, 2015). *Systemic factors* are forces that are often context-based, scaled, and usually beyond the control of an individual. For instance, systemic factors include aspects related to system flow or process, design of various contexts, and environmental distractions (Durham, 2015). Medication and pharmacological knowledge, skills, competencies, and cognition (such as critical thinking and awareness) are examples of *human factors* (Brady, Malone, & Fleming, 2009).

Within the research literature, a lack of preparation in medication knowledge and poor mathematical skills have been widely reported to be barriers for nurses to engage in safe medication administration practices (Bagnasco et al., 2016). In a study by Amster, Marquard, Henneman, and Fisher (2015), they examined medication errors generated by nursing students through an eye-tracking device that captured various moments of the medication administration process. It was identified that 40% ($N = 12$) of nursing students generated a medication error through administering a contraindicated medication which would have resulted in an allergic reaction for the patient (Amster et al., 2015). The specific medication error generated by nursing students in this study may have been contributed by their lack of preparation related to pharmacological knowledge (Amster et al., 2015). Given the significant consequences associated with medication errors and its impact on patient safety (Lukewich et al., 2015), a strong emphasis must be placed to continue to examine potential factors and or contributors (such as perceived self-efficacy and preparedness) that may assist in the understanding of medication safety.

Perceived Gaps in the Literature

Upon reviewing the literature, several gaps were noted with regards to nursing students' confidence and their knowledge, competence, and performance outcomes related to their clinical practice. Although individuals who possess high levels of self-efficacy may be strongly convinced that they are able to successfully perform certain behaviors or tasks, their actual knowledge, clinical skills, and abilities warrant further examination (Oetker-Black, Kreye, Underwood, Price, & DeMetro, 2014). Furthermore, nursing students' perceived confidence and its influence on actual clinical outcomes have yet to be determined (Liaw, Scherpbier, Rethans, & Klainin-Yobas, 2012; Shelton, 2016).

Lin (2015) have suggested that nursing students' enhanced confidence resulted in greater performance and passing rate with clinical skills examination; however, the relationship between confidence and actual impact on patient outcomes warrant further examination.

In addition, Lauder et al. (2008) suggested than an individual's self-confidence is not associated with their actual level of competence that is necessary to carry out the behaviour. For example, individuals who reported high levels of self-efficacy sometimes lacked the necessary skills to manage certain clinical scenarios and situations (i.e., pain management) (Stanley & Pollard, 2013). In a study that examined nursing students' knowledge and skills related to information literacy, it was found that students' confidence was negatively correlated with their knowledge and skills in information literacy (Robertson & Felicilda-Reynaldo, 2015). Furthermore, nursing students' self-perceived level of confidence may not accurately reflect their actual clinical performance as confidence has no impact on their clinical judgement and abilities (Yang & Thompson, 2010).

Research Questions and Rationale

Bandura's (1977) theory of self-efficacy postulates that the four different sources of efficacy expectations will promote and foster an individual's conviction of success in performing certain behavior. Providing further insights into the relationships between nursing students' confidence, preparedness, and clinical competency will assist in addressing the gaps identified in the literature. Therefore, based on the theoretical framework and design of this present study, the following research questions will be

addressed in an attempt to provide insights regarding confidence, preparedness, and medication errors:

1. What are the types of medication errors generated by nursing students during simulated medication administration?
2. Is there a difference in the generation of medication errors between nursing students with high perceived levels of confidence compared to low perceived levels of confidence?
3. Is there a difference in the generation of medication errors between nursing students with high perceived levels of preparedness compared to low perceived levels of preparedness?

Methods

Study Design

A secondary analysis of quantitative data arising from a pragmatic randomized control trial was used in the present study. The primary study from which secondary data was extracted aimed to examine the effectiveness of an advanced learning intervention for undergraduate nursing students (Booth et al., 2018b), related to use of an electronic medication administration record (eMAR) in clinical simulation. The primary study consisted of two phases of data collection including (a) at baseline; and, (b) at approximately two to four weeks after the baseline data was collected (Booth et al., 2018b). The primary study received ethics approval by the Health Sciences Research Ethics Board at Western University, London, Ontario, and consent for secondary analysis was obtained by the participants as part of their original consent to the primary study (Appendix A).

Sample and Setting

The primary study used a non-probability convenience sampling approach to recruit participants from a large, urban university located in southern Ontario (Canada). The inclusion criteria for the primary study included: (a) second year BScN students with no previous knowledge, experience, and/or training with medication administration; and, (b) second year BScN students who were enrolled in clinical simulation during the Fall 2017 academic term, or the Winter 2018 academic term. Based on these criteria, 115 BScN nursing students were recruited for the primary study. Of the 115 recruited students, 69 students completed the pre-test elements examining their confidence and preparedness with the medication administration process. Due to the research aim and questions of this secondary analysis, only 69 students who had completed the confidence and preparedness elements of the primary study were examined in this analysis.

Data Collection

Once participants were recruited and had consented to participate in the primary study, a baseline survey along with a demographic questionnaire was distributed via e-mail. The baseline survey used during the first phase of data collection in the primary study was adapted from a previously developed and tested instrument used to assess nursing students' self-efficacy regarding safe medication administration practices (Sung, Kwon, & Ryu, 2008). The baseline survey also consisted of items to assess nursing students' preparedness related to medication administration.

