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An Evaluation of The Pharmaceutical Calculation Competency Among Pharmacists in a Tertiary Hospital in Sabah, Malaysia: A Cross-Sectional Study

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Abstract

Introduction: Questions requiring pharmaceutical calculations are frequently encountered by pharmacists. Accurate pharmaceutical calculations are necessary to ensure accurate drug supply and precise intravenous drug preparation. Any inaccuracy potentially results in patient harm. This study aimed to determine the competency and performance in each category of pharmaceutical calculations among pharmacists at a tertiary hospital in Sabah, Malaysia. **Methods:** A cross-sectional study was conducted in pharmacy department, Queen Elizabeth Hospital (QEH), Sabah, Malaysia (March to July 2017). All pharmacists were required to attend a 20 minutes supervised test assessment. Primary outcome was the competency in performing pharmaceutical calculation (score ≥70%). Data was analysed descriptively and univariate analysis was used to determine factors associated with pharmaceutical calculation competency. **Results and Discussion:** A total of 82 pharmacists with mean aged of 28.7 (SD=3.9) years, predominantly female (n=57, 69.5%) were recruited in this study. Out of them, 58 (70.7%) were Fully Registered Pharmacists (FRPs) with a mean working experience of 50.9 (SD=41.2) months. Of note, 64.6% of the pharmacists obtained score ≥70% in the assessment. FRPs performed better than Provisionally Registered Pharmacists (PRPs) (n=45 (77.6%) vs n=8 (33.3%), χ^2=14.54, P<0.001). Pharmacists with longer working experience and previous ward experience were associated with higher competency. Assessment questions related to drug supply, preparation, administration, and compatibility demonstrated lower performance score. **Conclusion:** Among pharmacists in this tertiary hospital, 64.6% of them meet the predetermined competency threshold. Training should focus on strengthening areas related to drug supply, preparation, administration, and compatibility.

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Introduction

Medication errors can occur at any stage of patient care, from prescribing errors to patient non-adherence. A retrospective analysis from the Medication Error Reporting System in Malaysia (2009-2012) reported 323 cases causing serious harm or death, with 9.1% associated specifically with drug administration errors (Samsiah et al., 2016). These errors are often linked to inappropriate knowledge (Rajakumar et al., 2025), interruptions during medication verifications (Park & You, 2023) , and crucially, inaccuracies in pharmaceutical calculations (Turniški et al., 2024). The effect of pharmaceutical calculation errors is detrimental when involving intravenous drugs, where incorrect supply, dilution, or infusion rate may compromise patient safety (Mulac et al., 2022).

Previous studies highlighted variable results in the pharmaceutical calculation competency among healthcare professionals. For instance, studies among registered nurses consistently report inadequate competency in drug-dose calculations, particularly involving intravenous infusions, unit conversions, and dosing rate (Bayne & Bindler, 1988; Bindler & Bayne, 1991; Bliss-Holtz, 1994; Ross et al., 2000). Similarly, physicians often struggle with dosage calculations involving ratio and unit conversions (Oldridge et al., 2004; Wheeler et al., 2004). In a study in Christchurch, New Zealand, when compared to nurses, doctors were found to perform better in drug dose calculation. However, subgroup analysis within the doctor's group showed that not all doctors able to perform well (Perlstein et al., 1979). Given pharmacists' important responsibilities to ensure accurate dose, drug preparation, infusion rate, and quantity of medication supply, the assumption of pharmaceutical calculation proficiency among practising pharmacist requires further investigation. To our knowledge, published literatures related to pharmaceutical calculation competency among practicing pharmacists is limited (Oldridge et al., 2004; Perlstein et al., 1979).

Pharmaceutical calculation competency is one of the core professional requirements for pharmacists. Regulatory bodies such as the General Pharmaceutical Council (United Kingdom)(*Standards for the education and training of pharmacists*, 2021) and the National Association Board of Pharmacy (United States) (*NAPLEX Content Outline*, 2025) require the ability to perform accurate dose calculation skills prior to professional registration. Likewise, in Malaysia, pharmaceutical calculation competency also forms part of the inpatient pharmacy training during provisional registration under the Pharmacy Board Malaysia (*General Guide on Record of Training and Experience of PRP* 2023). These standards depicts that pharmaceutical calculations constitute a significant component of licensure examinations, emphasizing their importance in ensuring patient safety.

