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The Anatomy of Medication Errors

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Abstract

Medication errors constitute a category of errors that occur more frequently in healthcare units. They refer to every preventable event that may cause or lead to the inappropriate use of medicines or patient injury, during the therapeutic process. This type of events may be associated with professional practices, healthcare products, procedures, and systems including prescription, communication through instructions, drug labeling, packaging and nomenclature, reformulation, dissolution, distribution, administration, education, monitoring, and use. Classification and evaluation of medication errors according to their importance may constitute an important factor for process improvement in order to render the administration of medicines as safe as possible. The main categories of causes that lead to medication errors are those associated with the healthcare provider system, the healthcare professional, the pharmacy, and the scientific competence of the personnel. Technology has grown to be a constituent part of medicine these days. The appropriate technology is able to assist in increased efficiency, enhanced quality, and lessened costs. A few advantages that technology can supply are categorized as follows: the assisting of communication between clinicians; enhancing medication safety; decreasing potential medical errors and adverse events; rising access to medical information and encouraging patient-centered healthcare. The aim of this chapter is to provide a compendious literature review regarding the definition, the classification, the causes, and the main strategies for preventing medication errors.

Keywords: nursing error(s), medication error(s), definition, causes, classification, usage, adverse drug reaction(s) – adverse drug event(s), electronic medical record(s), patient safety

1. Introduction

The interest in the study of medication errors and adverse drug events has increased intensively after the publication of studies such as “To Err is Human: Building a Safer Health System” [1]

and “An Organization with a Memory” [2], which set a new milestone in patient safety. The administration of medicines constitutes a complex technique, which requires the participation of various healthcare professionals and takes place in a complex environment [3]. Nurses constitute a group of healthcare professionals who fill most of the prescriptions and spend 40% of their time in the hospital in order to administer pharmaceutical preparations to the patients [4]. Therefore, medication errors in nursing occur more frequently and have an impact not only on patient’s health and safety but also on the healthcare system since prolonged hospitalization of patients generates additional costs, as a whole, for the healthcare system [5, 6].

For half a century, nurses learn the basic principles of the medication administration phase which are included in the following tenet: “appropriate patient, appropriate medicine, appropriate dosage, appropriate routes of administration, appropriate time.” The implementation of the above tenet comprises an indicator of quality nursing care [7].

In 1981, Steel et al. discovered that more than half of the iatrogenic damages were associated with medication use. These consequences may vary from smaller or imperceptible to very serious and lethal [8].

The majority of studies regarding medication errors refer to hospital patients due to the fact that it is easier to perceive and register errors in hospitals than in the case of medication to be administered at home. It has been found that medication errors are mainly related to prescription, preparation, administration, and patient monitoring processes. Nurses’ involvement in processes (prescription, preparation, and medicine administration as well as patient monitoring) other than prescription is instrumental, since the aforementioned processes constitute nursing actions performed on a daily basis [9].

The incidence of medication errors is just as high in developing countries as in the developed ones [10, 11]. Approximately 5% of the adverse drug events (ADEs) that could be ascribed to nurses administering medications to patients are likely to put patients’ safety at risk [12]. Moreover, researches have shown that 1/3 of medication side effects (MSEs) result from medication errors [13]. The incidence of medication errors is higher in children than in adults, since dosages for children are estimated separately for each child depending on their age, weight, body surface, and clinical conditions. Additionally, the majority of medications for children are unlicensed and off-label [14–16].

According to the National Patient Safety Agency (NPSA), medication errors in the United Kingdom (UK) occur at all phases of the medication therapy: 16% in prescription, 18% in distribution, and 50% in medication administration. The equivalent rates in pediatrics range between 3–37% in prescription, 5–58% in distribution, 72–75% in administration, and 17–21% refer to clinical documentation errors. In a period of 8 years, 29 children have lost their lives due to medication errors in the UK [17]. Moreover, medication errors cause 1 of 131 outpatients and 1 of 854 inpatient deaths [1], and inpatient medication error rates are between 4.8% [18] and 5.3% [19]. It should be underlined that injury from medication errors is modest (0.9% of medication errors) [19]. Furthermore, the medications most usually involved with errors categorize insulin, opioid-containing analgesic, anticoagulant, amoxicillin-containing agent, and antihistamine/cold remedy [20].

