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MEDICATION CALCULATIONS COMPETENCY AMONG NURSES: A CROSS-SECTIONAL STUDY

Kholood E. Al-Nbabteh [1], Ayman M. Al-Qaaneh [2]*, Fida'a E. Al-Shatnawi [3], Fuad O. Abdullah [4], Heba N. Hudhud [5] and Muna S. Al-Kharabsheh [6]

[1,3] Department of Midwifery, Faculty of Nursing,
Al-Balqa Applied University (BAU), Al-Salt, Jordan.
Email: [1]kholoud.nababteh@bau.edu.jo, [3]fedaa.shatnawi@bau.edu.jo
[2] Department of Allied Health Sciences,
Al-Balqa Applied University (BAU), Al-Salt, Jordan.
*Corresponding Author Email: ayman.alqennh@bau.edu.jo, alqunneh@yahoo.com
[4] Department of Pharmacognosy, Faculty of Pharmacy, Tishk International University,
Erbil, Kurdistan Region, Iraq. Email: fuad.abdullah@su.edu.krd
[5] Department of Allied Health Sciences, Faculty of Nursing,
Al-Balqa Applied University (BAU), Al-Salt, Jordan. Email: heba.hudhud@bau.edu.jo
[6] Department of Nursing, Faculty of Nursing, Al-Balqa Applied University (BAU),
Al-Salt, Jordan. Email: muna.kharabsheh@bau.edu.jo

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Abstract

Background: Medication calculation, dispensing, and administration are one of the major tasks of nurses, and Medication Errors (MEs) are one of the most common errors in the medical field, where some of these errors are fatal. ME can be attributed to many causes, such as medication dosage calculation errors. Accordingly, this study aims to assess Jordanian nurses` competency regarding medication calculation and its associated factors. **Methods:** A descriptive cross-sectional study design was used to assess the medication calculation skills of 126 registered nurses in Jordan, representing different departments of three governmental hospitals. Nurses' dosage calculation skills were evaluated using self-administered Nursing Medication Calculation Competency Tool (NMCCT) prepared by experts in nursing practice assessing nurses' medication calculation competency in oral, parenteral, and intravenous flow rate. Data was collected, data entry was done on a Microsoft Office Excel sheet, and analyzed using SPSS 25.0. **Results:** Results show that 95% of participated nurses (n=120) did not receive any mathematical education during their university nursing program education, 84.9 % (n=107) reported absence of a medication calculation competency program at their respective hospitals. 79.7% (n=113) did not attend any medication calculation courses/programs after graduation and 90.5% of participated nurses reported unavailability of medication administration guidelines at their hospitals. The highest level of medication calculation competency was obtained for oral medications (65.1%) followed by intravenous flow rate calculation (57.9%), then parenteral/ intravenous medications calculation (48.9%). 27.8% (n=35) reported to be competent in the three aspects. The only factors that showed a significant impact on the total nurse's competency toward medication calculations were; the age of the participated nurse, availability of medication calculation competency programs at the participated hospitals, and attending medication calculation courses/programs after graduation (p= .045, .013, and <.001, respectively). **Conclusion:** Nursing curriculum and continuing education programs should recognize pharmaceutical education including drug calculation skills as an essential part of their content. Also, the researchers encourage the adoption of national wide learning/ competency program that is able to assess the level of competency, track gaps in medication calculation skills, and provide a supportive learning program in this aspect as needed.

Keywords: Medication Errors, Medication Calculations, Nursing Skills, Nursing Competency, Nursing Education.

1. INTRODUCTION

Medication calculation, dispensing, and administration are one of the major tasks of nurses. And Medication Errors (MEs) are one of the most common errors in the medical field, where some of these errors are fatal [1, 2].

ME is defined as “any error in the prescribing, supply, preparation, administration or monitoring of a medication, regardless of whether such errors lead to adverse consequence” [3, 4]. ME can be related to various causes such as: inappropriate practice, health care products, procedures, and systems, including prescribing, order communication, labeling, packaging, and nomenclature, dispensing, distribution, administration, education, monitoring, and use, and can happen at any of the following stages; prescription, transcription, preparation, dispensing, administration and/or monitoring [5, 6].

It is estimated that the annual cost of medication harm was €4.5–21.8 billion in Europe, which accounts for more than half of the overall preventable harm in medical care globally [7, 8]. Additionally, one study reported 237 million medication errors over a year in one country; 66 million of those errors are potentially clinically significant, and the estimated costs for the government in avoidable adverse reactions to medication are £98.5 million a year [9, 10].

Norwegian incident reporting system demonstrated that dosage errors are the most frequently reported medication errors, accounting for 38% of all errors [11]. Several studies have reported that dosage errors are common and have explored medication dose calculation errors as a subtype of dosage errors [12, 13]. Mulac et. al. analyzed 100 incidents reports from 2016 to 2017 from the Norwegian reporting system and reported that 77% of calculation errors are associated with the parenteral route, and 20% were associated with the oral route.

