RESEARCH PAPER

Mathematical Performance, Numeracy, and Mathematics Anxiety as Predictors of Drug Calculation Competence among Undergraduate Nursing Students: A Cross-Sectional Study

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ABSTRACT

Background and aim: Accurate medication calculations are essential for safe nursing practice. This study examined associations between mathematical achievement, numeracy, mathematics anxiety, academic year, and drug calculation competence among undergraduate nursing students in Saudi Arabia.

Methods: An analytical cross-sectional study was conducted at a metropolitan university in the Eastern Region in Saudi Arabia. All 1,062 undergraduate students were invited by university email to complete an online questionnaire during March–April 2026 (second semester); 320 participated (30.1%). Drug calculation competence, numeracy, and mathematics anxiety were assessed using the Drug Calculation Assessment Tool (DCAT), Lipkus Numeracy Scale, and the Short Mathematics Anxiety Ratting Scale (sMARS), respectively.

Results: Drug calculation scores correlated positively with mathematics/statistics grades ($r = .874$), numeracy ($r = .831$), and academic year ($r = .647$), and negatively with mathematics anxiety ($r = -.742$); all $p < .001$. The regression model explained 74.9% of variance in drug calculation scores ($R^2 = .749$). Mathematics/statistics grades ($B = .137$, $p < .001$), numeracy ($B = .070$, $p = .001$), and academic year ($B = .202$, $p = .019$) were significant adjusted predictors; mathematics anxiety was not ($p = .767$).

Conclusion: Mathematical achievement and numeracy were strongly associated with drug calculation competence. Longitudinal and multicenter research is needed to assess educational approaches and the generalizability of these findings.

Keywords: drug calculation competence; nursing students; numeracy; mathematics anxiety; medication safety

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INTRODUCTION

Medication administration is a fundamental responsibility in nursing practice and requires the integration of pharmacological knowledge, clinical judgment, and accurate dose calculation. Errors in medication preparation and administration can compromise patient safety, making the assessment of medication-related competence an important concern in undergraduate nursing education. A systematic review by Irvine et al. (2025) examined approaches to assessing nursing students' medication administration competency, while Westman et al. (2024) synthesized factors contributing to dosage calculation ability. Together, these reviews position drug calculation as an essential, but distinct, component of broader medication administration competence.

Drug calculation tasks require students to interpret prescriptions, select appropriate formulas, convert measurement units, and apply numerical reasoning in clinically meaningful situations. Dutra et al. (2022) reviewed instructional strategies for developing these skills, and Schneidereith and Barr (2023) documented variation in teaching methods and competency criteria across nursing education programs. These findings underscore the importance of examining students' underlying mathematical preparation rather than relying solely on completion of medication-related coursework.

Numeracy and previous mathematical achievement are plausible correlates of drug calculation competence. In a cross-sectional study of Australian undergraduate nursing students, Al-Ghraiybah et al. (2026) identified a positive association between numeracy and medication calculation competence. Similarly, Sainz-Rozas et al. (2025) examined mathematical competence in relation to medication calculation performance among nursing students. Research among nurses and upper-semester nursing students in Iranian special care units also found a

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positive correlation between pharmacology knowledge and drug calculation skills, although no examined demographic or educational predictor remained independently associated with drug calculation skills after adjustment (Maleki Jamasbi et al., 2026). These studies suggest that medication calculation competence should be evaluated alongside, but not equated with, related academic and clinical knowledge.

Psychological factors may also be relevant. Mathematics anxiety can affect students' experiences of learning and performing numerical tasks. Austerberry et al. (2024) investigated mathematics anxiety among undergraduate nursing students using mixed methods, while Abdul-Mumin et al. (2025) explored its perceived effects on pharmacological learning. Al-Ghraiybah et al. (2026) reported that mathematics anxiety was associated with calculation competence in unadjusted analysis but was not significant after adjustment for other factors. This distinction highlights the need to consider anxiety alongside numeracy and prior mathematical achievement in multivariable analyses.

Academic progression and educational exposure may also be relevant, as students encounter medication calculations through coursework, simulation, and clinical placements (Pol-Castañeda et al., 2022). Although previous studies have examined numeracy, mathematics anxiety, and calculation competence, evidence remains limited on how prior mathematics/statistics grades, numeracy, anxiety, and academic year relate to drug calculation performance when considered together, particularly in Saudi undergraduate nursing education (Al-Ghraiybah et al., 2026; Hijji, 2025).

To address this gap, the present cross-sectional study aimed to examin associations between mathematics/statistics grades, numeracy, mathematics anxiety, academic year, and DCAT scores among 1062 undergraduate nursing students in Saudi Arabia. It also aimed to assess the independent associations of these factors with DCAT performance in a multivariable model. The findings may inform targeted educational support, although the design does not establish causality.