While pharmaceutical calculation competency is assessed prior to practice, formal reassessment of applied pharmaceutical calculation skills after full registration is uncommon. Professional standards assume that competency is maintained through working experience and continuing professional development (CPD). Hence, the research question we seek to address is: What is the level of pharmaceutical calculations competency among practising pharmacists? Therefore, this study aims to determine the pharmaceutical calculations competency among pharmacists working at a tertiary referral hospital, to explore factors associated with pharmaceutical calculation competency, and to determine the perceived difficulties and performance in every pharmaceutical calculation category. Upon identifying the level of pharmaceutical calculation competency, we hope that our study findings may help pharmacy curriculum developers to improve current pharmacy syllabus by including practical skill that are essential to clinical practice.

Materials and methods

Study Design and Settings

A cross-sectional study was conducted in Queen Elizabeth Hospital (QEH), a tertiary care hospital in Kota Kinabalu, Sabah, Malaysia. Data were collected from March to July 2017. QEH has approximately 800 beds which provides various specialties and subspecialties services. The hospital also provides comprehensive inpatient and outpatient pharmacy services, including ward pharmacy, logistic pharmacy, therapeutic drug monitoring, and sterile preparation pharmacy unit.

Study Participants

A census approach was adopted in this study. The study population of interest were pharmacists who were actively involved in clinical practice and available during study period. All pharmacists working in QEH during the study period were eligible to be recruited. These included both Fully Registered Pharmacists (FRPs); pharmacists who have completed their provisional training and are fully registered with the Malaysian Pharmacy Board, and Provisionally Registered Pharmacist (PRPs); newly graduated pharmacists undergoing a one-year compulsory training period prior to full registration. In total, 92 pharmacists in QEH were eligible to be recruited for this study. Study participants were excluded if they are: the chief pharmacist (1), undergoing job relocation (1), research investigators (7) and pharmacist who were on long term leave (1) (e.g. extended annual leave or maternity leave).

Pharmaceutical Calculation Competency Assessment

All pharmacists recruited in this study were randomly assigned to attend an assessment test which were conducted for a total of 6 sessions. There were 12 to 14 pharmacists allocated in each of this session. This session consisted of 20 minutes supervised test assessment. It consisted of 4 scenario-based questions (with 4 to 5 sub-questions each) tested on 8 categories of pharmaceutical calculation (Table 1). This session was conducted as an open book test as it reflected real-world situation where pharmacist was tested on the ability to determine correct source of information and utilised appropriate information to solve calculation issues. For each scenario-based question, 5 minutes time limit were allocated to complete.

Table 1: Categories of Pharmaceutical Calculation and Examples.

	Categories	Description
1.	Dose-unit conversion	Calculations involving conversion between measurement units (e.g. mcg/ml to ml/hr).
2.	Preparation	Calculation on appropriate dilution volume, final concentration, or reconstitution requirements for intravenous drugs.
3.	Administration	Calculation involving infusion rate, duration of infusion, or maximum safe administration rate.
4.	Stability	Assessment of drug stability under specified conditions (e.g. room temperature and fridge storage) and diluent (e.g. saline, dextrose).
5.	Special population	Calculation involving specific patient characteristics such as renal impairment or fluid restriction patients.
6.	Compatibility	Determination of physical and chemical compatibility of medications with diluents.
7.	Supply	Calculation involving total quantity of medication required

		over a specific duration based on dose and frequency.
8.	Basic drug knowledge	Assessment of drug information such as strength per vial, standard concentration, or dosage form.