It is estimated that medication errors cost the US healthcare system \$77 million each year [21]. According to an older study, medication errors extend the hospitalization for an average of 4.6 days [22] and increase the cost at about \$2000–2500 per patient [23].

According to Allan and Barker, the purpose of examining medication errors is to measure the errors made in various healthcare organizations and the different error rates in relation to the implementation of different medication distribution systems, to identify the causes of these errors and to evaluate the practices employed for their prevention. The examination of all these parameters mainly aims at preventing the errors associated with medications for the protection of patients [24]. Originating a dependable area for all the categories of patients to be able to ask safety-related questions in a responsibility-free environment and urging, the errors and adverse events whenever they occur, revealed, along with the creation of layers of defense mechanisms (such as the use of computer based technical knowledge; uncomplicated images on wristbands and color coded alerts on handoff/sign-out materials) will all contribute to promote a genuine culture of safety on the inside of the healthcare system [25].

2. Summary of key points

Table 1 presents the most important points of the chapter concerning the medication errors.

Definitions	
Medication error	Any kind of error happening anywhere in the medication use procedure
Adverse drug event	An adverse result that can be ascribed to the action of a medicine
Epidemiology: statistics	
<ul style="list-style-type: none">Medication errors cause 1 of 131 outpatients and 1 of 854 inpatient deathsInpatient medication error rates are between 4.8 and 5.3%Injury from medication errors is modest (0.9% of medication errors)Medications most usually involved with errors are categorized as insulin, opioid-containing analgesic, anticoagulant, amoxicillin-containing agent, and antihistamine/cold remedy	
Risk factors	
Patient elements	Deterioration in renal or hepatic function, impaired cognition, comorbidities, and polypharmacy
Healthcare professionals' elements	Use of abbreviations, cognitive biases
Avoiding medication errors	
<ul style="list-style-type: none">Computerized physician order entryBar code-assisted administrationEnhanced medication labelingMedication reconciliation	

Table 1. Medication errors: summary of key points.

3. Medication errors: terms and definitions

Meurier et al. defined nursing errors as “every action, decision or omission of a nurse which was evaluated as incorrect by more experienced colleagues and had adverse effects on patients” [26]. In 1954, the American Hospital Association (AHA) defined for the first time medication error as “the administration of the wrong medication, medication dosage, diagnostic or therapeutic substance, to the wrong patient or at the wrong time, or the failure to administer these substances at a given time or according to the prescription or what is considered as acceptable practice” [27].

The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) defines medication errors as: “any preventable event, which may cause or lead to inappropriate use of medications or to patient injury, while medication therapy is under the control of a health care professional, patient or user of health services. Such events may be associated with professional practices, healthcare products, procedures and systems including prescription, communication via instructions, product labeling, packaging and nomenclature, reformulation, dissolution, distribution, administration, education, monitoring and use” [28].

Choo et al. defined medication error as “any error during the medication administration, regardless of whether they have consequences or not” [29]. According to an ethnographic study in 2003 regarding the impact and the significance of intravenous medication errors, intravenous medication errors are defined as: “a divergence between the preparation and administration of an intravenous medication and the medical prescription, the hospital strategy regarding intravenous administrations and the instructions of the manufacturer” [30].

The definitions of severity level for adverse drug events (ADEs) are presented in **Table 2** [31]. The relationship among medication errors, adverse drug events, and potential adverse drug events is illustrated in **Figure 1** [32].

Significant ADE	<p>Happens if the event brings about symptoms that while substance to the patient creates little or no threat to the patient’s life function. These ADEs could contain aggrandized or depressed laboratory test levels</p> <p>Examples of physical symptoms are categorized as sensation, physical tiredness, inability to defecate, muscle cramps, inability to sleep, headaches, and pedal edema</p>
Serious ADE	<p>Happens if the event brings about persistent alteration of life function. Moreover serious ADEs could contain aggrandized or depressed lab values that require medical intervention, exceptionally if they propose organ system dysfunction</p> <p>Examples of physical symptoms are categorized as a two-unit gastrointestinal bleed, a symptom requiring hospitalization, an altered mental status/excessive sedation, allergic reaction-shaking chills/fever, or symptomatic hypoglycemia</p>
Life-threatening ADE	<p>Happens if the event brings about symptoms or alterations that if not treated would put the patient at risk of death Life-threatening ADEs categorize laboratory values that are either aggrandized or depressed to the point that a crucial physiologic function is at risk of failure</p> <p>Examples of physical symptoms; patient transferred to ICU due to respiratory failure, cardiac arrest, and anaphylaxis</p>

Table 2. Definition of severity level for adverse drug events (ADEs).