Most errors (70%) involved intravenous administration route, where 52% were intravenous infusions, 18% were intravenous injections, and 7% were subcutaneous injections. Errors associated with the oral administration route involved tablet/capsule (11%) and liquid oral formulations (9%). The researchers reported that omission of double checks, lack of safety barriers to intercept prescribing errors, and emergency/stress are the most frequent error enablers [11]. On the other hand, In a review conducted by Sherriff et. al., it is demonstrated that a large number of international papers have identified that many nurses lack sufficient skills to calculate drug dosages correctly, raising concern about the mathematical skills and preparedness of nurses and nurses` students to nursing practice [14].

In Jordan, a systematic review reported that medication prescribing errors were the most common errors in the clinical healthcare settings. The prevalence of prescribing errors ranged from 0.1% to 96%, where the prevalence of unintentional discrepancies ranged from 47% to 67.9%, and the prevalence of documentation errors ranged from 33.7% to 65% which reflects a wide variation in the error prevalence rates in Jordanian healthcare settings [15].

On the other hand, a recent study conducted in Jordan by Rabadi et. al. reported that nurses who had the lowest experience (0–5 years) were the highest in committing MEs. Otherwise, gender, age, and education were not significantly associated with MEs and the most common causes of medication error were setting the infusion devices incorrectly, distraction, labeling and packaging problems [16]. Another study conducted by Mrayyan et. al. in Jordan found that female nurses reported a higher number of medication errors than male nurses. The researchers concluded that gender was the only predictable factor of ME in Jordan [16].

Most studies that conducted in Jordan assessed the prevalence and nurses` knowledge, attitude, and perceived causes of medication errors. Calculation-related

errors and nurses` competencies are hardly investigated in the literature. To the best of our knowledge, this is the first study conducted in Jordan that assesses the nurses` competencies in medication calculation and the associated factors. Therefore, the purpose of the current study is to assess Jordanian nurses` competency regarding medication calculation and its associated factors

2. METHODS

2.1 *Study Design:*

A descriptive cross-sectional study design was used to assess the medication calculation skills of nurses in Jordan.

2.2 Study setting and population

This study was conducted in 3 different hospitals located in different in different governorates in Jordan. Participants were recruited from different departments of the hospitals mainly medical, surgical, intensive care unit (ICU), cardiac care unit (CCU), neonates, pediatrics, and emergency departments. Forty-two registered nurses were selected from each hospital using a convenient sampling technique making a total sample of 126 nurses.

Inclusion criteria are: (i) registered nurse with a diploma of three years, bachelor, or postgraduate degree in nursing. (ii) Having continuous work experience in the specified department for more than three months. The exclusion criteria are (i) any nurse with three or less than three months of continuous experience in the specified department. (ii) Part-time nurses. Or (iii) nurse did not complete the distributed questionnaire.

2.3 Data collection tool:

To measure nurses' competency toward medication dosage calculation, a tool was developed by experts in the nursing fields representing academicians and head nurses with more than 10 years of experience in their respective fields. The validity of the tool was assessed by ten experts representing different departments of nursing. Pilot testing was conducted to check the reliability of the tool for which Cronbach's alpha value was found to be 0.81.

2.4 Data collection

The Nursing Medication Calculation Competency Tool (NMCCT) consists of four sections; **section I:** 12 items assess nurses' demographic data: including but not limited to if the nurse received any mathematical education during his/her nursing program education, availability of medication calculation competency program at his/her hospital, if the nurse attend any medication calculation course/ program after graduation, availability of medication administration guidelines at the hospital, and how the participating nurse rate himself/herself in medication calculations. **Sections II-IV:** are twelve open-ended medication calculation questions that measure nurses' competency in different dosage forms. **Section II** (four questions): access nurses' competency in oral medication dosage calculation. **Section III** (four questions): access nurses' competency in parenteral/intravenous medication dosage calculation. **Section IV** (four questions): access nurses' competency in intravenous flow rate calculation. The range of score of section II-IV is 0-12 (if answered correctly, the nurse will receive 1 grade, but if answered wrong, the nurse will receive zero grade). If the nurse

answered all four questions in the selected section correctly, then he/she is considered competent in that section. Otherwise, the nurse is considered noncompetent in that section. Furthermore, the nurse is considered competent in medication dosage calculation if he/she is competent in the three domains of the tool.

Data was collected from nurses working in different hospitals in Jordan. Participants were reached at the hospitals and were briefed about the research study by the principal researcher. Those nurses who were ready to participate in the study were asked to read the informed consent thoroughly and give formal consent for participation. Questionnaires were self-administered by the participants and were collected from the respondents after completion. After data collection, data entry was done on a Microsoft Office Excel sheet.

