Review Article

Medication Errors among Iranian Intensive Care Nurses: A Systematic Review

Abstract

Background: Medication Error (ME) is a major patient safety concern in Intensive Care Units (ICUs). Critical care nurses play a crucial role in the safe administration of medication. This study was conducted to comprehensively review the literature concerning the prevalence of ME and associated factors and outcomes in Iranian ICU nurses. **Materials and Methods:** An extensive search of the literature was carried in international databases including PubMed, Web of Science, Scopus, and Google Scholar, as well as Persian databases such as Magiran and Scientific Information Database (SID) using ME-related keywords and the Persian equivalent of these keywords, from the first article written in this field to artcles published on March 30, 2021. The appraisal tool (AXIS tool) was used to assess the quality of the included studies. **Results:** Fifteen studies were included in this systematic review. The prevalence of MEs made by ICU nurses was 53.34%. The most common types of MEs were wrong infusion rate (14.12%), unauthorized medication (11.76%), and wrong time (8.49%) errors, respectively. MEs occurred more frequently in morning work shifts (44.44%). MEs happened more frequently for heparin, vancomycin, ranitidine, and amikacin. The most important influential factor in the occurrence of MEs in ICUs was management and human factors. **Conclusions:** The prevalence of MEs made by Iranian ICU nurses is high. Therefore, nurse managers and policymakers should develop appropriate strategies, including training programs, to reduce the occurrence of MEs made by nurses in ICUs.

Keywords: *Intensive care units, Iran, medication errors, nurses, systematic review*

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Introduction

Patient safety is still a major challenge and the most important concern in the world's health systems.[1–3] Medication Error (MEs) are one of the most important factors that could jeopardize a patient's safety. According to the World Health Organization (WHO), MEs are the second most common factor that threatens patient safety.[3]

Patients admitted to the Intensive Care Units (ICU) are more vulnerable to MEs than patients in the other units because of high complexity of care, frequent use of high-risk medications, and patients' altered end-organ function which can affect a drug's pharmacokinetics and pharmacodynamics.[4,5] The occurrence of MEs is associated with an increased risk of several adverse outcomes in critically ill ICU patients. Previous evidence has shown that the prevalence of MEs in the ICU ranges between 9.4% and 73.43%.[4,6–8] Moreover, it has been revealed that MEs are responsible for 78% of all serious medical errors in the ICU.[9]

Nurses play a key role in the care of patients, management of drug measures, and improvement of patient safety due to their spending more time with critically ill ICU patients.[10,11] The nurses are primarily responsible for medication administration and they usually spend about 40% of their time on it.[12] The assessment of the pattern, prevalence, and factors associated with MEs made by critical care nurses can help nurse managers develop innovative solutions for,

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define a clear strategy for reducing the incidence of, and prevent potential negative outcomes of MEs among critically ill ICU patients. Therefore, this systematic review was conducted focusing on prevalence, factors, and outcomes associated with MEs made by ICU nurses in the context of Iranian healthcare.

Materials and Methods

This systematic review was carried out based on Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines for identification, screening, and eligibility of the studies.[13]

An extensive search was conducted in electronic databases including MEDLINE/PubMed, Web of Science, Scopus, and Google Scholar, as well as Persian databases such as Magiran and Scientific Information Database (SID) using related keywords such as "medication error", "prescribing error", "medication incidents", "medication administration error", "drug administration error", "drug error", "nurses", "nursing", "intensive care unit", "ICU", "critical care", and "Iran" and the Persian equivalent of these keywords, from the first article written in this field to those published on March 30, 2021. Medical Subject Headings (MeSH) was used to extract target-related keywords. The language of the studies was limited to Persian and English. The search strategy of the databases is presented in the selection process of studies was conducted by two researchers (ZH and MG), independently. In case of disagreement between the researchers as to whether a study met the eligibility criteria, a third researcher (AE) appraised the study and then selected or rejected it by consensus. The gray literature was not actively searched because they usually do not portray the whole picture of the results, and when fully published the results may change substantially.

EndNote X8 software was used to manage the included studies. In the first step, the researchers excluded duplicate studies electronically and manually. Then, according to the inclusion and exclusion criteria, the title and abstract of the studies were screened. Finally, the researchers screened the full-text of eligible articles. Also, the researchers screened a list of included study references for any relevant references missing in the database search. The study selection process was conducted by two researchers (SP and WJ) independently. In case of disagreement between researchers as to whether a study met the eligibility criteria, the third researcher (SK) appraised the study and then selected or rejected it by consensus.