During phase two of data collection in the primary study, which occurred approximately two to four weeks after the distribution of the baseline survey, data

collectors used the *Medication Error Heuristic Tool* to observe and document nursing students' medication administration process in clinical simulation. As the medication administration process occurred, data collectors observed and captured the types of medication errors generated by nursing students and its potential risk of harm (Booth et al., 2018b). The types and complexions captured on the heuristic tool included the particular type of medication error made by the student along with its risk of harm to the patient (i.e., no risk, low risk, moderate risk, high risk). For the present study, data collected during both phases of the primary study were used for analysis.

Data Sources and Instruments

The present study analyzed data collected during both phases of the primary study using two different tools including: (a) the confidence and preparedness survey; and, (b) the medication error heuristic tool.

Confidence and Preparedness Survey. During phase one of the primary study, an invitation to complete the survey was electronically distributed to all participants (nursing students) via e-mail, which contained a link to an electronic survey platform (Qualtrics, Provo, UT). The survey consisted of 17-items and included both demographic questions and other questions related to their confidence and preparedness related to medication administration. Demographic questions in the baseline survey included age, gender, and highest level of education completed. The survey questions related to confidence were adapted and modified based on a previously developed instrument that measured students' perceived level of self-efficacy with medication administration (Cronbach's alpha = 0.93) (Sung et al., 2008). Questions pertaining to a student's level of preparedness were also included in the survey. To complete the survey, nursing students

would rate their self-perceived level of confidence and preparedness, and provide a response based on a 7-point Likert scale (1 = not confident/prepared at all, 7 = absolutely confident/prepared).

Medication Error Heuristic Tool. During phase two of the primary study, participants were engaged in clinical simulation and were required to administer medications to standardized patients under the supervision of their clinical instructor. During the medication administration process, data collectors utilized the *Medication Error Heuristic Tool* to record information in the following four different sections: (a) demographic information; (b) type of medication error; (c) risk of harm of the corresponding medication error to the patient; and, (d) clinical instructor prompts. This heuristic tool was adapted based on a previously developed instrument and a standardized observational approach (Booth et al., 2017). Data collection training was provided to all data collectors prior to the beginning of the primary study to assist with the inter-rater reliability of the data collection.

During data collection, each data collector observed a student administering medications to a standardized patient. As the student began the medication administration process, data collectors stood approximately six feet from the student and documented their observations. Data collectors observed, identified, and documented the various types of medication errors generated by the student as they administered the medications. The potential types of error that could be generated by the students during the medication administration process were previously conceptualized and categorized into six categories including *infection control, assessment, verification, scanning, administration,* and *documentation* (Booth et al., 2017). The types and categories of medication errors are

defined below, with a brief description related to the types of events or instances that would denote a specific error(s):

- Infection control: instances related to hand hygiene during medication administration;
- Assessment: instances related to appropriate and required patient assessment during medication administration, including blood pressure and pulse;
- Verification: instances related to required patient verification during medication administration (e.g., patient name, date of birth, administration date, dosage, route, etc.);
- Scanning: instances related to required scanning of barcodes on patient and medication during medication administration;
- Administration: instances related to medication administration including positioning of the patient; and
- Documentation: instances related to appropriate documentation related to medication administration (i.e., signature and documentation) (Booth et al., 2017).

In addition to documenting the types of medication errors, its associated risk of harm to the patient (i.e., no risk, low risk, moderate risk, high risk) was also recorded. The risk of harm associated with the mediation error was pre-determined by the research team prior to the beginning of the primary study based on the specific medications that were to be administered in simulation and its potential consequences on the patient. For example, failing to conduct an appropriate assessment that included vital signs (specifically blood pressure and pulse) prior to administering a beta-blocker medication

that lowers blood pressure was considered to be a *high risk* of harm given its potentially devastating consequences on the patient. All recorded observational data was kept securely in the primary investigator's office during the study, and all personal identifiable information was removed prior to data analysis as per study protocol and adherence to ethical approval procedures.

Data Analysis Plan

All data and statistical analysis in this secondary analysis was conducted using the Statistical Package for Social Sciences (SPSS), version 25 (International Business Machines Corporation [IBM], 2018). The dataset was checked for missing data and a listwise deletion approach for missing data was used during analysis (Polit & Beck, 2017). A descriptive statistical analysis, consisting of measures of mean, median, central tendency, and frequency distribution was conducted for the total sample and variables of interest and to address the first research question. An inferential statistical analysis consisting of the *Mann-Whitney U-Test* was conducted to address the second and third research questions of this present study.

Descriptive Analysis

One of the primary aims of this secondary analysis was to examine the types of medication errors generated by nursing students in clinical simulation, and identify if there are differences in the generation of medication errors based on nursing students' self-perceived levels of confidence and preparedness. The independent variables of interest in this secondary analysis were based on data collected previously in the primary study and included nursing students': (a) self-perceived level of confidence; and, (b) self-

perceived level of preparedness. Perceived confidence and preparedness were collected via the *Confidence and Preparedness Survey* that was distributed during phase one of the primary study. Once distributed, students were asked to rate their confidence and preparedness related to medication administration for each domain and question (six questions for confidence, eight questions for preparedness). Students rated their response on a 7-point Likert scale (1 = not confident/prepared at all, to 7 = absolutely confident/prepared) (see Table 1). Subsequently, both descriptive and frequency analysis for each survey item of the entire sample were conducted (see Table 2). An overall measure including the mean and median were generated for the domains of confidence and preparedness.

