



Increasing nursing students' understanding and accuracy with medical dose calculations: A collaborative approach



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ABSTRACT

Background: Accurate calculation of medication dosages can be challenging for nursing students. Specific interventions related to types of errors made by nursing students may improve the learning of this important skill.

Objective: The objective of this study was to determine areas of challenge for students in performing medication dosage calculations in order to design interventions to improve this skill.

Design: Strengths and weaknesses in the teaching and learning of medication dosage calculations were assessed. These data were used to create online interventions which were then measured for the impact on student ability to perform medication dosage calculations.

Setting: The setting of the study is one university in Canada.

Participants: The qualitative research participants were 8 nursing students from years 1–3 and 8 faculty members. Quantitative results are based on test data from the same second year clinical course during the academic years 2012 and 2013.

Methods: Students and faculty participated in one-to-one interviews; responses were recorded and coded for themes. Tests were implemented and scored, then data were assessed to classify the types and number of errors.

Results: Students identified conceptual understanding deficits, anxiety, low self-efficacy, and numeracy skills as primary challenges in medication dosage calculations. Faculty identified long division as a particular content challenge, and a lack of online resources for students to practice calculations. Lessons and online resources designed as an intervention to target mathematical and concepts and skills led to improved results and increases in overall pass rates for second year students for medication dosage calculation tests.

Conclusion: This study suggests that with concerted effort and a multi-modal approach to supporting nursing students, their abilities to calculate dosages can be improved. The positive results in this study also point to the promise of cross-discipline collaborations between nursing and education.

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1. Introduction

Accurate medication dosage calculations (MDCs) can be simple or complex depending on the conversions required as well as the context, age, and weight of the patient. Medication errors include selection of the wrong medication, missed doses, and improper dose calculations; improper dose of medications represents up to one-third of the medication errors that occur (LaPointe and Jollis, 2003; Parshuram et al., 2008). These calculation errors can result in impacts ranging from minimal (loss of positive effect of the medication without harm) to extreme (death of a patient). A study in the neonatal unit found that nurses'

calculation errors would have resulted in administration of 10 times the prescribed dose (Simpson et al., 2004).

Nurses dedicate approximately 40% of their time administering medications (Armitage and Knapman, 2003); therefore, learning to accurately perform MDCs during nursing education is important to prevent medication errors. More than half of nursing students around the world fail numeracy and MDC tests (Jukes and Gilchrist, 2006; Grandell-Niemi et al., 2006; McMullan et al., 2010; Ramjan, 2011). While only limited work assessing capacity has been done in Canadian schools of nursing (Barkhouse-MacKeen and Murphy, 2013), anecdotal evidence from both faculty and students indicate that this problem does exist in Canadian nursing education.

The aim of this study was to evaluate the incidence and type of errors made by nursing students when performing MDCs and to subsequently design and test an online intervention resource with the goal of decreasing the incidence of MDC errors made by nursing students. In this innovative joint approach, faculty from both Nursing and Education combined

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expertise to examine the problem from both a mathematics education lens and a nursing education lens. To the best of our knowledge, this trans-disciplinary study is the first of its kind to be completed at a Canadian university.

2. Background

Numeracy is a key competency for registered nurses, as it forms the basis for many aspects of the nurse's role in practice; of central interest to this study, numeracy underpins the ability to safely administer medications. "To be numerate means to be competent, confident, and comfortable with one's judgements on whether to use mathematics in a particular situation, and if so, what mathematics to use, how to do it, what degree of accuracy is appropriate, and what the answer means in relation to the context." (Coben, 2000 as cited in Young et al., 2013 p e12). The inability to accurately perform medication dosage calculations (MDCs) can jeopardize patient safety. Inaccurate MDCs represents up to one-third of the medication errors that occur during medication administration (Armitage and Knapman, 2003; LaPointe and Jollis, 2003); errors in calculation become more significant when administering intravenous medication or when administering medication to children (Armitage and Knapman, 2003; Parshuram et al., 2008; Simpson et al., 2004). Despite the importance of this skill, evidence indicates that nursing students lack a solid foundation in numeracy (Dilles et al., 2011; Eastwood et al., 2011; Grandell-Niemi et al., 2006; Jukes and Gilchrist 2006; McMullan et al., 2010). Key requisite skills are multiplication, division, conversion of fractions to decimal equivalents, multiple computations, and understanding of conversion of SI and other units of measurement (Weeks et al., 2013a). It is therefore crucial to provide nursing students the opportunity to strengthen their numeracy skills during their nursing education.

