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Original Paper

Using Simulation in First Year Nursing Student Curriculum to Improve Dosage Calculations

Cynthia Dubs[1*]

[1] College of Nursing, University of South Florida, USA

[*] Cynthia Dubs, College of Nursing, University of South Florida, USA

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Abstract

Patient safety is of the upmost importance specifically when related to medication administration. Nurses are responsible for safe medication administration as a primary responsibility. Nursing education programs, especially associate degree nursing programs, use high-fidelity simulation to enhance medication administration and dosage calculation. First year nursing students are expected to pass a dosage calculation exam with accuracy to assess safe medication practices. The purpose of this quasi-experimental ex post facto design study was to examine the causal relationship between the medication administration simulation and the dosage calculation test scores in first year, associate degree nursing students. First year nursing students who participated in the high-fidelity medication administration had statistically significant differences in their dosage calculation test scores and the odds of passing the dosage calculation test on the first attempt than the students who did not participate. Age and gender demographic information of the students who participated in the high-fidelity simulation did not show any statistically significant information based on their participation. The study aims to examine which education intervention is effective in improving dosage calculation test scores in first year nursing students. Implementation of high-fidelity simulation experiences can improve dosage calculation exams scores and contribute to a safer nursing workforce.

Keywords

nursing education, simulation, nursing students, first-year nursing, dosage calculation

1. Introduction

Patient safety is of the utmost importance in the healthcare setting, primarily when related to medication administration. The issue is critical to address because medication errors can affect all patients and do not discriminate amongst social status, gender, or age. The patient populations most

affected by medication errors are children and older adults. Pediatric medication dosages are calculated specifically for the patient based on their weight using precise calculations. If the correct formula for dosing is not followed or the child's weight is inaccurate, there is a risk of a medication error. Older adults are at an increased risk for medication errors related to polypharmacy, defined as taking five or more medications per day (Masnoon et al., 2017). Older adults must communicate with their healthcare provider to assess prescribed medications for accurate dosages and possible interactions to eliminate risks. Special patient considerations include low literacy levels and language barriers (da Silva et al., 2016). These patients may have trouble in linguistic communication without the help of a medical interpreter, which can result in medication errors.

Safe medication administration begins with healthcare providers working together using a multidisciplinary approach to patient-centered care (Rodziewicz et al., 2021). The Joint Commission (2021) was created in 1951 to improve health care for the public by evaluating health care organizations for the delivery of safe and effective care. The Joint Commission developed National Patient Safety Goals to help healthcare institutions create a safer environment for practitioners and patients (The Joint Commission, 2021; Rodziewicz et al., 2021). The use of medications correctly and safely has been identified as one of the seven goals for 2021. The goal focuses on reducing errors by ensuring medications are correctly labeled and verification of high-risk medications.

Medication administration is a daily job responsibility in nursing. Nurses are responsible for safe medication administration practices using patient safety measures for quality care. Medication safety principles include the nurse correctly identifying their patients and medications. They perform dosage calculations to precisely measure the prescribed dose. Nurses assess the patient to determine acceptable routes to administer the medication. They plan administration around the dosing frequency ordered and use real-time documentation to record the medication administration. Since a great emphasis is on improving patient safety, increased efforts on medication safety such as prevention and education strategies will be key in advancing the patient safety agenda.

Medical errors and, most common medication errors, can result in patient harm and death. Strategies to improve patient safety primarily related to medication errors, especially in hospitalized patients, have been examined since the 1990s. The National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) was created in 1995 to confront medication errors' complex issues (Cousins & Heath, 2008). Their vision is that a medication error shall harm no patient. The council's mission is to increase awareness of medication errors and the promotion of medication error prevention strategies. However, even with increased initiatives, medication errors still exist. NCCMERP (2021) is an independent body comprised of 27 national organizations including representation from nursing organizations.

Patient safety is a core concept in nursing. Medication administration is a primary duty of a nurse. Hughes and Belgen (2008) found that nurses spend 40% of their shift focused on medication administration. Nurses play an essential role in preventing patient harm by using their education and expertise to identify and correct medication errors (Gaffney et al., 2016). Nurses play a key role in improving patient safety in applying safeguard measures (Gaffney et al., 2016). There has been a national focus on reducing medication errors with increased research and prevention strategies; however, little progress has been made.

