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Reducing Medication Administration Errors With Drug Dosage Simulation

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Reducing Medication Administration Errors

With Drug Dosage Simulation

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Abstract

Preparing nursing students for the high acuity and intense demand of patient care is a goal of nurse educators. Of considerable importance are the drug dosage calculation skills of these nursing students, for medication administration. The techniques used to develop these skills are varied, and research is being conducted to determine the best way to prepare the nurse to enter the work force. The purpose of this study was to examine the relationship between simulation and the drug dosage calculation skills of first year nursing students at one university.

Chapter 1

In 2006, the Institute of Medicine (IOM) found medication errors to be the most common cause of preventable adverse patient events (Flynn, Liang, Dickinson, Xie, & Suh, 2012). It is estimated that 98,000 people die every year from medical errors in the U.S. and a significant number of those deaths are associated with medication errors (Tzeng, Yin, & Schneider, 2013). Medication administration errors (MAE) account for 38% of all adverse drug events and occur in 3-8% of all administrations (Wimpenny, & Kirkpatrick, 2010). Medication error is defined as:

> Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of health care professional, patient or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use. (National Coordinating Council for Medication Error Reporting and Prevention, 2012, para.2).

As nurse educators seek to prepare nurses for the work force, the goal of understanding and preventing these medication administration errors has come to the forefront of current research. A medication error may occur at various times in the medication preparation process. The four types of errors that have been documented in occurrence are: 1) prescription error (wrong drug, dose, or form), 2) transcription and/or interpretation error (misinterpretation of abbreviations), 3) preparation and dispensing error with correct prescription (error in dispensing, calculation errors), and 4) administration errors (wrong dose or infusion rate, wrong time). The administration stage occurrence of type 4 error is estimated at 53% of all errors (Tzeng et al., 2013). With this information, making changes to the administration of medication can eliminate over half of all reported errors.

Background

Recognizing the technical proficiency needed for medication administration, a method of educating nurses for this skill set has become necessary. The Department of Health, in 2004, identified Objective Structural Clinical examination (OSCE) as a method to improve medicine management competence for nurses and doctors. The first OSCE was developed for the analysis of any area of health related programs by the University of Dundee. This study reviewed the development of OSCE in nursing education utilized for the area of medication management. (Meechan, Jones & Valler-Jones, 2011).

One form of OSCE is simulation. Simulation is defined as:

> activities that mimic the reality of a clinical environment and are designed to demonstrate procedures, decision making and critical thinking through techniques such as role playing and be very detailed and closely simulate reality or it can be a grouping of components that are combined to provide some resemblance of reality (Jefferies, 2005, p.96).

This method of education has been seen as highly effective and a safe method for learning a skill.

Framework

The framework of this study was designed around the philosophy of the nursing process. The nursing process includes assessing, planning, intervening and evaluating. A four step problem solving model was developed by Polya, in 1957(see Figure 1). Polya's Model describes understanding a problem (assessing), devising a plan (planning), carrying out the plan (intervening), and examining of outcomes (evaluation). Within Polya's model the important stage is the initial stage, of which is understanding the problem (Polya, 1957). For nurses who are novices it is useful to work through each problem utilizing these steps so they can examine if their decision is matching their knowledge (Wright, 2009). For example if the nurse determines through math calculations that the dose to deliver is 5ml subcutaneously, this answer upon evaluation should be questioned, as 5ml is too large a dose to be administered in this manner. The nurse should be prompted to start from the beginning of the process again and reexamine the problem

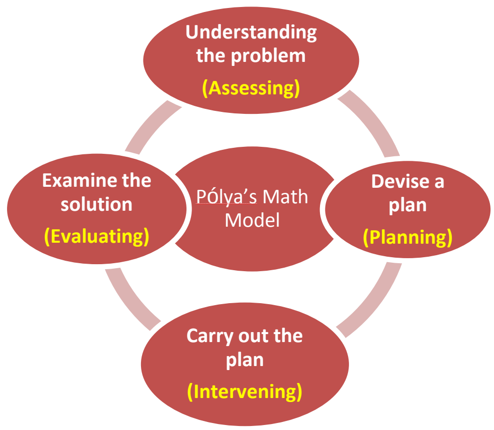

Figure 1.Polya's math model process

Purpose

The purpose of this study was to determine the effects of simulation on the mathematical calculation and medication administration skills of first year, first semester, nursing students. Despite understanding the critical role of nurses in the interception of inpatient medication errors, limited studies have been done to determine the conditions that may improve performance of nurses in this vital function (Valler-Jones, Jones, & Meechan, 2011).