The inclusion criterion was published original articles focusing on the prevalence and factors related to ME made by Iranian ICU nurses. The researchers excluded studies such as case reports, experimental studies, editorial letters, conferences, and reviews. Also, studies that evaluated ME made by nurses working in the Pediatric Intensive Care Unit (PICU) or Neonatal Intensive Care Unit (NICU) were excluded. The corresponding authors were contacted for articles with no access to their full text or for articles that were missing relevant data. In case of non-response of the corresponding author, the study was removed.

Information such as the first author's name, year of publication, location, design, sample size, male-to-female ratio, age, overall work experience and ICU, type of work shift, type of drug key results, including factors and outcomes associated with MEs, and total prevalence of ME were extracted from included studies using a predesigned extraction form. The appraisal tool for cross-sectional studies (AXIS tool)[14] was used to assess the quality of the included studies. AXIS evaluates the quality of studies using 20 items with a two-point Likert, including "yes" (score of 1) and "no" (score of 0). This tool evaluates report quality (seven items), study design quality (seven items), and the possible introduction of biases (six items). Finally, AXIS rates the quality of studies at three levels: high (70% to 100%), fair (60% to 69.9%), and low (0% to 59.9%).[14] Data extraction and quality assessment were performed by two researchers (ZH and AE), independently. In case of disagreement between researchers as to whether a study met the eligibility criteria, the third researcher (SK) appraised the study and then selected or rejected it by consensus. At this stage, factors associated with MEs made by ICU nurses were divided into subgroups of management and human, environmental, drug-related, and demographic factors [Table 2]. Finally, the available evidence was summarized based on the research question.

Ethical considerations

The protocol of this study was approved by the institutional ethics committee of Mazandaran University of Medical Sciences (IR.MAZUMS.REC.1399.8597). The authors avoided plagiarism in any form in writing the present study. The results of the analysis were quite honest. The authors avoided data fabrication. They never manipulated the data for their benefit.

Results

Study selection

A total of 908 studies (MEDLINE/PubMed = 99, Web of Science = 109, Scopus = 50, Google Scholar = 529, Magiran = 96, and SID = 25) were yielded by database search and 4 studies by evaluating the reference list of included studies. After excluding duplicate articles, 602 studies remained. Then, after screening the title and abstract of the articles 372 studies were removed due to inconsistencies with the purpose of the present study, and 171 studies were removed due to the non-cross-sectional nature of the studies. After screening the full text of 55 studies, 25 articles were removed due to inappropriate study design or outcomes, and 15 articles were removed due to lack of relevant information. Finally, 15 studies[7,8,15–27] were included in this systematic review. Flow diagram of the study selection process is presented in Figure 1.