Validation of Assessment Test Scenario Based Questions

Five sets of scenario-based assessments were developed. During content validation, the main eight categories of pharmaceutical calculation were researcher-derived and developed through joint focus group discussions involving a panel of senior pharmacists (5 persons) and ward-based pharmacists with extensive experience in intravenous drugs, such as the intensive care unit (ICU) (1 person) and emergency department (ED) (1 person). The categories were identified based on frequently encountered pharmaceutical calculation–related queries. All five sets of scenario-based questions were constructed to assess the same eight predefined pharmaceutical calculation categories. Each set comprised four clinical scenarios matched to identical calculation categories, differing only in drug names and contextual information. Formal statistical agreement was not calculated; however, consensus among expert panel was used to establish content equivalence across all five sets. For face validation, a set of question was pretested among 10 independent pharmacists who were not included in the final study population. Amendment to the word's choice, terminologies and arrangement were made if there were any confusion arises. Most of the questions were clear and easy to understand. The pretest responses were subsequently used to estimate internal consistency reliability of the assessment using the Kuder–Richardson Formula 20 (KR-20), as all items were scored dichotomously (correct = 1, incorrect = 0). The KR-20 coefficient (Range: 0.6237–0.7507), indicating acceptable internal consistency reliability. All questions were intended to measure a common (pharmaceutical calculation competency) construct.

Data Collection Method

To ensure consistency in data collection procedure, all research investigators were given thorough briefing and trained on data collection method. Two study instruments were utilized in this study; 1) A set of baseline characteristics data collection form and; 2) 5 sets of scenario-based question questions. The sets of questions were developed to assess the competency of pharmacists in performing accurate pharmaceutical calculation.

The first study instrument was a set of baseline characteristics data collection form. It was used to record pharmacist demographic data such as age, gender, position, working experience, current working rotation, any ward pharmacy experience, duration of ward experience, queries received (past 12 months), frequency of queries (past 12 months) and time of queries. Additionally, we incorporated 2 additional questions that evaluated on pharmacist perceived difficulties of pharmaceutical calculation category, frequency of encounter and types of queries related to pharmaceutical calculation received. A 5-points Likert scale (Never-Always; very easy-very difficult) was used to measure both type of questions, respectively. Pharmacists were allowed to choose never or not applicable if they had never experienced in a specific type of queries.

Second, a developed scenario-based questions were used to assess the performance of pharmaceutical calculation among pharmacists. Each correct answer from the questions asked was given 1 mark. The score ranges from 0 to 100%, with higher percentage represent higher pharmaceutical calculation competency. The score was calculated as below,

$$\frac{\text{Number of correct answers}}{\text{Total questions}} \times 100$$

To avoid sharing of questions, participants were randomly assigned to different sets of the assessment test.

Study Outcomes

The primary outcome was the competency in performing pharmaceutical calculation measured as percentage of pharmacists who scored ≥70% in the assessment. This passing score was based on General Pharmaceutical Council (GPhC) benchmarks and aligned with typical academic pass scores in the United Kingdom (Rutter & Watts, 2015). The secondary outcome was the factors associated with pharmaceutical calculation competency, and the perceived difficulties and performance in each pharmaceutical calculation category.

Statistical Analysis

All data were initially recorded in Microsoft Excel 2013 and then analysed with STATA 12.0 (StataCorp, College Station, TX, USA). Prior to data analysis, data cleaning was performed to detect any data input errors or missing information. Then, the sampling distribution was examined. A frequency distribution (histogram) and a Q-Q plot (quantile-quantile plot) were used to check for substantial deviations from normality in the data. The frequency distribution plots the observed values against their frequency, provides both a visual judgment about whether the distribution is bell shaped. On a Q-Q plot, normally distributed data appears as roughly a straight line. Continuous variables in normally distributed data were presented in mean and standard deviation (SD). If the data was not normally distributed, it would be reported as median and (interquartile range, IQR). For categorical data, result was presented as frequency and percentage. Both descriptive and univariate statistical analysis were adopted where appropriate. Chi-Square test was used to compare between groups on the factors associated with performance of pharmacists in pharmaceutical calculation. Further, an analysis on the performance of pharmacists in each pharmaceutical calculation category was calculated and presented. To compare the frequency/type of queries and the perceived difficulties of pharmaceutical calculation category encountered, a bar chart was used to present data visually. All statistical analysis was 2-sided and p value of <0.05 was significant.

Results

Baseline Characteristics

A total of 82 pharmacists in QEH participated in this study. Table 2 summarizes the baseline demographic data for all study subjects. Of them, about two-third were FRPs, with average working experience of about 4 years (mean= 50.9 months, SD=41.2). Among the FRPs recruited in this study, majority of them were based in ambulatory pharmacy (n=25, 30.5%). This was followed by ward pharmacy (n=13, 15.9%) and inpatient pharmacy (n=12, 14.6%). A total of 17 (29.3%) pharmacists had ward pharmacy exposure. These included pharmacists who were currently based in ward (n=13) and pharmacists that had previous ward pharmacy experience (n=4). On average, pharmacists that had ward pharmacy experience, spent approximately 3 years in this service. Out of total subjects recruited in this study, 29.3% (n=24) were PRPs.