To assist with the inferential analysis of this study, the median was used to develop dichotomous variables through categorizing low and high levels of confidence and preparedness based the student's response. The median has been suggested to provide a meaningful value that can be used to divides cases in half given its unique properties (Polit & Beck, 2017). Upon computing the median, the responses were categorized and analyzed for frequency distribution (see Table 4) in the following intervals: (a) low perceived level of confidence (<4.5); (b) high perceived level of confidence (≥ 4.5); (c) low perceived level of preparedness (<4.44); and, (d) high perceived level of preparedness (≥ 4.44). Subsequently, the independent variables of interest (confidence and preparedness) became dichotomous variables prior to the inferential analysis.

Table 1. *Variables of Interest*

Variables of interest	Level of measurement	Example
Independent variable		
Perceived self-efficacy/confidence	Ordinal/ Interval (Dichotomous)	*Please rate your level of confidence using a 7-point Likert scale (0=Not confident at all, 7=Absolutely prepared) with: Understand the correct steps to successfully complete medication administration*
Perceived preparedness	Ordinal/ Interval (Dichotomous)	*Please rate your level of preparedness using a 7-point Likert scale (0=Not prepared at all, 7=Absolutely prepared) with: Complete necessary patient assessment prior to medication administration*
Dependent variable		
Medication Error		
Infection control error	Ordinal	0= No risk 1= Low risk 2= Moderate risk 3= High risk
Assessment error	Ordinal	
Verification error	Ordinal	
Scanning error	Ordinal	
Administration error	Ordinal	
Documentation error	Ordinal	

Medication errors generated by nursing students in clinical simulation in conjunction with its corresponding risk of harm (i.e., no risk, low risk, moderate risk, high risk), were the dependent variables of interest in this present study (see Table 1). The medication errors generated by nursing students were collected by data collectors and subsequently coded and assigned against an ordinal measure, which encompassed not only an indication of a generated medication error, but also the potential risk of harm to a patient through the presence of the error (i.e., no risk, low risk, moderate risk, high risk). If a student generated more than one error in a specific type/category of medication error during simulation (e.g., verification), the highest risk of harm (with no duplication) was considered, coded, and included for analysis. A descriptive frequency analysis of all medication errors observed during the study was subsequently performed (see Table 4 and 5).

Inferential Analysis

Given the design, variables of interests, and levels of measurement within the data, the *Mann-Whitney U-Test* was selected for inferential analysis for research question two and three, with the level of significance set at .05. The Mann-Whitney U-test provides a researcher with the opportunity to examine if "…a relationship exists between two groups when one variable is dichotomous and the other variable is at least ordinal" (Plichta & Kelvin, 2013, p.111). The assumptions of the Mann-Whitney U-Test were tested and met prior to analysis: (a) the independent and grouping variables of interest are dichotomous and exclusive; (b) the measures for each variable of interest constitutes an independent random sample; (c) the dependent variable of interest is at least at an ordinal level of measurement; and, (d) the sample size is to exceed a minimum of eight subjects (Plichta & Kelvin, 2013).

In addition, based on the non-parametric properties of the Mann-Whitney U-Test, the characteristic of the data within the variables of interest satisfied such requirement as evident by the frequency analysis. The Mann-Whitney U-Test was conducted for each independent grouping variable with the dependent variables of interest. A total of 12 tests were conducted to address the research questions of this present study: (a) self-perceived confidence (low and high groups) with the six categories of medication errors, and, (b) self-perceived preparedness (low and high groups) with the six categories of medication errors.

Results

Participant Characteristics

The total sample in this secondary analysis consisted of 69 participants, enrolled in a second-year clinical simulation course in the baccalaureate nursing program. Based on the data generated from the demographic questionnaire, the sample had a mean age of 19.87 years (*SD* = 1.99), consisted of mostly female participants (88%), and a high school diploma (91%) was most frequently reported as the highest level of education obtained at the time of the primary study.

Table 2: *Demographic and Descriptive Information of Participant Characteristics*

	Total Participants (*N*=69)		
Demographic Information	**Mean (SD)**	**Frequency**	**%**
Age	19.87 (1.99)		
Gender			
Male		8	11.6%
Female		61	88.4%
Highest Level of Education Completed			
High School Diploma		63	91.3%
University Undergraduate Degree		4	5.8%
Other		2	2.9%

Descriptive Analysis

Confidence and preparedness. During the first phase of the primary study, nursing students reported their self-perceived level of confidence and preparedness based on a 7-point Likert scale (1 = not confident/prepared at all, 7= absolutely confident/prepared) in the online *Confidence and Preparedness Survey*. Each survey item under the domains of confidence and preparedness were analyzed individually and then

grouped to formulate measures of central tendency (i.e., mean, median). Two specific cases involving a sub-item in each domain of confidence and preparedness were missing respectively (as shown in Table 3), and were then excluded for the inferential statistical analysis based on a listwise deletion approach to maintain the integrity of the data and resulting analysis (Polit & Beck, 2017).

Nursing students reported an overall moderate level of confidence ($M = 4.18$, $SD = 1.29$) regarding their ability to administer medications in clinical simulation while integrating the electronic medication administration records system. Students reported to have the most confidence ($M = 4.75$, $SD = 1.74$) with using the barcode scanner to scan the patients' armband and medications prior to administration. Conversely, students reported to have the least confidence with administering medications in a time-efficient manner ($M = 3.75$, $SD = 1.42$).

