

# Evaluation of Drug Dose Calculation Ability of Nursing Students: An Interventional Study

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## Research article

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# Abstract

**Background:** Incorrect drug dose calculations by nursing students can cause drug errors and harm patients. Their ability to calculate the correct dosage of drugs consistently need to be evaluated regularly. The objective of the study was to evaluate the drug dose calculation ability of nursing students.

**Methods:** A pre-post interventional study was conducted among 99 undergraduate nursing students studying in 2nd, 3rd and 4th year. Pre-test was conducted using a 20-item self-administered questionnaire on drug dose calculation test followed by a 30 minute lecture on the methods of drug dose calculation. Post-test was conducted using the same questionnaire after a washout period of six weeks. Mean score, standard deviation, frequency and percentage were calculated. Student t test, one way ANOVA and McNemar Test were used for statistical analysis using SPSS version 11.5 at P-value of 0.05.

**Results:** Pre-test and post-test mean score were  $10.59 \pm 3.00$  and  $15.36 \pm 2.46$  respectively. There was 45.04% increase in mean score in the post-test after the intervention and it was statistically significant (P-value < 0.05). None of students scored more than 90% of mastery level in the pretest and 42 students (42.4%) scored more than 90% of mastery level in the post-test. The mean score was highest for third year students in both pre-test and post-test; however, it was statistically not significant (P-value > 0.05).

**Conclusions:** Drug dose calculation ability of the students was poor in the pre-test and it significantly improved after the intervention. The study findings highlight the need for regular continuing mathematical and drug dose calculation practice among the students.

## Background

Errors in drug dose calculation can be detrimental and costly to patients. Drug dose calculation and basic mathematical skills play a major role in the safe administration of medicines to the patients. Errors in drug dose calculation account for more than 15% of medication errors [1]. Studies conducted among doctors, nurses and paramedics have reported that many healthcare providers are not sufficiently competent in drug dose calculation [2–6]. Poor understanding of the drug concentration expressed in different ways, dose calculation errors and drug administration errors are some of the common incompetence in nurses and other health care workers [7, 8].

Nurses play a vital role in different phases of a patient's medication process. Being one of the essential skill, they need adequate competency in drug doses calculation to for administration of medicines safely. They need to calculate drug dose with complete accuracy and confidence [9]. However, they may face difficulties in converting ratio, mass concentration and percentage during drug dose calculation. The increased workload, time constraints, distracting environments, lack of resources and inadequate training have significant influence on the process of drug dose calculation among them [10]. The medicines are also available in various strengths like percentage and ratio which further complicate the process. Research has focused primarily on the numbers and types of errors being made by nurses. There is paucity of data on evaluation of drug doses calculation ability among nursing students. A basic

knowledge of performing drug calculations would help to design training modules by educators for the nursing students that ultimately leads to safe medication administration. The aim of the study was to evaluate the ability of drug dose calculation among nursing students studying at a tertiary hospital.

## Methods

A pre-post interventional study was conducted at College of Nursing, B.P. Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal from March-May 2019. The study populations was students studying Bachelor of Nursing. The students who gave consent to participate and studying in 2nd, 3rd and 4th year were enrolled. Data were collected using a pre-tested and pre-validated semi-structured questionnaire prepared after reviewing the literature [7, 11, 12]. It consisted of two parts; the first part contained questions on sociodemographic profile. The second part of the questionnaire comprised of a 20-items on drug-dose calculation; the first two questions were for assessing the awareness of the students regarding drug dose calculation and rest of the questions for evaluating their ability to calculate drug doses (**Appendix 1**). The questionnaire was again tested and validated in 10% of the study sample to make it more reliable and suitable to the study population and those study sample were not be used in the study. The sample size was calculated to be 99 using formula  $n = z^2 * p * q / L^2$  for finite population where p was 50% at 95% confidence interval and 80% power [13]. Total population enumeration sampling method was used. The purpose of the study was explained to the participants and written consent was taken. Pre-test was conducted using the self-administered semi-structured questionnaire. A one hour interactive lecture on drug dose calculation was conducted immediately after the pretest in the Lecture Theater at College of Nursing, BPKIHS. The lecture consisted of theoretical as well as practical demonstration of drug dose calculations related to various dosage forms like syrup, suspension, tablets, injections and various concentrations like percent and ratio. After washout period of six weeks, post-test was conducted using the same questionnaire used for pretesting. The survey was anonymous, calculator was permitted and 30 minutes were given to fill the questionnaire although 20 minutes time was sufficient. The students were informed to maintain anonymity in the filling of the questionnaire. The confidentiality of students was maintained. One mark was given for the correct answer and zero for the incorrect and missing answers. The total score was 18.

