

## Preventing medication errors in neonatology: Is it a dream?

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### Abstract

Since 1999, the problem of patient safety has drawn particular attention, becoming a priority in health care. A "medication error" (ME) is any preventable event occurring at any phase of the pharmacotherapy process (ordering, transcribing, dispensing, administering, and monitoring) that leads to, or can lead to, harm to the patient. Hence, MEs can involve every professional of the clinical team. MEs range from those with severe consequences to those with little or no impact on the patient. Although a high ME rate has been found in neonatal wards, newborn safety issues have not been adequately studied until now. Healthcare professionals working in neonatal wards are particularly susceptible to committing MEs due to the peculiarities of newborn patients and of the neonatal intensive care unit (NICU) environment. Current neonatal prevention strategies for MEs have been borrowed from adult wards, but many factors such as high costs and organizational barriers have hindered their diffusion. In general, two types of strategies have been proposed: the first strategy consists of identifying human factors that result in errors and redesigning the work in the NICU in order to minimize them; the second one suggests to design and implement effective systems for preventing errors or intercepting them before reaching the patient. In the

future, prevention strategies for MEs need to be improved and tailored to the special neonatal population and the NICU environment and, at the same time, every effort will have to be made to support their clinical application.

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**Key words:** Medication errors; Drug safety; Adverse events; Prevention; Newborn

**Core tip:** Although a high medication error (ME) rate has been found in neonatal wards, newborn safety issues have not been adequately studied until now. Healthcare professionals working in neonatal wards are particularly susceptible to committing MEs due to the peculiarities of newborn patients and of the neonatal intensive care unit environment. Current neonatal prevention strategies for MEs have been borrowed from adult wards, but many factors such as high costs and organizational barriers have hindered their diffusion. The present article reviews current issues related to MEs in Neonatology and discusses the strategies to prevent them and to improve the safety of newborns.

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### INTRODUCTION

Since 1999, following the publication of the United States Institute of Medicine (IOM) report "To err is human: building a safer health system", the problem of patient safety (PS) has drawn particular attention. This report has revealed that the problem of accidental patient injury was serious and that adverse events occurring during hospitalization were responsible for killing or damaging a large number of patients. It reported that from 44000 to

98000 deaths due to medical errors occurred every year in United States hospitals, while over 7000 deaths were due to medication errors (MEs) in or out of the hospital<sup>[1]</sup>.

Both individuals and society are burdened with medical error consequences. Physical and psychological uneasiness, delayed hospital discharge, and costs in terms of human lives weigh heavily on patients. The productivity reduction of workers, higher hospital costs, and increasing insurance premiums are some of the most important social costs. Accordingly, it is of utmost importance to investigate medical errors more extensively and to implement efficacious interventions to control and prevent them. Many efforts have been dedicated to the prevention of medical errors in adult wards, and to the improvement of adult PS. Conversely, PS is an unfrequently addressed and inadequately studied topic in neonatological literature, although the medication administration error rate in the Neonatal Intensive Care Unit (NICU) is quite high, reaching values up to the 15%<sup>[2]</sup>, and adverse drug events occur three times more frequently in newborns than in adults<sup>[3]</sup>.

The present article reviews the various issues related to MEs in Neonatology and discusses the strategies to prevent them and to improve the safety of newborns. The importance of creating a culture of safety in the neonatal ward is also emphasized.

## PATIENT SAFETY: A SHORT HISTORY

“Every hospital should follow every patient it treats long enough to determine whether the treatment has been successful, and then to inquire ‘if not, why not’ with a view to preventing similar failures in the future”. These words had been published in a pamphlet in 1914 by Ernest Amory Codman, an American surgeon that can be considered the forerunner of the modern preventive medicine. He introduced a new patient care system, which included an “End result card” containing demographic data, diagnosis, treatment and outcome of each treated patient. Codman believed that sharing mistakes and experiences recorded with this system in a public forum would allow physicians to learn from each other’s mistakes, improving quality of future patient care. Today this system represents the basis for many quality improvement plans<sup>[4]</sup>.