An overall moderate level of preparedness ($M = 4.29$, $SD = 1.08$) with medication administration was reported by the sample. Nursing students reported feeling most prepared ($M = 5.28$, $SD = 1.5$) with the use of the barcode scanner to scan the patient's armband and their medications. The act of documenting drug-drug interactions had the lowest level of preparedness as reported by the students ($M = 3.12$, $SD = 1.41$).

Subsequently, based on the descriptive analysis, the median was computed for confidence ($Mdn = 4.5$) and preparedness ($Mdn = 4.44$), and used to categorize participants into groups of low or high confidence/preparedness. The results (see Table 4) demonstrated that the divisions between the groups were relatively equal. The low confidence group had a frequency count of 33 compared to 35 in the high confidence

group. Groups with low preparedness and high preparedness were equal with 34 participants.

Table 3. *Descriptive Statistics for Confidence and Preparedness*

Variable	Mean (SD)	Median
Confidence (*N*=69) **(1=Not confident at all, 7= Absolutely confident)**		
1) Understand the medication orders on the eMAR	4.36 (1.46)	5
2) *Navigating the eMAR interface to perform medication administration in simulation	3.87 (1.38)	4
3) Understand the correct steps to successfully complete medication administration using the eMAR	4.07 (1.43)	4
4) Effectively using the eMAR barcode scanner to verify medications for administration	4.75 (1.74)	5
5) Integrating the eMAR into your nursing care during simulation	4.33 (1.43)	5
6) Using eMAR in a time-efficient manner	3.75 (1.42)	4
*Overall Confidence	4.18 (1.29)	4.5
Preparedness (*N*=69) **(1=Not prepared at all, 7=Absolutely prepared)**		
1) Read and interpret medication orders on the eMAR	4.57 (1.38)	5
2) Complete necessary patient assessments prior to medication administration	4.41 (1.25)	5
3 *Documenting that medications have been held due to due to patient contraindications or patient presentation	3.71 (1.45)	4
4) Document drug-drug interaction checks	3.12 (1.41)	3
5) Use barcode scanner to scan medications and patient identification armband	5.28 (1.5)	6
6) Administer medications using correct eMAR procedures	4.39 (1.44)	5
7) Documentation after medication administration	4.51 (1.43)	5
8) Complete necessary patient assessments after medication administration	4.45 (1.42)	5
*Overall Preparedness	4.29 (1.08)	4.44

**n= 68*

Table 4. *Frequency Distribution for Independent Variables*

Independent variables	Frequency	%
Confidence (*n*=68)		
Low perceived level of confidence (<4.5)	33	47.8%
High perceived level of confidence (≥ 4.5)	35	50.7%
Preparedness (*n*=68)		
Low perceived level of preparedness (<4.44)	34	49.3%
High perceived level of preparedness (≥ 4.44)	34	49.3%

Medication errors. Medication errors generated by nursing students during clinical simulation was the dependent variable of interest. The following table and figure (see Table 5; Figure 1) provided the frequency distribution computed for the medication errors generated by nursing students, along with the error's potential risk of harm to the patient (i.e., no risk, low risk, moderate risk, high risk). Based on the descriptive analysis and the methodology applied to data collection, a total of 178 medication errors were generated by the sample of nursing students ($N = 69$). Medication errors related to verification was found to be the most frequent error ($n = 57$) generated by the students, followed by infection control ($n = 36$), documentation ($n = 26$), assessment ($n = 22$), and scanning ($n = 20$). Medication errors related to the physical act of administering medications to the patients was the least frequent error generated ($n = 17$). Regarding the risk of harm to patients associated with the medication errors, the highest risk of harm generated were associated with verification ($n = 21$), followed by documentation ($n = 12$), scanning ($n = 8$), assessment ($n = 6$), administration ($n = 2$), and infection control ($n = 0$).

Table 5. *Descriptive Statistics for Medication Errors*

Medication Error	Frequency	Percentage (%)	Medication Error	Frequency	Percentage (%)
Infection Control			**Scanning**		
No error	33	47.8	No error	49	71.0
Low Risk of Harm	17	24.6	Low Risk of Harm	6	8.7
Moderate Risk of Harm	19	27.5	Moderate Risk of Harm	6	8.7
High Risk of Harm	0	0	High Risk of Harm	8	11.6
Assessment			**Administration**		
No error	47	68.1	No error	52	75.4
Low Risk of Harm	3	4.3	Low Risk of Harm	9	13.0
Moderate Risk of Harm	13	18.8	Moderate Risk of Harm	6	8.7
High Risk of Harm	6	8.7	High Risk of Harm	2	2.9
Verification			**Documentation**		
No error	12	17.4	No error	43	62.3
Low Risk of Harm	10	14.5	Low Risk of Harm	10	14.5
Moderate Risk of Harm	26	37.7	Moderate Risk of Harm	4	5.8
High Risk of Harm	21	30.4	High Risk of Harm	12	17.4