The data were coded and entered into Microsoft Excel 2010. The number of correct and incorrect answers were summated. Their scores were converted into percentage and also categorized into less than 90% and more than 90%. Descriptive statistics mean, standard deviation, percentage and frequency were calculated. Student t-test was used to determine statistically significant differences between or within groups for continuous data and one way ANOVA test and McNemar Test for categorical data. All the statistical analysis were conducted using SPSS version 11.5. P-value less than 0.05 was considered statistically significant.

## Results

All study participants were female. Mean age of the students was  $21.70 \pm 1.311$  years. Most of the students (39, 39.4%) were studying in 2nd year (Table 1).

Table 1  
Socio-demographic characteristics of the participants (n = 99)

| Variables                        | Categories         | Frequency | Percentage |
|----------------------------------|--------------------|-----------|------------|
| Academic year                    | 2nd year           | 39        | 39.4       |
|                                  | 3rd year           | 32        | 32.3       |
|                                  | 4th year           | 28        | 28.3       |
| Schooling                        | Government         | 10        | 10.1       |
|                                  | Boarding           | 89        | 89.9       |
| + 2                              | Government college | 5         | 5.1        |
|                                  | Private college    | 94        | 94.9       |
| Marks scored in + 2 (Percentage) | 50–75              | 54        | 54.5       |
|                                  | >75                | 45        | 45.5       |

Before the intervention, only 85 (85.8%) students agreed that it is necessary to double check our own drug dose calculations; however, after intervention 95 (95.9%) students agreed to this statement which was statistically significant ( $P$  value  $< 0.05$ ). Similarly before intervention, only 50 (50.5%) students agreed that it is necessary to check the dose with a second person during drug dose calculation and after intervention 65 (65.6%) students agreed to the statement which was statistically significant ( $P$  value  $< 0.05$ , McNemar Test). Pre-test and post-test score of the students ranged from 4–16 and 8–18 respectively. No one scored maximum score in pre-test; however, only 18 students (18.2%) achieved maximum score in the post-test (Fig. 1).

Pre-test and post-test mean score were  $10.59 \pm 3.00$  and  $15.36 \pm 2.46$  respectively. Both mean pre-test and post-test score were highest for 3rd year students. There was 45.04% increase in mean score of the students in the post-test after the intervention which was statistically significant ( $P < 0.05$ , Paired sample T test). None of students scored more than 90% of mastery level in the pretest whereas 42 students (42.4%) scored more than 90% of mastery level in the post-test. As age increased, mean score increased both in pretest and post-test; however, it was statistically not significant ( $P$  value  $> 0.05$ ). Third year students' score was highest in both pre-test and post-test compared to 2nd year and 4th year students' score; however, it was statistically not significant ( $P$  value  $> 0.05$ ). Those students who have completed their schooling from government school scored higher both in pre- and post-test than those who had completed their schooling from boarding school; however, it was statistically not significant ( $P$  value  $> 0.05$ ). The students having 50–75% mark in their higher secondary had got less mean score in the pretest

than those with more than 75% mark. After the intervention the mean score of both these group of students increased in the post-test; however, it was statistically not significant (P value > 0.05) (Table 2).

Table 2  
Correlation between baseline variables and mean score obtained by the students (n = 99)

| Variables  | Categories         | Pre-test mean score | Post-test mean score | P-value            |
|--|--------------------|---------------------|----------------------|--------------------|
| Academic year                                    | 2nd year           | 10.10 ± 2.78        | 14.92 ± 2.67         | 0.421*             |
|  | 3rd year           | 11.22 ± 2.84        | 16.03 ± 1.55         |                    |
|  | 4th Year           | 10.54 ± 3.42        | 15.21 ± 2.87         |                    |
| Schooling  | Government         | 11.00 ± 3.43        | 16.10 ± 1.72         | 0.936 <sup>§</sup> |
|  | Boarding           | 10.54 ± 2.97        | 15.28 ± 2.52         |                    |
| Higher Secondary                                 | Government college | 10.00 ± 2.91        | 16.60 ± 1.14         | 0.420 <sup>§</sup> |
|  | Private college    | 10.62 ± 3.02        | 15.30 ± 2.49         |                    |
| Mark in + 2 (Percentage)                         | Upto 75            | 9.59 ± 2.91         | 14.54 ± 2.28         | 0.049 <sup>§</sup> |
|  | >75                | 12.00 ± 2.62        | 16.53 ± 2.03         |                    |
| *One way ANOVA test; <sup>§</sup> Student t test |                    |                     |                      |                    |