Table 2: Baseline Demographic Characteristics (n=82).

Variables	N (%)
Age (Mean, SD)	28.7 (4.0)
Gender	
Male	25 (30.5)
Female	57 (69.5)
Position	
Fully Registered Pharmacists (FRPs)	58 (70.7)
Provisionally Registered Pharmacists (PRPs)	24 (29.3)
Working Experience	
FRPs (Months) (Mean, SD)	50.9 (41.2)
Working Experience (months)	
<13	24 (29.3)
13-60	30 (36.6)
>60	28 (34.2)
Current Working Unit	
Ambulatory Pharmacy	25 (30.5)
Ward Pharmacy	13 (15.9)
In Patient Pharmacy	12 (14.6)
Store and Purchasing Pharmacy	6 (7.3)

Therapeutic Drug Monitoring Pharmacy	1 (1.7)
Drug Information Centre Pharmacy	1 (1.7)
PRPs (Under Training Rotation)	24 (29.3)
Any Ward Pharmacy Experience (FRPs)	
No	41 (70.7)
Yes	17 (29.3)
Duration of Ward experience (months) (Mean, SD)	33.3 (20.1)
Queries Received (Past 12 Months)	
No	3 (3.7)
Yes	79 (96.3)
Frequency of Queries Received (Past 12 Months)	
Once every few months	14 (17.7)
1 time per month	12 (15.2)
2-3 times per month	38 (48.1)
2-3 times per week	9 (11.4)
Everyday	6 (7.6)
Time of Queries	
Working Hours	25 (31.6)
After Working Hours	30 (38)
Night Duty	24 (30.4)

Pharmaceutical Calculation Queries

96.3% (n=79) of pharmacists reported that pharmaceutical calculation related queries were common. Majority of them (n=38, 48.1%) reported that they received queries at least 2-3 times per month (Table 2). However, 6 pharmacists (7.6%) reported that they received queries related to pharmaceutical calculation almost daily. Although queries related to pharmaceutical calculation distributed almost equally between different working hours, majority of pharmacists reported that these queries were frequently received after working hours (n=30, 38%).

Figure 1 shows the frequency and types of pharmaceutical calculation queries encountered. More than half of the pharmacists had graded queries on drug administration, preparation and basic drug knowledge were commonly asked (Frequent-Always). While queries related to dose unit conversion, compatibility, special population, and stability were either never or rarely received. Queries related to supply of medication were also commonly received.

Pharmaceutical Calculation Competency

Table 3 shows the pharmaceutical calculation competency in this study. A total of 53 pharmacists (64.6%, 95% CI: 54.1, 75.2) obtained pharmaceutical calculation assessment score of more than 70%. On average, pharmacists able to score 100% in almost all pharmaceutical calculation categories. These categories included dose unit conversion, basic drug knowledge, special population, and stability. Of note, lower performance was observed in categories such as administration (median=79, IQR=33.4), preparation (median=75, IQR=27.5), and compatibility (median=83, IQR=100). Despite that the perceived difficulty pertaining to drug supply seem to be relatively very easy to easy, the score in this category were the lowest among all categories (median=58, IQR=50).

Table 3: Pharmaceutical Calculation Competency among Pharmacists (n=82).

