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RESEARCH ARTICLE
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STRENGTHENING CLINICAL COMPETENCY: DOES DRUG DOSE CALCULATION MUST BE A CORE COMPONENT OF NURSING EDUCATION?

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Abstract

Background: Drug dose calculation (DDC) is one of the critical competencies in nursing practice to avoid medication errors and thus the adverse events, such as toxicity or therapeutic failure. Despite this, nursing curricula do not emphasize DDC as a core skill.

Objective: To assess the competency and confidence of nursing students in solving drug dose calculations before and after a structured training session and to evaluate the necessity of integrating DDC into the core nursing curriculum.

Methods: A pre-post interventional study was conducted among undergraduate nursing students. A structured training session on drug dose calculation was conducted. Pre- and post-tests correctness of calculating the drug dosage, while a perception-based survey evaluated attitudes, confidence levels, and general anxiety in solving the mathematical calculations. The perceived importance of DDC was assessed through feedback.

Results: Significant improvement was noted in the mean post-test score (7.00) compared to the pre-test (6.16). Questions Q1, Q8, and Q10 showed statistically significant gains ($p < 0.05$). While most students agreed on the critical nature of DDC, less than 60% reported high confidence in performing these calculations. Anxiety and an inadequate mathematics background emerged as key barriers.

Conclusion: Targeted instruction led to measurable improvement in DDC competency and confidence. These findings strongly advocate for embedding drug dose calculation as a mandatory, practice-oriented component of nursing education to ensure safe clinical care.

Introduction

Medication administration is one of the most frequent and high-stakes responsibilities undertaken by nurses. Among these, drug dose calculation (DDC) is an essential clinical skill requiring a precise blend of pharmacological knowledge, mathematical ability, and critical thinking. Errors in this domain can be life-threatening, especially in vulnerable populations such as pediatric, geriatric, and critically ill patients, where even small miscalculations can lead to significant adverse outcomes.[1] Despite this, DDC is often underemphasized in nursing curricula, with a disproportionate focus on theoretical pharmacology and limited scope for applied computational practice.[2]

Globally, medication errors are one of the leading causes of avoidable harm in healthcare systems. The World Health Organization (WHO) has classified medication safety as a global patient safety challenge, estimating that errors result in billions of dollars in healthcare costs annually[3]. In India, where nurse-patient ratios are stretched and clinical environments are often resource-constrained, the margin for error is extremely thin. In such a context, the ability of nurses to perform accurate drug dose calculations is not just desirable—it is indispensable.[4]

Several studies have indicated that nursing students frequently struggle with dosage calculations due to poor mathematical background, cognitive overload, and lack of confidence.[5-7] These gaps are not merely academic—they translate into clinical practice, leading to medication errors, delayed care, and avoidable complications.[8] Yet, in most curricula, DDC remains a briefly touched-upon topic within pharmacology, without structured reinforcement or formal assessment. [9,10]

The present study was conceptualized in response to this educational void. It aims to evaluate the baseline competency of nursing students in drug dose calculation, measure the effectiveness of a structured DDC teaching session, and assess students' self-reported confidence and perceptions regarding the topic. By examining both cognitive and affective outcomes, this study attempts to make a compelling case for the formal integration of DDC as a core, examinable component of nursing education.

Materials and Methodology

Study Design and Setting

This was a prospective pre-post study conducted in the Department of Nursing Education at a tertiary teaching hospital in India. The objective was to assess the knowledge, confidence, and perceptions of nursing students regarding drug dose calculation (DDC) before and after a structured instructional intervention.

Study Participants

The study included undergraduate nursing students (2nd and 3rd year B.Sc. Nursing) enrolled in a pharmacology or clinical nursing module at the time of the intervention. Inclusion criteria were:

- Currently pursuing a recognized BSc nursing degree,
- Willingness to participate,
- Availability during both pre- and post-assessment sessions.

Students with prior advanced training in clinical pharmacology or those who had participated in similar DDC workshops within the last 6 months were excluded. A pre-test was conducted during their regular theory class. Later, we trained them with a pre-formulated set of DDC questions as part of the formulations and route of administration. The post-test was conducted after 3 months of training. The number of correct responses was noted, and each response with post-test answers was compared.