Nurses follow the rights of medication administration to ensure the safe delivery of medication to their patients. These rights are discussed in nursing education as a goal of safe medication administration. The five rights include: right patient, right medication, right dose, right time, and right route (Hughes & Belgen, 2008). Upholding these rights is critical to ensure patient safety. Healthcare delivery systems incorporate the rights of medication administration into their technological advances to complement to medication administration process and reduce the risk of errors (MacDowell et al., 2021). Nurses are still involved in medication errors despite all these safeguards, with incorrect doses remaining prevalent.

Nursing students are being prepared to transition to the workforce through their nursing education. As novice nurses, they are entering the profession with limited experience and expectations of taking care of an aging population with increased levels of acuity (Betts et al., 2019). Clinical judgment is defined as a greater intellectual concept that combines nursing knowledge, skills, decision-making, and critical thinking (Betts et al., 2019). Student nurses must learn how to demonstrate good clinical judgment to critically think and make sound clinical reasoning skills in patient situations (Betts et al., 2019; National Council of State Boards of Nursing [NCSBN], 2021). According to the NCSBN (2021), 50% of novice nurses are involved in errors, while 65% of errors are attributed to poor clinical decision-making. The NCSBN (2021) found that only 20% of employers were pleased with the clinical decision-making skills of novice nurses.

The use of clinical judgment leads to the improvement of patient outcomes. Nurses use clinical judgment to administer medication safely. Since novice nurses are expected to perform clinical judgment, these skills must be fostered in the nursing curricula. Nurse educators are tasked with developing clinical judgment assessments to ensure measurements of the skill are being performed regularly (Betts et al., 2019). Rohde and Domm (2018) researched clinical reasoning skills used to support safe medication administration and found minimal evidence of the skill being used in medication practice.

2. Method

2.1 Purpose

The purpose of this quantitative, quasi-experimental ex post facto design study was to examine the causal relationship between the medication administration simulation and the dosage calculation test scores in first year, associate degree nursing students. Data was analyzed to examine the first-time passage rate and the mean scores of the dosage calculation exam.

The following research questions guided this study:

RQ1. Is there a relationship between the medication dosage calculation exam score and the demographic factor of age in the students who participated in a simulation experience?

RQ2. Is there a relationship between the medication dosage calculation exam score demographic factor of gender in the students who participated in a simulation experience?

RQ3. Is there a significant difference between students who participate in a simulation experience and students who do not participate in a simulation experience on the first-time pass rate of a medication dosage calculation exam while controlling for student scores on the TEAS entrance exam among students in a first semester required nursing course?

RQ4. Is there a significant difference between students who participate in a simulation experience and students who do not participate in a simulation experience on the mean dosage calculation exam scores of a medication dosage calculation exam while controlling for student scores on the TEAS entrance exam among students in a first semester required nursing course?

Hypotheses

H_1 There is a significant difference between the medication dosage calculation exam score and the demographic factor of age in the students who participated in a simulation experience.

H_2 There is a significant difference between the medication dosage calculation exam score and the demographic factor of gender in the students who participated in a simulation experience.

H_3 There is a significant difference between students who participate in a simulation experience and students who do not participate in a simulation experience on the first-time pass rate of a medication dosage calculation exam while controlling for student scores on the TEAS entrance exam among students in a first semester required nursing course.

H_4 There is a significant difference between students who participate in a simulation experience and students who do not participate in a simulation experience on the mean dosage calculation exam scores of a medication dosage calculation exam while controlling for student scores on the TEAS entrance exam among students in a first semester required nursing course.

2.1.1 Research Design

The proposed research method was a quantitative, quasi-experimental ex post facto design. This ex post facto study was intended to examine the causal relationship between the medication administration simulation and the dosage calculation test scores in first year, associate degree nursing students. This design was appropriate to determine if a greater emphasis on simulation for improvement of dosage calculation is necessary.