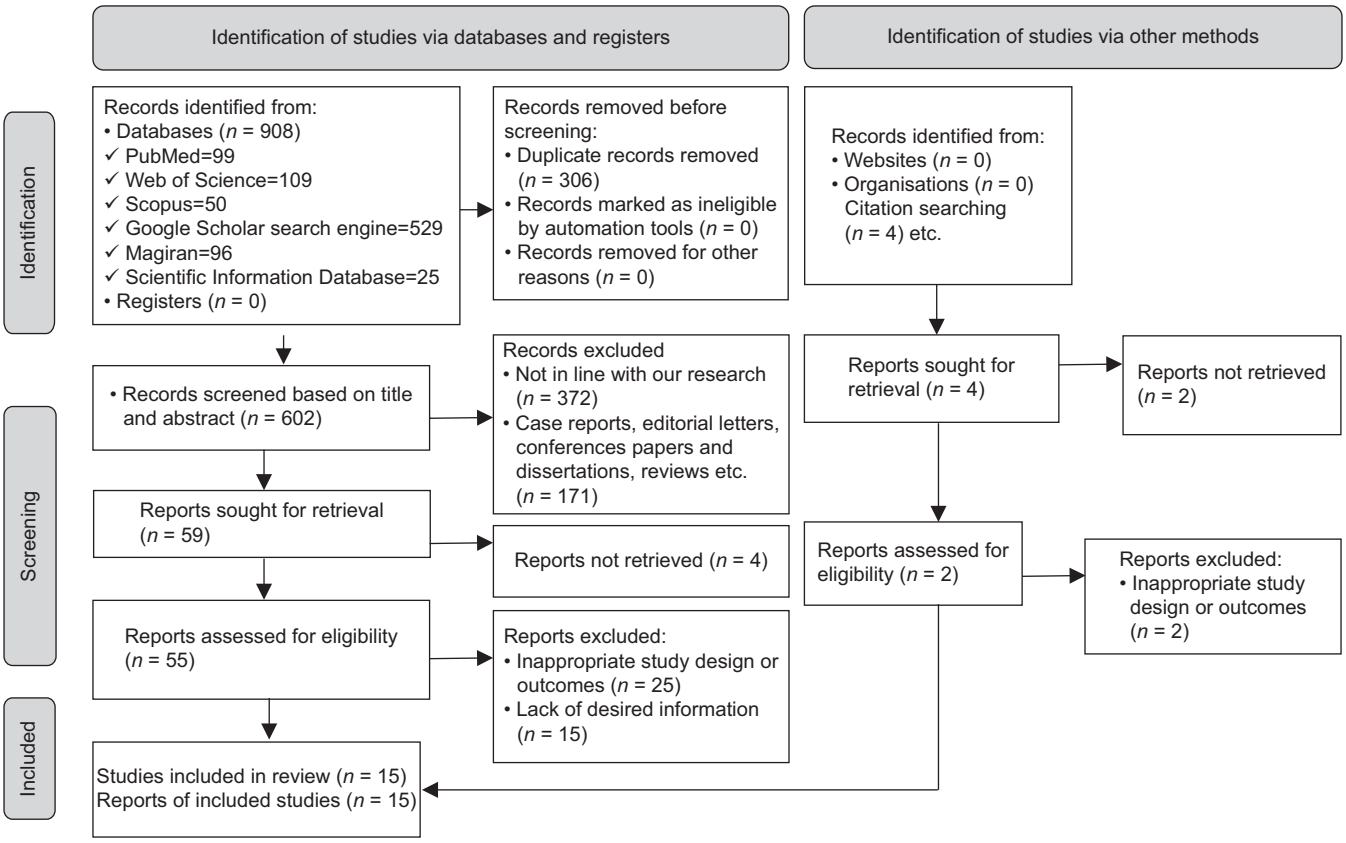

Figure 1: Flow diagram of the study selection process

Study characteristics

Based on the AXIS tool, the quality score of the included studies was 60%–80%. Fourteen studies[7,8,15–25,27] had a high quality and one study[26] had a fair quality [Figure 2]. A total of 1,277 ICU nurses were enrolled in 15 included studies.[7,8,15–27] All studies had a cross-sectional design. The age range of ICU nurses was 29–58 years with a mean (SD) age of 32.28 (5.52) years. Eleven studies[7,8,15–17,19,20,23–26] reported the nurses' gender (85.03% of nurses were women). In five studies,[7,19,24,26,27] the overall work experience of ICU nurses was reported (total mean (SD) of 7.87 (4.85) years). In four studies,[8,19,26,27] the ICU work experience of nurses was reported (total mean (SD) of 5.08 (3.96) years). Five studies[7,8,17,27] were performed in Tehran and three studies[15,16,21] in Fars. The characteristics of included studies are presented in Table 1.

Medication errors in intensive care unit nurses

According to the findings, the prevalence of MEs made by ICU nurses was 53.34%[7,8,15–24] [Table 1]. The most common types of MEs made by ICU nurses were wrong infusion rate (14.12%), unauthorized medication (11.76%), and wrong time (8.49%).[7,8,15-22,24] Additionally, MEs occurred more frequently in work shifts of the morning (44.44%), followed by the night (34.71%), and the evening (20.85%).[7,18,19,22] MEs happened more frequently for heparin (12.95%), followed by vancomycin (11.89%), ranitidine (10.84%), amikacin (7.71%), furosemide (6.40%), cefazolin (6.30%), hydrocortisone (6.24%), nitroglycerin (5.93%), metoclopramide (5.33%), midazolam (3.91%), dexamethasone (3.76%), metronidazole (3.47%), clindamycin (3.41%), dopamine (2.45%), phenytoin (2.32%), gentamycin (2.03%), ceftriaxone (2.01%), meropenem (1.53%), and imipenem (1.52%).[7,18,19]