Since the 1940s, high-risk industries such as aviation started to develop an appropriate approach to reduce the risk of human errors, designing a system able to intercept them or to provide means able to reduce their consequences in case of non-detection. This approach has led to the development of risk management programs that have proven to be effective in reducing risks and their consequences.

In the 1950s, risk management programs were introduced in United States hospitals based on the observation that physicians, like pilots, are required to have high level performance in a high risk environment and to make decisions under pressure; moreover, they are both aware

that their mistakes might cost human lives. At first, risk management programs were focused on preventing certain accidents to patients (*e.g.*, patient falls, and the oversight of sponges inside patients during surgery). Since the 1980s, individual and system factors leading to erroneous decisions of the clinical team were investigated, and programs to prevent medical errors were improved.

## CONCEPTUAL APPROACHES TO HUMAN ERROR: THE MEDICAL ERROR

The IOM<sup>[1]</sup> defined medical errors as “the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim”. In general, medical errors include all errors occurring in the health-care system: they may be made by all clinical team professionals during all stages in the care process, from diagnosis to treatment.

The consequences of this type of error burden society primarily with hospital costs resulting from the increased need of monitoring, of diagnostic tests, and of drug administration to control their effects. Furthermore, medical errors can lead to delayed hospital discharge, temporary or permanent patient disability, and cost of lives. Other important consequences are represented by the loss of patient trust in the healthcare system and the increase of insurance premiums. Finally, there are social consequences of medical errors such as the absence of children from school, the absence and less productivity of workers, and the worsening of population health status. Therefore, studying the causes of medical errors and developing the prevention strategies for reducing them are nowadays considered important targets to improve PS.

Two different approaches have been proposed to address the problem of human error: the person approach and the system approach. The first approach concentrates on individual errors resulting from the subjective mental state, such as inattention, negligence, and forgetfulness. In contrast, the second approach focuses on the working environment and conditions as the origin of errors<sup>[5]</sup>.

The combined effect of “active failures” by individuals and “latent failures” in the system has been found to be responsible for error occurrence. In the hospital setting, active failures may involve every professional in the team such as doctors, pharmacists, and nurses. By contrast, latent failures are weaknesses which usually lie dormant in the system until they combine with active failures or a triggering event, thus creating an accident opportunity that makes them manifest. Faulty information management, stressful environment, inadequate training of personnel and ineffective communication systems represent some examples of latent failures. According to the psychologist Reason, latent errors are those “waiting to happen”<sup>[6]</sup>. The analysis of these errors is very important as it can reveal how to change a system and make it safer<sup>[7]</sup>. According to the Swiss Cheese Model, every accident is not a consequence of a single error but is the

**Table 1** Stages of the medication pathway in the hospital setting

Stage	Healthcare professional involved
Decision on appropriate medicine	Physician
Prescription	Physician
Review of prescription	Pharmacist
Preparing, dispensing and checking the medicine	Pharmacist
Delivery of medicine to the ward (or home)	Pharmacy staff or nurses
Preparing to administer medicine	Nurse
Administering medicine to patient	Nurse
Recording medicine on patient chart	Nurse
Monitoring patient response	Nurse

end result of a chain of factors, accidentally placed in a proper sequence that penetrates or bypasses defences, barriers and safeguards, and results in an incident<sup>[5]</sup>.

## MEs: DEFINITION, TYPOLOGY AND SEVERITY

Medication is the commonest intervention within the health-care system. The errors resulting from medication may cause iatrogenic injuries which can be prevented.

ME is “any preventable event that occurs in the process of ordering, transcribing, dispensing, administering, or monitoring a drug, irrespective of whether an injury occurred or the potential for injury was present”<sup>[8]</sup>. Since MEs may happen at any step of the medication pathway process, they can involve every professional of the clinical team (Table 1).

The commonest types of MEs concern dose, time, rate (drug delivered more slowly or faster than prescribed), technique of preparation, route, and administering technique; additionally, omission errors and others (wrong site, wrong patients, unauthorized drug, *etc.*) have been reported<sup>[9]</sup>.