2.5 Data analysis:

The categorical variables are presented as absolute numbers and percentages. Continuous variables are presented as mean ± Standard Deviation (SD). Differences in the numbers of competent nurses and noncompetent nurses in relation to different demographics were assessed by the Chi-square test of independence or Fisher's-exact test as appropriate. In contrast, the chi-square goodness-of-fit test was used to assess the difference between the studied categorical variables vs. pre-identified value. A post hoc chi-square test using Bonferroni corrected p-value was utilized to determine the exact pair responsible for the significance as appropriate. All conducted tests were two-tailed and considered significant when p-value <0.05. No imputations were made for missing data points. All data used in the study were analyzed using SPSS 25.0 (IBM SPSS Statistics for Windows, Version 25.0 IBM Corp., Armonk, NY, USA).

2.6 Ethical consideration:

Research approval for the current study was obtained from the Ethical Committee of Al-Balqa Applied University (Ref. No. 26/03/01/2280, Date: 21/11/2023). Also, ethical approvals were obtained from IRB committees of all participating hospitals before the questionnaire distribution and data collection process. Participation in the study was voluntary. Formal informed consent was received from the participants assuring anonymity and confidentiality of their responses. Data was collected during October 2023 - Feb 2024.

3. RESULT

3.1 *Demographical data of sample:*

A total of 152 questionnaires have been distributed in the participating hospitals and 133 have been retrieved with retrieval percent equal to 87.5%. Among retrieved questionnaires, 7 have been excluded due to incomplete demographic data which keeps 126 questionnaires for analysis. Incomplete or missing calculations are considered as wrong answers and were included in the analysis.

Out of 126 nurses who filled out the questionnaire, 53.2% of them were female (n= 59). However, there was no significant difference between males and females in terms of participation. Most of the nurses were younger than 35 years (n=82, 62.7%) and 86.5% of participated nurses have a bachelor's degree in nursing (n= 109). 94 (75%) nurses reported having an experience of 15 years or less. Regarding the working department, ICU/CCU nurses represented the largest participating nurses (34.9 %),

followed by ER nurses, medical-surgical, neonates, and pediatric department nurses. Results showed that 95% of participated nurses (n=120) did not receive any mathematical education during their university nursing program education and 84.9 % (n=107) reported absence of a medication calculation competency program at their respective hospitals. 113 nurses (89.7%) did not attend any medication calculation courses/programs after graduation and 90.5% of participated nurses reported unavailability of medication administration guidelines at their hospitals which can be checked when needed. Detailed demographic data are presented in Table 1.

Table 1: Demographical data of the participating nurses

Parameter		n (%)	X^2 (*df*, N)	p-value
Demographical Data (n = 126)				
Gender	Male (n, %)	59 (46.8%)	X^2 (1, 126)= .508	.476
	Female (n, %)	67 (53.2%)		
Age group	≤ 25	31 (24.6%)	X^2 (4, 126)= 40.825	<0.001***
	26-35	48 (38.1%)		
	36-45	25 (19.8%)		
	46-55	17 (13.5%)		
	≥ 56	5 (4.0%)		
Academic level of nursing education	Diploma degree (3 years)	8 (6.3%)	X^2 (2, 126)= 160.333	<0.001***
	Bachelor's degree	109 (86.5%)		
	Postgraduate degree	9 (7.1%)		
Total years of experience as a nurse	≤ 5 years	47 (37.3%)	X^2 (3, 126)= 30.762	<0.001***
	6-15 years	47 (37.3%)		
	16- 25 years	18 (14.3%)		
	26- 35 years	14 (11.1%)		
Main work department	Emergency department	27 (21.4%)	X^2 (4, 126)= 30.587	<0.001***
	ICU/ CCU	44 (34.9%)		
	Medical/ Surgical department	31 (24.6%)		
	Neonates department	16 (12.7%)		
	Pediatric department	8 (6.3%)		
Main patients served	Neonates	42 (33.3%)	X^2 (2, 126)= .762	.683
	Pediatrics	38 (30.2%)		
	Adults	46 (36.5%)		
Did you receive any mathematical education during your nursing program education?	Yes	6 (4.8%)	X^2 (1, 126)= 103.143	<0.001***
	No	120 (95.2%)		
Do you have a continuous medication calculation competency program at your hospital?	Yes	19 (15.1%)	X^2 (1, 126)=61.460	<0.001***
	No	107 (84.9%)		
Did you attend any medication calculation courses/programs after graduation?	Yes	13 (10.3%)	X^2 (1, 126)= 79.365	<0.001***
	No	113 (89.7%)		
At your hospital, do you have medication administration guidelines that can be checked/ referred once needed?	Yes	12 (9.5%)	X^2 (1, 126)= 82.571	<0.001***
	No	114 (90.5%)		
How do you rate your medication calculation skills/ Capabilities	Poor	3 (2.4%)	X^2 (3, 126)= 107.968	<0.001***
	Fair	6 (4.8%)		
	Good	74 (58.7%)		
	Excellent	43 (34.1%)		

3.2 Level of medication calculations competency among nurses

Descriptive statistics revealed that the highest level of medication competency was obtained for oral medications (65.1%) followed by intravenous flow rate calculation (57.9%), then parenteral/intravenous medications calculation (48.9%). And 27.8% (n= 35) reported to be competent in the three aspects. Table 2. Figure 1.

