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Mapping drug calculation skills in an undergraduate nursing curriculum

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Summary The ability to calculate drug dosages correctly is an essential skill for registered nurses to possess. Performing drug calculations accurately is not a skill that new graduates have the luxury of developing over time. Drug errors are in many instances directly related to either the administration of an incorrect dose or incorrect infusion rate (Gladstone, 1995) caused by calculation errors. A strategy for implementing drug calculation skills into our new under graduate nursing curriculum was initiated to assist students in developing proficiency in drug calculations. The aim of this program is to promote the development of calculation skills in undergraduate nursing students, rather than simply assessing their skills.

Introduction

The ability to calculate drug dosages correctly is an essential skill for registered nurses (RNs) to possess. Administering medications is probably the highest-risk task a nurse can perform and accidents can lead to devastating consequences for the patient and the nurse's career (Anderson and Webster, 2001). Our department is committed to the development of calculation skills in our undergraduate students. To date however, the mechanism for assessing accuracy of these skills has been contained within the assessment components of individual clinical subjects, with each subject functioning in isolation with no integration between these assessments. This has lead to a situation where students may pass the subject without demonstrating mastery of drug calculations.

The *aim* of this paper, therefore, is to promote the importance of developing calculation skills in undergraduate nursing students, rather than simply assessing them. It will do so by describing the formal process and strategies we are implementing in our undergraduate nursing curriculum in Australia. The challenge of developing calculation competence amongst nursing students however is not a problem unique to Australia, as evidenced by the variety of literature published on the topic.

Initially, the issue of calculation skills arose in our previous undergraduate curriculum. In a now obso-

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lete clinical nursing subject, students had a calculation exam early in the academic year. Later that year when the skill was revisited, students who performed poorly on the initial exam were found to be still struggling with calculation skills. These students acknowledged that their calculation skills were poor, however, none of the students had attempted to improve them. We feel strongly that our role as academics is to assist students with their learning, not to simply pass or fail them. On reflection however, this clearly was not happening.

Secondly, the ability to perform drug calculations accurately is not a 'lower grade' skill that new graduates have the luxury of developing over time, unlike bed making, for example. It is a skill they must have mastered from the time they graduate because they will be using it from the first day they enter the workforce and is essential for competent practice as a registered nurse.

The ability to perform calculations accurately and administer drugs correctly is also reinforced through many of the Australian Nursing Council Incorporated (ANCI) Competencies (2000). For example, ANCI competency unit one states that RNs should fulfill the duty of care in the course of practice and act to enhance the safety of individuals and groups at all times. These ANCI competencies 'set' the standard of care for nurses working in Australia.

Thirdly, RNs are accountable for everything they do and therefore must be satisfied that the dose of a drug ordered is correct (Hutton, 1998a). If the medication dose ordered by a Medical Officer is wrong, the RN administering the drug is expected to be able to identify the error. If the RN does not recognize the error and administers the incorrect dose, he or she is accountable.

Calculation skills in the profession

A variety of literature has demonstrated a lack of calculation skills amongst nurses. Gillham and Chu (1995) assessed the drug calculation abilities of 158 undergraduate second year nursing students. Their test consisted of 10 questions of common clinical calculations. Only 88 students (55%) answered all questions correctly. Gillham and Chu (1995) found that students had a limited understanding of basic arithmetic and that the errors made were large in magnitude. For example, 22 students made calculation errors that could be deemed as clinically dangerous.

Blais and Bath (1992) assessed the calculation abilites of 66 first year nursing students and found that only seven obtained a score of 90% or higher and only three of these achieved 100%. Some students in their study took more than an hour to complete the 20 question exam. Santamaria et al. (1997) highlighted the inability of new graduates to calculate accurately. Their test consisted of 11 questions and of the 220 RNs who took the test, 58% were not able to calculate all dosages correctly. In one particular question, a large number of the RNs calculated a dose of insulin that was 10 times the prescribed dose. Alarmingly, the 220 new graduates who took the test had the highest academic grades of 597 applicants for the hospital's new graduate program.

The calculation skills of experienced RNs have also been evaluated. Bindler and Bayne (1991) assessed the calculation ability of 110 RNs and found that 81% of test scores were below a mark of 90% and 43.6% were below 70%. The RNs assessed in this study felt they had 'average' calculation skills. This is of great concern because those nurses are administering drugs regularly even when they know or believe their calculation skills are inadequate.

