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RESEARCH ARTICLE

Intravenous Medication Errors Among ICU Nurses: Differences In Knowledge Attitudes And Behavior

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Abstract:

Background:

Intravenous (IV) medication errors can lead to serious complications for ICU patients. ICU nurses' knowledge, training, attitudes, and behaviors toward medication errors are insufficiently investigated.

Objectives:

This study aims at investigating knowledge, behaviors, training, and attitudes among ICU nurses during the preparation and administration of IV medications and examining their differences according to certain variables.

Methods:

A cross-sectional-correlational design was used in this study. A convenience sampling technique included 206 ICU nurses from different types of hospitals in Jordan. The knowledge, attitudes and behavior related to medication errors questionnaire were used to collect data. Descriptive statistics, t-test, Pearson correlation, and Kruskal-Wallis H test were used to analyze the data.

Results:

ICU nurses showed adequate knowledge regarding IV medication preparation and administration, with gaps in basic professional behaviors. About 81.6% of the ICU nurses considered dosage calculation of intravenous drugs to reduce preparation errors. 81.1% of respondents agreed that clinical skills about the safe management of drug therapy should be regularly evaluated. Only (87.9%) of the ICU nurses agreed that handwashing is necessary before drug preparation and administration. Despite that 90.8% received training related to the preparation and administration of IV medications during undergraduate study, about 23.3% didn't receive topics related to the preparation and administration of IV drugs treated during the POST-basic courses. This study showed a strong positive correlation between ICU nurses' knowledge, attitudes, and behaviors.

Conclusion:

Education is essential to nurses' feeling safe at administering medications, especially in critical care units, which may affect their attitudes and behaviors. Continuous education that meets the needs of nurses is essential, along with continuous monitoring and evaluation of clinical practices to maintain safe and efficient medication practices and reduce related errors.

Keywords: Attitudes, Behaviors, Errors, ICU nurses, Knowledge, Medication.

Article History

Received: March 2, 2022

Revised: March 16, 2022

Accepted: March 30, 2022

1. INTRODUCTION

A medication error is a mistake that could occur in any step of prescribing, transcribing, preparing, dispensing, or administering a medication, whether there is an adverse effect.

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However, it was found that most errors take place in the administration step [1]. Globally, medication errors have been associated with an annual cost of 42 billion US Dollars every year, and the impact of these errors has been greater on people living in developing countries [2]. The risk of medication errors is higher in critical care units (ICUs) compared to other areas of care, as patients in ICUs are more frequently to be

prescribed medications in a complex medical setting [1]. In addition, intravenous (IV) route medication errors are often more serious and contribute to more than half of medication error's adverse effects [3].

Several factors contribute to medication errors in the ICU that could be related to the patient's condition, providers, the medication itself, ICU environment, or organization [4]. For example, a patient's medical condition and age are important factors that might contribute to the risk of medication errors. However, the errors also might be strongly affected by the provider who prepares and administers the medication. Registered nurses are mostly the providers who are responsible for these tasks. A lack of ICU nurses' knowledge was a significant predictor of medication errors [5]. In addition, poor attitudes and behaviors toward the medication process, such as negligence, failure to follow guidelines, and malpractice, are associated with increased medication errors among ICU nurses [5].

In a study in Italy, nurses reported that a complex ICU environment might be the source of distraction that increases their medication errors [6]. Regarding their attitudes, most nurses indicated that incident reporting effectively controlled the problem [6]. However, those who attended a postgraduate course about preparing and administering IV medications showed decreased attitudes toward medication errors [6]. In another study in Italy, nurses also showed increased attitudes regarding the importance of procedures for reducing medication errors and training programs. However, the study did not show a significant effect of undergraduate education on the nurses' attitudes [7]. It seems that there is a need to examine these undergraduate and postgraduate courses and their effects on nurses' attitudes toward medication errors.

Studies that addressed knowledge, attitudes, and practices toward medication errors, specifically among nurses, are scarce in developing countries. A study in Saudi Arabia examined knowledge, attitudes, and practices toward reporting medication errors among physicians and nurses in a tertiary hospital and found that more than half of the providers had clear knowledge about medication errors and increased attitudes toward reporting these errors [8]. In addition, the study found that females and nurses had more positive attitudes toward reporting medication errors compared to males and physicians [8]. Apparently, most available literature addressed the prevalence and the consequences of IV medication errors in general. Research needs to study how nurses' knowledge, attitudes, and behaviors play a role in reducing ICU medication errors.