Table 2: Level of medication calculations competency among nurses

	Non-competent (n, %)	Competent (n, %)
Oral medication	44 (34.9%)	82 (65.1%)
Parenteral/intravenous medication	65 (51.6%)	61 (48.4%)
Intravenous flow rate calculations	53 (42.1%)	73 (57.9%)
Overall medication calculation competency	91 (72.2%)	35 (27.8%)

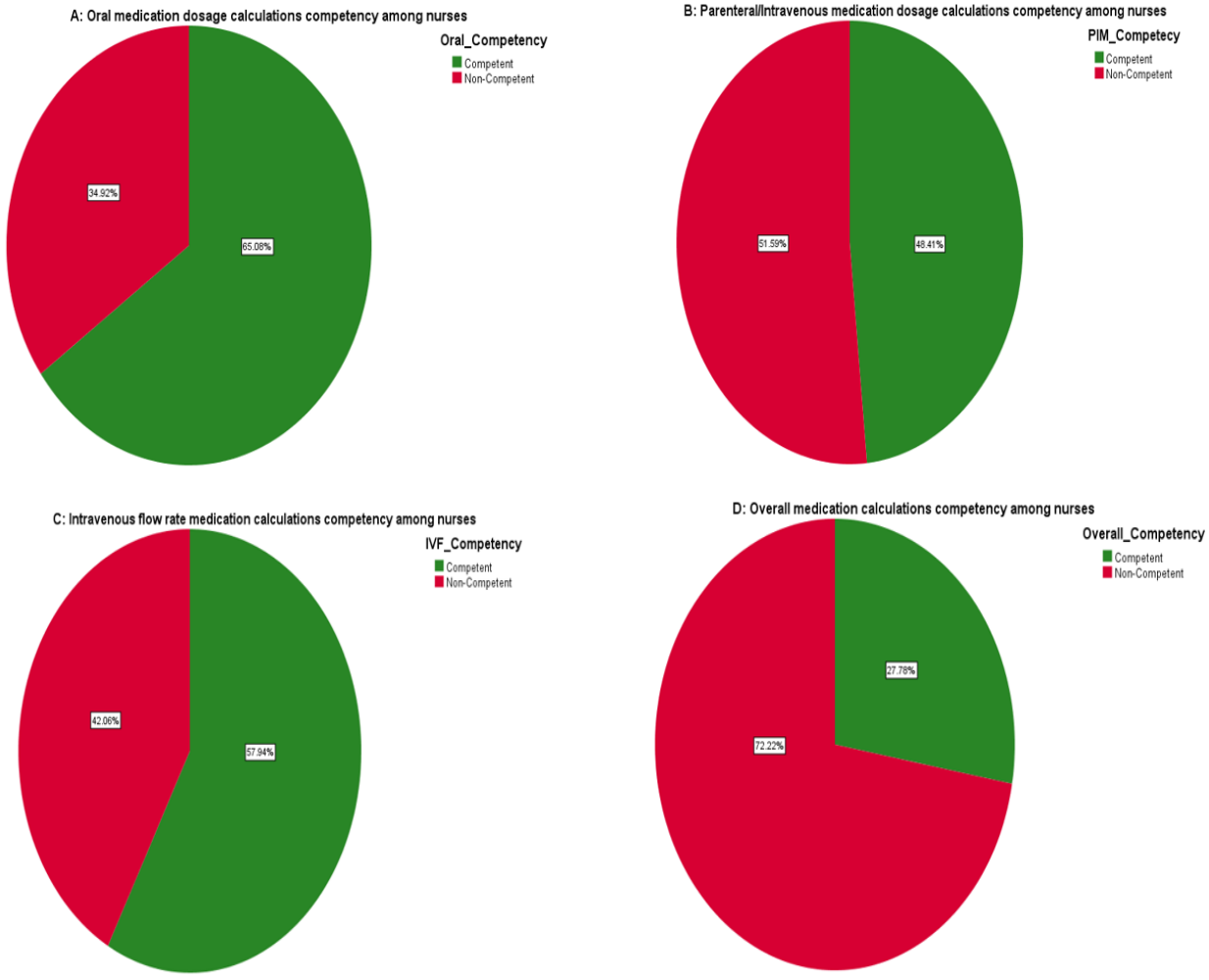

Figure 1: Level of medication calculations competency among nurses (A: oral medication; B: parenteral/ intravenous medication; C: intravenous flow rate; D: Overall medication calculation competency)

3.3 Oral medication dosage calculations competency

Bonferroni adjusted post hoc test revealed that nurses with age groups ≥ 59 years are statistically significant incompetent in oral medication dosage calculation (p= .0018). Furthermore, nurses who attended a medication calculation course/ program, after

graduation showed a statistically higher level of competency toward oral medication (p= 0.033).