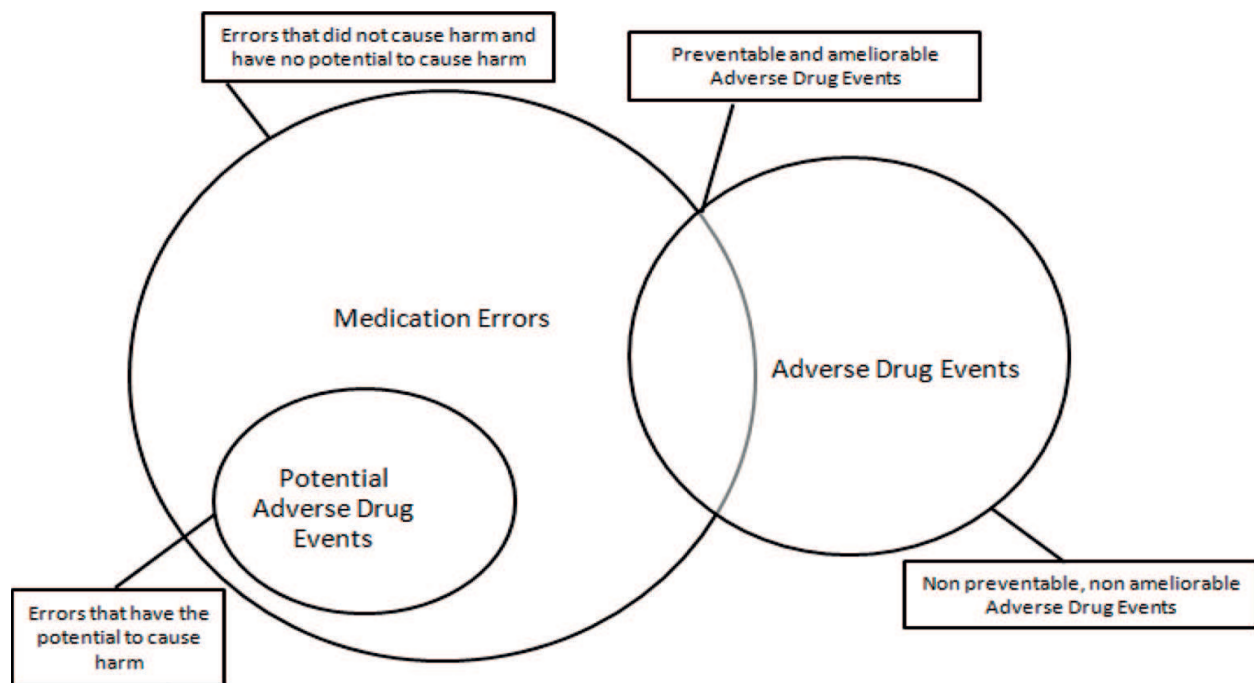


Figure 1. Relationship among medication errors, adverse drug events, and potential adverse drug events. Source: Gandhi et al. [32].

4. Classifications of medication errors

In 1960, Safren and Chapanis published the first study that documents the type of medication errors and classifies them into seven categories (wrong patient, wrong time, wrong dosage, omission of a dosage, administration of an extra dosage, wrong medicine, and wrong route of administration) [33].

Medication errors could be classified into two major categories: the ones that occur prior to medication administration, during the preparation, and upon medication administration [30].

i. Errors in preparation

Medication preparation for the purpose of administration is a process that involves all these actions performed by nurses in order to reach the medication to patients ready for use. Some of the nursing medication errors upon preparation for hospitalization are [30, 34]:

- Errors in copying medical instructions
- Wrong method of preparation and drug dissolution
- Incorrect content of the reconstituted drug
- Incorrect selection of medication due to similar packaging
- Incorrect dosage due to miscalculations

ii. Errors in administration

Some of the most common errors in medication administration involve [30, 34]:

- Administering the wrong medication to the wrong patient
- Incorrect route of medication administration
- Incorrect rate of administration
- Incorrect method of administration
- Incorrect time of administration
- Repeated medication administration
- Medication administration without medical prescription
- Interruption of medication administration whereas it should be continued
- Continue medication administration against doctor's order to interrupt it
- No medication administration