Ashby (1997) also assessed the calculation ability of Registered Nurses using a 20 item test. Only 43.5% of the 100 RNs attained a score of 90% or more and 19.4% scored less than 70%. These results are quite disturbing given the large number of medications an RN may administer in a shift. A further example by Gladstone (1995) highlights the issue of poor calculation skills of RNs. The study involved an audit of 79 medication error forms that were completed during a 12 month period. Gladstone (1995) found that more than half the errors were dose related and nearly 30% were either the incorrect dose or incorrect infusion rate. Clearly the standard of nurses' calculation skills is variable within each organization, department, ward and shift (Gray and Jackson, 2004).

Skill development in undergraduate program

Adams and Duffield (1991) suggested that because the ability to calculate drug dosages is '... one of the most common nursing functions ... educational institutions have a responsibility to introduce mastery tests throughout their curriculum'. They found that repeated mathematical drills in the form of calculation worksheets carried out over a number of weeks improved first year nursing students' ability to calculate drug dosages. This was evident by the improvement in the scores of the students as they progressed through the worksheets.

However, when the students were assessed during the next two years of the undergraduate program, their calculation skills had diminished. In our new undergraduate curriculum, the development of calculation skills is included in each of the three undergraduate years. We anticipate that the ability of our students to perform dosage calculations will improve across this program.

Whilst nurses should be performing every drug calculation correctly, it is somewhat idealistic to believe this occurs in reality as nurses are human and thus prone to error. Anderson and Webster (2001) described the 'law of large numbers' as a situation in which an accident occurs if a behaviour is performed enough times, even if it is low-risk behaviour. This suggests that all RNs will eventually make a calculation error. Registered nurses should therefore be doing everything they can to ensure that their calculations skills are proficient to help avoid such errors.

The process we are implementing in our new undergraduate program to address the development of calculation skills consists of the following key strategies. In the first year of the program, students have a basic calculation exam to establish a baseline of their abilities. We have an informal pass mark of 75%, used to identify students who perform outside a level we consider to be adequate for safe practice. These students are provided with feedback of their performance as incentive for them to develop their calculation skills.

In the second year of the program emphasis is placed on developing the students' calculation skills at a more complex level, in two medical—surgical nursing subjects. This primarily consists of an exam with three opportunities to achieve a pass mark of 85%. In addition, students in consultation with their tutors are given remedial work to help achieve the desired outcome. The third year of our program consists of the same format, but with a pass mark of 100%.

We decided that students would have at least one calculation assessment in each of the three years of their degree as assessing students only once does not guarantee improvement in skills. Calliari (1995), for example, found that nurses who failed a calculation test during their hospital orientation were more likely to make medication errors than nurses who passed the same test. Segatore et al. (1993) pointed out that '... any assumption that successful completion of high school and even university-level courses in mathematics predicts success is naïve, dangerous and ... unjustifiable'. This was reinforced by Kapborg (1995) who found a significant difference between the calculation abilities of nursing students who had come from a two year intergrated nurse education program at secondary school compared with those from a three year regular secondary school education.

We, therefore, begin with simple calculations and relevant concepts such as the metric system in first year. This is similar to Shockley et al. (1989) whose teaching of arithmetic skills included basic skills of addition, subtraction, multiplication, and division of whole numbers, fractions and decimals. The calculation assessments increase in difficulty each year, though we do not intentionally write difficult or obscure questions. All our exam questions are clinically realistic — they reflect the types of questions our students and graduates have to perform in the clinical area.

Setting the 'pass' mark

One of the main decisions we had to make when deciding to 'map' calculation skills over the three year program was what the pass mark for each assessment should be. Our first thought was that the pass mark for each assessment should increase each year, as should the nature and complexity of the questions, but we had to decide on a pass mark that was reasonable. Pass marks for calculation tests cited by other authors include 90% (Cunningham and Roche, 2001; Blais and Bath, 1992), 85% (Bliss-Holtz, 1994; Segatore et al., 1993; Shockley et al., 1989) and 70% (Hilton, 1999).

Our decision was to 'stagger' the pass mark for our calculation exams: 75% for first year students, 85% for second year students and 100% for third year students. This 'staggering' reflects the increasing complexity of the calculations over the three years and hopefully also the 'increasing mastery' of the skills by our students. By setting the final year pass mark at 100%, we are demonstrating that our graduates can perform calculations correctly, though obviously we are not guaranteeing that they will not make calculation errors in the clinical area. However, by ensuring that they know how to do the calculations correctly, we are giving them the opportunity to avoid calculation errors. If we do not ensure that students can calculate correctly, we are almost guaranteeing they will make mistakes.

