Original Article

Mathematical and Drug Calculation Skills of Nursing Students in Turkey

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Abstract

Background: Numerical and drug calculation skills are reported to be important for patient safety.
Aims: The aim of this study, which employed a descriptive and cross-sectional design, was to investigate the mathematical and drug dose calculation skills of nursing students.
Methodology: This research was conducted in 2014 at two nursing schools in two different Turkish cities. A total of 128 nursing students participated in the study. Validated numerical and drug calculation tests were given to senior-year nursing students. Mathematical and dose calculation skills did not differ between genders or between the students' schools. Nursing students were significantly more capable of performing calculations for solids, liquids and injections than for intravenous fluid and infusion rates.
Results: The median of the mathematical skill scores was 50%, and the range was between 0% and 100%. The drug dose calculation score varied between 10% and 100%, and the median was 60%. Of the 128 students, 36.4% scored below 60%, and 82.9% scored below 80%.
Conclusions: This study indicates that nursing students have poor mathematical and drug dose calculation skills.

Key Words: Drug dose calculation skill, mathematical skill, nursing student

Introduction

Drug administration is one of the most essential and common tasks performed by nurses (O'Shea, 1999). Errors in medication administration are a severe problem, despite the increased use of various technical tools and systems for safe administration of drugs (Huse, 2010). Effective and safe administration of drugs requires accurately calculating doses in addition to following eight rules. Drug calculation is a core nursing skill and is vital for patient safety. According to national and international studies in the literature, it has been determined that the rate of drug administration and dose calculation errors is high (Cınar et al., 2006; Fahimi et al., 2008; Sheu et al., 2008; Tang et al., 2007).

According to data from the National Patient Safety Agency (NPSA), 59.3% of drug administration errors occur over the course of drug preparation. Dose calculation errors comprise 28.7% of all reported drug errors (NPSA, 2007). Nurses' numerical skills and

their development of knowledge about and attitudes towards dose calculation are of great importance, as many drug administration errors arise from dose calculation errors (Greenfield et al., 2006; Wright, 2006). Dose calculation errors arise either from an inability to perform simple arithmetic operations, such as the four arithmetic operations and mathematics with fractional numbers and decimal numbers, or from neglect of the required data needed for generating correct equations (Wright, 2007).

Background

Based on international reviews and reports of adverse drug events, incorrect doses account for up to one-third of these events (Alsulami et al., 2013). Many health professionals find drug dose calculations difficult, and many studies indicate that nursing students have poor medication dose calculation and arithmetic skills. For example, in their study of 66 nursing students in the USA, Blais and Bath (1992) determined that 89% of nursing students failed drug calculation tests and had difficulties in calculating the correct dose. In another study, Jukes and Gilchrist (2006) assessed sophomore nursing students and showed similar results.

Dilles et al. (2011) reported that the pharmacological knowledge and calculation skills of nursing students were limited. McMullan et al. (2010) emphasized that 92% of 229 nursing students in England failed a drug calculation test and stated that efforts to improve essential numerical and drug calculation skills should be integrated into the university curriculum.

In a study conducted with the aim of determining the basic mathematical sufficiency and drug dose calculation skills of 204 nursing students who had graduated in Finland, Grandell-Niemi et al. (2001) stated that the students had difficulties learning mathematical and drug calculation skills. In this study, the students were found to have insufficient mathematical skills, and one-fifth of them failed a drug calculation test.

Gillham and Chu (1995) performed a study evaluating the students' basic mathematical skills and determined that 158 second-year nursing students had insufficient skills, particularly in division, formula use and multiplication of fractional numbers. In the same study, the students were given a test composed of 10 items related to widely used clinical calculations, and only 55% of the students were able to answer all of the questions correctly. Brown (2002) found similar results when a basic mathematical test was administered to 868 nursing students in the USA.

