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Medication Safety Competence and Its Related Factors among ICU Nurses: A Cross-Sectional Study

Mahin Roohani [1], Vajihe Mortazii [2], Mohammad Mahdi Mehrshad [3], Seyede Fatemeh Gheiasi [4*]

Abstract

Background: Medication Safety Competence (MSC) refers to the knowledge, skills, and attitudes needed to prevent medication errors. Assessing MSC in ICU nurses is essential due to high-risk medications and complex patient conditions.

Aim: The present study was conducted with aim to determine the MSC status and its related factors among nurses working in ICUs.

Method: This cross-sectional study was conducted in 2024 on 239 ICU nurses at teaching hospitals in Zanjan, Iran. Participants were recruited using a stratified random sampling. Data were collected through a demographic-occupational questionnaire and the MSC Scale (MSCS). Analysis of data was performed using SPSS software (version 16) and independent samples t-test, analysis of variance (ANOVA), multiple linear regression, Pearson's correlation coefficient, and chi-square test. $p<0.05$ was considered significant.

Results: The mean of MSC scores among the ICU nurses was 154.89 ± 13.50 (range: 114–180), indicating a satisfactory level of MSC according to the scale (151–180). Multiple regression analysis showed that rotating shifts (β= -5.118, $p=0.006$) and hospital type (β= 4.352, $p=0.027$) were significantly associated with MSC. Additionally, there was a weak but statistically significant correlation between MSC and total work experience (r= 0.130, $p=0.044$), suggesting that more experienced nurses may have slightly higher MSC.

Implications for Practice: ICU nurses demonstrated a satisfactory level of medication safety competence based on the average MSC score. Less experienced nurses and those working rotating shifts showed lower competence, indicating the need for targeted training and proper shift management.

Keywords: Intensive Care Units, Medication Safety Competence, Nurse, Patient Safety

1. Instructor of Medical Surgical Nursing, Department of Emergency and Critical Care Nursing, School of Nursing & Midwifery, Zanjan University of Medical Sciences, Zanjan, Iran
2. MSc of Nursing Student, Department of Emergency and Critical Care Nursing, School of Nursing & Midwifery, Zanjan University of Medical Sciences, Zanjan, Iran
3. General Physician, School of Medicine, Zanjan University of Medical Sciences, Zanjan,, Iran
4. Assistant Professor of Nursing, Department of Operating Room and Anesthesiology, School of Nursing and Midwifery, Zanjan University of Medical Sciences, Zanjan, Iran

* Corresponding Author Email: fatemeh.gheiasi@gmail.com

Introduction

In intensive care units (ICUs), due to their sensitive and complex nature, numerous incidents threaten patient safety, particularly during medication administration (1). Patients admitted to ICUs are more vulnerable to medication errors because of the high complexity of care, frequent use of high-risk medications, and the need for continuous monitoring, which can lead to serious consequences (2). Medication-related incidents also have financial and ethical implications, including prolonged hospital stays, increased mortality, and emotional stress for patients, their families, and healthcare professionals (3). Nurses play a central role in preventing these errors, as they are primarily responsible for administering medications and monitoring patients for side effects (4). Ensuring proper performance by ICU nurses is therefore essential to maintain medication safety and protect patients (5).

Medication safety competence (MSC) among nurses is considered a core component of healthcare quality (6). MSC refers to medication safety-related knowledge, attitudes, and skills applied by nurses in practice, which encompasses theoretical and cognitive knowledge, practical skills, and decision-making abilities (7, 8). According to Fleming's Safety Competence Framework, safety competence in healthcare professionals is achieved through the integration of knowledge, technical skills, safety attitudes, and situational decision-making, all of which directly align with the dimensions of MSC. This framework therefore provides the conceptual foundation for understanding how nurses develop and apply competencies that ensure safe medication practices (9). Research in the health sector indicates the inadequacy of medication safety conditions during patient care (10). In some studies, the MSC level among nurses has been reported to be moderate, far from an ideal status (6, 8). Existing evidence suggests that MSC in nurses is associated with factors such as age, work experience, education level, job title, and participation in medication safety training courses (11).