Chapter 2

Literature Review

A systematic review of the literature was conducted, to examine the effects of simulation on drug dosage calculation skills. The electronic database reviewed was CINAHL. Key search words were “simulation and drug dosage calculation skills”, “nursing education”, “medication error”, “medication administration”. Parameters of full text, January 2009 thru December 2013, and academic journals, yielded 909 articles. The reported research articles high-lighted in this paper were selected from this pool articles.

Determining the problem in medication administration is necessary to propose a solution. A literature review conducted by Jones S.W. (2009), found the nurse to be the key faulty component in the medication administration process. Important causes of medication errors were the poor calculation competence and knowledge of individual medications. The conclusion of this review stated that a combination of educational programs and visual reminder prompts for protocol are needed to improve medication administration safety.

Safe administration of medications, medication calculation skills development, and maintenance of ongoing competence in nurses was the focus of a literature review completed by Sherriff (2010). Studies indicated that negative attitudes toward mathematical calculations, mathematical anxiety, and poor numeracy skills are evident in both under graduate and post graduate nursing students. Several articles in this review found nurses’ lack sufficient skill to calculate drug dosages correctly, raising concerns for existing mathematical skills and preparedness of the educational process. They also recommended that teaching techniques need to be researched and evaluated for improving the retention and learning of nursing students.

A study examining the calculation skills of nursing students and Registered Nurses was conducted at a University in the United Kingdom. This was a correlational study of the relationship of age, status, experience, and drug calculation ability to numerical ability in nursing students and Registered Nurses attending a non-medical prescribing program. This group consisted of 185(81%) nursing students and 44(19%) registered nurses for a total of 229 participants. Seventeen (7%) were male and 212(93%) were female. The numeracy test was failed by 55% of students and 45% Registered Nurses, and the drug calculation test was failed by 92% nursing of students and 89% of nurses. The overall conclusion of this study was that time should be designated in the curriculum for nursing students to learn how to perform basic numerical and drug calculations, and learning should be reinforced through regular practice and assessment once nurses obtain fulltime employment (McMullan, Jones & Lea, 2010).

Looking at what other factors may influence drug calculation skills, McMullan et al. (2012) did another study at the same British university, examining mathematical anxiety, self-efficacy and numerical ability. A cross sectional study was done with a convenience sample of undergraduate nursing students. Four measuring tools were used; the Mathematics Attitudes Scale (MAS), the Numerical Ability Test (NAT), the Mathematics Self Efficacy Scale (MSES) and the Drug Calculation Ability Test (DCAT). The differences between the MAS and the MSES are that MAS measures confidence in learning mathematics and MSES measures confidence in doing mathematics. Both tests are done in a likert format and both tests were converted to percentages for analysis. No calculator was allowed for the NAT or DCAT, however, pen and paper for calculations were allowed. A strong relationship was found between anxiety, self- efficacy, and ability ($p < .001$). Those who failed the NAT and or DCAT were more anxious ($p<.001$) and less confident ($p<.002$) than those who passed the calculations tests.

Looking at patient safety, clinical outcomes and medication errors, Dr. McNeal (2010) and Dr. Norman (2012), found simulation events help to facilitate analysis and reconstruction towards prevention of errors. Simulation learning is also found to aid in the development of self-confidence, and clinical judgment. The external benefits post simulation intervention were found to include knowledge and skills, and communication. Also noted in the reading, traditional learning methodologies emphasize linear thinking, while simulation learning environments engage student thinking processes in an interactive manner that facilitates critical interpretation and analyses of multiple data sources. These outcomes all serve to augment the clinical practice with increased safety.