Sample Size Calculation

The sample size was calculated based on a paired t-test to detect a mean difference of 0.8 in pre- and post-test scores (out of 10), assuming a standard deviation of 2.0, power of 80%, and alpha error of **0.05**. Using the formula for paired samples:

$$n = \left(\frac{(Z_{1-\alpha/2} + Z_{1-\beta}) \cdot \sigma}{\delta} \right)^2$$

Where:

- $Z_{1-\alpha/2}$ = 1.96 for 95% confidence
- $Z_{1-\beta}$= 0.84Z for 80% power
- σ =2.0 standard deviation
- δ= 0.8 minimum detectable difference

$$n = \left(\frac{(1.96 + 0.84) \cdot 2.0}{0.8}\right)^2 = \left(\frac{2.8 \cdot 2.0}{0.8}\right)^2 = (7.0)^2 = 49$$

To account for a possible 20% dropout or incomplete responses, the final sample size was inflated to 60 participants.

The session was interactive and delivered by faculty with expertise in pharmacology and nursing education. A standardized PowerPoint and workbook were used to ensure uniform content delivery.

Data Collection Instruments
1. Knowledge Assessment (Pre- and Post-Test)

A validated 10-item multiple-choice questionnaire was administered both before and after the session. Questions were based on key DDC domains: unit conversion, formula-based calculation, infusion rates, body weight dosing, and ratio-proportion methods.

2. Perception and Confidence Survey
A 5 point Likert-scale questionnaire assessed:

- Confidence levels in performing DDC
- Attitudes toward DDC in clinical practice
- Anxiety associated with drug calculations
- Perceived adequacy of prior mathematical background
- Opinions on integrating DDC in core curricula

Data were entered into Microsoft Excel and analyzed using SPSS version 25.0.

- Paired t-tests were used to compare pre- and post-test knowledge scores.
- Descriptive statistics (mean, median, SD, frequencies) summarized Likert responses.
- A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Percentage of population who answered correctly for the dose calculation questions

Question	Pre-Test % Correct	Post-Test % Correct	p-value
Q1	59.79%	77.32%	**0.0138**
Q2	86.60%	86.60%	0.638
Q3	81.44%	85.57%	0.715
Q4	81.44%	81.44%	0.739
Q5	64.95%	76.29%	0.097
Q6	61.86%	71.13%	0.240
Q7	63.92%	70.10%	0.439
Q8	38.14%	67.01%	**0.00006**
Q9	35.05%	24.74%	0.0795
Q10	32.99%	61.86%	**0.00012**

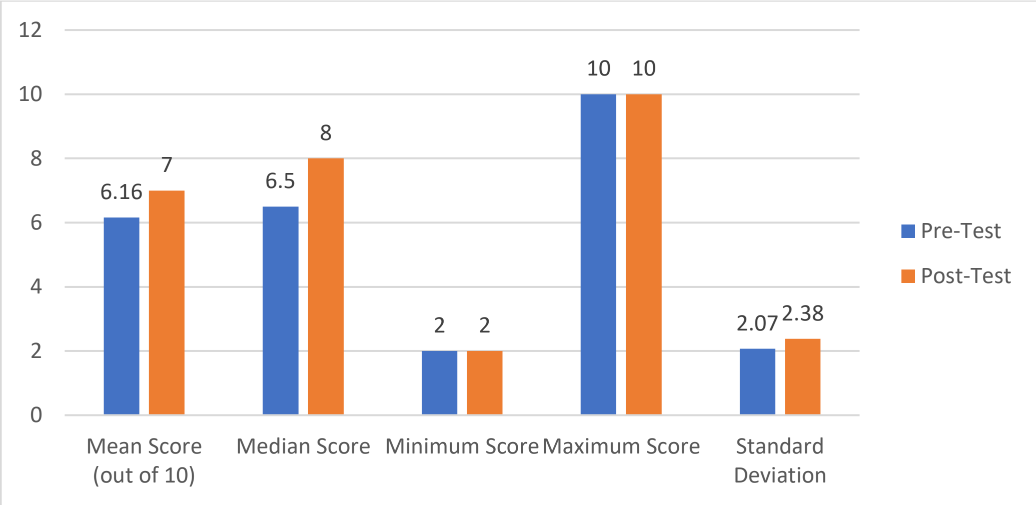

Figure 1: Mean scores of correct answers

Table 2: Comparison of observed average errors during pre and post-test

Error Type	Pre-Training Error Rate (%)	Post-Training Error Rate (%)	p-value
Incorrect dose calculation	18.3%	9.5%	0.02
Calculation delays	15.0%	6.8%	0.01
Failure to apply the formula	10.5%	4.0%	0.03
Total errors	43.8%	20.3%	0.001