Nevertheless, little research has studied this critical problem in developing countries to help reduce its impact on health and economic systems. To our knowledge, no previous studies were conducted in Jordan to assess ICU nurses' knowledge, behaviors, training, and attitudes during the preparation and administration of IV medications. Therefore, this study aimed to investigate knowledge, behaviors, training, and attitudes among nurses in the ICU during the preparation and administration of IV medications and examine their differences according to certain variables.

2. MATERIALS AND METHODS

2.1. Design

A cross-sectional-correlational design was utilized.

2.2. Sampling and Settings

The study was conducted using online surveys distributed to ICU nurses working in Jordanian hospitals. There are four types of hospitals in Jordan; private hospitals represent 57% of total health services, public 28%, military hospitals 13%, and university-affiliated hospitals 2% (Ministry of Health, 2019). The study targeted ICU nurses in all health sectors in Jordan.

A convenience sampling technique included 206 ICU nurses from different types of hospitals. The inclusion criteria were being a registered nurse, currently working in an ICU, having been involved in preparing and administering IV fluids in the ICU in the last 2 years, and reading and understanding English.

2.3. Data Collection

Data collection began after obtaining ethical approval. Data were collected utilizing an electronic self-administered questionnaire using Google forms due to the COVID-19 pandemic. Convenient sampling using snowballing techniques was used to reach the target population. Also, nurses' social media groups were used to distribute the questionnaire.

The questionnaire contains a description that provides the participant with information about the study purpose, data collection procedure, and rights of the participants, followed by a consent statement that has to be checked for acceptance if the participant was willing to participate in the study before answering the instrument questions. The data collection process took place in the period between September and October 2020.

2.4. Ethical Considerations

Ethical approval was obtained from the Scientific Research Committee at the Faculty of nursing in Al-Ahliyya Amman University (approval number:1/2020-2021). The Helsinki Declaration has been followed for involving human subjects in the study. Participation was entirely voluntary, and nurses were assured that their responses would be confidential. The anonymity of the participants was ensured throughout the study. Data were secured in a password-protected computer. Permission was obtained from the authors to use the questionnaires.

2.5. Measures

The Knowledge, Attitudes, and Behavior (KAB) related to medication errors questionnaire was used in this study [5]. The questionnaire was valid and reliable in previous studies [5, 6, 9, 10]. For this study, expert researchers in the field assessed content validity, who reviewed questionnaire items and ensured their appropriateness to the study population. Cronbach's alphas for the seven knowledge, seven attitudes, and five behaviors subscales in the current study were 0.77, 0.86, and 0.89, respectively.

The questionnaire consisted of six sections: Demographic and personal characteristics, access to bibliography update

(four items), knowledge about the use of IV medications (seven items), attitudes on to the use of IV medications (seven items), behaviors on the preparation and administration of IV medications (five items), and perceived training needs (three items). Knowledge and behaviors were measured using a five-point Likert scale (ranging from disagree (1) to agree (5)), while the attitudes questions were measured using a three-point Likert scale (disagree (1), uncertain (2), and agree (3)). The higher the scores, the more agreement nurses have on the items.

2.6. Data Analysis

Descriptive statistics using central tendency and dispersion measures were used to describe the study's variables. Item

analysis was conducted using percentages and frequencies per scale. T-test, Kruskal-Wallis, and Pearson correlation were used to test differences and associations. Alpha set at 0.05.

3. RESULTS

3.1. Sociodemographic and Professional Characteristics

Two hundred and six ICU nurses completed the survey. The average age of the respondents was 31.5 years (\pm 8.9). Of the respondents, 60% were males, and 40% were females. The average nursing experience was 8.9 years (SD= 6.4). Most participants had a baccalaureate degree in nursing (79.1%) (Table 1).

Table 1. Sociodemographic and professional characteristics of the study sample.

Variables (N = 206)		n	%
Gender			
	Male	123	59.7
	Female	83	40.3
Hospital type			
	Private hospitals	107	51.9
	Governmental hospitals	57	27.7
	Educational hospitals	25	12.1
	Military hospital	17	8.3
Your educational level			
	Diploma degree	3	1.5
	Bachelor degree	163	79.1
	Master degree	36	17.5
	Ph.D. degree	4	1.9
Did you receive topics related to the preparation and administration of IV drugs treated during the basic courses?			
	Yes	187	90.8
	No	19	9.2
Did you receive topics related to the preparation and administration of IV drugs treated during the POST-basic courses			
	Yes	158	76.7
	No	48	23.3
Knowledge of the English language			
	Low	13	6.3
	Intermediate	68	33
	Good	84	40.8
	Excellent	41	19.9
Availability of the Internet in the workplace			
	Yes	156	75.7
	No	50	24.3
Availability of a library (also online) in the workplace			
	Yes	121	58.7
	No	85	41.3
Hours per week dedicated to continuing medical education			
	None	75	36.4
	<1	49	23.8
	1-5	66	32
	6-10	6	2.9
	>10	10	4.9

Table 2. ICU nurses' knowledge of IV medications.