A study using simulation concurrently with medication administration, involving second year, Bachelor of Science nursing students, in Ontario Canada, tested if simulation would increase students' abilities to safely administer medication in the clinical area. This was a randomized control group post-test only design, replacing early-term clinical hours with simulated case scenarios. Fifty-four students participated with 24 receiving simulation and 30 receiving no simulation. The results yielded fewer medication errors among the students who received simulation. Seven errors were assessed from the intervention group of 24 students as compared to twenty-four errors assessed during observation of the 30 students in the control group (Sears, Goldworthy, & Goodman, 2012).

Another simulation study conducted by Costello (2011) involved 26 nursing students in a four year baccalaureate nursing program. The students volunteered to participate in the study with simulation and drug dosage calculation. The study involved physical manipulation of the medication, syringes, intravenous pumps and intravenous tubing in a clinical lab setting. All students completed a 20 question written medication calculation pre-test before the simulation exercise and then at one month post instruction and again at six months post instruction. The findings showed immediate improvement following simulation and improvement still was maintained at the one and six month post instruction with the simulation intervention. There was an improvement of 9.76 points from pre-test scores to post-test scores. These post-test gains were maintained at one and at six months evaluations.

A longitudinal study of comparative design was done involving ninety nursing students currently enrolled in an undergraduate nursing program. Ninety students were randomly chosen based on the number of months completed in nursing school. Thirty students were selected from each time period, eight months, twenty months and thirty months of educational completion program, and were named as cohorts one, two and three respectively. Cohort 3 having completed 30 months of the program was used as the control group, as they had not received any simulation in their educational program because it had not been available to them. All three cohorts received the same drug administration simulation activity testing. Mean scores were compared between the cohorts to determine if the change within curriculum of adding simulations, had any effect upon the knowledge and drug administration skills. The authors of this study concluded that early simulation improves drug administration abilities. In a ten item questionnaire cohort one had a mean of 8.43, cohort two had a mean of 9.87, and cohort three had a mean of 7.33 (Meechan et al., 2011). Both cohorts one and two with simulations as part of the curriculum scored higher than cohort three with no simulation.

This brief review of the literature reveals improvement in nursing students' initial lack of ability in determining the problem, examining calculations, and focusing on safe medication administration simulation as an intervention for correcting the weaknesses in these areas. While simulation has been found useful for improving this skill more studies are needed to determine timing and best practice instruction for simulation implementation. A need exists for continued research and discovery of additional methods to improve the mathematical and drug dosage calculation skills of nursing students, while increasing confidence and proficiency at medication administration.

Chapter 3

Description

The goal of the study was to determine the effectiveness of a simulation education intervention, in overcoming the risks of error and increase safety in patient care, through emphasis on correct mathematical drug dosage calculation and medication administration. A pre-test/post-test study was conducted, with first year, first semester nursing students. The Medication and Dosage Calculation pre-test and post-test, both consisted of ten questions with the same questions being ask on both tests, with a change in dosages or orders written on the post-test. A written physician order for the medication, along with a picture of the medication bottle or pills, and the syringe or proper administration tool, was presented with each question.

In addition to the drug dosage pre-test and post-test, the students had a Likert scale questionnaire, *Self-Perceived Judgment in Dosage Calculation Scale (SPJDS*), designed by Dr. Huse, the research advisor, to evaluate their responses for each question. This tool was based upon the constructs of Polya's Model: four phases of problem solving. Each test question had an individual *SPJDCS*. The objective with using the *SPJDCS* was to enable the students to engage in critical thinking in evaluating their answers and calculations.

Following the post-test, the students completed three assessment tools developed by the National League of Nursing. The tools used were: *1) Student Satisfaction and Self Confidence in Learning, 2) Educational Practice Questionnaire (student version)* and 3) *Simulation Design Scale (student version)*. These tools were used for student responses and self- perceived effectiveness of the simulation and testing process.