Figure 1. *Medication Errors Generated and Classified by Risk of Harm*

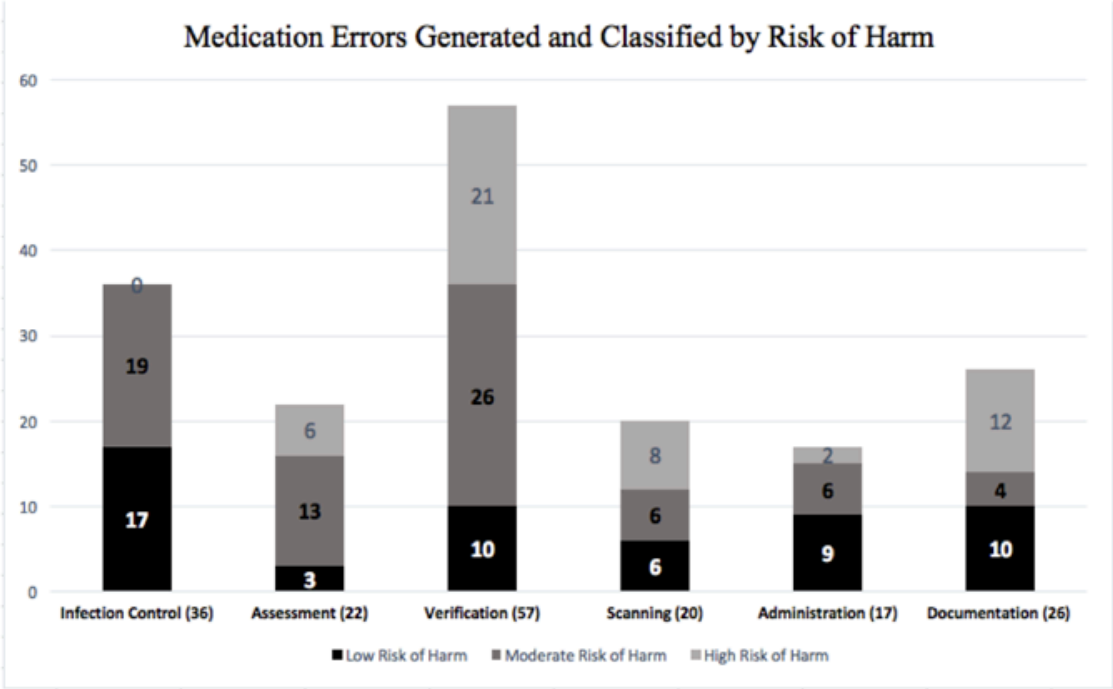

Fig 1. Medication errors associated with no risk of harm (i.e., no error made) were excluded from the visual depiction.

Inferential Analysis

A total of 12 Mann-Whitney U-Tests were conducted for each of the two independent grouping variables of interest in this study with each of the six categories of medication errors. The results of the inferential analysis are presented in the following table and consist of the Mann-Whitney U-Test statistic (U), Z-score, and significance (Table 6). Based on the results, no statistically significant ($p < .05$) differences were found between the grouping variables of interest and the categories of medication errors, with one exception noted between self-perceived confidence and scanning-related medication error ($p = .04$). These findings demonstrated that no statistically significant differences were detected between nursing student's self-perceived confidence, preparedness, and the generation of medication errors except for between confidence and scanning.

Table 6. *Mann-Whitney U-Test Output Summary*

	Medication Errors					
Grouping Variable	Infection Control	Assessment	Verification	Scanning	Administration	Documentation
Confidence						
U	501.5	503	492	440.5	533.5	575
Z	-1.01	-1.11	-1.10	-2.09	-.71	-.04
p	.31	.27	.27	.04*	.48	.97
Preparedness						
U	515	550.5	497.5	524	568.5	477
Z	-.83	-.41	-1.03	-.82	-.16	-1.43
p	.40	.68	.30	.41	.88	.15

**p* <.05

Discussion and Implications

The purpose of this study was to examine the types of medication errors generated by nursing students in clinical simulation and identify if there are differences in the generation of medication errors based on nursing students' self-perceived levels of self-efficacy (confidence) and preparedness. Bandura's (1977) theory of self-efficacy served as the theoretical underpinning of the study, and the theory suggested that individuals who possess greater self-efficacy may be more positively influenced to engage in certain behaviors with the conviction of success. However, the results and analysis of this present study indicated that nursing students' perceived confidence and preparedness had no statistically significant differences in their generation of medication errors, with one exception noted between confidence and scanning-related errors. In addition, the results also contributed to a greater understanding of the various types of medication errors and the potential risk of harm generated by nursing students in simulated medication administration. The cumulative findings of this study provided insights and opportunities to develop meaningful implications related to nursing students and their medication administration practices.

Confidence, Preparedness, and Medication Errors

Based on the results of the inferential analysis, only one statistically significant difference was identified within the variables of interest. A significant difference ($p = .04$) was found between nursing students' perceived level of confidence related to medication administration and the generation of scanning-related medication errors. A difference was noted in the scanning-related medication errors generated between students who reported high levels of confidence compared to students who reported low levels of confidence. It can be suggested that the students' perceived level of confidence with medication administration demonstrated a significant difference in the prevalence of scanning-related medication errors. Furthermore, it is interesting to note that based the descriptive analysis, nursing students also reported feeling most confident and prepared with using the scanner as part of the medication administration process. However, students' self-reported measures of confidence and preparedness may not necessarily reflect their actual knowledge with the theoretical background or other processes related to all components required safe medication administration practices.