The NCC MERP created an algorithm in order to classify medication errors into nine categories, based on the extent of the damage they may cause to the patient [35]:

- iii. Conditions and events that may lead to an "error"
- iv. An error that finally did not cause any damage to the patient
- v. An error that occurred to a patient but did not cause any damage
- vi. An error that occurred to a patient but required further monitoring or intervention in order to ensure that it did not cause any damage
- vii. A temporary damage to the patient that requires intervention
- viii. A temporary damage to the patient that requires initial or extended hospitalization
- ix. Permanent disability of the patient
- x. Intervention required in order to keep the patient alive
- xi. Death of the patient

5. Assessment of medication errors

According to the literature, one of the main characteristics of medication errors is their severity. In 1986, the El Dorado Medical Centre in Tucson, Arizona, developed a tool for the evaluation of medication errors, the so-called El Dorado Medication Error Tool (EDMET). This

tool is objective, is uncomplicated to use, and defines clearly the four parameters, which are related to the severity of medication errors. These parameters are associated with the type of errors (i.e., wrong time, route, date, dosage, preparation, rate of administration, extra dosage, omission of a dosage), the route of administration (i.e., intravenous, intramuscular, oral, etc.), the classification of drugs according to a particular list that includes drugs with serious side effects in case of an error (i.e., heparin, digoxin, potassium), and the time between the medication error and the identification thereof. The last parameter constitutes an important role regarding patient's outcome, since it determines early or belated initiation of interventions that will prevent or reverse adverse consequences. Moreover, the abovementioned parameters are further categorized and rated each time depending on the situation. Finally, the total score depends on whether the patient has stated any allergies to a certain medication. This tool is particularly easy to use; it is designed to be accurate and reliable, and it has been used by the center in order to evaluate the severity of errors on the one hand and to determine further interventions by nursing staff on the other. According to these data, classification and evaluation of medication errors depending on their severity may constitute an important tool for the improvement of processes in order to make medication administration as safe as possible [36].

6. Etiology of medication errors

Safren and Chapanis were the first to classify the causes of medication errors into 10 categories (not following any audit process, illegible medical instructions, errors in copying instructions, errors in classifying instructions, errors in calculating the dosage, improvisations, wrong medication labels, patient assignment to two nurses at the same time, poor oral communication, and more). Other criteria for the documentation involve the status of the person that made the mistake (student or worker), the nursing department where the error occurred, the time of day, and the severity of the patient's condition [33].

Wakefield et al. classified the causes of medication errors into five categories this time [37]. The first category refers to the causes associated with the system (regular interruptions of nurses upon administering the medications, regular changes of nurses, simultaneous administration of medication for all the patients, poor authentication of patient's identity). The second category refers to the causes associated with the healthcare professional (failure to transcribe instructions into the medication cards, poor communication between nurses regarding medication dosages that have not been administered, errors in copying instructions, non-compliance with the medication administration processes). This category also includes poor compliance of the healthcare professional with hospital policies and procedures, fragmentary personal experiences of the nurses [38], and memory lapses [39].

Other categories refer to causes related to doctors (illegible, unclear instructions, frequent changes of the instructions), pharmacies (imprecise medication dosage and administration or wrong dosages), and the adequate knowledge of the staff (inadequate knowledge

regarding adverse reactions of medications, poor access to Manuals of Pharmacology). Apart from these five categories of errors, it is worth referring to the causes that have been mentioned by other authors including incorrect mathematical calculations; poor dosage adjustment, in order to prevent liver and kidney damages; inability to obtain a proper medical history that may also include possible allergies to medication preparations; and inability to prevent synergistic effects between two or more drugs and to further convey this information to health professionals [40, 41]. Part of medication errors is largely attributable to lack of relevant information regarding the new technologies, such as the function of medical drug delivery pumps [39].

Other causes of medication errors are associated with working conditions at the sites where medical products are produced, i.e., lighting conditions, noise, packaging, and nomenclature for medical products, i.e., medications with similar names, distribution and storage processes, and processes and protocols specified in every agency [42–45].