Numerical and drug calculation skills are reported to be important for patient safety (Department of Health, 2000). Furthermore, Wright (2010) and Sheriff et al. (2011) have concluded that more research should be performed on drug dose calculation errors in clinical practice. Therefore, we sought to determine the drug dose calculation and mathematical skills of nursing students to contribute to the literature.

Methodology

Design

A descriptive and cross-sectional study.

Setting and sample

The study used a convenience sample of 128 senior-class students from two nursing schools in two different cities in Turkey. The total number of senior-class students in the two schools was 329.

In Turkey, university nursing programmes are 4 years in duration, and the graduates of these schools have a licence to practise nursing.

Ethics

Ethics committee approval was obtained from the X Nursing Faculty. Verbal informed consent was obtained from the students.

Data Collection

A questionnaire form developed by the researchers based on the literature, which was composed of drug dose calculations and mathematical unit conversions, and a demographic data form were used for data collection.

The data were collected from the senior students at the end of the second term. For study purposes, at both schools, the participants were gathered in a classroom

and asked to complete the tests under the supervision of a researcher. The participants were not allowed to use a calculator, which could act as a substitute for mathematical knowledge and skills, or to talk to one another when completing the test, and they were allowed to use pencil and paper only. The students were asked to complete the test within one hour.

Instruments

Socio-demographic Descriptive Form

The demographic data form consisted of questions regarding age, gender, the high school from which the nurse had graduated, whether the education on drug dose calculation in the nursing curriculum was sufficient and clear, and whether the student thought that he or she had sufficient drug dose calculation and mathematical skills.

Mathematical Skill Test

The mathematical skill test comprised 10 open-ended questions about addition, subtraction, division, metric-system conversions, fractional numbers and decimal numbers. Each correct answer was awarded one point, so the total score varied between 0 and 10. The scores were converted to percentages between 0% and 100% for analysis.

Dose Calculation Skill Test

This test consisted of 10 questions about solid-liquid pharmaceutical dose calculations, dose calculations for injections, and intravenous liquid and infusion rate calculations. Each correct answer was awarded one point, so the total score varied between 0 and 10. The scores were converted to percentages between 0% and 100% for analysis. Before the mathematical and dose calculation skill tests were applied, the opinions of 10 experts on content validity were obtained to estimate the extent to which the questions within the tests were relevant. The content validity index (CVI) was 0.69 for the mathematical skill test and 0.71 for the dose calculation skill test. Unanswered questions (n=20) were evaluated as incorrect.

Data Analysis

The data were analysed using the Statistical Package for the Social Sciences (SPSS) 18. The chi-square test and Pearson's correlation analysis were used for analysis of the data and the number and percentage distributions. As a passing grade of 60% is required at most universities in Turkey, the students with a total score of ≥60 points were considered as successful.

Results

Demographic Characteristics

The response rate of the study was 38.9%. Of the total sample of students, 58.6% were from Ege University Nursing School, and 41.4% were from Uludağ University Nursing School.

In total, 64.8% were female, and the mean age was 23.33±1.88. Approximately 38.3% of the students reported that their dose calculation skills were sufficient, 33.6% stated that they found their dose calculation education to be sufficient and clear, 92.2% stated that they trusted their mathematical calculations, and 78.9% stated that they found their mathematical skills to be sufficient.

Mathematical Skill Test

The median of the mathematical skill scores was 50%, and the range was between 0% and 100% (Table 1). Based on a passing grade of 60%, 52% of the students had grades below 60, and based on a passing grade of 80%, 73.6% of the students were determined to have failed (Table 2).

A statistically significant difference was not detected between the mathematical skill levels with regard to gender or the students' school ($t=0.15$, $df=125$, $p=0.87$ and $t=0.68$, $df=125$, $p=0.49$, respectively).