METHODS

Study Design and Setting

An analytical cross-sectional study was conducted at a metropolitan university in Eastern Region in Saudi Arabia, during the second semester (March–April 2026).

Participants and Recruitment

The undergraduate nursing student population comprised 1,062 students. All 1,062 students were invited to participate through a Google Forms questionnaire sent to their university email addresses. The analytical sample comprised 320 students from the first through fourth academic years, representing 30.1% of the invited population.

Study Instruments

The questionnaire collected age, sex, academic year, grade point average, mathematics/statistics grades, clinical placement experience, previous mathematics/statistics assessment, and self-rated confidence in drug calculations. Drug calculation competence was assessed using the DCAT, based on the instrument described by Al-Ghraiybah et al. (2026). Numeracy was assessed using the 11-item Lipkus Numeracy Scale, and mathematics anxiety using the 25-item sMARS, as described by Al-Ghraiybah et al. (2026). Item-by-item equivalence of the administered DCAT to the published version and equivalence of its scoring procedures were not independently established.

Data Collection and Measurement Quality

The online Google Forms questionnaire was sent to students' university email addresses during March–April 2026 (second semester). Al-Ghraiybah et al. (2026) reported internal consistency coefficients of KR-20 = .97 for the DCAT, KR-20 = .83 for the Lipkus Numeracy Scale, and Cronbach's α = .97 for the sMARS, calculated in their study sample.

Data Analysis

Data were analyzed using IBM SPSS Statistics (Version 26.0). Categorical variables were summarized using frequencies and percentages, and continuous variables using means and standard deviations. Pearson correlation coefficients were calculated to assess associations between DCAT scores and mathematics/statistics grades, numeracy, mathematics anxiety, and academic year. Multiple linear regression was used to examine adjusted associations with DCAT scores. Statistical significance was defined as a two-sided $p < .05$.

Ethical Considerations

Ethical approval was obtained from the local Ethics Committee (1HPO003/015). Before beginning the online questionnaire, students were provided with information about the study and informed that participation was voluntary. Informed consent was implied by their decision to proceed with the survey after reviewing this information.

Results

Sociodemographic and Academic Characteristics of Participants

The study included 320 nursing students (mean age 21.15 years, SD = 1.31), of whom 56.6% were male. Most were in their second (51.3%) or third (34.1%) year, and B+ was the most frequently reported GPA grade (53.1%). The mean mathematics/statistics grade was 85.64 (SD = 2.64); 63.1% had not started clinical placement, and 72.8% reported being very or extremely confident in drug calculations (Table 1).

Table 1. Sociodemographic and Academic Characteristics of Participants (n = 320)

Items	Total n= (320)	
	No.	%
Age		
Mean (SD)	21.15(1.31)	
Gender		
Male	181	56.6
Female	139	43.4
Year of Study		
Year 1	39	12.2
Year 2	164	51.3
Year 3	109	34.1
Year 4	8	2.5
Self-Reported GPA		
C	2	.6
C+	8	2.5
B	61	19.1
B+	170	53.1
A	71	22.2
A+	8	2.5
Self-Reported GPA (on 100 scale)		
Mean (SD)	82.75(4.52)	
Baseline mathematics/statistics		
Mean (SD)	85.64(2.64)	
Started any clinical placement		
No	202	63.1
Yes	118	36.9
Have you been formally tested In Mathematics/statistics		
No	13	4.1
Yes	307	95.9
Confidence are you in your ability to perform drug calculations		
Not confident at all	2	.6
Slightly confident	8	2.5
Moderately confident	77	24.1
Very confident	154	48.1
Extremely confident	79	24.7

Table 2 shows that DCAT scores were positively correlated with mathematics/statistics grades (r = .874), numeracy scores (r = .831), and year of study (r = .647), but negatively correlated with mathematics anxiety (r = −.742); all correlations were statistically significant (p < .001; Table 2).

Table 2. Correlation between baseline participants' mathematics/statistics grades and their scores in drug calculation ability test (DCAT). (n=320)

Item	***Drug calculation ability scores***	
	R	*P-value*
Baseline mathematics/statistics grades	0.874**	≤0.001
Numeracy Score	0.831**	≤0.001
Math Anxiety score	-0.742**	≤0.001
Year of Study	0.647**	≤0.001

The regression model was significant (F = 234.49, p < .001; R^2 = .749). Mathematics/statistics grades (B = .137, p < .001), numeracy (B = .070, p = .001), and year of study (B = .202, p = .019) were positively associated with DCAT scores, whereas mathematics anxiety was not significant (B = −.003, p = .767; Table 3).