Lack of information about patient and drug can lead doctors to make errors in the phase of drug ordering<sup>[7]</sup>. Calculation errors are the most frequently described prescribing errors<sup>[3,9,10]</sup>. They include miscalculation of the dose, incorrect expression of the measurement unit, wrong decimal point placement, and indication of mistaken drug administration rate<sup>[11]</sup>. Difficult-to-read handwritten physician orders is another important factor increasing ME risk and patient harm<sup>[12]</sup>. Hartel *et al.*<sup>[13]</sup> found a generally bad readability of the handwritten prescriptions, rated as bad in 52%, and unreadable in 4% of cases. They documented a good readability of the handwritten prescriptions only in 2% of them, and a moderate one in 42%.

The most frequently documented type of MEs is over-dose, the least is reduced interval<sup>[3]</sup>. The absence of a specified administration route has been found to be the commonest error in the phase of transcription<sup>[10]</sup>. Pharmacists are mainly prone to make dispensing errors both in reviewing medical prescriptions and in diluting stock solutions to administer extremely low doses<sup>[14]</sup>.

Nurses normally intervene at the end of the pharmacotherapy process, preparing and administering drugs. Therefore, they have the opportunity to detect errors made by doctors during the prescribing step, and to intercept them before they reach the patient<sup>[15]</sup>. Furthermore, nurses should be specifically trained to follow the Six Rights of medication administration, paying attention that the right medication is administered to the right individual, in the right dose, at the right time, *via* the right route, with the right documentation<sup>[16]</sup>. Recently, other items have been added to the six rights: in particular, nurses also have to pay attention to the right reason for the drug to be administered, the medication levels, and the date of expiry<sup>[17]</sup>.

MEs have been classified both on the basis of their severity and on the basis of their causes. Six severity levels of errors were identified by the American Society of Hospital Pharmacists, ranging from level 1-“No injury” to level 6-“Mortality”<sup>[9]</sup>. MEs have been categorized into two main groups according to their cause: errors of commission and errors of omission. The first group includes all the errors due to the execution of an order not required, not needed or wrongly applied. The second type of errors happen when a drug is not prescribed or when an order necessary for the health of the patient is not applied<sup>[18]</sup>. A commission error occurs when a nurse violates one or more of the Six Rights of medication administration, while an omission error occurs whenever a prescribed medication is not administered to the patient<sup>[16]</sup>.

## MEs IN THE NEONATAL WARD

The reported rates of MEs in pediatric care vary greatly depending on different factors, including the setting of the study and the detection method used. Researchers usually quantify MEs using incident reports or chart reviews. Generally, as compared to incident reports, chart reviews are able to identify more errors.

Selected literature data on the epidemiology of MEs in hospitalized neonates and children are summarized in Table 2<sup>[8,19-25]</sup>. It should be noted that the wide variability in study design, clinical setting, detection method and study period prevents any comparison of ME rate across studies.

In general, newborn infants are more exposed to MEs and their adverse effects than adults due to their intrinsic characteristics. In particular, NICU patients have been shown to be more frequently exposed than hospitalized adults to potentially harmful errors<sup>[14]</sup>. Small size, physiological immaturity, limited compensatory abilities<sup>[26]</sup>, rapid changes in weight and body surface area, and objective barriers to communication with the caregiver<sup>[9]</sup> are the main distinctive features of newborns, leading them to be more susceptible to negative effects resulting from MEs. In particular, newborns exhibit liver and kidney immaturity leading to a reduced drug metabolism and excretion, and thus they are particularly prone to more serious outcomes resulting from MEs<sup>[27]</sup>. Other pharmacokinetic processes are also immature in newborn patients, particu-