## Discussion

The ability of undergraduate nursing students to calculate the drug dose correctly and consistently has been a concern for a long time. This was a pre-post interventional study that had evaluated the ability of nursing students to calculate drug dose at a tertiary teaching hospital in Eastern Nepal. Findings from this study confirm that more than most of the nursing students were unable to perform drug dose calculations competently in the pre-test and after the intervention, there was significant increase in the ability.

There was statistically significant improvement in their awareness regarding importance of double checking of own drug dose calculations and the necessity to check the calculated dose with a second person during the dose calculation. The increased awareness certainly enhances the accuracy in drug dose calculation and help to prevent dug dose related errors. It is of utmost importance to inculcate such culture at the beginning of the nursing education so that they can practice it for rest of their professional career.

Our study showed that the mean score of the students was more than 50% both in pre-test and post-test. Brown found similar results in which the mean score was 75% [14]. No one achieved 100% score in pretest and only one-fifth of the students scored 100% in post-test. Similar findings were also reported in

other studies [6, 15]. Errors in drug dose calculation occur either because of the numerical inability of the students to perform basic functions such as addition, subtraction, multiplication, division and use of decimals and fractions or due to their inability to conceptually extract the correct information from the drug dose calculation problems in order to set up the mathematical calculations needed [16]. The students who perform poorly on the written tests on drug dose calculations are assumed to have poor skills in practice. Therefore, the nurse educationist should also focus on the education of nursing students regarding accurate drug dose calculations.

Drug dose calculation ability of the students was poor in the pretest in our study which improved in the post-test after the intervention. Other researches also showed that the ability of drug dose calculation of nursing students was poor [16, 17]. Similarly majority of the nursing students failed on drug calculation test at a 90% pass level in other researches as well [18, 19]. The students who scored less than 90% may benefit from frequent education and skill test on drug dose calculation that might help to improve their skills in the area and to decrease the potential patient safety issues. Frequent and mandatory drug calculation modules, both practical and theoretical, should be included in the nursing curriculum from 1st to 4th year which will reinforce the knowledge and skill and make them more competent. Higher secondary education with marks more than 75% was associated with better score among the students in our study. Similar findings were also reported by Grandell-Niemi et al [19]. Therefore previous knowledge and experience on mathematical skills should be considered before planning and implementing effective modules on drug dose calculation ability among nursing students.

The educationist should address mathematical skills and concepts, linking numeracy competency with meaning and context and teaching drug calculation formulae and practical calculation examples should be provided for developing the competency in drug dose calculations [20, 21]. We have to revise effective teaching and learning strategies to support and facilitate nursing students to learn this skill and make them competent [21]. Perhaps there is a need for collaboration between the Nursing Council of Nepal and other relevant authority to establish a core set of competencies and good nursing practice for clinical education of nursing health care professionals. It would be more practical to include drug dose calculation related objective problems during service entry examination of nurses. Researches need to be conducted frequently to check the competencies in drug dose calculation of the nursing students as well as nursing personals. With the advent of more accessible and affordable computer and mobile technology, more use of online materials should be encouraged to enhance mathematical skills among nurses.

Our study had some limitations also. The sample size of the study was small. The arithmetical, conceptual and computational errors were not evaluated. Being a single-center study, the findings may not be generalized to other nursing students studying at different institutions.

## Conclusions

Our study showed that the drug dose calculation ability of nursing students was poor in the pre-test which significantly improved after the intervention. The study findings highlight the need for regular continuing drug dose calculation practice and the use of other educational measures to ensure a higher competency in drug dose calculation among the students. Our study recommends frequent reinforcement of drug dose calculation both in the classroom and ward posting through practice and assessment.

## **Declarations**

### **Ethics approval and consent to participate:**

The study was ethically approved by Institutional Review Committee, B.P. Koirala Institute of Health Sciences

### **Consent for publication:**

Written consent was obtained from the participants.

### **Availability of data and materials:**

It is available on reasonable request.