Convenience sampling included the first-year student population who participated in the medication administration simulation and those who did not participate. Students who participated in the study were enrolled in their first semester in an associate degree nursing program in a community college in Florida. The nursing program admits 140 students every fall and spring semester at the community college and divides students into cohorts of approximately 25 to 30 students each. Based on the program admission standards, the estimated population for the study was approximately 420 students. The medication simulation being studied began in the fall 2020 semester. Data was collected by analyzing archived data of dosage calculation test scores from fall 2020, spring 2021, and fall 2021 semesters of all the first semester students enrolled in the associate degree nursing program at a community college in the state of Florida.

2.1.2 Data Collection

First-year nursing course at the community college was Essentials Concepts of Patient Management. Students in several of the cohorts attended a medication administration simulation as part of their course, while other cohorts do not. The instrumentation used in this study was the Dosage Calculation Exam. The exam was designed an original summative assessment for first year nursing students using the concepts of medication administration principles and dosage calculation problems using a mathematical formula. The exam was constructed by expert didactic faculty who teach the Essential Concepts of Patient Management course at the community college. Faculty members agreed that the testing instrument was an actual representation of medication and dosage calculation skills needs for a first-year student. Psychometric testing was not completed on the testing instrument, as it has been in use since the fall 2020 semester and the intent of this research study is to determine if simulation improved the test scores. Written permission for the use of this instrument was not obtained from the original exam authors as the test was constructed using the publishers test bank for Kee et al. (2017) Clinical Calculations 8^{th} edition. The test bank is authorized for use as part of the publisher's

instructional package purchased by the college.

The 30-question exam instrument was created by expert didactic faculty using a program called ExamView Test Generator. Once the exam was created, it was converted into a file that was uploaded in the learning management system, Canvas. The exam was administered to all first semester students enrolled in the Essential Concepts of Patient Management course via the learning management system, Canvas. The testing environment was in a face-to-face setting using a computer classroom. Students were allowed to use blank scratch paper and a basic calculator as assistive devices. Students were given one and half minute per question per the nursing program's testing policy. Students were given a total of 45 minutes to complete the exam.

3. Analysis and Results

This research study examined first year students in a two-year program. The institution where the study was conducted admits 140 nursing students in the fall and spring semesters and students are divided into cohorts. Students are taught dosage calculation through a didactic lecture in the first-year nursing course at the community college, Essentials Concepts of Patient Management. Cohorts perform practice of dosage calculation in the nursing lab or simulation setting. The chapter contains results of data analysis to understand which education intervention is effective in improving dosage calculation test scores in first year nursing students.

The study contributes to the nursing profession and provide education advancement opportunities to advance the reduction of preventable medication errors and improve patient outcomes. The intent of this research was to examine which education intervention is effective in improving dosage calculation test scores in first year nursing students. In this research study, demographic factors of students participating in the simulation were reviewed to understand if a relationship exists between age and gender of the students and their score on the dosage calculation exam. The Test of Essential Academic Skills (TEAS) is a standardized test used as an admission requirement for most nursing schools. In this study, the TEAS test scores were used as archival data and the controlling variable to show basic math proficiency among all nursing students in the study.

Research Question 1

Research Question 1 examined the relationship between the medication dosage calculation exam scores and the demographic factor of age on students participating in the simulation. The statistical test used to analyze the data set was a Spearman's rank order correlation. There was no statistically significant correlation between the dosage calculation scores and age of the students who participated in the high-fidelity simulation.

This analysis finding is consistent with the literature review findings. Demographic factors of nursing students are used in educational research to identify the makeup of the sample population but are rarely

researched for relevance. Studies that were researched in the literature review did not show any statistically significant improvement in dosage calculation scores in relation to a nursing students age (Fusco et al., 2021; Gregory et al., 2019; Kuo et al., 2020).

Research Question 2

Research Question 2 examined the relationship between the medication dosage calculation exam scores and the demographic factor of gender on students participating in the simulation. The statistical test used to analyze the data set was a two-way ANOVA. There was no statistically significant interaction between gender and simulation participation for the dosage calculation test scores.