Dose Calculation Skill Test

The drug dose calculation score varied between 10% and 100%, and the median was 60% (Table 1). Of the 128 students, 36.4% scored below 60%, and 82.9% scored below 80% (Table 2). When the drug dose calculation skill test was divided into two categories (solid-liquid dose and injection calculations and intravenous fluid and infusion rate calculations), the scores on the solid-liquid dose calculations and injections varied between 0% and 100%, and the median was 74.6% (Table 1).

Among the students, 20.2% obtained scores below 60%, and 58.3% obtained scores below 80%. Intravenous fluid and infusion rate calculation skill scores were worse, ranging between 0% and 100%, with a median of 50.1% (Table 1).

The scores of 85.4% of the students were below 80%, and the scores of 73% of the students were below 60% (Table 2). There was a strong correlation between the mathematical skills and the dose calculation skills of the students ($r=0.47$, $n=128$, $p<0.001$).

However, the dose calculation skills did not differ according to gender or the students' school ($t=0.25$, $df=126$, $p=0.79$ and $t=-0.56$, $df=126$, $p=0.57$, respectively).

Table 1: Mathematical and drug dose calculation skills: median and mean (SD)

	Median	**Mean (SD)***
Mathematical skills %	50	50.3 (30.4)
Drug calculation skills %	60	58 (23.1)
Drug calculation skills (solid-liquid drugs and injections) %	80	74.6 (27.6)
Drug calculation skills (intravenous fluid and infusion rates) %	60	55.3 (32.2)

*SD, Standard deviation

Table 2: Mathematical and drug dose calculation skill core distributions

	Percentage of nursing students with a score <60%	**Percentage of nursing students with a score <80%**
Mathematical skills	52	73.6
Drug calculation skills	36.4	82.9
Drug calculation skills (solid-liquid drugs and injections)	20.2	58.3
Drug calculation skills (intravenous fluid and infusion rates)	73	85.4

Appendix

Examples of the questions on the mathematical and dose calculation skill tests:

1. 8.3x0.07=
2. 111-3+25x0.1=
3. 0.007 L=…….ml
4. 0.075 gr=…….….mg
5. An adult has been prescribed 0.06 g codeine. The available dose is 30 mg per tablet. How many tablets should the patient take?
6. 20 mg/5 ml phenytoin is available. How many ml would be required to administer 30 mg phenytoin?
7. 250 mg/5 ml penicillin syrup is available. How many mg of penicillin are there in 20 ml syrup?
a. 750 b. 1000 c. 1250 d. 2000
8. 20 mg/5 ml phenytoin is available. The patient was ordered 30 mg phenytoin. How many ml should you give?
a. 7.5 ml
b. 75 ml
c. 8 ml
d. 80 ml
9. 5000 units/5 ml heparin is available. How many ml of heparin are needed to administer 900 units of heparin?
a. 0.9 ml
b. 9.0 ml
c. 5.5 ml
d. 55 ml
10. The patient was ordered 25 ml/hour 750 ml saline solution. How many hours later is the solution finished?
a. 25 hours
b. 30 hours
c. 33 hours
d. 36 hours
11. You are asked to administer 80 ml of liquid that contains 75 mg gentamycin within 35 min. Please calculate the required rate in ml/hour.
a. 136 ml/hour
b. 137 ml/hour
c. 171 ml/hour
d. 172 ml/hour
12. 250 ml of solution is ordered to be administered within 3 hours. Please calculate the number of drops per minute.

a. 24 b. 25 c. 26 d. 27

13. A 27 kg child is ordered amoxicillin 40 mg/kg/daily in four doses. What is the amount of a single dose of amoxicillin?

a. 250 mg/dose b. 260 mg/dose

Discussion

Mathematical Skill Test

Although essential mathematical skills are key skills that nurses should possess, 52% of the nursing students in the current study failed the mathematical skill test, with a score below the passing grade of 60%. These results indicate that the mathematical skills of these students are quite poor. The results of our study are similar those of studies conducted in the USA, Australia, Finland, and England (Blais & Bath 1992; Brown, 2002; Gillham & Chu 1995; Grandell-Niemi et al., 2001; Jukes & Gilchrist 2006; McMullan et al. 2010).