On the other hand, there were no statistical differences in oral medication dosage calculation competency in terms of gender, academic level of nursing education, total years of experience, main work department, main patients served, receiving mathematical education during nursing program education, availability of continuous medication calculation competency program at participated hospitals, and availability of medication administration guidelines. Table 3

3.4 Parenteral/intravenous medication dosage calculations competency

Male nurses who attended medication calculation courses/ programs after graduation showed a significantly higher level of competency toward parenteral/intravenous medication dosage calculations (p=.03 and p<.001, respectively). However, other factors showed no significant impact on nurses' parenteral/intravenous medication dosage calculation competency. Table 3

3.5 Intravenous flow rate calculations competency

The person chi-square test revealed that the main work department has a significant effect on the nurses' competency in the intravenous flow rate calculation (P= .037). However, the Bonferroni adjusted post hoc test couldn't reveal the reason for this significance. On the other hand, other factors showed no significant impact on intravenous flow rate calculation competency. Table 3

3.6 Medications calculation competency among nurses

Based on the previously identified definition, the nurse is defined as competent in the medication calculation, if and only if s/he scored competent in the three elements (oral, parenteral, and intravenous flow rate).

The only factors that showed a significant impact on the total nurse's competency toward medication calculations were; the age of the participated nurse, the availability of medication calculation competency programs at the participated hospitals, and attending medication calculation courses/programs after graduation (p= .045, .013, and <.001, respectively).

In terms of nurses' age, we can notice a consistent decline in the nurses' competency toward medication calculation as the nurse gets older (except for the age group 36-45 years), with the maximum competency obtained with the age group 36-45 years.

While for availability of medication calculation competency programs at the participated hospitals, 8**2** (76.6 % of non-competent nurses) nurses reported having no continuous medication calculation competency program at their respective hospitals were noncompetent. Furthermore, 88 (77.9 % of non-competent nurses) didn't attend any medication calculation courses/programs after graduation. Table 4

Table 3: Comparison in medication calculation competency among nurses using different parameters.

.	Parameter		Non-competent (n, %)	Competent (n, %)	X^2 (*df*, N)[a]	p-value
Oral medication dosage calculation competency	Gender	Male (n, %)	19 (32.2%)	40 (67.8%)	X^2 (1, 126)= 0.360	0.579[a]
		Female (n, %)	25 (37.3%)	42 (62.7%)		
	Age group	≤ 25	11 (35.5%)	20 (64.5%)	X^2 (4, 126)=14.90	.004**[a]
		26-35	14 (29.2%)	34 (70.8%)		
		36-45	5 (20.0%)	20 (80.0%)		
		46-55	9 (52.9%)	8 (47.1%)		
		≥ 56	5 (100.0%)	0 (0.0%)		
	Academic level of nursing education	Diploma degree (3 years)	3 (37.5%)	5 (62.5%)		0.780[b]
		Bachelor's degree	39 (35.8%)	70 (64.2%)		
		Postgraduate degree	2 (22.2%)	7 (77.8%)		
	Total years of experience as a nurse	≤ 5 years	16 (34.0%)	31(66.0%)	X^2 (3, 126)=6.277	.102[a]
		6-15 years	14(29.8%)	33 (70.2%)		
		16- 25 years	5 (27.8%)	13 (72.2%)		
		26- 35 years	9 (64.3%)	5 (35.7%)		
	Main work department	Emergency department	11 (40.7%)	16 (59.3%)	X^2 (4, 126)=1.034	.909[a]
		ICU/ CCU	16 (36.4%)	28(63.6%)		
		Medical/ Surgical department	9 (29.0%)	22 (71.0%)		
		Neonates department	5 (31.3%)	11 (68.8%)		
		Pediatric department	3 (37.5%)	5 (62.5%)		
	Main patients served	Neonates	19 (45.2%)	23 (54.8%)	X^2 (2, 126)=5.267	.077[a]
		Pediatrics	8 (21.1%)	30 (78.9%)		
		Adults	17 (37.0%)	29 (63.0%)		
	Did you receive any mathematical education during your nursing program education?	Yes	3 (50.0%)	3 (50.0%)		.420[b]
		No	41 (34.2%)	79 (65.8%)		
	Do you have a continuous medication calculation competency program at your hospital?	Yes	4 (21.1%)	15 (78.9%)	X^2 (1, 126)=1.893	.201[a]
		No	40 (37.4%)	67 (62.6%)		
	Did you attend any medication calculation courses/programs after graduation?	Yes	1 (7.7%)	12 (92.3%)		.033*[b]
		No	43 (38.1%)	70 (61.9%)		
	At your hospital, do you have medication administration guidelines that can be checked/ referred once needed?	Yes	6 (50.0%)	6 (50.0%)		.340[b]
		No	38 (33.3%)	76 (66.7%)		
	How do you rate your medication calculation skills/ Capabilities	Poor	2 (66.7%)	1 (33.3%)		.182[b]
		Fair	0 (0.0%)	6 (100.0%)		
		Good	26 (35.1%)	48 (64.9%)		