Caution must be given when considering the statistically significant difference identified in this present study between confidence and scanning-related medication errors. Based on the operational definition that was used in the primary study, scanning only referred to the instances that required students to barcode scan the patient's armband and medications using the barcode scanner (Booth et al., 2017). Scanning within the context of this study therefore only referred to the physical act of utilizing the barcode scanner to scan patient's arm band and the medication, and does not encompass other elements involved within the entire medication administration process (e.g., verification).

For example, correctly scanning the patient's armband and their medications does not indicate that the student had appropriately verified that the armband belonged to the correct patient. Therefore, the significant relationship that was found between confidence and the generation of scanning-related medication error can only be inferred solely on the physically act of using the barcode scanner, to scan the arm band and the medication, and not the overall medication administration process. This is supported by the findings of this study as no other additional significant differences were found between (a) nursing students' perceived level of confidence and medication errors (except scanning); and, (b) nursing students' perceived level of preparedness and medication errors.

Although less scanning-related medication errors were made when compared to the other types of medication errors, verification-related errors were still prominently generated. This confirms that despite students' feeling of confidence with scanning, it does not indicate or demonstrate that students actually possess nor understand the other important and essential elements (such as verification) within the medication administration process. Rather, it could suggest that perhaps students were more confident with the actual use of technology as opposed to a full understanding of the purpose and rationale for integrating technology into the provision of care (such as medication administration).

In addition to verification- and scanning-related medication errors, all other types of medication errors with varying risk of harm for patients were generated by the nursing students. Given the unique design and data collection strategies in the primary study, it has enabled subsequent analyses to identify the specific type, frequency, and risk of harm associated with each error. Based on the findings of this present study, medication errors

associated with elements of *verification* related to the medication administration process were the most common errors generated by the students, followed by infection control, documentation, assessment, scanning, and administration.

Specifically, a total of 57 verification-related medication errors were generated by the students during clinical simulation. Within the context of the primary study, verification-related errors involved instances where nursing students failed to verify pertinent patient/medication information, including but not limited to patient's name, medications, medication dosage, and allergies (Booth et al., 2017). These verification errors could result in the wrong medication given to the wrong patient, a wrong dose of medication, or inducing an allergic reaction as patient's allergies were not verified. Further, *Metoprolol* (a beta-blocker medication used to treat hypertension or cardiac dysrhythmias) was the medication that students had to administer in simulation during the primary study. Based on the pharmacological properties of this medication, students who failed to appropriately verify pertinent information prior to administering this medication may pose an unnecessary risk of harm to their patients (e.g., lowered blood pressure and heart rate). The significant prevalence of verification-errors that were generated by the nursing students in this present study demonstrates that they likely lacked the appropriate knowledge, skills, and competencies that is essential for safe medication administration practices and to ensure patient safety.

Infection control-related medication errors were the second-most generated type of error found in this study. More than half of the students in this study have made an infection control error during the medication administration process. Based on the contextual conceptualizations of medication errors in the primary study, this finding

demonstrates that more than half of the students did not perform and adhere to hand hygiene practice (i.e., hand-washing) prior to interacting with the patient. Failing to perform appropriate hand hygiene is the leading mechanism for the transmission of bacteria which contributes to health care associated infections (World Health Organization, 2009). Despite rigorous theoretical and clinical learning opportunities regarding infection control during their previous year of study, nursing students continued to generate such errors that can pose significant health and safety risk for all patients. This finding provides opportunities for nursing educators to further examine the variables that may have contributed to the high frequency of infection control errors, and to generate educational interventions to target the potential latency of this error type in the larger medication administration process.

Given these findings, nursing educators and researchers must continue to seek meaningful ways to educate, assess, and evaluate nursing students' competency related to medication administration during their formal academic preparation. Future considerations must be given to potential pedagogical and curriculum changes that best align learning objectives and outcomes. Recognizing that the medication administration process is complex in nature, nursing educators must provide sufficient resources and opportunities for students to develop a thorough understanding and comprehension of the components that contributes to safe medication practices and to promote a culture of safe clinical practice. Additional influences and relationships that may influence the generation of medication errors within both clinical simulation and clinical practice settings should also be examined.

Limitations of this Study

Several limitations should be considered when interpreting the findings of this study. The single cohort and small sample size of the primary study lacked statistical power, and limited the findings and generalizability of subsequent analyses. Another potential source of limitation for this analysis may have also resulted from the types of data and variables of interest. The independent variables were based on self-reported measures and may have been subject to response bias or other desirability response effects. The dependent variables of the primary study (nursing students' generation of medication errors) may have been subjected to the Hawthorne effect as they were being observed by both their clinical instructor and data collectors (Sedgwick & Greenwood, 2015). Furthermore, data collected by the data collectors were also subjected to inaccuracies as they may be influenced by external factors given the pragmatic nature of the primary study. Another potential factor that may have posed as a limitation in this analysis was the randomization of participants that occurred in the primary study. In the primary study, students were randomized with one group receiving an advanced learning resource and the other group receiving the traditional learning resources. Despite the randomization and exposure to the intervention, no significant differences were noted between the two groups of students (Booth et al., 2018a).