Table 3: Response for the feedback questions from participants

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Accurate drug dose calculation is one of the most critical skills for a nurse	28.24%	37.65%	18.82%	5.88%	9.41%
I feel confident in my ability to perform drug dose calculations correctly	22.35%	32.94%	27.06%	11.76%	5.88%
I feel anxious or stressed when I have to perform drug dose calculations	9.41%	28.24%	38.82%	10.59%	12.94%
My mathematics background is strong enough for drug dose calculations	10.59%	29.41%	35.29%	15.29%	9.41%
I believe errors in drug calculations are a major threat to patient safety	25.88%	37.65%	17.65%	10.59%	8.24%
I am concerned about making a drug calculation error in clinical practice	17.65%	42.35%	21.18%	9.41%	9.41%
I enjoy learning and practicing drug dose calculations	22.35%	37.65%	24.71%	9.41%	5.88%
I believe that drug calculation skills improve significantly with practice	30.59%	35.29%	20.00%	5.88%	8.24%
It is acceptable to rely solely on automated dispensing systems for drug calculations	12.94%	28.24%	37.65%	15.29%	5.88%
I understand the formulas and principles behind different types of drug calculations	16.47%	36.47%	27.06%	11.76%	8.24%
Can you independently prepare and administer medications that require complex calculations?		-	-	-	100%
I feel more confident in solving drug dose calculation problems after this session	8.24%	42.35%	41.18%	4.71%	3.53%

Most participants (65.89%) agreed or strongly agreed that accurate drug dose calculation is a critical nursing skill. Confidence in performing calculations was reported by 55.29%, while 37.65% felt anxious. Only 40% considered their mathematics background strong, and 63.53% agreed that calculation errors are a major safety threat. Concern about making errors was expressed by 60%. Enjoyment in learning calculations was reported by 60%, and 65.88% believed skills improve with practice. Reliance solely on automated systems was less accepted (41.18% neutral/disagree). Understanding formulas was confirmed by 52.94%. After the session, 50.59% felt more confident, though 41.18% remained neutral, suggesting room for improvement. All of them denied that they can independently calculate the dose for administering drug.

Table 4: Student engagement and satisfaction scores after the training

Engagement Metric	Mean Score ± SD
Interest level during the session	4.2 ± 0.7
Usefulness of training materials	4.3 ± 0.6
Perceived improvement in confidence	4.0 ± 0.8
Overall satisfaction with training	4.4 ± 0.5
Willingness to recommend the session to peers	4.1 ± 0.7

Table 5: General anxiety level while DDC based on 5-point Likert score

Item	Pre-Training Mean ± SD	Post-Training Mean ± SD	p-value
Feel nervous when performing DDC tasks	3.4 ± 1.1	2.7 ± 1.0	0.001
Avoid doing calculations without help	3.1 ± 1.2	2.5 ± 1.1	0.003
Concerned about making errors in calculations	3.6 ± 1.0	2.9 ± 1.2	0.005
General anxiety about math-related tasks	3.8 ± 1.0	3.0 ± 1.1	0.0005

The 5-point score of general anxiety level was significantly reduced after the training.

DISCUSSION

The present study demonstrates that structured training in drug dose calculation (DDC) significantly improves both accuracy and confidence among nursing students while reducing error rates and anxiety. The findings are consistent with previous literature emphasizing that numeracy and calculation competence are critical components of safe medication administration in clinical practice.[10,11]

Improvement in Knowledge and Accuracy: Post-training performance showed statistically significant improvement in several calculation questions, most notably Q1 (59.79% to 77.32%, p=0.0138), Q8 (38.14% to 67.01%, p=0.00006), and Q10 (32.99% to 61.86%, p=0.00012). The marked gains in these items likely reflect increased familiarity with multi-step calculations and formula application. This aligns with findings by McMullan et al. (2010), who reported that targeted numeracy training yields the most significant benefits for complex dosage problems rather than basic arithmetic.[9] Grandell-Niemi H et al who compared the Medication Calculation Skills between 364 nurses and 282 graduating nursing students also observed that nursing students still required practice.[12]

Reduction in Error Types: The observed decline in total errors from 43.8% to 20.3% (p=0.001) is a critical outcome, as medication errors are a major patient safety concern (Fry & Dacey, 2007). Specific error categories—incorrect dose calculation (18.3% to 9.5%, p=0.02), calculation delays (15.0% to 6.8%, p=0.01), and failure to apply formulas (10.5% to 4.0%, p=0.03)—all demonstrated statistically significant improvement, suggesting enhanced procedural fluency and reduced cognitive overload during problem-solving. **Bourbonnais FF et al** also interpreted that levelling the clinical experiences of nursing students in administering medications to include understanding of system factors, and thus the systematic teaching of drug dosage calculation is crucial.[14]

Perceptions and Attitudes Toward DDC: Feedback responses indicate that 65.89% of students agreed or strongly agreed that DDC is among the most critical nursing skills, supporting the integration of such training into the nursing curriculum. However, only 55.29% expressed confidence in performing DDC accurately, and 38.82% reported anxiety when faced with calculation tasks. This is consistent with earlier reports highlighting the persistence of "math anxiety" among nursing students.[9,13] Importantly, 65.88% believed DDC skills improve with practice, reinforcing the need for ongoing reinforcement rather than one-off interventions. The reluctance to rely solely on automated dispensing systems (only 41.18% neutral/disagree) reflects awareness that technological tools should complement rather than replace fundamental calculation competence, as also recommended by the National Patient Safety Agency (NPSA, 2007).