While some studies assessed MSC, evidence from Iran remains limited, as few studies have focused specifically on ICU nurses or examined individual and work-related factors affecting MSC. To address these gaps, the present study uses the MSC Scale, previously adapted and validated for nurses in Iran, to assess MSC among ICU nurses—a group at higher risk for medication errors. This study is innovative in Iran, as it is the first to apply the MSC Scale to ICU nurses and examine the factors influencing their competence. Therefore, evaluating MSC is not only a research necessity but also a strategic priority within the healthcare system. Therefore, evaluating MSC is not only a research necessity but also a strategic priority within the healthcare system. The findings of the present study provide valuable insights for policymakers and nursing managers, which can help in designing and formulating strategies for empowering nurses to enhance patient safety. Considering these challenges and the limited available evidence in the Iranian context, the present study was conducted with aims to assess MSC of ICU nurses and examine the demographic, professional, and work-related factors associated with MSC.

Methods

This cross-sectional study was conducted on 239 ICU nurses at Ayatollah Mousavi and Valiasr hospitals in Zanjan, Iran, from March to May 2025. The target population comprised all nurses working in various ICUs (Coronary Care Unit (CCU), Pediatric ICU (PICU), Neonatal ICU (NICU), open-heart, neurological, trauma, burn, and Emergency ICU (EICU) at Valiasr and Ayatollah Mousavi hospitals, both affiliated with Zanjan University of Medical Sciences (n = 300).

To ensure an adequate sample size, the calculation was based on the mean estimation formula for the MSC variable. Using parameters from Kim & Lee (2022) (12), which reported a standard deviation of 0.49, a confidence level of 95% ($\alpha = 0.05$, Z_{1}-$\alpha/2 = 1.96$), and a margin of error (d) of 0.065, the required sample size was estimated to be 230 participants. To improve precision and account for a potential 10% attrition, a final sample of 253 participants was considered. Ultimately, 239 nurses completed the questionnaires, providing sufficient statistical power for the planned analyses. The stratified random sampling was applied based on hospitals. The total population of ICU nurses was first divided into two homogeneous strata: Ayatollah Mousavi Hospital (8 ICUs) and Valiasr Hospital (3 ICUs). Using proportional allocation, the number of participants required from each hospital was determined according to the relative size of their ICU nursing staff. Within each stratum, using a complete numbered staff list and a computer-generated random number table (random.org). Nurses who met the inclusion criteria were selected through simple random sampling This procedure ensured

that all eligible nurses had an equal chance of selection while maintaining proportional representation of each hospital and its ICUs.

Nurses with at least a bachelor's degree and a minimum of one year of work experience in an ICU were included in the study. Incomplete or blank questionnaires were not included in the analysis. After obtaining the necessary permissions, the researcher visited the ICUs of Valiasr and Ayatollah Mousavi Hospitals across different shifts to distribute the questionnaires. Participants were briefly informed about the study objectives, methodology, and they were assured about the confidentiality of their data, and written consent was obtained prior to participation. Questionnaires were collected in person and any questions from participants were addressed as needed.

The questionnaires used in this study encompassed a demographic-occupational information questionnaire and the MSC Scale (MSCS). Data collection was conducted in person using self-report questionnaires. The demographic-occupational information questionnaire included questions about age, gender, marital status, education level, work experience, ICU work experience, shift work, participation in refresher courses, and employment status.

The MSCS was developed by Seomun and Park in Korea. This questionnaire consists of 36 items rated on a 5-point Likert scale ranging from never (1) to always (5). The tool included six factors, including medication management and patient assessment, improving safety issues in the medication process, management of influencing factors, safety risk management, multidisciplinary collaboration, and accountability as a professional nurse. In this scale, the score range is 36-180. Higher scores indicate better medication safety competence. A score of 36-90 denotes poor MSC, 91-150 indicates moderate MSC, and 151-180 shows satisfactory MSC. The MSCS used in this study was previously translated into Persian, culturally adapted, and psychometrically validated for use among Iranian nurses. Moreover, a Cronbach's alpha coefficient of 0.96 was reported (6, 13). The reliability of the MSCS was confirmed using the internal consistency method, yielding a Cronbach's alpha coefficient of 0.91.

The data were analyzed by SPSS software (version 16). The Kolmogorov-Smirnov test was employed to check the normal distribution of quantitative data. Data analysis was carried out using descriptive statistics (mean, standard deviation, frequency, and percentage) and statistical tests (independent samples t-test, analysis of variance (ANOVA), Pearson’s correlation coefficient, and chi-square). In cases where the ANOVA test was significant, pairwise comparison tests were conducted using the Least Significant Difference (LSD) pairwise comparison method. To identify the predictors of the MSC score, hierarchical multiple linear regression was used. Before administering the regression model, the basic assumptions, including the normality of the residual distribution, the linearity of the relationship between independent and dependent variables, the independence of errors, and the absence of multicollinearity were examined. The Variance Inflation Factor (VIF) and tolerance indices were utilized to assess multicollinearity. Ultimately, the coefficient of determination (R^2) and adjusted R^2 were employed to gauge the model's goodness of fit. $P<0.05$ was considered significant.

