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SPECIAL ARTICLE

Medical errors in hospitalized patients

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Abstract

Objective: to review the current literature and to discuss medical errors in hospitalized patients emphasizing its incidence, predisposing factors and prevention mechanism. Special attention is given to medication errors and adverse drug events in newborn infants and pediatric patients.

Sources: bibliographic review of the current literature through electronic search in Medline data-base, with selection of the most relevant articles.

Summary of the findings: even though most medical errors are not reported, it is important to notice that its incidence is greater than previously assumed. In the USA, approximately one million of patients/ year are victims of medical errors and adverse drug events. Today, deaths resulting from these episodes are the fourth cause of mortality in the USA. In neonatal and pediatric intensive care units, where the complexity and frequency of technical procedures are high, medical errors are frequent. Fifteen percent of all admissions to a neonatal intensive care unit is followed by medical errors. Most of these errors occur during night shifts and include incorrect administration of drugs (35%) and errors regarding the interpretation of medical prescription (26%). Environmental factors (noise, heat), psychological factors (anxiety, stress) and physiologic factors (fatigue, absence of sleep) contribute to the occurrence of errors. Recent study shows that after working 24 hours without sleeping, the performance of a health professional is similar to a legally drunk person (serum alcohol level $\geq$ 0.08%).

Conclusions: errors are part of human behavior. The prevention of errors should include a careful review of the organizational system. Medical errors should be seen as an opportunity to change or re-structure the system and to improve the quality of health care delivered and patient safety.

J Pediatr (Rio J) 2002; 78 (4): 261-8: medical errors, newborn infants, pediatric patients, hospitalized patients.

Introduction

Despite the remarkable advances in all medical fields, medical errors have been a dire reality, threatening health professionals at large.

Errors regarding medical techniques and procedures can result in tragedy for patients and their families, lengthen hospital stay and increase hospital costs. On top of that, these errors can have a dramatic effect on the life of health professionals devoted to and involved in patient care.

Currently, medical errors have been the focus of attention on the media and have constantly made sensational headlines.[1]

Therefore, the cases that are made public represent the tip of the iceberg, since most medical errors do not result in

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consequences that are perceived by patients and health professionals, but are seen as unusual or isolated incidents.[2] Nevertheless, as most medical errors are related to the use of medications, they could be sometimes avoided. The aim of the present article is to warn health professionals of this problem, to discuss the reasons why medical errors occur, their consequences and the best way to deal with them. Medical error will be used in this article as a broader term that designates the error committed by any health professional (physicians, nurses, physical therapists, etc).

Medical errors - definition

The literature related to errors in the health area has substantially increased in the last few years, but different definitions are found. This does not allow us to have a uniform collection of information, which hinders the establishment of comparisons.[3] To minimize this problem, it has been suggested that the most common terms be standardized, as described next.

Medication error: any error that occurs from the moment of prescription up to the administration of the drug to the patient.

Prescription error: incorrect selection of medication, miscalculated dosage, inappropriate route of administration, wrong concentration, inadequate infusion speed, or indecipherable prescriptions.

Preparation error: incorrect dilution, inappropriate reconstitution, mixture of drugs that are physically and chemically incompatible, expired medication.

Administration error: inadequate procedure or technique for medication administration: incorrect route; correct route but incorrect site (e.g.: the medication should have been used in the left eye but was used in the right eye); incorrect speed of administration; interdose interval does not match the prescribed interval; omission (the prescribed medication is not administered) and extra doses. Administration errors also include errors caused by similar appearance and/or name of the medication.

Adverse drug events: injuries caused by the use of a given drug, which range between a simple skin reaction and death. There are two types: error-related events and drug-related events. Error-related events are called preventable, and drug-related events, which cannot be prevented, are the so-called adverse reactions.

Medical error and adverse drug events in clinical practice: the scope of the problem

Given the complexity of clinical practice and the large number of interventions each patient receives, a high error rate comes as no surprise. For instance, a patient at the intensive care unit receives on average 178 interventions a day. The occurrence of 1.7 errors per patient a day (1% of total interventions) indicates that the efficiency of health professionals is 99% in this case. This 1% error rate seems to be negligible when analyzed separately; however, when it is compared to other sectors, such as industrial production and service sectors, it becomes unacceptable. Even a 0.1% error rate, which represents a success rate of 99.9%, is not allowed in clinical practice.

This low error rate (0.1%) can cause catastrophic problems in other sectors. For example, with such an error rate, two defective airplanes would be manufactured a day, 16,000 letters would be led astray every hour, and 32,000 checks would be discounted at the wrong bank every hour in the United States.[3]

In the United States alone, approximately one million patients fall victim to adverse drug events (drugs administered by health professionals). Of these, 140,000 die every year.[4]

According to recent statistics, the death risk from adverse drug events in hospitalized patients (390/day) is three times higher than that attributed to motor vehicle accidents (125/ day), and infinitely higher than the risk of dying in a plane crash (0.27/ 1 million takeoffs).[5]

If we consider that three million pieces of luggage circulate every day in airports worldwide, we may be alarmed to know that the probability of medication error in hospitalized patients is higher than one piece of luggage being lost.[6]

Several publications in the last few years have assessed the epidemiology of medical error with special focus on the prevalence and consequences of such errors and on the professionals involved.

In 1991, Brennan et al. assessed 30,121 hospital admissions in 51 New York hospitals (Harvard study) and found a 3.7% rate of adverse drug events, which resulted in prolonged hospital stay or in sequelae for the patients. Of these, 69% were caused by medical error.[7]

Recent studies carried out in the United States have shown higher rates than those observed in the Harvard study.[8,9] According to these studies, adverse drug events from medical error prolong hospital stay in two to four days and produce an additional cost of approximately 4,500 dollars per patient.