		Excellent	16 (37.2%)	27 (62.8%)		
Parenteral/ intravenous medication dosage calculation competency	Gender	Male (n, %)	24 (40.7%)	35 (59.3%)	X^2 (1, 126)= 5.287	.032*[a]
		Female (n, %)	41 (61.2%)	26 (38.8%)		
	Age group	≤ 25	15 (48.4%)	16 (51.6%)	X^2 (4, 126)=2.021	.751[a]
		26-35	25 (52.1%)	23 (47.9%)		
		36-45	11 (44.0%)	14 (56.0%)		
		46-55	11 (64.7%)	6 (35.3%)		
		≥ 56	3 (60.0%)	2 (40.0%)		
	Academic level of nursing education	Diploma degree (3 years)	3 (37.5%)	5 (62.5%)		.631[b]
		Bachelor's degree	58 (53.2%)	51 (46.8%)		
		Postgraduate degree	4 (44.4%)	5 (55.6%)		
	Total years of experience as a nurse	≤ 5 years	25 (53.2%)	22 (46.8%)	X^2 (3, 126)=1.963	.601[a]
		6-15 years	21 (44.7%)	26 (55.3%)		
		16- 25 years	10 (55.6%)	8 (44.4%)		
		26- 35 years	9 (64.3%)	5 (35.7%)		
	Main work department	Emergency department	11 (40.7%)	16 (59.3%)	X^2 (4, 126)=3.903	.428[a]
		ICU/ CCU	25 (56.8%)	19 (43.2%)		
		Medical/ Surgical department	16 (51.6%)	15 (48.4%)		
		Neonates department	7 (43.8%)	9 (56.3%)		
		Pediatric department	6 (75.0%)	2 (25.0%)		
	Main patients served	Neonates	22 (52.4%)	20 (47.6%)	X^2 (2, 126) =3.830	.151[a]
		Pediatrics	15 (39.5%)	23 (60.5%)		
		Adults	28 (60.9%)	18 (39.1%)		
	Did you receive any mathematical education during your nursing program education?	Yes	2 (33.3%)	4 (66.7%)		.429[b]
		No	63 (52.5%)	57 (47.5%)		
	Do you have a continuous medication calculation competency program at your hospital?	Yes	7 (36.8%)	12 (63.2%)	X^2 (1, 126) =1.948	.214[a]
		No	58 (54.2%)	49 (45.8%)		
	Did you attend any medication calculation courses/programs after graduation?	Yes	1 (7.7%)	12 (92.3%)	X^2 (1, 126) =11.183	<.001***[a]
		No	64 (56.6%)	49 (43.4%)		
	At your hospital, do you have medication administration guidelines that can be checked/ referred once needed?	Yes	5 (41.7%)	7 (58.3%)	X^2 (1, 126) =.523	.552[a]
		No	60 (52.6%)	54 (47.4%)		
	How do you rate your medication calculation skills/ Capabilities	Poor	1 (33.3%)	2 (66.7%)		.928[b]
		Fair	3 (50.0%)	3 (50.0%)		
		Good	38 (51.4%)	36 (48.6%)		
		Excellent	23 (53.5%)	20 (46.5%)		