### **Competing interests:**

None

### **Funding:**

None

### **Authors' contributions:**

BKK, DPS and ES designed the study, BKK and DPS participated in data collection, and data analyzed by DPS. The final report and article were written by DPS, BKK and ES and approved by all the authors.

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## Appendix 1

### The questionnaire

1. When calculating drug doses, is it necessary to double-check your own calculations?

Yes\* b. No c. Do not know

2. When calculating drug doses, it necessary to check the dose with a second person?

Yes\* b. No c. Do not know

3. Convert 5 mg into microgram.

2000 mg b. 3000 mg c. 4000 mg d. 5000 mg\*

4. 8 mL of a drug solution contains:

8 microlitre b. 80 microlitre c. 800 microlitre d. 8000 microlitre\*

5. How much sodium (in grams) is there in a 500 mL infusion of sodium chloride 0.9%?

9 g b.4.5g\* c. 2.5 g d. 1.5 g

6. You have a 5 mL ampoule of dopexamine 1%. How many milligrams of dopexamine are there in the ampoule?

20 mg b. 30 mg c. 40 mg d. 50 mg\*

7. You have a 10 mL ampoule of adrenaline 1 in 1000. How much adrenaline in milligrams does the ampoule contain?

10 mg\* b. 20 mg c. 30 mg d. 40 mg

8. You plan to suture an 80 kg patient. Given the maximum safe dose of lignocaine is 3 mg/kg, what is the maximum safe volume, in mL, of 2% lignocaine solution that can be given?

8 ml b. 10 ml c. 12 ml\* d. 14 ml

9. Sodium hypochlorite is available as 10% solution in 1 litre bottle. How much water should be added to this solution so that its concentration becomes 2%?

1000 ml b. 2000 ml c. 3000 ml d. 4000 ml\*

10. You are attending the cardiac arrest of a 60-year-old male. How many mL of 1:10000 adrenaline do you need to give a dose of 1 mg of adrenaline?

0.5 ml b. 1 ml c. 10 ml\* d. 20 ml

11. Atropine vials are found on emergency trolleys in our hospital. Each 10 mL vial contains 1 mg of atropine. What is the concentration in mg/mL of this solution?

0.01 mg/ml b. 0.1 mg/ml\* c. 1 mg/ml d. 10 mg/ml

12. A 45 kg female patient develops symptomatic bradycardia. You elect to treat this with atropine, 20 microgram/Kg, given intravenously. How many mL of an atropine (available as 1 mg in 10 mL) will be required?

3 mL b. 6 mL c. 9 mL\* d. 12 mL

13. The physician orders 375 mg of cefuroxime for the patient. The drug is available in 750 mg vial. You plan to dilute it in 10 mL of sterile water. How much should you give to your patient?

5 mL\* b. 6 mL c. 7 mL d. 8 mL

14. A pediatric patient recovering from accidental fall is about to be given with 130 mg paracetamol syrup. The drug is available in 250 mg per 5 mL preparation. How much should you give to your patient?

1.6 mL b. 2.6 mL\* c. 3.6 mL d. 4.6 mL

15. You need to give a patient 125 micrograms of digoxin orally. You have digoxin elixir 50 micrograms/mL supplied with a dropper pipette. How much do you need to draw up for this patient?

1 mL b. 1.5 mL c. 2 mL d. 2.5 mL\*

16. You need to give 1 g of erythromycin orally. You have erythromycin suspension 250 mg in 5 mL. How much of the suspension do you need to give?

20 mL b. 30 mL c. 40 mL d. 50 mL

17. You have gentamicin injection 40 mg/mL in 2 mL ampoules. Amount of gentamicin required is 4 mg/kg for a 60 kg patient. How many ampoules will you need?

6 ampoules\* b. 8 ampoules c. 10 ampoules d. 12 ampoules

18. The physician orders 1,500 mg of calcium carbonate for the patient. The drug is available in 250 mg tablets. How many tablets should be given to the patient?

2 tablets b. 4 tablets c. 6 tablets\* d. 8 tablets

19. A patient is prescribed 75 mcg of levothyroxine sodium (thyroxine sodium) but the strength of the tablets available is 25 mcg. How many tablets are required?

1 tablet b. 2 tablets c. 3 tablets\* d. 4 tablets

20. Determine the number of tablets to administer 0.25 mg of the drug from a medication stock of 62.5 microgram per tablet.

1 tablet b. 2 tablets c. 3 tablets d. 4 tablets\*

\*The correct answer