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Medication error in critical care

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Abstract
In critical care, medication errors are frequent, serious, and predictable. Critically ill patients have prescribed twice as many medications as patient outside of the intensive care unit (ICU) and nearly all will suffer a potentially life-threatening medication error at some point during their hospital stay.
Medication errors (MEs) are the most common error in critical care. In fact, 78% of all serious errors in ICUs are due to medication errors. Therefore, detecting MEs are significant. Efforts should be taken to correct the wrong administration technique and inappropriate monitoring in order to improve the quality of care in the ICU and to reduce MEs. The beneficial technique to reduce such medication errors includes computerized prescribing, education and pharmacist input. This article provides a systematic review of medication errors in critical care, help to identify risk factors for medication errors, suggest strategies to prevent medication errors and manage their consequences.

Keywords: medication errors, adverse drug event, critical care, computerized physician order entry, intensive care unit

Introduction
Medication Errors are common in most health care systems and are reported to be the seventh common cause of death [1]. Medication errors can be defined as "preventable mistakes in prescribing or delivering medication to a patient, that is, an improper use of medicine or one that cause harm to a patient". Of importance, medication errors are independent of the occurrence of patient injury. Medication errors can occur at any stage of the medication process, most occur at the stage of administration. Critically ill patients receive nearly twice as many medications as patients in other care units [2].
The higher frequency of medication errors (MEs) in ICU wards is due to several reasons which include:

- First, in comparison with the patients in other hospital units, ICU patients generally need more medications.
- Second, most of the drugs in an ICU are administered intravenously. Drugs prepared for intravenous injection require calculations.
- Third, because ICU patients are mostly in a low consciousness state, they are unable to report harmful effects.
- Fourth, compared to other patients, ICU patients are, in general, weaker physiologically. The above mentioned reasons cause ICU patients to be considered highly vulnerable to medication errors [3].

Classification: Medication Errors
James Reason developed a well- recognized system for classification of human errors based on observations from industries. He classified errors into two groups according to the working system: active failures and latent conditions [4].

Active failures are unsafe acts by people who are in direct contact with the patient which include: slips, lapses, and mistakes (Table 1). Slips and lapses are skill behavior errors when a routine behavioris misdirected or omitted. The person performs the wrong execution but he has the right idea. For example, lapse means forgetting to restart a heparin infusion postoperatively and slip is restarting the heparin infusion and knowing the correct infusion rate but entering an incorrect rate [5].
Mistakes are due to perception, inference, judgment, and interpretations which are knowledge- based errors and occur due to incorrect thought processes or analyses. For example, the patient who diagnosed with heparin- induced thrombocytopenia is prescribed with heparin is a mistake. Situational factors such as fatigue, drugs, alcohol, stress, and multiple activities can divert attention and increase the risk of active failures [6].
Latent conditions are due to reasons within the system. Latent failures occur when individuals make decisions that have unintended consequences in the future. Once latent conditions are identified, prevention requires an ongoing tenacious search and corrective actions. For example, institutions that use staffing models to routinely perform clinical duties above and beyond their normal responsibilities paradoxically risk introducing time pressures, fatigue, and low morale into their workforce [7].
Errors can alternatively be classified as omission errors or commission errors (Table1). Errors of omission are the failure to perform an appropriate action. Errors of commission are the process of performing an inappropriate action. Most of the patient safety study pieces of literature focus on errors of the commission such as wrong drug or wrong dose [8].

Table 1: Definitions

Medical error	The failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim.
Medication error	Any error in the medication process, whether there are adverse consequences or not.
Adverse drug event	Any injury related to the use of a drug. Not all adverse drug events are caused by medical error, nor do all medication errors result in an adverse drug event.
Preventable adverse event	Harm that could be avoided through reasonable planning or proper execution of an action
Near miss	The occurrence of an error that did not result in harm
Slip	A failure to execute an action due to routine behavior being misdirected
Lapse	A failure to execute an action due to lapse in memory and a routine behavior being omitted
Mistake	A knowledge- based error due to an incorrect thought process or analysis
Error of omission	Failure to perform an appropriate action
Error of commission	Performing an inappropriate action

Consequences of Medication Errors

Medication errors are an important cause of patient morbidity and mortality in healthcare settings. Only 10% of medication errors result in adverse drug events. The IOM report highlights that as a result of medication errors 44,000 to 98,000 patients die each year. A large portion of these is related to medications. Approximately 19% of medication errors are life- threatening in ICU and 42% are of sufficient clinical importance to warrant additional life- sustaining treatments. Many patients experiencing costly and prolonged hospital stay undergo greater human and societal burden and some patients never fully recovering to their premorbid status. In 1995 Bates and colleagues estimated that the annual cost of $2.9 million serious medication errors per hospital in America. Errors can harm patient, family, and public confidence in healthcare organizations [9].

Risk Factors for Medication Errors

The ICU brings together high- risk patients and an intervention from multiple health care professionals in a complex environment (Table 2).Patient illness severity is the single strongest predictor of an ADE. Critically ill patients have prescribed twice as many medications as patients outside of the ICU. Most of the medications in the ICU are administered as weight-based infusions and so these infusions require mathematical calculations, which increase the risk of error [10].

Multicentered studies by Ridley and colleagues and Calabrese and colleagues founded that potassium chloride, heparin, magnesium sulfate, vasoactive drugs, sedatives, and analgesics are the medications with a high risk of error. Antibiotics are frequently prescribed in the ICU and errors have potential implications for both individual patients and population [11].