Intravenous flow rate calculation competency	Gender	Male (n, %)	26 (44.1%)	33 (55.9%)	X^2 (1, 126)= .183	.720[a]
		Female (n, %)	27 (40.3%)	40 (59.7%)		
	Age group	≤ 25	16 (51.6%)	15 (48.4%)	X^2 (4, 126)=6.545	.163[a]
		26-35	24 (50.0%)	24 (50.0%)		
		36-45	7 (28.0%)	18 (72.0%)		
		46-55	5 (29.4%)	12 (70.6%)		
		≥ 56	1 (20.0%)	4 (80.0%)		
	Academic level of nursing education	Diploma degree (3 years)	2 (25.0%)	6 (75.0%)		.576[b]
		Bachelor's degree	48 (44.0%)	61 (56.0%)		
		Postgraduate degree	3 (33.3%)	6 (66.7%)		
	Total years of experience as a nurse	≤ 5 years	18 (38.3%)	29 (61.7%)	X^2 (3, 126)=5.939	.116[a]
		6-15 years	17 (36.2%)	30 (63.8%)		
		16- 25 years	8 (44.4%)	10 (55.6%)		
		26- 35 years	10 (71.4%)	4 (28.6%)		
	Main work department	Emergency department	7 (25.9%)	20 (74.1%)	X^2 (4, 126)=10.100	.037*[a]
		ICU/ CCU	15 (34.1%)	29 (65.9%)		
		Medical/ Surgical department	18 (58.1%)	13 (41.9%)		
		Neonates department	10 (62.5%)	6 (37.5%)		
		Pediatric department	3 (37.5%)	5 (62.5%)		
	Main patients served	Neonates	18 (42.9%)	24 (57.1%)	X^2 (2, 126)=.153	.948[a]
		Pediatrics	15 (39.5%)	23 (60.5%)		
		Adults	20 (43.5%)	26 (56.5%)		
	Did you receive any mathematical education during your nursing program education?	Yes	4 (66.7%)	2 (33.3%)		.238[b]
		No	49 (40.8%)	71 (59.2%)		
	Do you have a continuous medication calculation competency program at your hospital?	Yes	5 (26.3%)	14 (73.7%)	X^2 (1, 126)=2.277	.207[a]
		No	48 (44.9%)	59 (55.1%)		
	Did you attend any medication calculation courses/programs after graduation?	Yes	2 (15.4%)	11 (84.6%)	X^2 (1, 126)=4.234	.072[a]
		No	51 (45.1%)	62 (54.9%)		
	At your hospital, do you have medication administration guidelines that can be checked/ referred once needed?	Yes	5 (41.7%)	7 (58.3%)	X^2 (1, 126)=.001	1.000[a]
		No	48 (42.1%)	66 (57.9%)		
	How do you rate your medication calculation skills/ Capabilities	Poor	1 (33.3%)	2 (66.7%)		.641[b]
		Fair	1 (16.7%)	5 (83.3%)		
		Good	31 (41.9%)	43 (58.1%)		
		Excellent	20 (46.5%)	23 (53.5%)		

[a] Person Chi-Square test; [b] Fisher's Exact Test

* *p*<0.05 is statistically significant; **p<0.01 is statistically very significant; ***p<0.001 is statistically extremely significant

Table 4: Overall medication calculations competency among nurses using different parameters.

Parameter		Non-competent (n, %)	Competent (n, %)	X^2 (*df*, N)[a]	p-value
Gender	Male (n, %)	40 (67.8%)	19 (32.2%)	X^2 (1, 126)= 1.083	.325[a]
	Female (n, %)	51 (76.8%)	16 (23.9%)		
Age group	≤ 25	21 (67.7%)	10 (32.3%)		.045*[b]
	26-35	35 (72.9%)	13 (27.1%)		
	36-45	14 (56.0%)	11 (44.0%)		
	46-55	16 (94.1%)	1 (5.9%)		
	≥ 56	5 (100.0%)	0 (0.0%)		
Academic level of nursing education	Diploma degree (3 years)	5 (62.5%)	3 (37.5%)		.824[b]
	Bachelor's degree	79 (72.5%)	30 (27.5%)		
	Postgraduate degree	7 (77.8%)	2 (22.2%)		
Total years of experience as a nurse	≤ 5 years	34 (72.3%)	13 (27.7%)	X^2 (3, 126)=7.035	.068[a]
	6-15 years	30 (63.8%)	17 (36.2%)		
	16- 25 years	13 (72.2%)	5 (27.8%)		
	26- 35 years	14 (100.0%)	0 (0.0%)		
Main work department	Emergency department	16 (59.3%)	11 (40.7%)	X^2 (4, 126)=5.297	.263[a]
	ICU/ CCU	30 (68.2%)	14 (31.8%)		
	Medical/ Surgical department	25 (80.6%)	6 (19.4%)		
	Neonates department	13 (81.3%)	3 (18.8%)		
	Pediatric department	7 (87.5%)	1 (12.5%)		
Main patients served	Neonates	30 (71.4%)	12 (28.6%)	X^2 (2, 126)=3.116	.217[a]
	Pediatrics	24 (63.2%)	14 (36.8%)		
	Adults	37 (80.4%)	9 (19.6%)		
Did you receive any mathematical education during your nursing program education?	Yes	5 (83.3%)	1 (16.7%)		1.000[b]
	No	86 (71.7%)	34 (28.3%)		
Do you have a continuous medication calculation competency program at your hospital?	Yes	9 (47.4%)	10 (52.6%)	X^2 (1, 126)=6.889	.013*[a]
	No	82 (76.6%)	25 (23.4%)		
Did you attend any medication calculation courses/programs after graduation?	Yes	3 (23.1%)	10 (76.9%)		<.001***[b]
	No	88 (77.9%)	25 (22.1%)		
At your hospital, do you have medication administration guidelines that can be checked/ referred once needed?	Yes	9 (75.0%)	3 (25.0%)		1.000[b]
	No	82 (71.9%)	32 (28.1%)		
How do you rate your medication calculation skills/ Capabilities	Poor	2 (66.7%)	1 (33.3%)		.301[b]
	Fair	3 (50.0%)	3 (50.0%)		
	Good	57 (77.0%)	17 (23.0%)		
	Excellent	29 (67.4%)	14 (32.6%)		

[a] Person Chi-Square test; [b] Fisher's Exact Test
* *p*<0.05 is statistically significant; **p<0.01 is statistically very significant; ***p<0.001 is statistically extremely significant

4. DISCUSSION

Ozyazicioglu et al. reported that the ability of nurses to calculate and deliver the medications properly is a highly developed skill [17]. Based on the results of this research, there are many identified factors affecting medication calculation skills among nurses, which is considered one of the challenging issues in safe medication administration practice. Also, we focus on the factors that can improve nurses' medication calculation accuracy which will have a significant impact on decreasing medication errors [14, 18]. This research highlights the factors that may affect nurses' competency regarding medication calculation skills, whether demographic factors or work-related factors.