The NCC MERP documented 10 basic factors that influence medication use process and are frequently associated with the causes of medication errors. These 10 factors involve information related to the medical history of the patient; medications; communication between healthcare professionals, in order to convey information regarding medications; nomenclature and packaging of medication preparations; storage, safekeeping, and standardization of medication; acquisition, use, and monitoring of medication devices; environmental factors; competence and education of the staff and the patient; and quality and risk management processes [46].

7. Consequences of medication errors

The consequences of medication errors vary; the instance, however, that the error becomes apparent and the immediate action for the prevention or reversal of adverse events are of critical importance. The impact of medication errors on patients who are admitted in intensive care units (ICU) is more serious, since most of the times these patients receive a considerable amount of medications and they are often characterized by impaired capacity to adapt to the consequences of such errors (due to organ failure, possible immunosuppressant, poor communication, etc.). The consequences of medication errors may be associated with extended hospitalization and application of additional interventions, or they may be life-threatening for the life of the patient and may even lead to death [11].

In a study of Bates et al., every error related to drugs was responsible for an average of 2.2 more days of stay in the ICU [47]. In another study, despite the fact that no lethal errors were observed, 26 of them were potentially threatening to patients' lives, whereas 55 of them were considered important [48]. Moreover, a study of Calabrese et al. did not observe any lethal errors, but five of them contributed to the need for increased monitoring of the patient and two of them led to the implementation of an appropriate intervention [49]. On the contrary, Flaatten and Hevroy found that one error led to the death of a patient; five (5.7%) were evaluated as important, whereas twenty two (25%) contributed to the implementation of an appropriate intervention [50]. Finally, in a study of Rothschild et al. (2005), 120 AE were reported,

14 of which (11.6%) were threatening for the life of patients and 2 (1.6%) of them were lethal, whereas 24 (11%) of the 222 errors which were reported were evaluated as potentially threatening for the life of patients [51].

8. Prevention of medication errors

The use of technology contributes to the improvement of the quality of the services provided and maximizes the protection and safety of patients against eventual errors and events throughout healthcare provision. Intranet installation as well as the use of personal computers in healthcare provision units contributes to the implementation of automated (computerized) systems for the writing of medical instructions, therefore eliminating errors attributable to illegible handwritings [52].

It also minimizes errors that occur while copying instructions on medication cards and prevents questions and misinterpretations, since every prescription includes mandatory fields that must be completed, such as route and time of administration as well as the precise dosage. Using special software for pharmacology, nurses can also be informed about possible allergies or side effects from incompatible medications every time they check on a patient's medical record. The placement of barcodes on every medication as well as the placement of identification wristbands for every patient upon admission to the hospital may decrease errors associated with inappropriate administration of medications with similar packaging and the administration of the wrong medication to the wrong patient. Using a wireless device at the time of hospitalization, nurses are able to monitor the administration of the appropriate medication preparation to the correct patient in the appropriate dosage using the appropriate route [53].

The use of "smart" infusion pumps for intravenous medication administration and more specifically for the administration of unsafe preparations, such as heparin or insulin, predetermines the infusion rate and provides security alarms. Such pumps have been used for several years in specialized departments, such as ICU. The rapid technological development contributed to further improvement of the existing pumps by customizing them and giving the healthcare professional the ability to enter information, such as possible allergic reactions, for every patient or install a software with pharmacology data [54].

Additionally, nurses should ensure the correctness of their actions not only during the preparation but also during the execution of hospitalization, thereby eliminating any external interference. Preparation of hospitalization is also advised as well as dissolution of intravenous preparations, at a separate, individual space and not in the room, where patients may pose various questions to the nurse. Moreover, patients' escorts should not be in the wards during hospitalization, so that it is quite and the nurses can concentrate on the administration of medications without anything distracting their attention [54].

Last but not least, the medication errors may also be prevented by simplifying nursing actions, by developing and establishing guidelines and protocols that will be followed systematically during the preparation and the administration of medications. Yet it is imperative to ensure the proper staffing of every health institution with nursing staff, in order to increase the ratio of nurses to patients.

9. Electronic medical records and medication errors

Electronic medical records (EMRs) constitute the only reliable implementation of medical, nursing, and laboratory work, since they have limited errors and improved productivity, and the medical decisions of the past provided essential support regarding the administration of medication treatment and the detection of abnormalities in laboratory examinations. They have also improved significantly the quality of the health services provided. The complete development and implementation of EMRs further require the development of an integrated information system [55, 56].