Item	Disagree	Agree a little	Quite agree	Strongly agree	Totally agree
	n (%)	n (%)	n (%)	n (%)	n (%)
Knowledge					
Dosage calculation of intravenous drugs reduces preparation errors	5 (2.4)	2 (1)	31 (15)	44 (21.4)	124 (60.2)
A computerized provider order entry system (CPOE) reduces errors during the preparation phase.	10 (4.9)	8 (3.9)	54 (26.2)	59 (28.6)	75 (36.4)
Provision of pre-packaged packages by the pharmacy reduces medication errors risk	5 (2.4)	10 (4.9)	34 (16.5)	75 (36.4)	82 (39.8)
The availability of informative protocols, posters and brochures in the wards promotes the decrease of the error risk.	1 (.5)	7 (3.4)	34 (16.5)	67 (32.5)	97 (47.1)
The assistance of a pharmacist during drug preparation reduces the error risk.	8 (3.9)	10 (4.9)	35 (17)	70 (34)	83 (40.3)
Alarm noises and ward emergencies may cause distractions during drug preparation and administration.	12 (5.8)	15 (7.3)	56 (27.2)	71 (34.5)	52 (25.2)
Workload (double shifts, extra time) contributes to pharmacological therapy errors.	2 (1)	9 (4.4)	54 (26.2)	66 (32)	75 (36.4)

The majority of the respondents (90.8%) received training related to the preparation and administration of IV medications during undergraduate study, while 76.6% received training related to the preparation and administration of IV medications after graduating. The internet was available at the workplace for 57.7% of the respondents, while libraries at the workplace were available for 58.7%.

3.2. ICU Nurses' Knowledge

About 81.6% of the ICU nurses considered dosage calculation of IV medications reduces preparation errors (Strongly agree or totally agree). Also, 79.6% of them agreed that the availability of informative protocols, posters, and brochures in the wards promotes decreasing the error risk. Only 59.7% of the nurses believed that alarm noises and ward emergencies might cause distractions during medication preparation and administration (Table 2).

3.3. ICU Nurses' Attitudes

Regarding the attitudes of the ICU nurses toward IV medication errors, 81.1% agreed that clinical skills about the

safe management of drug therapy should be regularly evaluated. The second highest agreement between nurses was that ongoing and specific training on the safe management of IV medications could reduce the risk of errors (77.7%). On the other hand, only 73.3% considered the workers' motivation to improve their professional performance during the whole medication process. Table 3 shows these attitudes.

3.4. ICU Nurses' Behaviors

The highest percentage of ICU nurses agreed on the item "A check of vital signs before and after the vasoactive drug administration (dopamine, dobutamine, nitroglycerine, et) reduces complications," in which 88.8% were either strongly agreed or totally agreed. The two items "Hand-washing is necessary before the drug preparation and administration" and "Following the 8 R rule (right patient, right medication, right dose, right route, right time, right documentation, right reason, right response) reduces errors" were agreed by 87.9% of the nurses. The behavior that received the least agreement between ICU nurses was "Respecting the speed of infusion of the IV administrated solutions (such as chemotherapy, antibiotics, amines, heparin, etc.) reduces errors" (82.5%) (Table 4).

Table 3. Attitudes of ICU nurses toward IV medication errors.

Item	Disagree	Uncertain	Agree
	n (%)	n (%)	n (%)
Attitudes			
Ongoing and specific training on the safe management of IV drugs could reduce the risk of errors.	2 (1)	44 (21.4)	160 (77.7)
Awareness of the prevention of the errors and management of the clinical risk could reduce the errors during the preparation and administration phases of the drugs.	3 (1.5)	48 (23.3)	155 (75.2)
The motivation of the workers can improve their professional performance during the whole medication process.	4 (1.9)	51 (24.8)	151 (73.3)
For secure management of the entire managing process of IV drugs, some authoritative guidelines drawn up taking into account the available scientific evidence are necessary	3 (1.5)	48 (23.3)	155 (75.2)
Protocols/ guidelines/ procedures can affect professional behaviour, ensuring proper management of the therapeutic process.	3 (1.5)	46 (22.3)	157 (76.2)
Clinical skills about the safe management of drug therapy should be regularly evaluated.	3 (1.5)	36 (17.5)	167 (81.1)
Medication errors should be reported to become an opportunity to improve the care service.	3 (1.5)	48 (23.3)	155 (75.2)

Table 4. Behaviors of ICU nurses on the preparation and administration of IV medications.