Variables	N (%)	Median* (IQR)
Pharmaceutical Calculation Competency		
≥70%	53 (64.6)	
<70%	29 (35.4)	
Pharmaceutical Calculation Category Score		
1) Dose-unit conversion		100 (50)
2) Preparation		75 (27.5)
3) Administration		79 (33.4)
4) Stability		100 (100)
5) Special population		100 (100)
6) Compatibility		83 (100)
7) Supply		58 (50)
8) Basic drug knowledge		100 (100)

* Negatively Skewed data

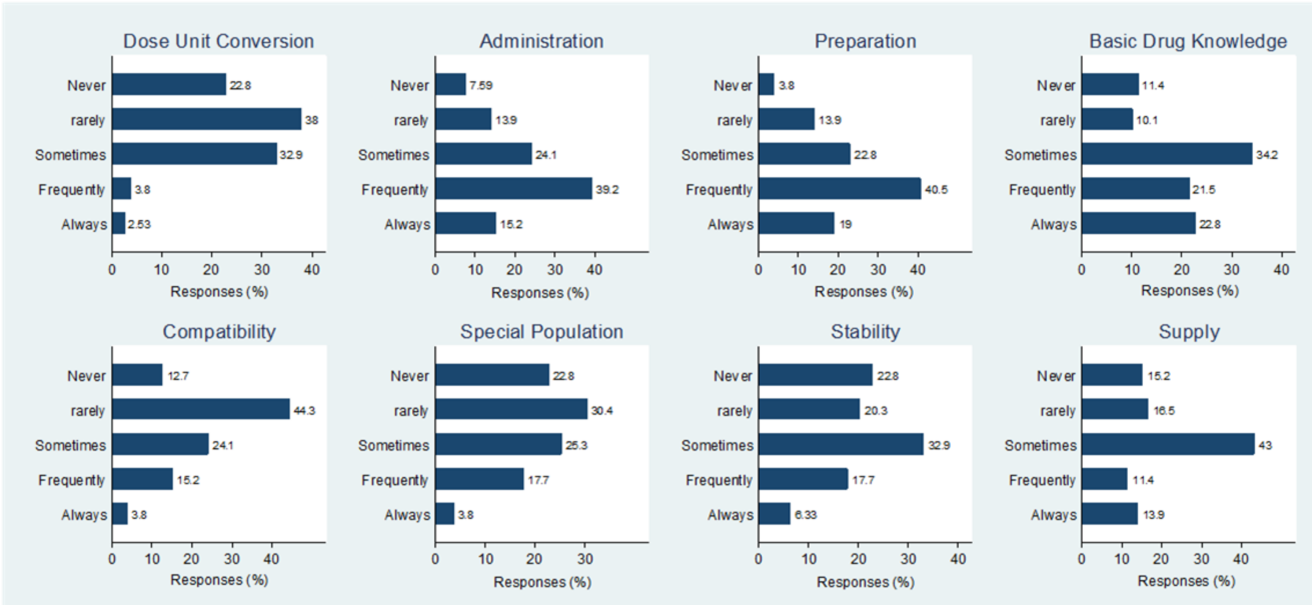

Figure 1: Frequency and types of queries related to pharmaceutical calculation (n= 82). Bars represent the percentage of pharmacists reporting the frequency and type of queries encountered in practice over the past 12 months.