Outcomes associated with medication errors

Bagheri-Nesami *et al*.[19] assessed the outcomes associated with MEs in patients. In the study, 71% of MEs were not associated with any adverse outcomes. Additionally, 28.2% of MEs led to adverse outcomes such as hypertension, hypotension, nausea, vomiting, tachycardia, bradycardia, flushing, hypoglycemia, hyperglycemia, dysrhythmia, and sedation. Also, 0.8% of MEs led to death due to pancuronium bromide injection without respiratory support.[19]

Factors associated with medication errors

Twelve studies assessed factors associated with MEs made by ICU nurses.[8,15,17,19–27] The researchers classified ME-related factors into the following four categories: (1) management and human factors, (2) environmental factors, (3) drug-related factors, and (4) demographic factors. Details of factors related to MEs in the included studies are presented in Table 2.

Table 1: Basic characteristics of the included studies in this systematic review

First Author/ Year	Location	Sample Size	Female %	Age Mean (SD)	Work Experience in the ICU Mean (SD)	Overall Work Experience Mean (SD)	Key Results	ME* Prevalence
Fahimi *et al*., 2008[7]	Tehran	28 nurses	92.86	29.65 (2.98)	N/A	4.04 (2.59)	The most common type of ME (43.40%) was related to bolus dose injections. The fourth time medication at 9 a.m. had the highest ME rate (19.80%). Amikacin had the highest ME rate (11.00%) among the drugs selected.	9.41
Bagaei *et al*., 2012[26]	West Azerbaijan	202 nurses	86.63	32.20 (4.00)	3.70 (2.60)	8.40 (4.70)	90.00% of ICU** nurses believed that team coordination, educational, environmental, human, and managerial factors were the cause of ME in ICU.	N/A
Cheraghi *et al*., 2012[8]	Tehran	64 nurses	89.06	33.00 (7.40)	4.00 (3.70)	N/A	The most common types of ME were drug infusion rate (44.68%) and administration of incorrect drug dosages (23.40%).	73.43
Vazin *et al*., 2012[15]	Fars	38 patients	52.63	50.63 (19.63)	N/A	N/A	Administration errors (9.80%) was the most common type of ME in ICU nurses.	7.64
Vazin *et al*., 2012[16]	Fars	27 patients	40.74	47.90 (19.90)	N/A	N/A	Administration errors (42.99%) and transcription errors (2.61%) were the most common types of ME in ICU nurses.	69.71
Fathi *et al*., 2014[17]	Tehran	40 nurses	83.30	N/A	N/A	N/A	The most common types of MEe were unauthorized medications (23.56%), monitoring error (19.65%), and wrong time administration (18.65%). There was a significant relationship between the sex and shift type with ME in ICU nurses.	47.53
Sohrevardi *et al*., 2014[18]	Yazd	843 intravenous doses	N/A	N/A	N/A	N/0A	The most common types of MEs were fast drug infusion (34.26%), preparation (15.69%), administration (9.23%) and compatibility with doctor's order (6.24%).	65.42

Contd...

Table 1: Contd...

First Author/ Year	Location	Sample Size	Female %	Age Mean (SD)	Work Experience in the ICU Mean (SD)	Overall Work Experience Mean (SD)	Key Results	ME* Prevalence
Bagheri-Nesami *et al*., 2015[19]	Mazandaran	192 nurses/2,542 patients/20,240 intravenous doses	92.20	33.96 (6.61)	6.28 (4.94)	9.30 (5.87)	The most common types of MEs were wrong dose (27.10%), wrong dose (17.90%), and wrong infusion rate (17.20%).	64.38
Dehvan *et al*., 2015[20]	Semnan	56 nurses	92.8	N/A	N/A	N/A	The most common types of MEs were improper timing (30.40%), improper dosing (26.80%), and improper infusion rate (19.60%).	69.50
Khammarnia *et al*., 2015[21]	Fars	40 patients	N/A	N/A	N/A	N/A	MEs were high in the ICU. Illegible orders were the cause of most MEs in the ICU.	17.30
Sohrevardi *et al*., 2017[22]	Yazd	94 patients	N/A	58.00 (28.50)	N/A	N/A	The most common error was the wrong time of administration. Errors of wrong dose preparation and administration accounted for 24.04% and 25.31% of all errors, respectively.	76.59
Rezaiamin *et al*., 2017[27]	Tehran	117 nurses	N/A	31.88 (6.63)	6.36 (4.59)	8.91 (5.82)	High work commitment in ICU nurses reduced MEs.	N/A
Farajzadeh *et al*., 2018[23]	Kurdistan	106 nurses	35.85	N/A	N/A	N/A	The most common type of MEs was wrong infusion rate. There was a significant relationship between MEs and variables such as work experience, work shift, and workload.	52.83
Dashti *et al*., 2019[24]	Ardabil	191 nurses	95.81	32.99 (5.50)	N/A	8.71 (5.29)	The most common types of MEs were included wrong time and omission.	86.40
Kaboodmehri *et al*., 2019[25]	Guilan	281 nurses	96.80	N/A	N/A	N/A	The most important environmental factors associated with MEs were poor lighting, high noise levels, and inappropriate room temperature.	N/A