The present study revealed that 72.2 % of registered nurses failed the drug calculation ability, and 65.1% of nurses are competent in oral medication dosage calculations, followed by Intravenous flow rate medication calculations (57.9%), and then parenteral/ intravenous medication dosage calculations (48.4%). The results of this study were similar to previous studies found that nurses were more competent in tablet calculations and fluid dosage calculations than they did on drip rates [19, 20]. Although the highest level of competence was among nurses in emergency departments and critical care units (67% competency), the significance level couldn't be determined.

The current study showed that only 28% of nurses are competent, which is similar to McMullan et al. who reported that only 11% of registered nurses were competent in drug calculation test [21].

On the other hand, the current study found that the majority of nurses did not receive any mathematical education during their university nursing program education, didn't attend any medication calculation courses/ programs after graduation, and their respective departments didn't have any specific competencies about medication calculation which were in alignment with Mullan et al. and Elliott et al. studies who reported that the teaching and evaluation of medication calculation skills with frequent practice and assessment throughout the undergraduate program had shown a significant increase in nurses' calculating skills [21, 22]. Also, Fleming et al. study reported that 4% of nurses achieved a perfect score and 60% of nurses answered correctly, which attributed to the time spent by the nurses in learning these calculations in universities, as well as the time spent in hospital training on these skills [23]. However, there are still no international or national standards dictating how much or how little medication calculation should be covered in undergraduate nursing programs [21]. On the other hand, another study reported that only 45% of registered nurses in a university program did not pass the medication mathematics exam [21]. Accordingly, studies encouraged the nurses to take medication calculation courses/programs before graduation within the nursing curriculum or attend any training courses after graduation especially when they are at the top of their work in hospitals [21, 23]. Many studies have shown that nursing curricula and continuing education programs have insufficient teaching content regarding medication calculation skills, and they still focus on pharmacology knowledge rather than actual clinical practice [24-26]. Another suggested method to enhance medication calculation skills after graduation is by adopting hospital as well as national protocols in maintaining competencies in medication calculations. This suggestion is assessed by Tromp et al. who reported that applying such protocol reduced errors in the preparation and administration of intravenous medications significantly [27]. Nowadays, annual

medication calculation competency for nurses is part of Joint Commission International Accreditation requirements [28].

The results of this study might help in conducting an orientation program that provides training on medication calculation for the newly employed nurses, and a continuous education program for all nurses in all hospital wards, as well as might help in remodeling the nursing curriculum of nursing bachelor program at Jordanian universities to provide nurses with required medication calculation skills. This eventually may help in improving the level of competency of nurses regarding medication calculations, reducing the incidence of medication errors, and enhancing the quality of healthcare systems and patients' safety which is the ultimate goal of our healthcare institutions.

5. LIMITATIONS

The study limitations include a small sample size and the selected sample did not reflect all country regions. Also, the current study did not include nurses working in outpatient settings and clinics.

6. CONCLUSION

The present study revealed that nurse age, availability of continuous medication calculation competency programs, and attending medication calculation courses/ program after graduation are significantly associated with nurses' skills/competency regarding medication calculation. Accordingly, the study suggests that nursing curricula and continuing education programs should recognize pharmaceutical education including drug calculation skills as an essential part of their content. Furthermore, the researchers encourage the adoption of national wide learning/ competency program that is able to assess the level of competency, track gaps in medication calculation skills, and provide a supportive learning program in this aspect as needed. Further studies are needed to determine the exact causes of medication calculation incompetency between nurses rather than knowledge insufficiency.

Declarations

Ethics approval: The research was conducted in compliance with the ethical guidelines in Jordan and the ethical approval was obtained from the IRB committee of Al-Balqa Applied University and all participating hospitals and registered under (NO:26/03/01/2280),(NO:01/2023/4164) and (MBA20005).

Consent to participate: Written consent was obtained from the nurses, and they were assured of the confidentiality of their information.

Availability of data and materials: Data are contained within the article.

Competing interests: The authors declared no conflict of interest.

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Authors' contributions: Conceptualization: K.N.; Methodology and formal analysis: A.Q. AND L.H.; Data collection: H.H., M.K., AND S.A.; Writing the initial draft: A.Q., F.S., F.A., AND H.H.; Review and editing; A.Q., AND H.H.; Supervision and project administration: K.N.; Final approval: All authors.

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