Ethical Consideration

This study was conducted after receiving approval from the Ethics Committee of Zanjan University of Medical Sciences (ethical code: IR.ZUMS.REC.1403.320). Research ethics principles were observed throughout all stages of the study. After being fully informed about the study's objectives, the participating nurses voluntarily joined the study, and written informed consent was obtained.

Results

A total of 14 questionnaires were not included in the analysis process due to unwillingness to cooperate and incomplete responses. Incomplete or blank questionnaires were excluded, resulting in a final analytic sample of 239 nurses. The participation and response rate of nurses was 94.50%. The majority of participating nurses were female (79.50%), married (78.20%), had a bachelor's degree (94.60%), permanent employment status (64.90%), worked at Ayatollah Mousavi Hospital (72.80%), adult ICU (AICU) nurses (22.60%), and had rotating work shifts (65.70%). The frequency distribution of demographic variables is presented in Table 1.

The mean of MSC scores among the ICU nurses participating in the study was 154.89 ± 13.50 (range: 114–180), indicating a relative diversity in MSC levels among the participants.

Table 1. Demographic-occupational information of participating nurses (n = 239)

Qualitative Variables	Frequency (Percentage)
Gender	
Male	49 (20.50)
Female	190 (79.50)
Marital status	
Single	52 (21.80)
Married	187 (78.20)
Education level	
Bachelor	226 (94.60)
Master	13 (5.40)
Employment status	
Temporary	28 (11.70)
Contractual	23 (9.60)
Fixed-term	33 (13.80)
Permanent	155 (64.90)
Hospital	
Mousavi	174 (72.80)
Valiasr	65 (27.20)
Ward	
ICU	46 (19.20)
CCU	44 (18.40)
AICU	54 (22.60)
CICU	24 (10.00(
NICU	39 (16.30)
PICU	17 (7.10)
EICU	15 (6.30)
Work shift	
Morning	39 (16.30)
Evening	23 (9.60)
Night	20 (8.40)
Rotational	157 (65.70)
Error report	
No	145 (60.70)
Yes	94 (39.30)
Refresher course	
No	73 (30.50)
Yes	166 (69.50)
Quantitative Variables	**Mean ± SD**
Age (year)	34.53 ± 6.61
Work experience (year)	10.95 ± 6.36
ICU work experience (year)	6.84 ± 5.11

ICU: Intensive Care Unit; CCU: Coronary Care Unit; AICU: Adult ICU; CICU: Cardiac ICU; NICU: Neonatal ICU; PICU: Pediatric ICU; EICU: Emergency ICU; SD: Standard deviation

An analysis of the MSC level classification showed that 62.80% of nurses (n=150) were in the 'satisfactory' level, while 37.20% (n=89) were within the 'moderate' level. No participants scored in the 'poor' level. These findings indicate that the overall MSC level among ICU nurses was favorable. The findings also revealed a statistically significant difference in the MSC levels of ICU nurses based on their hospital of employment (p=0.004) and work shifts (p=0.011). Additionally, a weak but statistically significant correlation was observed between MSC and total work experience (r = 0.130, p=0.044) (Table 2).

Multiple regression analysis was conducted to identify predictors of nurses' MSC scores. All demographic variables, including gender, marital status, education level, hospital of employment, ward of employment, work shift, total work experience, ICU work experience, error reporting, and refresher courses, were initially entered simultaneously into the model. A stepwise elimination method (p<0.05) was then applied to remove non-significant variables. The final model included

rotational work shifts and hospital of employment, which significantly explained the variance in MSC scores. Specifically, the rotational work shift had a significant negative effect (β = −0.18, b = −5.118, *p*=0.006), and nurses at Valiasr Hospital had higher MSC scores than those at Ayatollah Mousavi Hospital (β = 0.144, b = 4.352, *p*=0.027). The model accounted for 6.5% of the variance in MSC scores (R^2 = 0.065, Adjusted R^2 = 0.057, F (5.341) = 8.222, *p*=0.001) (Table 3).