**Table 2** Epidemiology of medication errors in hospitalized neonates and children: Selected studies

Ref.	Study design	Clinical setting	Detection method	Study period	Type of medication studied	MEs per 1000 pt-days	MEs per 100 admits	MEs per year
Raju <i>et al</i> <sup>[19]</sup> , 1989	Prospective study	NICU, PICU	Incident/error reports	4 yr	All types	8.80	14.70	-
Vincer <i>et al</i> <sup>[20]</sup> , 1989	Prospective study	NICU	Incident/error reports	2 yr	All types	13.40	-	-
Ross <i>et al</i> <sup>[21]</sup> , 2000	Retrospective review	Ward, NICU, PICU	Incident/error reports	65 mo	All types	0.51	0.15	-
Kaushal <i>et al</i> <sup>[8]</sup> , 2001	Prospective cohort study	Ward, NICU, PICU	Chart reviews	6 wk	All types	157	55	-
Frey <i>et al</i> <sup>[22]</sup> , 2002	Prospective survey	NICU, PICU	Incident/error reports	1 yr	All types	-	-	284
King <i>et al</i> <sup>[23]</sup> , 2003	Retrospective cohort study	Tertiary care pediatric hospital	Incident/error reports	6 yr	All types	4.49	-	-
Sangtawesin <i>et al</i> <sup>[24]</sup> , 2003	Retrospective review	Pediatric hospital	Incident/error reports	15 mo	All types	-	1	-
Manias <i>et al</i> <sup>[25]</sup> , 2014	Retrospective clinical audit	Ward, NICU, PICU	Incident/error reports	4 yr	All types	6.58	1.96	-

NICU: Neonatal intensive care unit; PICU: Pediatric intensive care unit; ME: Medication error.

larly in those born prematurely. In fact, differences in pH and in emptying time of the stomach may influence absorption phase, while high body water contents and low serum protein concentration may affect drug distribution.

Furthermore, the scarcity of data about pharmacokinetics, dosing, clinical use, efficacy, and safety of many medications in the newborn results in the frequent use of unlicensed or off-label drugs in the neonatal population. It was documented that approximately 10% of prescriptions in NICU were for unlicensed medications, while 55% were off-label<sup>[28]</sup>. As compared to licensed drug use, unlicensed use in the neonate was found to be more often associated with MEs<sup>[29]</sup>.

Further possibilities of MEs in neonates result from the lack of concentrations and dosage forms appropriate to neonatal administration, the need to calculate individualized doses, the narrow therapeutic margin of many drugs, and the need of accurate and appropriate delivery systems (*i.e.*, pumps).

In addition, patient misidentification errors have been frequently documented in the NICU. The inability of NICU patients to take part in the identification process, the similar appearance of these patients in the first days of life that makes them not easily distinguishable, and the loss or removal of wrist identification bands are the main factors contributing to this type of error<sup>[30]</sup>.

MEs are more common in the particular NICU environment, potentially resulting in patient injury<sup>[31]</sup>. In particular, they have been found to account for approximately 50% of the iatrogenic complications in neonatal intensive care<sup>[32]</sup>. The NICU is a complex system, where the environment is often chaotic with multiple unplanned admissions of critically ill patients requiring intensive care. In such complex systems, dedication, training, and vigilance of staff are insufficient to prevent errors<sup>[14]</sup>. Many factors have been found to influence the intrinsic risk of MEs, such as intensity of workload, understaffing, handoffs among health care providers, poor communication within the team, day shift, poor knowledge of the procedures, inappropriate use of technology, inadequate training, and absence of consciousness of errors<sup>[17,31,33]</sup>.

Inexperience represents an additional risk factor for MEs. New staff make MEs more often because prescriptions are commonly written by junior doctors who may be less skilful in using medications<sup>[33]</sup>. Other factors related to caregivers such as inattention, distraction, haste, and fatigue principally affect the susceptibility to error<sup>[7]</sup>.