The alignment between the theoretical underpinning of this study and the variables of interest could also be viewed a theoretical limitation within this study's execution. Bandura's (1977) theory of self-efficacy suggested that an individual's conviction of success related to a certain behaviour may positively improve their effort and intention to perform such behaviour. The theory, however, does not specifically

suggest whether or not the outcomes of an individual behaviour related to their level of self-efficacy. For example, according to Bandura (1977), an individual who is highly confident is convinced that although they can successfully perform a certain task, their positive belief is not related to the actual outcomes of their behaviour. However, the intent of this study was to extend Bandura's (1977) theory by examining nursing students' perceived self-efficacy and preparedness in the generation of medication errors and its associated risk of harm (by measuring outcomes), as opposed to an evaluation of self-efficacy itself.

Conclusion

The concept of self-efficacy and its impact on influencing positive behaviour and increasing an individual's conviction of success has been previously examined in the literature. However, an individual's feelings of success do not necessarily translate into measurable findings or actual outcomes. The findings of this present study demonstrated that nursing students' perceived confidence and preparedness were not statistically significant to produce differences in their generation of medication errors, with one exception noted. Although students' perceived levels of confidence were identified to demonstrate a significant difference with the generation of scanning-related medication errors, additional examination of the underlying contributing factors may be beneficial. The potential impact of other extraneous variables and limitations of this study provide opportunities to further examine other relationships associated with the generation of medication errors, and to provide implications to mitigate such errors and its associated harm and consequences for patients.

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CHAPTER THREE

The aim and goal of this secondary analysis was to examine the types of medication errors generated by nursing students in clinical simulation, and identify if there are differences in the generation of medication errors based on nursing students' self-perceived levels of self-efficacy (confidence) and preparedness. To provide greater insight, various types of medication errors along with its corresponding risk of harm to patients were included for analysis. The findings of this study have demonstrated that no statistically significant differences were found between nursing students' confidence, preparedness, and the generation of medication errors, with the exception of a significant difference identified between students' confidence and scanning-related medication errors. Further examination of such relationships may be beneficial in providing additional insights and implications regarding additional factors and influences related to nursing students and the generation of medication errors.

Overall, nursing students reported moderate levels of confidence and preparedness related to medication administration. However, substantive number of medication errors were generated and identified within each error category measured in this present study. Particularly, verification- and infection control- related medication errors were the two leading types of errors generated by nursing students. Specifically, 83% (N = 69) of nursing students generated a verification-related medication error which indicated that they failed to verify the necessary information related to medication administration (e.g., name of client, name of medication, dosage of medication, etc.). At the same time, greater than half of the students failed to adhere to infection control practices (e.g., failed to conduct hand hygiene). Additionally, 74% of all the medication

errors generated by the students possessed a potential moderate or high risk of harm to patients. Therefore, future efforts to identify, examine, and address potential factors that may influence nursing students and their generation of medication errors is warranted.

Implications for Nursing Education

Given the complexities and potential negative consequences associated with medication errors, various modified pedagogical strategies have been suggested to support nursing students' learning with medication administration such as integrating an advanced medication administration training program in nursing curricula (Cebeci, Karazeybek, Sucu, & Kahveci, 2015). Teaching and learning strategies that are adapted to learners' needs related to safe medication administration practices, such as integrating workshops and high fidelity simulated scenarios that accurately reflects the clinical environment in the curriculum may also support and develop nursing students' knowledge, skills, and competencies with medication administration (Koharchik & Flavin, 2017; Zimmerman & House, 2016).

A well-designed nursing curriculum that embeds education related to medication administration will not only assist in preparing future nurses with the necessary knowledge and skills to engage in safe clinical practice, but also assist in the prevention of medication errors (Tshiamo, Kgositau, Ntsayagae, & Sabone, 2015). Faculty and nursing educators are encouraged to examine issues and implications related to the medication errors from both a specific (student) perspective and from a broad curriculum/pedagogical perspective (Gregory, Guse, Dick, & Russell, 2007). For example, recognizing the presence of additional factors that may influence a student's

performance such as the differences in expectations between academic and clinical environments, course structure, and learning objectives may result in a more comprehensive and informative nursing curriculum (Gregory et al., 2007; Landeen et al., 2016).

The lack of mathematic skills and pharmacological knowledge has been commonly reported in the nursing education literature as a reason for the generation of medication errors (Dilles, Vander Stichele, Van Bortel, & Elseviers, 2011; Hunter Revell & McCurry, 2013; Wright, 2004). The findings of this present study have demonstrated that the majority of medication errors generated by students were related to some element of the *verification* process, which may also include dosage calculation. Therefore, a curriculum that promotes and ensures nursing students' development of mathematical competency may potentially contribute to reducing the risk of medication errors generated by nursing students (Williams & Davis, 2016).

Despite efforts in preparing nursing students with the knowledge, skills, and competencies with medication administration, it is important to recognize that given the complexity of the process and potential interruptions in the clinical environment, students will inevitably continue to generate medication errors (Pitkänen, Teuho, Uusitalo, & Kaunonen, 2016). Nursing students must recognize that although they are in a vulnerable position to generate medication errors, it is essential to utilize such errors as valuable learning opportunities to reflect and improve their skills with both medication administration and patient safety (Sanko & Mckay, 2017; Scott, 2016; Wheeler, Duncan, & Hohmeier, 2017). Generating the awareness of the significant importance of

medication errors may also assist in the reduction of such errors and prevent unnecessary risk and outcomes for all patients (Abdel-Latif, 2016).