Table 2. Comparison of nurses' mean scores for medication safety competence in demographic subgroups

Qualitative Variables	Mean ± SD	Test results	
		Statistic	*p*-value
Gender			
Male	153.28 ± 14.92	T=0.93	0.351
Female	155.31 ± 13.12		
Marital status			
Single	155.17 ± 13.78	T=0.16	0.867
Married	154.81 ± 13.46		
Education level			
Bachelor	154.65 ± 13.43	T= -1.17	0.243
Master	159.15 ± 14.53		
Employment status			
Temporary	154.42 ± 15.24	F=0.56	0.693
Contractual	156.91 ± 8.97		
Fixed-term	152.45 ± 11.30		
Permanent	155.20 ± 14.17		
Hospital			
Mousavi	153.36 ± 13.48	T= -2.90	0.004
Valiasr	158.98 ± 12.97		
Ward			
ICU	156.95 ± 13.66	F=1.07	0.380
CCU	156.97 ± 13.29		
AICU	155.27 ± 15.39		
CICU	150.29 ± 8.73		
NICU	154.76 ± 14.88		
PICU	151.64 ± 12.64		
EICU	152.46 ± 8.23		
Work shift			
Morning	158.17 ± 9.08	F=3.82	0.011 I-IV<0.025 III-IV<0.042
Evening	159.73 ± 12.60		
Night	159.25 ± 13.91		
Rotational	152.81 ± 14.11		
Error report			
No	155.28 ± 12.66	T=0.56	0.576
Yes	154.28 ± 14.76		
Refresher course			
No	153.64 ± 13.31	T= -0.95	0.343
Yes	155.44 ± 13.59		

Nurses' MSC	Pearson's Correlation Coefficient	Significance
Age (year)	0.107	0.098
Total work experience (year)	0.130	0.044
ICU work experience (year)	0.058	0.370

F: ANOVA test; T: Independent t-test

SD: Standard deviation; ICU: Intensive Care Unit; CCU: Coronary Care Unit; AICU: Adult ICU; CICU: Cardiac ICU; NICU: Neonatal ICU; PICU: Pediatric ICU; EICU: Emergency ICU; MSC: Medication safety competence; ANOVA: Analysis of variance

Table 3. The multiple regression model results for predicting the medication safety competence score variable

	Medication safety competence							
Variable	b	SE	B	t	P	CI (b) 95%	Tolerance	VIF
Fixed	157.07	1.66		94.59	0.0001	[153.82, 160.32]		
Rotational	-5.118	1.83	-0.18	-2.78	0.006	[-8.70, -1.52]	0.94	1.05
Hospital	4.352	1.96	0.144	2.22	0.027	[0.51, 8.19]	0.94	1.05
Model Statistics	Overall R^2 = 0.065; Adjusted R^2 = 0.057; F (5, 341) = 8.222; P = 0.001 Nurses' MSC = 157.074 – 5.118 × rotational + 4.352 × hospital							

MSC: Medication safety competence; b: Unstandardized beta; SE: standard error; β: Standardized beta; t: T-test statistic; p: Probability value; VIF: Variance Inflation Factor; R2: Coefficient of determination

Discussion

The purpose of the current study was to determine the MSC status and its related factors among ICU nurses. The medication safety competence (MSC) of ICU nurses in this study was satisfactory. These findings are consistent with previous Iranian research identifying medication safety as a core competency for ICU nurses. A qualitative study on newly recruited ICU nurses in Iran highlighted medication safety among essential competencies, emphasizing the importance of practical experience and knowledge for safe medication management (14). Similar results have been reported in previous research. In the study by Zhang et al. in China, nurses achieved comparable scores on the MSCS total and subscales (15).

The relatively favorable MSC observed among participants in the present study may be related to prior participation in refresher courses, although this factor was not formally evaluated. Despite the generally satisfactory level, some gaps in practice may still exist. Considering the complexity of ICU care, ongoing efforts are essential to strengthen nurses' knowledge, clinical reasoning, and decision-making in medication safety. Contrary to the findings of the present study, Lee et al. reported a moderate MSC level among ICU nurses (16). Moderate levels were also observed in other studies (6, 8, 12, 17). These differences are likely attributable to variations in the measurement tool, sample characteristics, or research setting.

Based on the findings of the present study, nurses' MSC levels varied depending on their hospital of employment and work shift. Additionally, a significant difference was observed between MSC levels and total work experience. This may indicate the role of individual, professional, and organizational factors in shaping and strengthening MSC in sensitive environments like ICUs. Medication safety is influenced by various factors, including a nurse's characteristics, skills and competencies, clinical processes, and the clinical environment (8).