*MEs: Medication errors, **ICU: Intensive care init

Management and human factors

These factors were reported in eight studies.[8,15,19–21,23,26,27] Management and human factors included workload (n = 5), lack of manpower (n = 4), illegibility of doctor's orders (n = 4), fatigue (n = 3), lack of pharmacological information (n = 3), poor communication between physicians and nurses (n = 2), lack of adequate supervision (n = 2), transcription error (n = 2), managers' inattention to education (n = 1), insufficient education (n = 1), incorrect medication calculations (n = 1), illiteracy of the nursing Kardex (n = 1), violations of rules (n = 1), memory failure (n = 1), poor communication in the workplace (n = 1), inappropriate drug distribution systems in the hospital (n = 1), multiple prescription changes and inappropriate medical record documentation (n = 1), low access to pharmacological information (n = 1), and work commitment (n = 1).

Table 2: Factors associated with medication errors in intensive care nurses

First Author/Year	Factors Associated with Medication Errors
Bagaei *et al*., 2012	Management and human factors: 1) Workload and fatigue, 2) Lack of manpower, 3) Poor communication between physicians and nurses, 4) Lack of adequate supervision, 5) Managers' inattention to education Environmental factors: 1) Unsuitable environmental conditions, 2) Lack of sufficient equipment Demographic factors: 1) Age, 2) Work experience
Cheraghi *et al*., 2012	Drug-related factors: 1) A high variety of drugs, 2) Use of abbreviations, 3) The similarity of drug names, 4) Use of some drugs in rare cases, 5) Different drug doses Management and human factors: 1) Workload and fatigue, 2) Lack of manpower, 3) Insufficient education, 4) Lack of pharmacological information, 5) Incorrect medication calculations, 6) Illiteracy of the nursing Kardex, 7) Illegibility of doctor's orders
Vazin *et al*., 2012	Management and human factors: 1) Violations of rules, 2) Memory failure, 3) Lack of pharmacological information, 4) Preparation error, 5) Faulty dose checking, 6) Poor communication in the workplace, 7) Inappropriate drug distribution systems in hospital, 8) Transcription error, 9) Lack of adequate supervision
Fathi *et al*., 2014	Demographic factors: 1) Male gender, 2) Work shift
Bagheri-Nesami *et al*., 2015	Management and human factors: 1) Illegibility of doctor's orders, 2) Multiple prescription changes and inappropriate medical record documentation, 3) Transcription error, 4) Poor communication between physicians and nurses, 5) Lack of pharmacological information, 6) Low access to pharmacological information, 7) Non-compliance with the appropriate distance between two doses by nurses, 8) Workload, 9) Lack of manpower Drug-related factors: 1) Similarity of drug names, 2) Similar appearance of drugs, 3) Similar packaging of drugs, 4) Small instructions on drug packaging, 5) Receiving incorrect drug doses from a pharmacy, 6) Incorrect labeling on drugs, 7) Lack of access to pharmacists
Dehvan *et al*., 2015	Management and human factors: 1) Fatigue, 2) Lack of manpower, 3) Illegibility of physician orders, 4) Lack of sufficient time Drug-related factors: 1) Similar packaging of drugs
Khammarnia *et al*., 2015	Management and human factors: 1) Illegibility of physicians' orders, 2) Writing error dosage, 3) No drug dosage
Sohrevardi *et al*., 2017	Demographic factors: 1) Work shift
Rezaiamin *et al*., 2017	Management and human factors: 1) Work commitment
Farajzadeh *et al*., 2018	Demographic factors: 1) Work experience, 2) Work shift Management and human factors: 1) Workload
Dashti *et al*., 2019	Demographic factors: 1) Age, 2) Type of employment
Kaboodmehri *et al*., 2019	Environmental factors: 1) Poor lighting, 2) High noise levels, 3) Inappropriate room temperature, 4) High number of patients, 5) Lack of appropriate equipment for injection safety, 6) Inadequate space for medication preparation