It is important to remember that compared with other patients critically ill patients have fewer defenses against adverse events. Their ability to participate in medical care is limited and they lack the physiological ability to tolerate additional injury. Finally, after the discharge from the ICU lack of continuity of care causes the patient at risk for errors and highlights the importance of communication with the future caregivers [12].

Table 2: Risk Factors For Medication Errors in the Intensive Care Unit Factors Specific Risk Factors

Patient	▪ *Severity of illness*
	Strongest predictor of ADE ICU patients more likely to experience ADE than patients in other units
	▪ *Extreme of ages*
	Increased susceptibility to ADEs Prolonged hospitalization Increased exposure and susceptibility to ADE
	▪ *Sedation*
	Patients unable to participate in care and defend themselves against errors
Medications	▪ *Types of medications*
	Frequent use of boluses and infusions Weight-based infusions derived from estimated weights or unreliable determinations Mathematical calculations required for medication dosages Programming of infusion pumps
	▪ *Number of medications*
	Twice as many medications prescribed as for patients in other units Increased probability of medication error and medication interactions
	▪ *Number of interventions*
	Increased risk of complications
ICU environment	▪ *Complex environment*
	Difficult working conditions make errors more probable High stress High turnover of patient and providers
	▪ *Emergency admission*
	Risk of an adverse event increases by approximately 6% per day
	▪ *Multiple care providers*
	Challenges the integration of different care plans

Prevention of Medication Errors

By avoiding situational risk factors, optimizing the medication process safety, and providing strategies to prevent medication errors and mitigate their consequences, this can improve the medication safety. Several potential strategies have been shown to decrease medical error in the ICU (Table 3). To improve the safety of the medication process is the safest and most efficient means of improving patient safety. Strategies that have been shown to decrease the medication error include: medication standardization, computerized physician order entry (CPOE), barcode technology, computerized intravenous infusion devices, and medication reconciliation [13].

Table 3: Strategies to Prevent Medication Errors

Optimize the medication process
1. Medication standardization
2. Computerized physician order entry and clinical decision support
3. Bar code technology
4. Computerized intravenous infusion devices
5. Medication reconciliation
Eliminate situational risk factors
1. Avoid excessive consecutive and cumulative working hours
2. Minimize interruptions and distractions
3. Trainee supervision and graduated responsibility
Oversight and error interception
1. Intensivist participation in ICU care
2. Adequate staffing
3. Pharmacist participation in ICU
4. Incorporation of quality assurance into academic education

Computerized Physician Order Entry (CPOE)

CPOE targets the stages of prescription and transcription in the medication process. The technology permits clinicians to enter an electronic order into a computer system that is linked to a hospital clinical information system. The main advantage of CPOE include: they can track allergies, recommend drug dosages, and provide adjustments for patients with altered renal or hepatic function, and identify potential drug-drug interactions [14].

There are some limitations for implementation which include provider willingness to adopt the technology, capital costs and worries about technical malfunctions and paradoxical increases in medication errors at the period of implementation. CPOE systems that interface with the pharmacy order verification system can be used to remove the problematic step of transcription, allows the pharmacists and nurses to focus more on clinical responsibilities. All of these advancements can help in improving safety and efficiency. CPOE technology shows the important distinction between error and harm; errors are the intermediate outcome, but the ultimate goal is to prevent patient harm. But currently, this CPOE technology is not widely used in the majority of ICUs [15].

Bar Code Technology

Bar code technology target the phase of administration in the medication process. Bar code technology for medication administration provides a double-check which helps to verify the medication, dose, route, patient, and dosing time. This technique will help to ensure that the correct patient gets the correct dose of the correct drug at correct dose by the correct route at the correct time. Administration errors have been reported to be reduced by 60% [16].

Computerized Intravenous Infusion Device

In case of intravenous medications, the computerized intravenous infusion devices allow the incorporation of both CPOE and bar code technology such that this will provide infusion rates, standardized concentrations, and dosing limits which will help to prevent intravenous medication errors [17].

Medication Reconciliation

Majority of patient medications are stopped when the patient admitted to the ICU. Most of these medications are not restarted when patient discharged from the ICU (88%) or hospital (30%). Medication reconciliation is the process that matches the patient's current medication regimen in hospital against a patient's long-term medication regimen. A combined medication reconciliation program will prevent drug withdrawal and which ensure that life-saving medications are restarted as soon as appropriate [18].

Situational risk factors can change provider's attention and which increase the risk of failures. These have to be minimized. Additional risk factors represent trainee supervision and graduated responsibility that needs to be managed.

Clinical inexperience can also cause errors. When providers start in new environments, train them and then provide graduated supervision to develop experience [19].

Physicians, nurses, and pharmacists are integral to medication error interception. It has been reported that the decrease in medication errors from 22% to 70% by the participation of an intensivist in patient care in the ICU, complications by 50%, ICU mortality, ICU length of stay, and hospital length of stay and to improve patient safety. Similarly, pharmacists have an important role in medication safety. First, all intravenous medications should be prepared using a standardized process and standardized medication concentrations by the pharmacists within the pharmacy department. Second, pharmacist participation in clinical rounds improves patient safety by reducing preventable ADEs by 66% and also shortening patient's length of hospital stay, decreasing

mortality, and decreasing medication expenditure [20].

Conclusion

Drug errors in critical care are common and have serious deleterious effects on morbidity and mortality so the patient safety is an important health care issue because of the consequences of iatrogenic injuries. Medication errors in critical care were serious, frequent and predictable. In nonmedical settings, human factor research suggests that demanding greater vigilance from medical care providers may not result in meaningful safety improvement. A more promising way to reduce human error is the approach of identifying failures and redesigning faulty systems.

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