As stated in Research Question 1, the analysis finding is consistent with the literature review findings. Studies that were researched in the literature review did not show any statistically significant improvement in dosage calculation scores in relation to a nursing students' gender (Fusco et al., 2021; Gregory et al., 2019; Kim & Lee, 2020; Kuo et al., 2020). The literature review did find that age and gender demographics of nursing students play a role in increased satisfaction with learning and improved self-confidence (Dincer & Ataman, 2020; Gregory et al., 2019; Kim & Lee, 2020; Kuo et al., 2020).

Research Question 3

Research Question 3 analyzed the effects of participation in simulation, the independent variable, on the first-time passing score of the dosage calculation exam, the dependent variable, while using the TEAS entrance exam as the controlling variable. The statistical test used to analyze the data set was a binomial logistic regression. The two predictor variables of the simulation cohort and the TEAS exam were statistically significant. High fidelity simulation participants had 11.5 times higher odds of passing the dosage calculation exam on the first attempt than those in the low fidelity simulation group. Passing the TEAS exam added an increased likelihood of passing the dosage calculation exam on the first attempt by 1.1% (Laerd Statistics, 2017).

The literature review examined studies with nursing students who participated in a simulation and its effect of the first-tine passage rate of the dosage calculation exam. The high-fidelity simulation studies showed there is significant improvement in dosage calculation accuracy (Craig et al., 2021; Fusco et al., 2021; Kim & Lee, 2020; Kuo et al., 2020; Sanko et al., 2015). The results of the data analysis were consistent the literature findings for this research study.

The controlling variable of the TEAS exam highlighted the importance of having proficient math scores upon entering nursing school. The literature findings reveal that demonstrating a proficient level on the TEAS exam will define math success of a first semester nursing student (Assessment Technologies Institute [ATI], 2021). A proficient level on the TEAS exam is defined as 58.7-77.9% (ATI, 2021). The sample population of this study had a mean score of 73.8% on the TEAS exam, which identifies the nursing students as being proficient in math and prepared for drug calculation math.

Research Question 4

Research Question 4 analyzed the effects of participation in simulation, the independent variable, on the mean score of the dosage calculation exam, the dependent variable, while using the TEAS entrance exam as the controlling variable. The statistical test used to analyze the data set was a one-way ANCOVA. There was a statistically significant difference in dosage calculation test scores between the simulation groups.

High-fidelity simulation was widely researched to show the effects on improvement of learning outcomes. This study highlighted the use of high-fidelity simulation to improve dosage calculation scores. Results of this study were consistent with literature review findings. The studies reveal statistically significant improvements in medication administration skills and dosage calculation scores when nursing students are exposed to high-fidelity simulation compared to low-fidelity laboratory practice (Grugnetti et al., 2014; O'Reilly et al., 2020).

Results of this research study should promote further incorporation of high-fidelity simulation. It should influence nursing educators to provide the opportunity to participate in high-fidelity simulation at the beginning of a student's nursing education. Many nursing organizations promote changes and practices to improve safety and quality of patient care, with a major focus on reducing medication errors (Agency for Healthcare Research and Quality [AHRQ], 2021; The Joint Commission, 2021). Educating first-year nursing students using high-fidelity simulation is beneficial to provide active learning strategies that will help improve knowledge and confidence in medication safety. Simulation involving medication administration highlights the student medication error, especially with incorrect dosages (Green, 2018). Errors are associated with medication administration 94% of the time in practice, while medications requiring calculations are considered one of the most common risk factors for medication errors (Hughes & Belgen, 2008).

Nursing students who continually build up on their knowledge develop clinical judgment and graduate from a nursing program with a competency level that is prepared to face the challenges of real-world nursing. High-fidelity simulation can increase performance on dosage calculation exams, which leads to safe medication administration practices. Ultimately, this research study adds to the emerging literature on high-fidelity simulation and the reduction of medication errors with the overarching goal of creating a safe healthcare environment for the patient population.