Method

During a campus, clinical preview session, all first year, final semester nursing students were informed of class participation in a simulation study. Of the 79 first year, first semester nursing students at Southern Adventist University (SAU), 77(97%) completed the entire study. An additional student took the pre-test but didn't complete the post-test so is not included in the data. Ethics approval was granted for this research by a research Institutional Review Board (IRB) at Southern Adventist University, in September, 2012.

An attempt to relieve anxieties was made by removing any grade association with the pre or post-test math calculation test. A required Medication Administration Calculation (MAC) test was waived as a reward for any student obtaining a 100% on either the pre-test or post-test. The MAC is a drug dosage calculation test that all nursing students at SAU must pass with a score of 100% prior to participating in hospital clinicals and administering medications. The pre-test and post-test both consisted of 10 questions and were identical to the required MAC test.

The pre-test was given to the students in two divided groups. There was a Tuesday session and Thursday session. On Tuesday 41 students were present for pre-test and on Thursday 37 students were present. Neither group received any instruction or explanations prior to the administration of the pre-test. The ability to take the test was merely based on the student's ability to understand simple algebraic math. The test was taken in a classroom where the students meet on a regular basis for lecture. Students were not made aware of their results on the pre-test to prevent discussion among or between groups.

One week after the pre-test, the same students participated in a simulation intervention immediately followed by the post-test. The groups were divided into Tuesday and Thursday sessions. Eight groups participated on Tuesday and Thursday, 40 students participating in simulation and post-test on Tuesday and 37 students participating on Thursday.

The simulation and instruction time involved the students being given a case study to discuss and verbally answer questions guided by an instructor. Instructions for mathematical calculations and manipulation of various syringes and medicine cups were given. The students then actively participated in a simulated patient scenario under supervision of an instructor. The simulated scenario was the same as the case study they had previously discussed. All students were given opportunity for medication administration in the simulation setting and had equal opportunity to demonstrate success. After a debriefing session and open question time, the students then went to another room where the post-test was administered. Once the post-test was completed the students then completed the NLN tools for simulation experience evaluation.

To preserve confidentiality for the students, all information containing personal information was maintained in a locked faculty office. When entering data into SPSS 21 for analysis, all demographics were entered under a research number.

Results

The demographic analysis of participants who completed the entire study is reported as: 49 women and 28 men ranging in age from 19 to 35 with the mean age of 22.4. The students' ethnicity groups are reported as: 5 African-American, 15 Asian, 35 Caucasian, and 20 Hispanic, with 2 students categorizing themselves as "other". The GPA of the students ranged from 2.14 to 3.97 with a mean of 3.33.

A Pearson co-efficient was calculated on pre-test and post-test questions for the relationship between the total scores as analyzed by question. Pearson correlation coefficient applies to measures of criterion-relation validity. Question four was found to have a negative coefficient. This question was the only question in the pre-test and post-test which was related to the computing of liquid intake. Knowledge regarding foods included in liquid calculations data was necessary to answer this question. So reliability of the 10 questions on the pre-test and post-test was computed including question four with a Cronbach's alpha of .607 and excluding question four yielding a Cronbach's alpha of .700. Strong reliability is indicated by values close to 1.00.

Examining the pre dosage calculation scores and the post calculation scores a Wilcoxon test showed significant difference in the scores (*Z*=5.815, *p*<.000) (see Figure 2). The pre-test scores were *m*= 8.2(*sd*= 1.54) and post-test scores *m*=9.5(*sd*=.84) (see Figure 3). Post dosage calculation scores were significantly higher after attending simulation. Fifty- two students performed better, 19 students obtained the same score on both pre-test and post-test and six scored worse on the post- test.