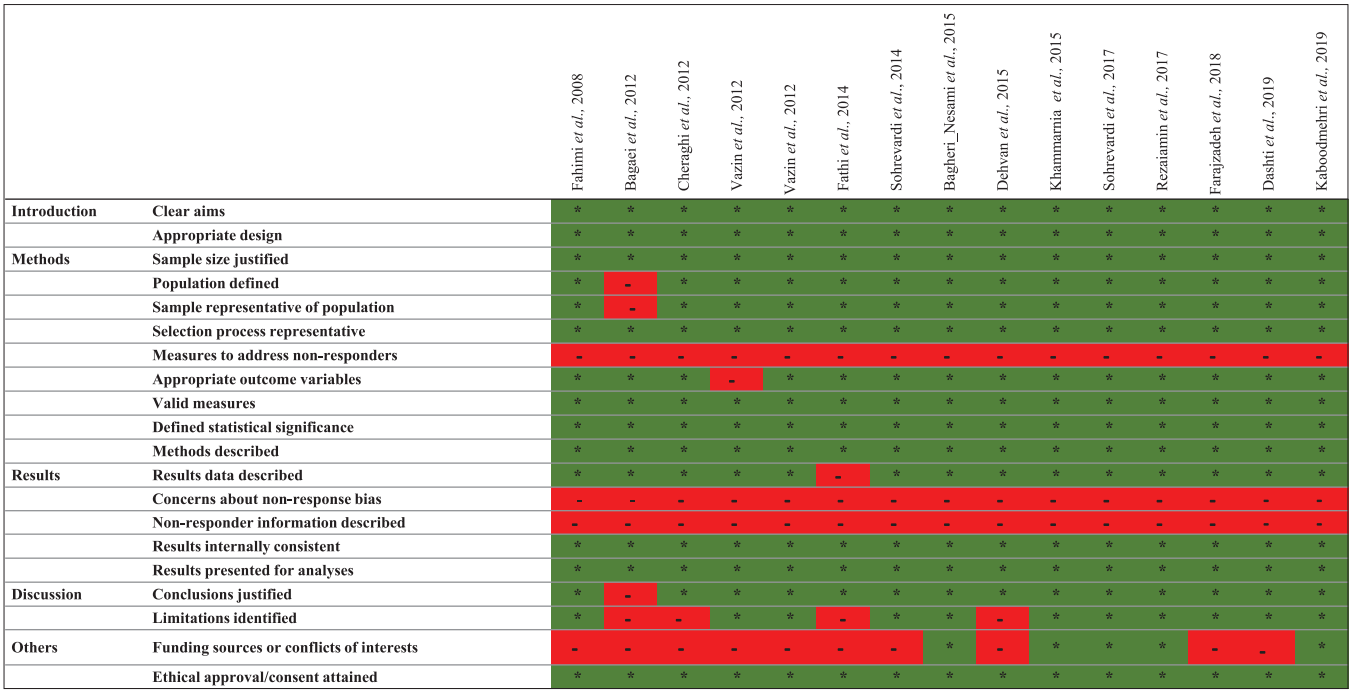

Figure 2: Assessment of the quality of the included articles

Environmental factors

These factors were reported in two studies.[25,26] Environmental factors included unsuitable environmental conditions, lack of sufficient equipment, poor lighting, high noise levels, inappropriate room temperature, a high number of patients, lack of appropriate equipment for injection safety, and inadequate space for medication preparation.

Drug-related factors

These factors were reported in three studies.[8,19,20] Drug-related factors included the similarity of drug names (n = 2), similar packaging of drugs (n = 2), a high variety of drugs (n = 1), use of abbreviations (n = 1), use of some drugs in rare cases (n = 1), different drug doses (n = 1), the similar appearance of drugs (n = 1), small instructions on drug packaging (n = 1), receiving incorrect drug doses from a pharmacy (n = 1), incorrect labeling on drugs (n = 1), and lack of access to pharmacists (n = 1).

Demographic factors

These factors were reported in five studies.[17,22–24,26] Demographic factors included work shift (n = 3), age (n = 2), work experience (n = 2), male gender (n = 1), and type of employment (n = 1).