Calculators

Cooper (1995) stated that to expect humans to perform at an error-free standard without aid is unrealistic. We, therefore, allow students to use calculators in their examinations for the following reasons. Firstly, RNs are allowed to use calculators in the clinical area. Secondly, a calculator will only do what the operator tells it to do. If the mathematical concepts used by the students were sufficient, use of a calculator would only remedy any numerical deficiency. Weeks et al. (2000) point out that the ability to solve problems involves understanding the logic of a problem and utilizing processes which involve coding of information into a meaningful whole. Put more simply, if mathematic concepts were deficient, the use of calculator would not aid the user in arriving at the correct answer (Bliss-Holtz, 1994).

Shockley et al. (1989) found that although the use of calculators resulted in a decrease in arithmetic errors, an increase in conceptual errors occurred. Perhaps this is due to the ignorance of some students who believe that if you can use a calculator you do not have to understand how to perform the calculation. Finally, Tarnow and Werst (2000) found that calculators did not make a significant difference in a calculation exam performed by 85 undergraduate nursing students. In fact, of the 38 students who did not pass the test with 100% accuracy, 23 used a calculator.

Remedial development

Another important issue we had to address is what to do with students who fail the assessments. Segatore et al.'s (1993) policy for dealing with students who did not meet the minimum pass mark of 85% was for faculty to recommend the student be withdrawn from their course, as they had not met course objectives. Although these students were given three attempts at the exam and all students had passed by the third attempt. Cunningham and Roche (2001) set their pass mark at 90% for their calculation exam and students were allowed two retakes. Of the 52 students assessed, all passed by the second exam.

We adopted a similar 'streamlined' strategy. Our students are given an additional three attempts to pass the exam. We feel it is important that students have numerous attempts because of our focus on facilitating our students learning, rather than purely assessing their skills. In between each exam our students are given remedial work and active feedback from a tutor in the specific areas requiring development. The student thus has up to four opportunities to pass the assessment before other action would be considered, such as excluding them from their clinical practicum.

Implementation

So how did our students actually perform in this system? Of the 130 students enrolled in first year, 25 scored a mark of less than 75% for the 20 question exam. In comparison, Pozehl (1996) reported that of 56 students assessed, only 17.9% obtained a mark of 70% or better. Our first year students were informed of their exam mark but were not 'followed up'.

Of the 145 students enrolled in second year, 19 (13%) scored a mark of less than 85% on the first attempt. This is a very low 'failure' rate compared with the results of a Grandell-Niemi et al. (2003). Of the 546 graduate nurses they assessed, only 17% attained a score of 100%, despite rating their calculation skills as 'sufficient'. In a similar study (Grandell-Niemi et al., 2001) of 204 graduating nursing students, only one student answered 17 calculation questions correctly. Though of the 157 nurses assessed by Hamner and Morgan (1999), 5% failed to meet the pass score of 85%.

Most of the errors made by our students were simple miscalculations, though some students clearly did not understand the concepts involved. For example, suggesting that 14 ml would be an appropriate volume to inject intramuscularly. Though in one study (Hutton, 1998b) nursing students gave the impression that a sensible answer (and an error) would only be recognized in a 'real' situation.

Of our 19 second year students who failed on the first attempt, only three failed on the second attempt and all these students passed on their third attempt. This means that no students failed the subject because of their inability to pass a calculation exam, unlike the students described by Segatore et al. (1993) who were required to withdraw from their course after three failed attempts. Between each examination attempt, our students were shown what their mistakes were and why they made them. They were also given remedial work to complete. This year we will be implementing our new policy in the third year of our undergraduate program for the first time. So far the implementation of our new calculation assessment policy has been successful with no student unable to obtain the desired skill level.

Conclusion

This paper has highlighted the deficiency of calculation skills in nursing students and RNs. It has described the strategy being implementing into our undergraduate nursing curriculum to assist students in developing proficiency in drug calculations. Our immediate plan for the future is to evaluate the success of our program both formatively and summatively. We also need to consider the length of time allocated to complete each exam. For example, whilst 30 minutes is adequate time in which to answer 20 questions, it is not clinically realistic. Pending the success of our program for teaching and assessing calculation skills, we anticipate a similar strategy will be used for the development of other skills seen as 'essential' for safe clinical practice.

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