Implications for Nursing Practice and Research

In addition to implications for nursing education, nursing practice and research continues to play an integral role with providing opportunities to expand the current knowledge and evidence related to medication errors. Based on the findings of this present study, no significant differences (except one) were identified between nursing students' self-perceived levels of confidence, preparedness, and the generation of medication errors. Therefore, further investigation of the relationships between additional psychological and emotional constructs (such as stress) with medication errors in addition to confidence and preparedness may be beneficial (Bari, Khan, & Rathore, 2016; Tanaka et al., 2012). For example, identifying and examining the potential impact and effects of mediating or moderating variables such as age, gender, years of experience, and clinical specialty, in addition to psychological constructs such as personality traits and attitudes, may be beneficial to generate a more comprehensive and meaningful research outcome (Baron & Kenny, 1986; MacKinnon, 2011). The implications derived from further research may better inform new strategies and interventions to assist in the reduction of medication errors and risk of harm to patients.

In addition, it has been widely reported that the current evaluation techniques used within both academic and clinical practice settings have posed as a common limitation for accurately identifying the prevalence of medication errors (Allard, Carthey, Cope, Pitt, & Woodward, 2002). For example, previous literature that has examined the causes of

medication errors have relied upon techniques including, but not limited to, chart and documentation reviews, computer system reviews, incident report reviews, and direct observations (Buckley, Erstad, Kopp, Theodorou, & Priestley, 2007; Montesi & Lechi, 2009). Although each strategy present unique strengths, limitations also exist. For example, inconsistencies among chart auditors and failing to have a systematic procedure to review charts have been reported as common barriers to producing valid, reliable results related to the prevalence of medication errors (Vassar & Holzmann, 2013). Observer bias, environmental distractions, proximity, ethical considerations, and the potential variation of medication errors resulted from increased attention (i.e., Hawthorne effect), have also been considered as challenges associated with direct observations (Maricle, Whitehead, & Rhodes, 2007; Sedgwick & Greenwood, 2015). The lack of a consistent and standardized approach towards examining medication errors may inhibit the development of meaningful implications and strategies to reduce medication errors (Berdot et al., 2012). Therefore, research should continue to place a strong emphasis on developing consistent, valid approaches and techniques to accurately examine and reflect the prevalence of medication errors in the clinical practice setting (Koppel et al., 2008).

Within the clinical practice setting, a variety of factors have also been suggested to influence the generation of medication errors made by registered nurses. For instance, staffing levels, management decisions/policies, patient acuity, nurses' health status, and other systemic factors (such as system failures), are factors that contribute to the generation of medication errors in the clinical setting (Keers, Williams, Cooke, & Ashcroft, 2013). However, many of these additional factors and its actual impact on medication errors have not been examined (Mark & Belyea, 2009; Tanaka et al., 2012).

Therefore, further research involving a more comprehensive and systemic evaluation of medication errors and its relationship with potential factors and other contextual/latent variables found within the clinical practice setting will provide a greater understanding while generating more meaningful implications to prevent or reduce medication errors (Moyen, Camiré, & Stelfox, 2008).

Summary

The findings of this study demonstrated that nursing students generated a variety of medication errors during clinical simulation. Further, students' perceived level of confidence and preparedness did not produce statistical differences with the generation of medication errors (with the exception of confidence and scanning-related errors). Careful considerations must be given when utilizing psychological constructs to examine clinical performance and outcomes. Continuous effort to examine additional variables that may influence the generation of medication errors by nursing students may be beneficial. Implications for nursing practice and research to address the issue of medication errors have also been provided.

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APPENDICES

Appendix A: Ethics Approval

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Delegated Initial Approval Notice

Principal Investigator: Dr. Richard Booth
Department & Institution: Health Sciences\Nursing,Western University

Review Type: Delegated
HSREB File Number: 109180
Study Title: Evaluation of a technology-enabled, gamified electronic medication administration record (eMAR) system for use in the simulated clinical education

HSREB Initial Approval Date: June 06, 2017
HSREB Expiry Date: June 06, 2018

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Western University Protocol		2017/06/06
Other	Appendix A - Skeleton of Game Interface - Received for Information	2017/03/22
Instruments	Appendix B - Semi-Structured Interview Guide	2017/03/22
Instruments	Appendix B2 - Demographics Survey	2017/05/26
Other	Appendix C - One scenario for eMAR game - Received for Information	2017/03/22
Other	Appendix D - Game Workflow Tree - Received for Information	2017/03/22
Other	Appendix E - Interface with Tutorial Arrow/Instruction - Received for Information	2017/03/22
Instruments	Appendix F - Medication Administration Checklist - Data Collector Participants	2017/03/22
Instruments	Appendix G - 'Pre-/Post-' Survey	2017/03/22
Other	Appendix G1 - Email to 'Pre-' Survey	2017/03/22
Other	Appendix G2 - Email to 'Post-' Survey	2017/03/22
Instruments	Appendix H - Game Motivation and Cognition Survey	2017/03/20
Recruitment Items	Appendix I - Focus Group Invitation	2017/03/22
Recruitment Items	Appendix J - In-Class Recruitment Slides	2017/05/26
Letter of Information & Consent	Appendix K	2017/05/26
Other	References - Received March 22, 2017 for Information Only	

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer, on behalf of Dr. Joseph Gilbert, HSREB Chair
EO: Erika Basile ___ Grace Kelly ___ Katelyn Harris ✓ Nicola Morphet ___ Karen Gopaul ___ Patricia Sargeant ___

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