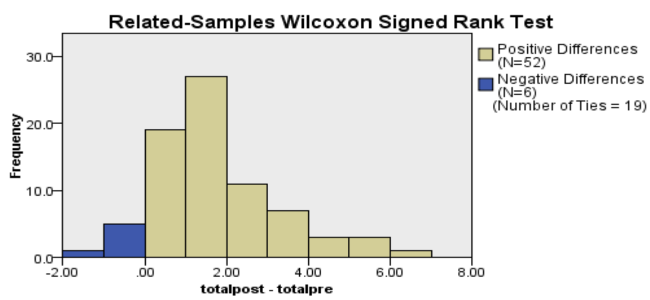

Figure 2.Wilcoxon rank graph of post-test variation from pre-test scores.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
totalpre	77	3.00	10.00	8.2078	1.54185
totalpost	77	6.00	10.00	9.4545	.83580
Valid N (list wise)	77				

Figure 3.Pre-test/Post-test table of means.

A Pearson correlation was calculated examining the relationship between participants' pre-test scores and post-test scores. A weak correlation which was not significant was found (r (75) =.263, p>.05).

To add depth to the findings of this study an additional statistical analysis was done. A multiple linear regression was run to predict participants pre-test scores based on their gender, ethnicity, age, and GPA. The regression equation was not significant (F (4, 72) = 4.066, p>.05), R^2 =.139. Gender, ethnicity, age, and GPA, are not significant predictors of pre-test scores. These factors were also not significant for predicting the post-test scores (F (4, 72) = 2.244, p>.05), R^2 = .061.

Additional regression models were set up to examine math ACT and gender as predictors of pretest scores. Both were significant predictors (F (2, 59) = 8.335, p=.001), R^2 = .22. In the pretest model, math ACT was the stronger predictor (t = 3.217, p=.002) as compared to gender (t= -2.176, p=.034). Gender became non-significant when used for testing a post-test model. Math ACT, however, was significantly predictive of post-test dosage calculation test score (F (1,60) = 25.305, p<.001), adj. R^2 = .285.

Discussion

The results of 52 students scoring higher on post-test than pre-test shows the positive effect of simulation on drug dosage calculation skills, without correlation of any factors related to age, ethnicity, or gender or GPA. Math skills, however, as measured by math ACT, account for a significant portion of the success on the pretest, before students have their medication calculation education. Following training, the math ACT remains a significant predictor of student success, accounting for nearly one third of the post-test variance.

The results of the significance in math ACT for both pre-test and post-test performance demonstrate support for the higher math ACT standard of pre-nursing school entry currently held at SAU. Simulation, along with math ACT, aid students to perform better on medication dosage calculation increasing safety in medication administration.

Examination of simulation later in the nursing program is needed to see the effect of simulation on medication dosage calculations and its effect on safety in medication administration. Additionally it would be of interest to see if students' progress through their nursing curriculum and their associated clinical practice eliminates the effect of math ACT on dosage calculation tests.

Limitations

Complications involved in the study were in the printing, which became obvious during the administration of the pre-test. After the pre-test had already started, it was discovered that two of the questions were missing data. Immediate arrangements were made to have the page reprinted while the students were finishing the other questions. This confusion in the order of the questions answered during the pre-test could have caused students not to perform as well on the pre-test.

Chapter 4

Research Assistant Duties

My participation in this study, under the leadership of head researcher, Dr. Jaclyn Huse, included testing material packet preparation, administering all pre-tests and post-tests during the four testing days, and entering data into SPSS 21 for analysis. Each packet was numbered and a demographic sheet, pre-test, post-test, SPJDS, and the NLN tools of Student Satisfaction and Self Confidence in Learning, Educational Practice Questionnaire (student version) and Simulation Design Scale (student version) were numbered and placed in the packet. Four eight hour days were spent in pre-testing, simulation intervention, and post-testing to collect the data. Once the testing was complete, pre-test and post-test data was entered into SPSS 21. This process of data entry involved three, eight hour days.