Recently, the level and type of MEs in NICUs and neonatal units have been investigated, documenting that 37.8% of the nurses committed 1-2 MEs in a 6-mo period. The most frequent errors during injectable drug use were found to concern the time of drug administration, pharmaceutical calculation, and the ignorance of drug interaction in case of simultaneous prescription of more than one drug. Errors in pharmaceutical calculations and in medication dose were the most frequently observed in non-injection medication use<sup>[27]</sup>. Other studies documented that drug administration at the wrong time is the most frequent administration error<sup>[16,34,35]</sup>. A literature review by Chedoe *et al*<sup>[36]</sup> identified dose errors as the most frequent type of ME; they were found to result from an inexact recorded patient weight, a wrong unit of measurement, an incorrect recording of dosage regimen, or an erroneous placement of decimal point during dose calculation. Kunac *et al*<sup>[37]</sup> applied a technique named Failure Mode and Effects Analysis to the NICU medication process in order to identify high risk processes and to develop system improvement actions. This technique is used in industry to evaluate system safety and identify potential errors before they happen. The Authors documented that the most potential errors occur during drug prescription and preparation. Wrong setting of infusion pumps, incorrect doses, time and route of administration were the more frequently identified errors during administration step<sup>[37]</sup>.

## PREVENTION STRATEGIES FOR MEs IN NEONATOLOGY

Promoting a culture of safety has to be considered the most important tool to prevent MEs. A work environment where the culture of safety is widespread, and PS is considered more important than efficiency and produc-



tivity, can be defined a high-reliability organization, able to guarantee PS. The safety culture of an organization depends on many factors, namely group and individual values, competencies, perceptions and behavior models, that decisively influence ability and commitment to a safety management<sup>[38]</sup>.

Since the 1950s, an increasing consciousness about the need to prevent MEs started spreading. In 1999, the IOM defined PS as “freedom from accidental injury”, and established that it was a priority in improving quality of care. This esteemed institution laid out a comprehensive strategy and drew up a concise list of recommendations, offering a road map toward a safer health system<sup>[1]</sup>. Today, PS is an emerging concern of politicians, managers and caregivers. Measuring newborn PS is important in preventing MEs and helps to improve NICU safety, because it allows to propose changes and to monitor both the effects of PS interventions and the safety trends over time. The best PS measure is represented by the rates of events, that are mainly obtained from reporting, direct observation, chart review, and automated methods<sup>[39]</sup>.

Recently, a list of alert events, including death or severe lesions due to drugs, has been drawn up. These events are called “sentinel events” as they are indicative of a malfunctioning in the healthcare system that requires immediate research and action<sup>[18]</sup>.

Many intervention procedures have been developed to decrease the risk of MEs, and it is essential that all NICU staff are involved in the prevention of them<sup>[14,40]</sup>.

Two different generic strategies have been proposed. The first strategy consists of identifying human behavioral factors resulting in errors and redesigning all the work in the NICU in order to minimize them; the second one suggests to design and implement dependable systems for preventing errors or intercepting them before reaching the patient<sup>[31]</sup>.

Although system deficiency or failure is the primary source of errors, individual healthcare professionals' behavior also plays a role in the occurrence of MEs. Therefore, education and training of caregivers are considered an important step in the ME prevention policy.

Training programs are firstly aimed at improving communication competence between healthcare professionals and their patients and at building and reinforcing team communication ability. Training courses should also be held to provide caregivers with instructions and practice in performing mathematical calculations for drug dosage and patient monitoring during therapy administration. Recently, Campino *et al.*<sup>[41]</sup> have studied the effects of a multidisciplinary education intervention on the number and type of MEs made in a NICU in the prescribing phase. The investigators documented that the implementation of this strategy led to a significant reduction of this type of errors from 20.7% to 3%, probably due to a behavior modification of doctors in the prescribing phase, and the spreading of a PS culture among health professionals. Another recent study has investigated the effects of an educational program on the rate and severity of some

NICU MEs. The program consisted of several theoretical and practical lessons directed at nurses, about the preparation and administration of the most used drugs. The error rate decreased after the intervention period from 49% to 31%, although remaining significantly high. The authors concluded that this typology of intervention is able to reduce the error rate in medication preparation and administration. However, it is not sufficient alone to reach an adequate medication safety<sup>[42]</sup>.