The results of the present study regarding the hospital of employment demonstrated that the MSC levels of nurses working at Valiasr Hospital were significantly higher than those of nurses working at Ayatollah Mousavi Hospital. However, the proportion of nurses with high MSC levels was greater at Ayatollah Mousavi Hospital than at Valiasr Hospital. This difference could be attributed to the managerial structure, error reporting system, organizational support, and safety culture within the investigated hospitals. According to the results of Oh et al.'s study, nurses' MSC levels were positively correlated with their work environment. A positive work environment in the nursing profession through the implementation of structured policies, resource management, and systematic human resource development can culminate in enhanced MSC and improved nurse performance (18). A professional work environment with greater investments in innovation and training further supports professional performance. A high level of patient safety culture, an improved work environment, and a high degree of trust in management also seem to encourage nurses to utilize methods that reduce medication errors and provide higher-quality nursing care (19).

The findings of the current research regarding nurses' work shift patterns revealed that the MSC level was lower among nurses with rotating shifts than those with either morning or night shifts. This finding can be explained by the physiological and psychological consequences of a rotating shift

work. Rotating work shifts disrupt the circadian rhythm, leading to fatigue, reduced concentration, an increased likelihood of medication errors, and a decreases patient safety and care quality, particularly in ICUs (20). According to Kim et al.'s study, the MSC level was higher among nurses with fixed work shifts than in those with rotating work shifts; however, this difference was not statistically significant (12), which was contrary to the present study results. Possible reasons for this discrepancy could be attributed to differences in sample size, the research setting, and the organizational culture of the investigated hospitals. Aljuaid et al. reported a statistically significant relationship between work shifts and medication errors, such that the rate of medication errors was higher during night work shifts than day work shifts (21). The relationship between work shifts and the rate of medication errors was not directly assessed in the present study; however, the rate of medication errors is higher among nurses with lower MSC levels (8). Designing training programs for nurses on rotating work shifts, providing organizational support, and considering an appropriate work-rest balance can apparently help improve MSC.

According to the findings of the present study, the MSC level was higher among nurses with greater work experience, although the correlation was weak. This finding is likely attributable to their greater practical experience, exposure to diverse clinical situations, and enhanced knowledge of medications, administration processes, error recognition, and anticipation of adverse effects. Correspondingly, the results of Kazemi et al.'s study (22) suggest that the rate of medication errors is lower among nurses with high work experience. As shown in the studies by Kim et al. (12) and Oh et al. (18), there was no statistically significant association between nurses' MSC levels and their work experience, which was inconsistent with the results of the present study. In some work environments, work experience alone does not apparently lead to increased MSC levels unless it is accompanied by continuous training, participation in clinical decision-making, and ongoing feedback.

In total, high work experience and fixed work shifts (morning or night work shifts) are two key components in promoting nurses' MSC levels in clinical settings, particularly in ICUs. These results underscore the importance of paying attention to organizational factors, such as work shift scheduling and utilizing experienced personnel in sensitive wards like ICUs. Therefore, it is recommended that, in human resource policymaking, two effective strategies be taken into account for improving MSC, i.e., fixed work shifts and purposeful utilization of experienced nurses.

This study had some limitations. The cross-sectional design limits causal inference, and participants from only two hospitals may reduce generalizability. Voluntary, in-person questionnaire completion may have introduced self-selection bias. Despite these limitations, the study provides valuable insights into ICU nurses' medication safety competence.

Implications for practice

To strengthen medication safety competence (MSC) among ICU nurses, healthcare organizations should implement ongoing training programs, ensure managerial support, and enforce clear medication safety policies. Rotational work shifts should be structured to reduce potential negative effects on competence, and hospital-specific strategies can be developed to maintain consistent and safe nursing practices across units.

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Conflicts of interest

The authors declare that they have no competing interests.

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Authors' Contributions

V. M. was responsible for the design and implementation of the study, data collection, and drafting of the manuscript. MM.M. contributed to data collection and manuscript drafting. M. R. provided guidance in the study design, supervised the implementation of the study, and revised the manuscript. F.Gh contributed to the data analysis, review, and final editing of the article. All authors reviewed the final version of the article and take full responsibility for the accuracy and originality of its content.

Artificial Intelligence statement

We acknowledge the use of ChatGPT (Open AI) to improve the clarity and language of manuscript. All concepts, data, analysis, and conclusion were prepared and developed by the authors.

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