Once data entry was completed, as a research assistant, I sought counsel from research professor, Dr. Jeff. Gates, School of Nursing faculty member, as to which test to use for this project. One of the learning points discovered about this particular project was the correlation between the questions. Understanding the questions and how they fit together helped to explain the Cronbach's alpha reliability score. Understanding how to look at a research question and determine what analysis is needed to answer the question was an important learning event for me as a researcher. A variety of statistical tests are available to examine research data, collaboration with experienced researchers can assist in the selection of the most suitable tool for use.

Conclusion

As hospital stays decrease and inpatient acuity increases, nursing confidence and accuracy in medication administration is necessary. Simulation is definitely found to yield positive results in improving knowledge and skills regarding dosage calculation and medication administration skills. Nursing educators must continue to search for methods of instructional design to help produce nurses and nurse practitioners with problem solving techniques that will continuously improve their own practice, and increase patient safety. Practice environments must be created and sustained to support nurses as they learn to employ practices which are known to assist in interrupting medication error (Flynn, et al., 2012). Once a nursing program builds simulation into the curriculum, further studies are needed to conclusively measure the extent of its effect on the nurses' ability in: determining the problem in medication administration, examining medication calculation, decreasing medication error, and increasing patient safety during a hospital stay.

References

Costello, M. (2011). The use of simulation in medication calculation instruction. *Nurse Educator, 36*(5), 181-182.

Flynn, L., Liang, Y., Dickson, G., L., Xie, M., & Suh, D. (2012). Nurses' practice environments, error interception practices, and inpatient medication errors. *Journal of Nursing Scholarship, 44*(2), 180-186.

Jefferies, P. (2005). A framework for design, implementing, and evaluating simulations used as teaching strategies in nursing. *Nurse Education Perspective* 26(2): 96-103.

Jones SW (2009) Reducing medication administration errors in nursing practice. *Nursing Standard.* 23, 50, 40-46.

McMullan,M.,Jones, R.,& Lea, S. (2012). Math anxiety, self-efficacy, and ability in British undergraduate nursing students. *Research in Nursing Health.* 35:178-186

McMullan, M., Jones, R., & Lea, S. (2010). Patient safety: Numerical skills and drug calculation abilities of nursing students and registered nurses. *Journal of Advanced Nursing, 66*(4), 891-899.

McNeal, G. (2012) Simulation and nursing education. *The American British Nursing Foundation Journal*,(fall),p.78.

Meechan, R., Jones, H., & Valler-Jones, T. (2011). Do medicines OSCEs improve drug administration ability? *British Journal of Nursing, 20*(13), 817-822.

National Coordinating Council for Medication Error Reporting and Prevention. (2012). *Consumer information for safe medication use.* Retrieved from www.nccmerp.org/consumerinfo.html

Norman, J. (2012). Systematic review of the literature on simulation in nursing education. *ABNF Journal, 23*(2), 24-28.

Polya, G., (1957) *How to solve it*. (2nd Edition) Doubleday. New York.

Sears, K., Goldsworthy, S., & Goodman, W. M. (2010). The relationship between simulation in nursing education and medication safety. *Journal of Nursing Education, 49*(1), 52-55.

Sherriff, K., Wallis, M., Burston, S. (2010). Medication calculation competencies for registered nurses:A literature review. *Australian Journal of Advanced Nursing,* 28(4), 75-83.

Tzeng, H., Yin, C., & Schneider, T., E. (2013). Medication error-related issues in nursing practice. *MEDSURG Nursing, 22*(1), 13-50.

Valler-Jones, T., Meechan, R., & Jones, H. (2011). Simulated practice -- a panacea for health education? *British Journal of Nursing*, *20*(10), 628-631.

Wimpenny, P., & Kirkpatrick P. (2010). Roles and systems for routine medication administration to prevent medication errors in hospital-based, acute care settings: A systematic review. *Joanna Briggs Institute Library of Systematic Reviews* 8(10), 405-446. JBL000297.

Wright, K. (2009). Supporting the development of calculating skills in nurses. *British Journal of Nursing*, *18*(7), 399-402.

Wright, K. (2010). Do calculation errors by nurses cause medication errors in clinical practice? A literature review. *Nurse Education Today*, *30*(1), 85-97.