The Italian Society of Neonatology<sup>[43]</sup> drew up a practical guide aimed at reducing the risk of MEs in newborns. It consists of a formulary and a software program that provide neonatologists with a useful tool able to describe drug characteristics, the administration route and drug interactions, and to calculate the right prescription. It allows the creation of a personal file for each patient, reporting name, date of birth, weight and gestational age. The software program is able to work offline and can be updated over time<sup>[43]</sup>. Future studies are required to assess the effectiveness of this computerized support system.

Another strategy that was proven to reduce MEs is represented by the full-time presence of a dedicated clinical pharmacist in the NICU. This professional performs a daily review of medical prescriptions, suggests therapy changes, provides pharmacokinetic monitoring, educates and informs NICU staff and patients and helps in discharge planning<sup>[32]</sup>.

Many efforts have been made to draw up detailed recommendations to prevent physician prescription errors which are due to unclearly legible prescriptions. It has been underlined that, in the prescription, physicians have to report any appropriate information on the patient (name, date of birth, weight, *etc.*). Furthermore, medication name, dose, quantity to be dispensed, administration route and frequency, therapy duration, and name of prescriber have to be clearly reported<sup>[44]</sup>. In case of the prescription written by physician assistants, the printed name, address, phone number, and signature of the supervising doctor will also have to be included. An additional control on medical prescriptions is made by nurses verifying dosage calculations, documenting all prescriber verbal orders, and repeating the orders back to him/her to verify them. Nurses' duties also include the verification of patient identity before giving the drug, and the administration of all doses at planned times<sup>[44]</sup>. For these reasons, nurse training should include a specific pharmacological education. An important step in the strategy of ME reduction regards clinical pharmacists in that they are responsible for the preparation and dispensing of prescribed drugs<sup>[44]</sup>.

One of the most popular methods to investigate the processes involved in medical errors and adverse events has been the incident reporting system. This method is used to identify high-risk areas that may require and be amendable to structural changes in the healthcare organization. Reporting systems are mainly characterized by a centralized data collection and expert analysis of reports of errors, near-misses, and adverse events by healthcare

professionals; they are confidential or anonymous, non-punitive reporting and provide important information about the type, etiology, outcome and preventability of incidents, suggesting specific interventions to enhance PS. A number of reporting systems with different characteristics are available, but none is totally suitable for all types of errors and adverse events and none is accepted by healthcare professionals in all cases. Mandatory and voluntary reporting systems are the main proposed typologies of incident reporting. The mandatory system focuses on errors resulting in severe harms or death. This system is able to identify only a part of the errors and underestimates iatrogenic ones. The voluntary system focuses on near-misses, allowing to identify weak points in the systems and to improve patients' safety<sup>[45]</sup>. This system requires that healthcare providers voluntarily collaborate and trust the system, overcoming some barriers as the fear of punishment by superiors or of legal exposure. Snijders *et al*<sup>[26]</sup> reported that a voluntary and non-punitive approach is suitable in providing important information about the type, etiology, and outcome of incidents, and to suggest appropriate avoiding strategies when applied in the NICU wards. Another reporting system classification includes the comprehensive national voluntary and the specialty-based systems. The first one provides the reporting of all types of medical errors and adverse events, while the second one is tailored to specific branches of healthcare system and allows to identify patterns of errors that are specific to each specialty. It has been documented that healthcare professionals better accept the specialty-based system that is considered more feasible<sup>[46]</sup>. A voluntary, anonymous, and specialty-based reporting has been found to be more powerful in improving PS, identifying a broad range of medical errors in the NICU and promoting collaborative learning among different disciplines<sup>[46]</sup>.

Recently, a pilot study has been conducted to test the feasibility and utility of performing a real time safety auditing during routine work in a NICU. This tool was shown to promptly identify a wide error range, and allowed to detect significant safety problems. Clinical staff performed safety audits soon after work rounds, having a prompt feedback regarding team efficiency. Rapid changes in practice and policy were adopted by the health caregivers involved in this study, in order to improve PS<sup>[47]</sup>.