Item	Disagree	Agree a little	Quite agree	Strongly agree	Totally agree
-	n (%)	n (%)	n (%)	n (%)	n (%)
Behaviors					
Handwashing is necessary before drug preparation and administration.	0 (0)	3 (1.5)	22 (10.7)	22 (10.7)	159 (77.2)
A check of vital signs before and after the vasoactive drug administration (dopamine, dobutamine, nitroglycerine, etc.) reduces complications.	0 (0)	3 (1.5)	20 (9.7)	27 (13.1)	156 (75.7)
Respecting the speed of infusion of the IV administrated solutions (such as chemotherapy, antibiotics, amines, heparin, etc.) reduces errors.	4 (1.9)	7 (3.4)	25 (12.1)	41 (19.9)	129 (62.6)
Following the 8 R rule (right patient, right medication, right dose, right route, right time, right documentation, right reason, right response) reduces errors.	0 (0)	3 (1.5)	22 (10.7)	32 (15.5)	149 (72.3)
Before administration, it is necessary to perform a double check to verify the right correspondence among prescription, preparation and administration of the IV drug.	1 (0.5)	5 (2.4)	23 (11.2)	47 (22.8)	130 (63.1)

3.5. Differences in ICU Nurses' Knowledge, Attitudes, and Behaviors toward Medication Errors according to Selected Variables

ICU nurses' knowledge significantly differed only according to hospital type ($\chi^2(3) = 12.61, p = 0.006$), with the highest mean rank for nurses who worked in military hospitals (MR= 119.38). Regarding ICU nurses' attitudes, there was a positive correlation between nurses' attitudes and their English competencies ($r = 0.28, n = 206, p < .001$). There was a statistically significant difference in ICU nurses' behaviors in preparing and administering IV medications according to the availability of library in the workplace ($t(202) = -2.367, P=0.019$), gender ($t(203) = -3.78, P<0.001$), and receiving training related to IV medications after graduating ($t(97) = -2.49, P=0.014$). Higher behavior scores were among nurses who don't have a library available in the workplace (M=23.31), female nurses (M=23.64), and ICU nurses who didn't receive training related to IV medications after graduating (M=23.62).

There was a statistically significant difference in ICU nurses' behaviors towards the preparation and administration of IV medications according to educational level ($\chi^2(3) = 8.67, p = 0.034$), with the highest mean rank for nurses who had Ph.D. or diploma qualified (MR=159). Moreover, there was a statistically significant difference in ICU nurses' behaviors according to hours per week dedicated to continuing medical education ($\chi^2(4) = 14.85, p = 0.005$), with the highest mean rank for nurses who received more than 10 hours per week (MR= 141.8). Interestingly, Pearson correlation showed strong and positive correlation between ICU nurses knowledge and attitudes ($r = 0.504, n = 206, p < .001$), knowledge and behavior ($r = 0.546, n = 206, p < .001$) and attitudes and behavior ($r = 0.496, n = 206, p < .001$).

4. DISCUSSION

The intravenous route is an essential method of drug administration that provides rapid action. Errors in the preparation and administration of IV medications have been reported frequently among ICU nurses [11], especially in the dilution and dose interval of antibiotics with an 8.15% error rate and in the dilution and infusion rate of high-risk medications with a 2.94% error rate [12]. Lack of knowledge by ICU nurses is associated with many medication errors. This

study investigated the ICU nurses' knowledge, behaviors, training, and attitudes during the preparation and administration of IV medications.

Regarding ICU nurses' knowledge, 81.6% of the nurses considered dosage calculation of IV medications reduces preparation errors; 79.6% of them agreed that the availability of informative protocols, posters, and brochures decrease the error risk; 59.7% believed that alarm noises and ward emergencies might cause distractions during preparation and administration, and 68.4% believed that workload contributes to these errors. In another study that examined Italian ICU nurses' knowledge of IV medications, the percentages of the previous measures were 92.6%, 90.8%, 80.5%, and 93.8%, respectively [6]. Compared to nurses in the previous study, nurses in the current study had an inadequate level of knowledge. Almost 80% of the nurses considered the availability of informative protocols, posters, and brochures in the wards to decrease the risk for medication errors. An interventional study that included ICU nurses from Iran found that educating nurses using wall posters and informative pamphlets regarding the correct preparation and administration of IV medications reduced the number of errors [11]. In the current study, 68.4% believed that workload contributes to medication errors. Similarly, another study that examined the frequency and causes of medication errors in ICU found that nurses considered 51.5% of the errors were associated with work conditions [13]. The availability of standardized protocols could decrease errors and improve the safety and efficiency of medication administration. A study in Australia found a significant variation in the preparation of IV medications across the ICUs. In this study, nurses suggested that pre-prepared infusions and standardization improve practice [14].