Table 3. Multiple linear regression for factors influencing baseline DCAT scores (n=320)

Predictors	B	Standard error of B	t	P-value
Constant	-3.430-	.925	-3.708-	*<0.001*
Baseline mathematics/statistics grades	.137	.007	18.308	*<0.001*
Math Anxiety score	-.003	.011	-.296-	.767
Numeracy Score	.070	.021	3.265	.001
Year of Study	.202	.086	2.362	.019
Model summary	R^2 =0.749	F=234.49	p<0.001	

N.B. ***B:*** *Unstandardized coefficient*, ***t:*** *t test,* R^2: Coefficient of Determination, ***F:*** *ANOVA test,*P<0.05 significant.*

DISCUSSION

This study examined academic and psychological correlates of drug calculation competence among 320 undergraduate nursing students in Saudi Arabia. Three findings warrant attention. Mathematics/statistics grades and numeracy showed strong positive associations with drug calculation scores and remained significant in the multivariable model. Mathematics anxiety was strongly associated with poorer performance in bivariate analysis, but not after adjustment. Academic year was also positively associated with calculation competence. Together, these findings suggest that mathematical preparedness is particularly relevant to students' calculation performance, while highlighting the need to distinguish statistical associations from causal explanations.

Mathematics/statistics grades showed the strongest correlation with drug calculation competence ($r = .874$, $p < .001$), followed by numeracy ($r = .831$, $p < .001$). Both retained independent associations in the adjusted model ($B = .137$, $p < .001$, and $B = .070$, $p = .001$, respectively). This convergence is consistent with Al-Ghraiybah et al. (2026), who identified basic numeracy as a strong correlate of medication calculation competence among Australian nursing students, and with the integrative review by Westman et al. (2024), which identified mathematical factors relevant to dosage calculation ability. The present results extend this literature to a Saudi undergraduate nursing cohort and indicate that both academic achievement and directly assessed numeracy provide information relevant to calculation performance.

Recent international findings reinforce this interpretation while illustrating differences across settings and assessments. Hijji (2025) highlighted concerns about foundational mathematical skills among Saudi baccalaureate nursing students. In Spain, Sainz-Rozas et al. (2025) studied 224 second-year nursing students and reported mathematical competence as the principal predictor of paediatric medication calculation performance, with their model explaining 60.9% of the variance. Comparable challenges have been observed beyond nursing: Frankart et al. (2025) examined 922 first-year pharmacy students across two US institutions and reported particularly weak performance on unit conversions (mean 29.7%). Although the populations and instruments are not directly comparable, these studies collectively indicate that difficulties with basic numerical operations can persist into professional health education.

The association is educationally plausible. Medication calculations require more than recall of formulas: students must interpret prescriptions, select appropriate operations, apply proportional reasoning, and convert units accurately (McMullan et al., 2010; Williams & Davis, 2016). Mathematics/statistics grades may capture accumulated academic performance, whereas a numeracy measure more directly samples foundational quantitative skills. Their simultaneous associations with DCAT scores suggest that neither should be treated as a complete substitute for the other. However, the very strong correlations also warrant caution: the measures may share mathematical content, and the cross-sectional design cannot establish whether higher mathematical achievement leads to better medication calculation performance. Early numeracy screening, followed by structured practice using clinically realistic problems, is therefore a reasonable curricular response rather than an intervention effect demonstrated by this study (Dutra et al., 2022; Minty-Walker et al., 2024).

Mathematics anxiety was strongly negatively correlated with drug calculation competence ($r = -.742$, $p < .001$), yet it was not independently associated with DCAT scores after adjustment for mathematical grades, numeracy, and year of study ($B = -.003$, $p = .767$). Al-Ghraiybah et al. (2026) reported a similar attenuation of the anxiety association following adjustment. This distinction is central to interpreting the present findings: students with greater mathematics anxiety tended to perform less well, but anxiety did not account for additional variation once the other measured factors were included. The adjusted result should not be interpreted as evidence that anxiety is irrelevant to students' learning experiences.

Research among nursing students describes mathematics anxiety as an important educational concern (Austerberry et al., 2024; Abdul-Mumin et al., 2025). Anxiety may coincide with difficulties in number processing, concentration, or confidence; conversely, repeated experiences of mathematical difficulty may contribute to anxiety (Skagerlund et al., 2019). These pathways cannot be separated in the present dataset, and neither mediation nor direction of effect was tested. The findings are thus compatible with overlap between mathematical proficiency and anxiety, but do not establish that mathematical proficiency explains or causes the observed anxiety–performance relationship.