Developing effective teaching strategy involves an understanding of the barriers to student success. With respect to MDCs, these barriers are limited procedural fluency, reduced conceptual competence, significant math anxiety, and lack of self-efficacy (Hunter-Revell and McCurry, 2013; McMullan et al., 2012; Ramjan et al., 2014; Weeks et al., 2013c). Limited opportunity to practice this skill during nursing programs also reduces proficiency (Barkhouse-MacKeen and Murphy, 2013). Nursing students with low self-efficacy and higher math anxiety experience higher anxiety and reduced performance on MDC tests (Andrew et al., 2009; McMullan et al., 2012); they are concerned that their lack of math skills may result in "killing the patient" (Ramjan, 2011 p e19). While anxiety and self-efficacy are important in accurate MDCs, this study was concerned with only procedural fluency and conceptual competence. Analysis of student errors indicates that conceptual errors constitute approximately one-third of errors while mathematics procedural errors explain the other two-thirds of errors by nursing students on MDC tests (Eastwood et al., 2011; Weeks et al., 2013a).

Procedural fluency or arithmetic/computational skills include addition, subtraction, multiplication, division, fractions, decimals, and conversion between SI units or between fractions and decimals. Errors in procedural fluency occur at a rate of 20%, with the most common errors resulting from division of whole numbers and conversion of fractions to decimals or conversion of mg to mcgs (Weeks et al., 2013a). These skills are learned in grades 6–8 in the Ontario school curriculum (Ontario Curriculum, Grades 1–8 Mathematics, 2005). A knowledge gap around one or more of those basic math skills is likely due to an earlier lack of understanding of the underlying concept of fractions and unit fractions (Bruce et al., 2014). This lack of understanding and the related procedural difficulties with operations may remain hidden through high school only to reappear when healthcare providers need these skills to safely administer medications. These errors are known as "dropped stitches associated with absence from primary or secondary school as a critical time or failure to understand a key mathematical concept that resulted in a missing link in the learning process" (Weeks et al., 2013a p e44). A basic numeracy test could detect this type of error and allow remediation at entry to a nursing

program (Barkhouse-MacKeen and Murphy, 2013). Use of calculators can eliminate mathematical errors but may produce clinically implausible answers, thereby unmasking the contextual errors.

For nursing, conceptual competence involves the ability to "a) Understand the elements of prescription charts, dispensed medication labels and medication data sheets and monographs, and then subsequently extract the numerical information necessary to set up the dosage correctly. b) Position the numerical information appropriately and correctly in the equation format for calculation." (Weeks et al., 2013c p e25) This competence is simple to describe theoretically, but a theory–practice gap exists that is very difficult to bridge. Nursing students have limited clinical experience when learning how to perform MDCs; without an understanding of how the answer will be used, it is difficult to understand how to achieve the answer. The use of contextualized teaching and assessment methods has been shown to reduce errors by nursing students on MDC tests (Costello, 2011; Eastwood et al., 2011; Ramjan, 2011; Ramjan et al., 2014; Weeks et al., 2013b, 2013a). A dissenting opinion as to the validity and relevance of MDC testing to predict for clinical errors does exist (Dyjur et al., 2011; Wright, 2010); however, MDC testing is currently standard practice in nursing education in Canada.

Nursing students must learn to precisely calculate drug dosages in their practice. This critical issue deserves attention in two particular forms. First, there is a need to understand where the mathematics skills and knowledge related to MDCs (including fractions) is breaking down for nursing students. Second, there is a need for continued research on the effects of nursing education that focus on MDCs in context. The aim of this study was to address the first need by evaluating the incidence and type of errors made by nursing students when performing MDCs program and to address the second need by designing a precise online intervention resource to decrease the incidence of MDC errors made by nursing students. In this innovative joint approach, faculty from both Nursing and Education combined expertise to gain a broader and deeper understanding of the mathematics challenges nursing students were facing and to develop effective resources to support these students.

3. Methods

Given the background above on existing research and some of the challenges nursing programs are facing, the research team asked two main questions.

- 1) Is there a problem with dose calculations abilities of this population of nursing students, and if so, what types of errors are the nursing students making?
- 2) Can a well-developed and targeted online intervention help to improve student performance on drug calculation tests?

3.1. Participants

Eight nursing students in years 1–3 of an accredited 4-year nursing program volunteered to be interviewed for qualitative data collections regarding challenges and areas of success in MDCs. Eight faculty/staff members involved in teaching MDCs were also interviewed to determine what they found difficult to teach and/or observed as difficult to learn in the areas of fractions concepts and MDC procedures. Data from 57 nursing students in year 2 of the same program were also gathered to assess the type of calculation errors that occurred most frequently; these baseline data assessed MDC ability before online interventions were made available to students. Comparative data from nursing students were gathered after the implementation of online resources for students, in the next academic year.

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