Discussion

The prevalence of MEs made by Iranian ICU nurses was 53.34%. The most common types of MEs made were wrong infusion rate, unauthorized medication, and wrong time. Additionally, MEs occurred more frequently in the morning, night, and evening work shifts. MEs occurred more frequently for drugs such as heparin, vancomycin, ranitidine, and amikacin. ME-related factors were management and human, environmental, demographic, and drug-related factors.

Somewhat consistent with the present study, the prevalence of MEs in ICU nurses in two studies from Ethiopia[28,29] and one study from South Korea[30] were 51.8%, 40%, and 53.6%, respectively. Inconsistent with the present study, the prevalence of MEs made by ICU nurses in France[31] and Brazil[32] were 6.6% and 7.47%, respectively. These discrepancies may be due to factors such as different definitions of MEs in these studies, different methods for diagnosing MEs, lack of knowledge of ICU nurses about MEs, and differences in the studied populations.[33] However, this study and previous evidence indicate the high prevalence of MEs made in the ICU which remains a global patient safety challenge for critically ill patients.[33–35]

The present study revealed that the most common types of MEs made by Iranian ICU nurses were wrong infusion rate (14.12%), unauthorized use of medications (11.76%), and wrong time (8.49%). Consistent with the present study, the wrong infusion rate in a study in France was the second type of ME made in the ICU (22%).[31] However, in other studies, omission error was one of the most common MEs made in the ICU[28,29,31] which was not one of the most common types of MEs made in Iranian ICUs (4.88%). One of the reasons for this discrepancy may be the lower overall prevalence of MEs in previous studies compared to the present study.

Based on the results of the present study, MEs occurred more frequently in the morning (44.44%), night (34.71%), and evening (20.85%) work shifts. Although assessment of this factor can be effective in prevention of MEs, it has been less

considered in previous studies globally. This may be due to differences in medication delivery timing based on different routines, which vary depending on the type of medication, the patient's condition, and the physician's prescription pattern. On the other hand, the higher incidence of MEs in the morning shift may be due to the fact that most drugs are prepared and administered in the morning shift. However, some previous studies reported a higher rate of MEs among night shifts nurses, due to fatigue and sleep deprivation.[36]

As shown in the present study, MEs occurred more frequently for drugs such as heparin, vancomycin, ranitidine, and amikacin. Therefore, anticoagulants, antibiotics, and gastrointestinal medications are the most common classes of drugs leading to MEs made in Iranian ICUs. This finding was supported by a study in Ethiopia.[29] However, the results of a study in the United States reported a higher rate of MEs for opioid analgesics (13.2%), β-lactam antibiotics (8.4%), and anticoagulants (6.4%).[37]

In the present study, management and human, environmental, demographic, and drug-related factors were associated with the occurrence of MEs. Consistent with the present study, previous studies[38,39] showed that non-compliance of nurse--to--patient ratio, nurses' workload and fatigue, insufficient supervision, and managers' inattention to staff education were the main reasons for the occurrence of MEs. However, human factors are also a major issue in the occurrence of MEs. The results of a study in Australia indicated that the incidence of interruptions in the preparation or administration of drugs in nurses increased the rate of MEs by 12.5%.[40] On the other hand, if the drugs were given without interruption, MEs reduced by 2.3%.[41]

Deficits in pharmacological knowledge and weakness in applying mathematical principles to drug calculations are other important factors in the occurrence of MEs. It is believed that the most important strategy in preventing the occurrence of MEs is ongoing continuing education of nurses in pharmacology, with a focus on drug safety and drug dose calculation.[42]

To minimize MEs, healthcare organizations must institute clear reporting channels and resolve any associated issues such that healthcare workers are able to openly report incidents of MEs without feeling intimidated or worrying about unwarranted punitive measures.[43] Modern technologies such as electronic prescriptions should be instituted across the healthcare system.[44] On the other hand, regular education programs are necessary to keep ICU nurses and other healthcare workers updated with newer drugs and standards.[10]

Although the current study adhered to standard systematic review protocols and presented robust findings, there are some limitations. A meta-analysis was not possible due to difference in the data and tools used in the studies. Also, only one study reported adverse events of MEs.

Conclusion

The prevalence of MEs made by Iranian ICU nurses is high. The most important influential factor in the occurrence of MEs in ICUs was management and human factors. Therefore, nurse managers and policymakers should develop appropriate strategies, including training programs, to reduce the occurrence of MEs made by nurses in ICUs.

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Conflicts of interest

Nothing to declare.

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