Intervention evidence further suggests that performance, confidence, and anxiety should not be treated as interchangeable outcomes. In a multicentre randomized trial, Mahou et al. (2024) reported improvements in dosage calculation knowledge and practical performance with screen-based simulation, alongside greater satisfaction and self-confidence, without a significant between-group difference in anxiety. Importantly, their anxiety outcome was not identical to mathematics anxiety in the present study. Taken together, the evidence supports approaches that strengthen numerical skills while providing supportive, low-threat learning and assessment environments; it does not justify assuming that reducing anxiety alone will improve calculation scores.

Academic year was positively correlated with DCAT performance ($r = .647$, $p < .001$) and remained significant after adjustment ($B = .202$, $p = .019$). Students in later years may have encountered more pharmacology teaching, clinical calculations, and supervised medication-related tasks. Nevertheless, the association represents a comparison across different student cohorts at one point in time, not observed improvement within individuals. Moreover, only eight participants were in the fourth year, limiting confidence in inferences about the most advanced students.

Existing research cautions against assuming that progression through a degree automatically ensures competence. Sainz-Rozas et al. (2025) documented calculation difficulties among second-year nursing students. In contrast, Altuwaijri et al. (2026) found generally high self-reported pharmaceutical calculation confidence among 141 senior pharmacy students at King Saud University, alongside demand for more clinically relevant learning activities. Because that study assessed perceived competence rather than objectively tested performance, it cannot be used to infer superior calculation ability among senior students. Studies of nursing students' medication calculation and administration education likewise underscore the importance of how clinical problems are taught and assessed (Pol-Castañeda et al., 2022; Irvine et al., 2025). Thus, the present year-of-study association is best interpreted in the context of differing educational exposure and opportunities for practice, rather than as a direct effect of academic progression.

Implications for Nursing Education

The findings support a curriculum-wide approach to drug calculation education that begins with assessment of foundational numeracy and continues through progressively complex, clinically contextualized exercises. Mathematics/statistics grades may help identify students who would benefit from additional support, but direct numeracy and drug calculation assessments remain important because course grades do not necessarily capture applied medication calculation competence. Structured feedback, repeated practice, and simulation may be useful instructional options, although evidence for particular approaches varies (Dutra et al., 2022; Stake-Nilsson et al., 2022; Mahou et al., 2024). Educators should also attend to students' anxiety and confidence without presuming that these constructs independently determine calculation performance. Future multicentre longitudinal studies, ideally incorporating repeated objective assessments, could clarify how competence develops across academic years and evaluate whether targeted numeracy instruction improves performance. These recommendations arise from observed associations and supporting literature, not from intervention effects tested in the present study.

Strengths and Limitations

This study included 320 undergraduate nursing students across four academic years and examined academic and psychological correlates of drug calculation competence. Correlation and multivariable regression analyses enabled assessment of both unadjusted and adjusted associations. However, the cross-sectional design precludes causal inference. The single-university setting limits generalizability, and participation by 320 of 1,062 invited students (30.1%) raises the possibility of nonresponse bias. Online recruitment may also have introduced self-selection bias. Internal consistency was not estimated in the present sample because item-level responses were unavailable; published reliability coefficients may not generalize to this population. Exact equivalence of the administered DCAT items and scoring with those described by Al-Ghraiybah et al. (2026) was not independently established. Finally, assessment scores do not necessarily reflect medication administration performance in clinical practice.

CONCLUSION

Among undergraduate nursing students at the metropolitan University at Eastern Region in Saudi Arabia, drug calculation competence was positively associated with mathematics/statistics grades, numeracy, and academic year, and negatively correlated with mathematics anxiety. In adjusted analysis, mathematics/statistics grades, numeracy, and academic year remained significant predictors, whereas mathematics anxiety did not. The model explained 74.9% of the variance in drug calculation scores. These findings support attention to foundational mathematics and numeracy in nursing curricula, including opportunities for repeated medication calculation practice and assessment. Multicenter and longitudinal studies are needed to examine whether educational strategies improve calculation competence and translate into safer medication administration.

Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Committee of the University of Hafr Al Batin (reference: 1HPO003/015). Before beginning the online questionnaire, students were provided with information about the study and informed that participation was voluntary. Informed consent was implied by their decision to proceed with the survey after reviewing this information.

Availability of data and materials
The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request, subject to applicable ethical requirements and protection of participant confidentiality.

COMPETING INTERESTS
The author declares that he has no competing interests.

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AUTHORS' CONTRIBUTIONS
FA contributed to the conception and design of the study, data collection, analysis and interpretation, and drafting and critical revision of the manuscript. The author read and approved the final manuscript and agrees to be accountable for all aspects of the work, including ensuring that questions concerning its accuracy or integrity are appropriately investigated and resolved.

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