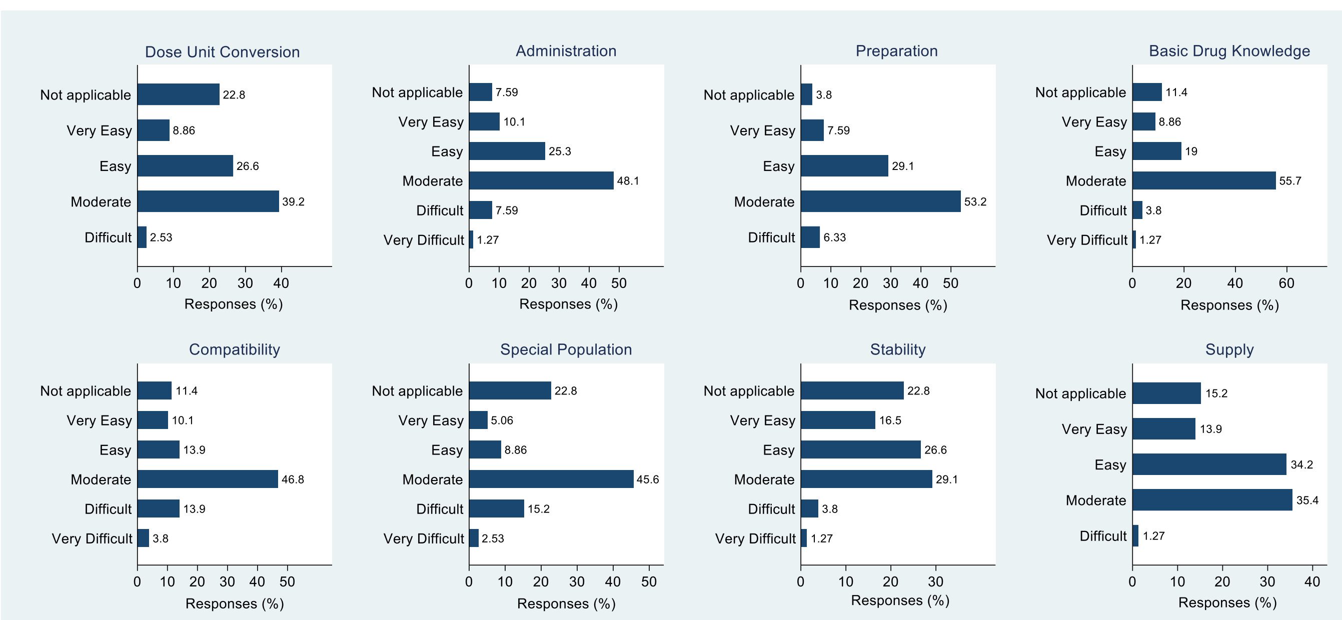

Figure 2: Perceived difficulties of pharmacists across pharmaceutical calculation categories (n=82). Bars represent the percentage of pharmacists reporting perceived difficulties for each pharmaceutical calculation category.

Table 4: Factors Associated with Pharmaceutical Calculation Competency (n=82).

Factors	***n***	**Pharmaceutical Competency**	**Calculation**	**χ^2 (*df*)**	***p* value[a]**
		Score < 70% *N* (%)	**Score ≥70% *N* (%)**		
Pharmacist Position					
PRPs	24	16 (66.7)	8 (33.3)	14.54 (1)	<0.001
FRPs	58	13 (22.4)	45 (77.6)		
Pharmacist with Ward Experience					
No	65	28 (43.1)	37 (56.9)	8.15 (1)	0.004
Yes	17	1 (5.9)	16 (94.1)		
Working Experience (months)					
<13	24	16 (66.7)	8 (33.3)	20.06 (2)	<0.001
13-60	30	11 (36.7)	19 (63.3)		
>60	28	2 (7.1)	26 (92.9)		

[a] Chi Square Test for Independence

Factors Associated with Pharmaceutical Calculation Competency

Table 4 shows the factors associated with pharmaceutical calculation competency. FRPs performed significantly better than PRPs. The proportion of FRPs passed the assessment test was approximately twice more than PRPs (77.6% vs 33.3 %, χ^2=14.54 (1), p=<0.001). Meanwhile, compared to pharmacists without ward experience, nearly all pharmacists with ward experience scored ≥70% (94.1% vs 56.9%, χ^2=8.15 (1), p=0.004). Longer working experience was similarly associated with better performance in pharmaceutical calculation than those who just entered the service (92.9% vs 33.3%, χ^2=20.06 (2), p=<0.001).

Perceived Difficulties in every Pharmaceutical Calculation Category

Figure 2 shows the perceived difficulties of pharmacists in each category of pharmaceutical calculation. Majority of the pharmacists perceived that each category of pharmaceutical calculation as relatively very easy to moderate difficulty. Among these categories, queries related to stability and supply were found to have the highest percentage of very easy and easy responses. On the contrary, pharmacists perceived that queries related to administration, compatibility and special population were either difficult or very difficult. Although it was infrequent, basic drug knowledge and stability types of queries were deemed difficult to very difficult to some pharmacists.

Discussion

Apart from the routine work of dispensing, pharmacist's role has extended to provide recommendation during preparation and administration of intravenous drugs, therapeutic drug monitoring, and in-ward drug supply, which require accurate pharmaceutical calculation. 96.3% (n=79) of pharmacists in this study received pharmaceutical calculation-related queries in their daily practice, with many (n=38, 48.1%) need to respond to queries at least 2-3 times per month. This emphasizes the importance of having high competency to conduct accurate pharmaceutical calculation in practice. Despite this expectation, the competency of practising pharmacists in pharmaceutical calculation remains uncertain. Hence, our study is warranted to fill this knowledge gap and assess the level of pharmaceutical calculation competency among practising pharmacists.