Some of the most important benefits of EMRs regarding medications are [55–60]:

- i. Elimination of medical errors
- ii. Physician productivity improvement
- iii. Minimization of cost
- iv. Encouragement of greater cooperation between sectors
- v. Quality improvement of the provided services
- vi. Systematic organization and nursing documentation through the use of legible medical records
- vii. Prevention of medication errors
- viii. Minimization of the time that is required for written procedures
- ix. Avoiding duplication of information required for the daily planning of the interventions
- x. Communication through the use of a common language
- xi. Easy and quick search and data recovery aiming at information but also with the potential of immediate information processing and grouping
- xii. Faster and more efficient communication and arrangement of procedures that require cross-sectorial cooperation
- xiii. Valid economic analysis of hospitalization costs for every patient based on the registered interventions, laboratory exams, medications, and materials
- xiv. Statistical process and evaluation of clinical nursing applications
- xv. Possibility of data and folder filing with simultaneous space saving
- xvi. Access of nurses to electronic libraries
- xvii. Familiarity and active participation of nurses in the information society and the circulation of knowledge
- xviii. Improvement of information quality (clear, inclusive, reliable, always available)

- xix.** Direct dissemination of common information at every level of information management (order, supply, administration, implementation of intervention, charge)
- xx.** Complete workflow automation
- xxi.** Process definition and implementation at section level and cross-sectorial cooperation
- xxii.** Increase of individual and group efficiency and effectiveness
- xxiii.** Possibility of direct and effective intervention of the competent institution in cases of any discrepancies in the management of medication products, materials, and laboratory exams
- xxiv.** Ability to monitor the availability of every type of pharmaceutical products
- xxv.** Ability to monitor physical and electronic stocks of every department
- xxvi.** Positive impact on the financial management of the insurance funds and the hospital due to a decrease of fictitious overconsumption of medications.

10. Clinical vignette

Louisa Bright, a 77-year-old, used to wake up at night with a difficulty in breathing with wheezing. Her doctor diagnosed her with asthma and gave her a prescription with albuterol, a bronchodilator. Two days later, Mrs. Bright was admitted to the coronary care unit (CCU) of a hospital with a heart attack. In his letter to the team leader of the medical department, the cardiologist reported that Mrs. Bright's doctor had made a wrong diagnosis regarding the wheezing of congestive heart failure and had prescribed a wrong treatment for asthma. The cardiologist reported that the therapy could have accelerated heart attack.

11. Conclusion

Errors in the administration of medication treatment constitute a consequential causation of morbidity and mortality, yet it could be an unclear and underappreciated understanding. A medication error is any error that happens in the medication use procedure. It has been assessed by the IOM that medication errors bring about 1 of 131 outpatient and 1 of 854 inpatient deaths. Medication elements (e.g., sounding names, below normal-level therapeutic index), patient elements (e.g., unsatisfactory renal or hepatic function, impaired knowledge, polypharmacy), and healthcare professional elements (e.g., use of abbreviations, perceptual biases) are able to bring about faster medication errors. Frequent effects faced by physicians after medication errors can be categorized as loss of patient trust, civil actions, criminal charges, and medical board discipline. Procedures to prevent medication errors from happening (e.g., use of information technology, better drug labeling, and medication reconciliation) have been used with inconsistent satisfactory outcome.

If an error or an adverse drug event is realized, most patients anticipate disclosure that is at a suitable time, given in person, and accompanied with an apology and attempt to prevent future adverse drug events and errors. Learning more about medication errors may improve healthcare professionals’ capacity to make available cautious healthcare to their patients. Future research should concentrate on recognizing the errors and adverse drug events that most usually cause patient injury. Furthermore, a better knowledge in what manner of information technology, labeling, medication reconciliation, and improved care transitions decrease medication errors and adverse drug events is needed. A concentration of easy-to-use and cheap techniques for medication error lowering will probably have the greatest influence.

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Competing interests

The author affirms that she has no competing interests.

Abbreviations

ADEs	adverse drug events
AEs	adverse events
AHA	American Hospital Association
CCU	coronary care unit
EDMET	El Dorado medication error tool
EMRs	electronic medical records
ICUs	intensive care units
MSEs	medication side effects
NCC MERP	National Coordinating Council for Medication Error Reporting and Prevention
NPSA	National Patient Safety Agency
UK	United Kingdom
US	United States

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