Positive attitudes can reduce errors during the preparation and administration phases of medications. In this study, 81.1% of the nurses agreed that clinical skills about the safe management of drug therapy should be regularly evaluated, and 77.7% of the nurses agreed that ongoing and specific training on the safe management of IV medications could reduce the risk of errors. Compared to nurses' attitudes in another study, where 86% of the nurses agreed that frequent training and continuous evaluation of clinical skills regarding

IV medications could reduce errors, nurses in the current study had a lower level of attitude [6]. About 77.7% believed that ongoing and specific training on the safe management of IV medications could reduce the risk of errors. Nurses in the current study had more negative attitudes compared to another study where 90.2% of the sample considered improving their knowledge about IV drug preparation and administration fundamental to reducing medication errors [6].

Regarding behaviors on administering IV medications, 88.8% believed they should check vital signs before and after administering vasoactive drugs. Interestingly, only 87.9% adopted aseptic behaviors and the 8 R rule in drug administration, and only 82.5% of the nurses adhered to the infusion rate when administering IV medications. In another study of ICU nurses, nearly all the nurses adopted these fundamental handwashing behaviors, and more than 97% respected the infusion rate of IV medications and checked vital signs before and after vasoactive drug administration [6]. Behaviors of nurses in the current study regarding drug preparation and administration present a gap in basic professional behaviors. The dilution of IV medication to achieve the proper concentration of the drug and calculating the infusion rate of IV medications are essential competencies that ICU nurses should have [12]. Only 87.9% of the nurses in our study followed the 8 R rule when preparing and administering medications. According to another study, the most common IV medication administration errors were the wrong medication, the wrong dose, and the wrong infusion rate errors [13]. Unfortunately, only 82.5% of the nurses considered respecting the IV infusion rate reduces medication errors. In a study conducted to evaluate medical errors among ICU nurses, the most common type of medication error was an infusion rate [15]. We found that these incorrect IV medication preparation and administration behaviors were associated with an unacceptable level of knowledge and attitude.

Although 76.6% of the nurses reported receiving topics related to the preparation and administration of IV medications after graduation, 60.2% received less than an hour per week of continuous education. This means that most nurses in this study received insufficient continuous education hours. Nurses who received more than 10 hours per week of continuous education had significantly more correct IV medication preparation and administration behaviors. This finding is alarming as adequate knowledge is essential in decreasing medication errors. Nursing education was one of the interventions that reduced medication errors [16].

4.1. Implications

Since administering medication is an essential responsibility of the nurse, nurse educators need to build more substantial pharmacology knowledge for nursing students to prevent medication errors in the long term. Also, sufficient continuous training after graduation is essential, along with standardized protocols available for all nurses. Beside these measures, continuous monitoring of nurses' skills in preparing and administering medications could identify gaps in practice and provide a window for improvement. This study included young nurses; further studies include older nurses to investigate

the role of experience are needed.

CONCLUSION

Nurses had inadequate knowledge and attitudes regarding IV medication preparation and administration. Nurses lacked some fundamental professional behaviors essential to prevent medication errors. Continuous education that meets the needs of nurses is essential, along with continuous monitoring and evaluation of clinical practice. This study has some limitations to be addressed. The cross-sectional design used limits the ability to detect causal relationships. Moreover, the use of self-reported questionnaires that relies on the nurses' responses regarding their knowledge, skills, and behaviors may limit the generalizability of the findings; for example, nurses reporting as "I am very competent" may not reflect being proficient in the administration of IV medications which necessitates future observational studies. Also, the convenient snowballing and online recruitment method used to select the sample could have led to selection bias.

LIST OF ABBREVIATIONS

(ICU)	=	Intensive Care Units
KAB	=	Knowledge, Attitudes, and Behavior
IV	=	Intravenous

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Scientific Research Committee at the Faculty of nursing in Al-Ahliyya Amman University (approval number:1/2020-2021).

HUMAN AND ANIMAL RIGHTS

No animals were used for studies that are the basis of this research. All the humans used were in accordance with the Helsinki Declaration of 1975.

CONSENT FOR PUBLICATION

Informed consent has been obtained from the participants involved.

STANDARDS OF REPORTING

Strobe guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available within the article.

FUNDING

No funds were received from any agency or institution.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest to disclose.

ACKNOWLEDGEMENTS

Declared none.

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