Impact on Anxiety Levels: Pre- to post-training analysis showed a statistically significant reduction in general anxiety related to DDC (p<0.005 for all measured parameters), echoing the work of Coben et al. (2014), who found that confidence-building interventions can mitigate math-related stress and improve performance under pressure. This is particularly important given the documented association between anxiety and reduced calculation accuracy. Similar to our outcome, even **Williams B et al** had opined that mathematics anxiety was one of the commonest barriers in calculating the accurate drug dosage.[14] A similar observational study by **Wright K et al** revealed that the nursing students had difficulties in multiplying fractions and interpreting information. The questionnaire further interpreted that drug calculation skills were related to education level, confidence, and enjoyment of maths at school.[15] Thus, we suggest providing more opportunities for training nursing students from the second year of their curriculum to strengthen their skills in DDC.

Engagement and Satisfaction: High satisfaction scores (overall satisfaction 4.4 ± 0.5; usefulness of materials 4.3 ± 0.6) indicate the training was well-received and perceived as relevant to clinical practice. Willingness to recommend the program to peers (mean 4.1 ± 0.7) suggests scalability and potential for integration into broader nursing education programs.

Role of DDC Training in Reducing Medication Errors: Enhancing DDC competency directly addresses one of the most preventable causes of medication-related harm—incorrect dose administration. The significant post-training reduction in incorrect dose calculations (from 18.3% to 9.5%, p=0.02), calculation delays (from 15.0% to 6.8%, p=0.01), and failure to apply formulas (from 10.5% to 4.0%, p=0.03) underscores the direct safety benefit of such interventions. By improving calculation accuracy and fluency, nurses can make faster, more reliable decisions during high-pressure clinical situations, reducing the likelihood of dosing errors that could lead to under-treatment, toxicity, or adverse drug events. Furthermore, reduced anxiety levels following training may help prevent stress-induced calculation mistakes, thereby further enhancing patient safety. These findings align with global patient safety goals, which prioritize medication accuracy as a cornerstone of harm prevention. **Keers RN et al** had mentioned in their systematic review that wrong calculation has been one of the major components in medication error.[16] **Ford DG et al** included the nursing staff from MICU to compare medication administration error rates before and after the provision of educational sessions using either traditional didactic lecture or simulation-based training. The mean quiz scores were significantly improved after education sessions in ICUs, which is almost the same as our outcome.[17] Hence, the outcome suggested the need for repeated training sessions.

Mandatory Integration of DDC into the Nursing Curriculum: The results of this study strongly advocate for the mandatory inclusion of structured DDC training as a core component of nursing education. With nearly two-thirds of participants recognizing it as one of the most critical nursing skills, yet only just over half expressing confidence in their abilities, there exists a clear competency gap that cannot be left to informal learning or incidental clinical exposure. The observed post-training improvements—in both calculation accuracy and error reduction—demonstrate that targeted instruction is highly effective in bridging this gap. Even **Chendake MB et al,** another Indian study stated that the students faced difficulties in drug dosage calculations. They exhibited less confidence and poor competence in mathematical abilities.[18] Given that medication errors remain a leading cause of preventable harm in healthcare, ensuring every graduating nurse possesses both the knowledge and confidence to perform accurate drug calculations is a non-negotiable patient safety measure. Embedding DDC training into the curriculum, reinforced through repeated assessments and practical application, will ensure these skills are not only acquired but retained throughout professional practice.

Limitations of the present study: The study was limited to a single cohort, and post-test evaluation occurred shortly after the intervention, potentially inflating retention estimates. Long-term follow-up is necessary to determine sustained skill competence. Additionally, self-reported confidence and anxiety measures may be subject to bias.

Conclusion

The training intervention led to significant improvements in DDC accuracy, reduced calculation errors, and decreased anxiety levels, with positive participant perceptions and engagement. Given the central role of dosage accuracy in patient safety, integrating such training into nursing curricula is strongly recommended.

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