Strong foundational pharmaceutical calculation skills are expected of pharmacist because topics related to pharmaceutical calculation were taught specifically during pharmacy undergraduate studies. Nevertheless, in this study, nearly one third of the pharmacist (35.4%) did not meet the predetermined competency threshold (score of ≥ 70%). Among other healthcare professionals, registered nurses demonstrated an average performance in the drug calculation tests (Bjoerg O Simonsen et al., 2014). Likewise, a survey conducted among tertiary hospital doctors showed that only 28% of participants scored over 90% (Simpson et al., 2009). Our study findings are consistent with existing evidence suggesting that low pharmaceutical calculation competency may be concerning among healthcare professionals.

Pharmaceutical calculations in clinical practice require more than basic skills; they demand integration of mathematical skills with pharmacological understanding, clinical judgement and contextual interpretation of patient-specific conditions (Weeks et al., 2000). Unlike traditional pharmaceutical calculations taught during undergraduate which mainly focus on formulation, compounding, and unit conversion, pharmaceutical calculations in clinical settings often involve multiple processes from intravenous drug supply, dosing rate calculation, and drug concentration-volume adjustment in fluid restricted patients (Kahn & Reddy, 1996). These calculations are always or most of the time needed in real-time patient care settings. Despite the complexity of pharmaceutical calculations in clinical settings, current pharmacy curricula continue to emphasize foundational compounding calculations, with limited exposure to patient-centred clinical calculations (Stockton, 2022). This imbalances potentially leaving pharmacists inadequately prepared for the complexity and variability of clinical practice (Bin Abdul Jamil et al., 2024; Spence et al., 2024).

We ascertained that longer working experience was associated with higher pharmaceutical calculation competency. FRPs with a longer working experience excelled likely because of more exposure to drug calculation in their working history allowing them to execute drug calculation with confidence and yield better performance. PRPs that account for about 22% of the studied pharmacists were recently graduated from the school of pharmacy and still under first year training in the hospital setting. They have relatively insufficient practical skills and lack of conceptual knowledge in dilution and concentration, which may explain their poor performance in pharmaceutical calculation assessment test. This is similar to a comparative study between undergraduate nursing students and working nurses. Working nurses who had at least 1 year of working experience were more competent in performing accurate drug-dose calculation with lower risk of error than nursing students (B. O. Simonsen et al., 2014). In another study, senior doctors like consultant and registrar staff who have been working for more than 3 years achieved better scores in drug-dose calculation test than junior doctors (Simpson et al., 2009). These evidences prove that longer working experience is associated with better pharmaceutical calculation skills.

Apart from longer general working experience, pharmacists with previous ward experience also showed higher pharmaceutical calculation competency compared to those without ward experience. Ward pharmacists frequently calculate dosages and administration rate of intravenous medications, especially in acute and critical care setting. This is similar to previous study which found that those doctors working in critical care specialties such as intensive care, emergency medicine and anaesthesia performed significantly better in drug-dose calculations as compared to those in non-critical care specialties (Simpson et al., 2009). This indicates potentially weaker pharmaceutical calculation competency for pharmacists in other routine job than ward setting. Pharmacists without ward experience may have factual knowledge, but lack procedural knowledge and ability to apply the knowledge to problem solving. Therefore, to improve transfer of calculations learning to daily clinical practise, frequent practice of calculations is needed.

Our study found a lower pharmaceutical calculation competency in category such as administration, preparation, compatibility, and supply of injectable drugs. Except for supply related category, these categories were perceived as difficult-to-very difficult by pharmacists. Among registered nurses, previous study reported that calculation on drip rates have the lowest scores compared to metric conversions, tablet and fluid dosages calculation (Fleming et al., 2014). Likewise, a similar finding was reported where nursing students were found to perform worse in intravenous fluid and infusion rate calculations, compared to calculations involving solid-liquid drugs and injections (Gunes & Baran, 2016). Calculations to determine infusion rates and final concentration of intravenous fluids are often complex. Not only factors such as inadequate mathematical skill, but lack of clinical practical experience and conceptual understanding in pharmaceutical calculation module in Bachelor of Pharmacy program, may contribute to poor performance in these areas. To address these, continuous education through e-learning or classroom teaching and regular assessment of pharmaceutical calculation skills throughout professional careers were recommended (B. O. Simonsen et al., 2014).