4. Discussion

4.1 Research Discussion

In conclusion, the problem was the high rates of medication errors, which results in thousands of preventable patient deaths annually. The goal was to highlight medication reduction measures using optimal educational experiences in nursing education. The use of high-fidelity simulation as an active

learning strategy to enhance medication administration safety with accurate dosage calculations prepares at every level in their nursing education beginning with first year nursing students. The development of nursing expertise and clinical judgment throughout their nursing education contributes to a safe and effective associate degree nursing student. The competency of the ADN students transitioning to the professional role of a registered nurse reduce medication errors with safe medication administration practices and clinical judgment. Overall, this will save patient's lives.

Considering the lack of research for the ADN student population and the prevalence of medication errors, this research is of particular interest to nurse educators preparing the future nursing workforce. Medication administration is central to the registered nurse role and makes up half of an inpatient nurse's time each shift (Craig et al., 2021). Nursing faculty are tasked with creating high quality educational interventions such as high-fidelity simulations that will enhance medication safety practices (Craig et al., 2021). Using active learning strategies engages the student in the course material and builds knowledge and skills acquisition (Rubaiy, 2021).

4.1.1 Limitations

Limitations of the study include the use of a convenience sample, research design, and data analysis. Study limitations include using a convenience sample of ADN students from one community college in Tampa, Florida. Convenience samples from one institution can limit the findings of the research and be generalized to a larger population (Ross & Bibler Zaidi, 2019). A convenience sample from one institution can potentially result in unintentional sampling errors, which may not reflect the larger population accurately (Ross & Bibler Zaidi, 2019). An ex post facto design does not allow the research to have any control over the variables as it explores the data after the fact (Jacobsen, 2021). An experimental design would allow the research to initiate a true experiment over the group of students being examined. Additionally, the examination of the demographic data was completed using Spearman's rho. This statistical test evaluates the relationship between variables not causation (Laerd Statistics, 2017).

4.1.2 Implications for Future Research

Recommendations for future research include studying ADN students from varying community colleges across the state of Florida and the United States. The larger sample size would increase the generalizability of the findings to provide useful research for the use of high-fidelity simulation to improve dosage calculation test scores. A qualitative study involving nursing students and nurse educators is also recommended. A qualitative study will provide an in-depth examination of ADN students' and nursing educators feelings about the use of high-fidelity simulation to improve dosage calculation test scores. Findings in the literature indicated the use of high-fidelity simulation played a role in increased satisfaction with learning and improved self-confidence (Gregory et al., 2019; Kim & Lee, 2020; Kuo et al., 2020).

Experimental studies with randomized experimental and control groups would help further define the use of high-fidelity simulation to improve dosage calculation test scores. The experimental research design will allow for further exploration of true casual effects of high-fidelity simulation and dosage calculation test scores. Such an experimental design may lead to more significant results with using a controlled environment and randomization (Jacobsen, 2021). Ex post facto research designs can only suggest if there is a casual relationship since the information is explored after the fact (Jacobsen, 2021).

Finally, a longitudinal study that follows the same cohort of students throughout each semester of their nursing education to show the continued improvement of dosage calculation test scores while using high-fidelity simulation would be valuable. Future research evaluating the use of high-fidelity simulation combined with the novice to expert theory would assist nursing educators on developing dosage calculation assessments to increase levels of competency in nursing students (Whelan et al., 2016). Students will graduate from the nursing program with a higher level of competency and ready to advance into the challenging arena of professional nursing.

Findings from this research study suggested a causal relationship exists between the medication administration simulation and the dosage calculation test scores in first year, associate degree nursing students. Additionally, the use of the TEAS exams as admissions criteria to the nursing program ensures that students entering the program had a proficient level in basic math skills. Study results examined demographic student data using age and gender and participation in high-fidelity simulation and found no relationship existed. The purpose of this study was fulfilled through the examination of the data and literature findings. The significance of the study highlighted the use of education experiences, such a high-fidelity simulation to increase medication dosage accuracy. These will have a substantial impact on saving patients' lives and creating a stronger nursing workforce that is prepared to prevent medication errors and ensure patient safety.

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