Recently, technology systems have been developed to provide further tools for ME prevention by processing inserted data, offering information and an accurate modality of communication, and alerting caregivers in the case of potential error occurrence. The information technology system that is currently recommended in the hospital setting is the Computerized Physician Order Entry (CPOE). It functions as a firewall to reduce the ME risk<sup>[44]</sup>. However, the CPOE effectiveness in lowering the rate of preventable NICU MEs has not yet been clearly demonstrated. Nevertheless, the opinions of experts and adult and pediatric data support the CPOE use in the NICU. There are different typologies of CPOE, all characterized by the automatic medication-ordering

process. Most of the CPOE systems are integrated with a more or less sophisticated clinical decision support (CDS) that provides warnings or suggestions about drug doses, routes and frequencies of administration. The most advanced models are implemented with other important items, for example a drug-drug interaction analysis. A basic CPOE system only accepts typed orders in a standard format, and guarantees a complete, clear and standardized drug order<sup>[48]</sup>. In the full CPOE system, a doctor prescribes a medication by CPOE and CDS software, which transmits the information to the software of the pharmacy. The latter keeps track of the movements of a robot able to read the electronic drug order and to prepare a specific drug's unit dose to be given to a particular patient, by a specific route and at a stated time. Then, a barcode label holding all this information is automatically tagged to the unit dose, and subsequently delivered to the patient unit. At the patient's bedside, the nurse scans the barcode applied to the unit dose package, the barcode on his/her identification badge, and that on the patient's wristband. The barcode scanner communicates these data to a computerized system which verifies the correspondence with the medical prescription and indicates that the unit dose of the drug can be administered. In the end, the nurse notifies the system that the drug dose has been administered<sup>[31]</sup>. In 2009, an Iranian study evaluated the effects of CPOE use in a neonatal ward on reducing MEs concerning two drug classes. The error rate remained constant after the CPOE introduction, while decreased significantly from 53% to 34% after the decision support system was added to the CPOE. Prescription error rate, but not transcription error rate, was modified by the introduction of this system. The most frequently intercepted errors were dose errors, namely over-dose errors<sup>[3]</sup>. New typologies of MEs have been identified after the introduction of CPOE systems. Physicians were found to be at risk for selecting an unrequested drug from a list of multiple proposed medications<sup>[36]</sup>. Ignoring warnings was identified to be another important reason for the partial failure of CPOE system. A recent study has documented that physicians ignore the warnings when they are not able to understand the reason of the alert appearing, and accordingly they perceive them as inappropriate. Introducing an explanation of warnings that allows the prescribers to understand the reason for the alert appearance has been suggested as a useful tool for increasing the physicians' compliance with the system suggestions, thus further reducing MEs<sup>[3]</sup>.

Unfortunately, in spite of the potential benefits resulting from the CPOE use in preventing MEs, this electronic prescribing system has not yet been introduced into the majority of hospitals for different reasons, including organizational barriers, resistance to change from neonatologists, and high costs.

## CONCLUSION

Since 1999, the problem of PS has drawn particular attention, becoming a priority in health care. All healthcare

professionals are susceptible to committing MEs, especially those working in neonatal wards. Newborn infants show an increased risk of MEs because of multiple factors, including small size and reduced compensatory abilities of the neonatal population, the frequent use of unlicensed or off-label drugs in this population, and the complexity of the NICU environment<sup>[49]</sup>.

Although a high ME rate has been found in neonatal wards, newborn safety issues have not been adequately studied until now. Vigilance, training, and dedication are not enough to prevent this type of error, especially in a complex system such as the NICU. Current prevention strategies have been borrowed from the adult wards, but many factors such as high costs and organizational barriers have hindered their diffusion. In the near future, prevention strategies for MEs need to be improved and tailored to the special neonatal population and the NICU environment and, at the same time, every effort will have to be made to support their clinical application. Finally, it is of utmost importance to create a culture of safety among healthcare professionals, with the ultimate aim of improving the general reliability of any system that provides neonatal care.

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