Despite the questions being perceived as easy, pharmacists were found to perform poorly in questions related to medication supply. Questions in this category assessed the ability to determine the appropriate quantity of medications required over a specified supply duration. Previous studies have identified supply-related factors as contributors to medication administration errors and incorrect drug infusion rate which may be caused by inexperienced nurses who prepared and administered intravenous drugs incorrectly (Keers et al., 2013). Furthermore, errors in the appropriate number of vials supplied had also been associated with an increase in the risk of incorrect dilution during preparation (Cousins et al., 2005). Although supply-related calculations may appear straightforward, inaccuracies in pharmaceutical calculation due to lack of attention and impression that the error will not cause detrimental harm, the pharmacists could have underestimated the importance of accurate calculation in supply of medications.

There are few limitations worth consideration in this study. First, selection bias, as this study was conducted in a single tertiary hospital, which may limit the generalisability (external validity) of the results to pharmacists practicing in other healthcare settings such as district hospitals and health clinics. Although the inclusion criteria for the study involve all pharmacist from different units, pharmacists in tertiary hospitals may have higher exposure to more variety of intravenous drugs compared to those practicing in district or health clinics settings. Second, while the pharmaceutical calculation assessment conducted using scenario-based questions ensured standardisation, pharmacist who never encounter a particular intravenous drug may be unfamiliar with it, hence affecting their confidence in answering the question. Lastly, small sample size in this single centre study limits the data analysis to univariate statistical analysis. Potential confounding variables such as working experience, and prior ward pharmacy experience could not be fully accounted for. For future study, a multi-centre studies involving tertiary, major/minor specialist hospitals, district hospitals, and health clinics with a comprehensive variety of intravenous drugs may be suggested. With bigger sample size, multivariable modelling is warranted to obtain a more robust and better estimate of pharmaceutical calculation competency among pharmacists.

Conclusion

This study found out that 64.6% of the

pharmacists were competent in pharmaceutical calculation. FRPs, longer working experience and prior ward experience were found to show higher pharmaceutical calculation competency. Overall, a substantial proportion of pharmacists demonstrated difficulties in calculations related to medication preparation, administration, compatibility, and drug supply. Our findings highlight the importance of enhancing pharmaceutical calculation skills beyond traditional pharmaceutical compounding calculations during pharmacy undergraduate study, but also emphasize on pharmaceutical calculation related to clinical settings. These ensure that pharmacists equip with the competencies required to practice safe intravenous drugs management.

Authors contributions

JES: Conceptualisation, Methodology, Formal analysis, Writing-Original Draft, Writing-review and editing. **SNT**: Conceptualisation, Investigation, Validation, Writing - Original Draft, Writing - review and editing, Supervision **YCT**: Conceptualisation, Writing - Original Draft, Writing - review and editing Angeline: Writing - Original Draft, Writing - review and editing. **BCC**: Writing - Original Draft, Writing - review and editing. **YYT**: Conceptualization, Investigation, Writing-Original Draft. **CHL**: Conceptualization, Investigation, Writing-Original Draft. **CL**: Conceptualisation, Investigation, Writing-Original Draft. **RK**: Conceptualisation, Investigation, Resources, Writing - Original Draft, Writing - review and editing. All authors have complete excess to study data and support the publication of this research.

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Ethical approval statement

This research was registered with the National Medical Research Registry (NMRR), and it was approved by the Malaysian Research Ethics Committee (NMRR-17-1495-36701). This manuscript was written based on STROBE Statement that emphasize on quality in observational research reporting (von Elm et al., 2007).

Informed consent statement

All pharmacists working in QEH were briefed about this research and study information sheets were also provided. A research consent form was signed before they were recruited and participation in this study was strictly voluntarily.

Conflict of interest

The authors declare that they have no competing interests. No external funding received in conducting this research. All research materials were obtained from available resources at the study site.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author did not use AI (e.g. ChatGPT, Gemini and others) to improve readability and language. The preparation of this manuscript follows standard manuscript writing process.

Data availability

A copy of the assessment test questions may be obtained from the corresponding author upon request.

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