There are several nursing training programmes in Turkey (high schools, schools of health, schools of nursing, nursing departments of health sciences faculties and nursing faculties). This study was conducted with only students from schools of nursing. There are substantial differences in entry points between a school of nursing and a faculty of nursing. Whereas students must obtain a high score to enter a nursing licencing programme at the faculty level, they may begin a programme at a school of nursing if they obtain a lower score. These factors may explain why students in the present study failed the mathematical skill test. Another important factor is the common use of calculators among students and practising nurses, even for the simplest calculations in daily life and clinical practice. In the current study, the students were not allowed to use calculators when completing the questionnaire. Calculators are widely used in clinical practice, and they are known to significantly reduce calculation errors (Bliss-Holtz, 1994; Segatore et al., 1993). However, although calculators reduce arithmetic errors, their use leads to an increase in conceptual errors by providing a false sense of security and by causing regression in mental arithmetic (McMullan et al., 2010). Finally, another reason for the limited mathematical skills observed in the present study may be that the students had forgotten their arithmetic skills with the passage of time since their higher-education examination.

Dose Calculation Skill Test

Dose calculation skills were scored below 60% for more than one-third of the students and below 80% for approximately 83% of the students; these results are alarming. The solid-fluid drug dose and injection calculation skills of the students were better than the intravenous liquid and infusion rate calculation skills; these poor intravenous fluid and infusion rate calculation skills are worrisome. The dose calculation skills of students have been shown to be poor (Grandell-Niemi et al. 2001; McMullan et al., 2010). Dose calculation skills are among the most commonly used skills in clinical practice. Even a single error can threaten a patient's life, so correct dose calculation among students is of vital importance for patient safety. Solid-fluid drug dose and injection calculations are conceptually easy, but students make errors due to poor mathematical skills (Blais & Bath 1992; McMullan et al., 2010; Wright, 2006). However, intravenous fluid and infusion rate calculations are more complex, and students' knowledge of the rate-proportion concept is very important for making these calculations correctly. The intravenous fluid and infusion rates will be calculated incorrectly if the data are not correctly placed within the dose calculation equation. Therefore, these issues should be better addressed in educational programmes for nurses. Because of the great number of students in nursing schools, the intensive educational programmes of nursing schools, the various clinical practice conditions, and individual differences between students, it is suggested that students do not receive sufficient practice and that these factors lead to problems in teaching dose calculation skills to students.

Our results revealed that the gender of the students and the school at which the study was conducted did not affect mathematical and dose calculation skills. However, previous studies have shown that gender differences in mathematical performance may be observed and that the problem-solving skills of women are worse than those of men (Ben-Chaim *et* al., 1988; Gallagher et al., 2000; Linn & Petersen 1985; Tartre, 1990). The small number of male students in

the current study could have affected the results. The lack of a difference in numerical skills between the schools may have been due to the facts that the schools were schools of nursing, that the entrance grades were similar and that the schools were composed of students at similar levels.

Conclusion

This study indicates that nursing students have poor mathematical and drug dose calculation skills, which indicates a need to change educational strategies used in nursing curricula. Medication errors represent a leading medical cause of patient mortality. Consequently, accurate medication administration should be a primary focus of nursing education curricula. Evidence-based modifications of a nursing curriculum can improve student nurses' ability to think critically and to conceptualize medication dosage problems. The current body of evidence was reviewed and was found to include valuable nursing education strategies that may improve the accuracy of mathematical calculations related to medication administration by student nurses. Nursing students must be taught mathematical calculation skills for medication administration early and often in the curriculum.

Study limitations

Our study has certain limitations. First, the response rate was very low. The amount of knowledge required to answer the questions and the use of open-ended questions caused reduced participation. Second, the study was conducted at only two schools. Therefore, the conclusions can only be applied to the students at these two schools.

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