In 1998, Lazarou et al. published a meta-analysis with the aim of estimating the incidence of serious and lethal adverse reactions to medication in hospitalized patients. Thirty-nine prospective studies carried out in U.S. hospitals were selected. These authors estimated that approximately 2,216,000 hospitalized patients had a serious adverse reaction to medication and that 106,000 of them died in 1994. According to these data, adverse reactions to drugs from medical errors have been recently considered the fourth leading cause of death in the USA (Table 1).[10]

Table 1 - Death causes in the USA in 1994

	Disease	Total number of deaths/year
1st	Cardiovascular diseases	743,460
2nd	Cancer	529,904
3rd	Stroke	150,108
4th	Adverse response to drugs	106,000
5th	Lung diseases	101,077
6th	Accidents	90,523
7th	Pneumonia	75,719
8th	Diabetes	53,894

Modified from Lazarou et al., 1998[10]

In general, young physicians, especially those in their first years of training, make errors at a higher frequency. No medical specialty is free from error. Whenever new technologies are introduced or whenever new resident doctors join the team, the number of medical errors increases substantially. The most frequent errors are concerned with prescription (56%) and administration (24%). The drugs most commonly associated with these errors are analgesic, antibiotic, sedative, chemotherapy, cardiovascular, and anticoagulant drugs.[11]

Some studies have shown that the major factors related to medical error are patient's age (children and the elderly) and complex surgical procedures. The length of hospital stay also predisposes to error, since the risk of adverse drug event increases 6% every day spent at the hospital, especially at intensive care units, where the number of procedures and interventions is higher.[11]

Despite the alarming statistics, the incidence of medical error and adverse drug events reported in the literature has probably been underestimated, as research methods are not normatized, the definitions of error types are not standardized, and health professionals are reluctant to admit their errors.

Errors involving newborns and pediatric patients

The distressing routine at a neonatal ICU is often strewn with errors related to medical techniques and procedures. These errors can range from simply not checking the ideal temperature of the thermoneutral environment to more serious errors, sometimes fatal, such as the misadministration of drugs. Medical errors can easily occur due to complex procedures on preterm and very-low-weight patients, and due to the frequent implementation of new technologies. In addition, the miscalculation of very low doses, involving decimals, speed of drug infusion, conversion from milligrams to micrograms, for example, may cause tragic consequences.[12]

As most errors go unnoticed, the health professional team takes for granted that the error rate is very low. Moreover, some adverse reactions to drugs can mimic an infection episode, characterized by apnea, peripheral perfusion disorder, electrolytic and acid-base disorders, and lead to unnecessary interventions.

A recent study has revealed that the error rate related to medical techniques and procedures in nurseries and neonatal intensive care units are more frequent than expected.[12]

It has been estimated that in every six to eight admissions to the neonatal ICU, one (15%) includes medication error. At these intensive care units, errors occur due to indecipherable (3%) or unclear (1.9%) prescriptions, incorrect dose (4%), or due to unspecified route of administration (28%) (Table 2).

Table 2 - Main causes of errors in neonatal ICU

Type of error	%
Indecipherable prescription	3
Unclear prescription	19
Incorrect dose	4
Unspecified route of administration	28

Modified from Vincer et al., 1989[12]

Amongst these errors, the most frequent ones are concerned with misadministration of drugs, misinterpretation of prescriptions, incorrect speed of infusion, and conversion of units[12] (Table 3).

Errors related to medical techniques and procedures are more frequent during the night shift (8 p.m. to 8 a.m.) than during the day shift (8 a.m. to 8 p.m.).[13]

The reduction of sleeping time to five or six hours considerably affects the ability to take quick and accurate decisions in emergency situations.[14]

Table 3 - Main accidents with drugs in neonatal ICU

Type of error	%
Incorrect administration (drug, dose, route, dilution, patient)	35
Misinterpretation of prescriptions	26
Incorrect prescription	16

Resident doctors often work 60 hours or more a week, with nonstop 24-hour duty shifts. According to recent studies, by the end of these duty shifts, these doctors show fatigue, loss of concentration, and signs of depression.[15,16] Lower clinical performance, drug-related errors, and time to carry out functions that require manual dexterity (tracheal intubation and vascular catheterization, for instance) significantly increase with sleep deprivation.[17]

A provocative study about the relationship between clinical performance of physicians and their sleeping time recently published in JAMA has stated that, after a nonstop 24-hour duty shift, psychomotor performance of a health professional is similar to that of a legally drunk individual (blood alcohol level = 0.08%)[18] (Table 4)!

Table 4 Periods of greater incidence of error at neonatal ICU

Type of error	Day	Night
Infiltration of IH	+	+++
Delayed IH infusion	+	+++
Incorrect use of respirator	+	+++
Error involving drugs	+	+++
Acidosis (pH < 7.20)	+	+++
Death (NB< 1,500g)	+	+++

IH: intravenous hydration (modified from Vincer et al., 1989)[12]

The chances of medical errors in pediatric patients are lower than in adults. One reason for this is that pediatric patients receive fewer drugs during their hospital stay than adult patients (seven versus 15 medications).[4]

The error rate involving pediatric patients accounts for 9% of all medical errors in the USA, of which 5% occur at emergency services. Selbst et al. have investigated medical errors at a pediatric emergency room in Philadelphia and have observed that the major errors were related to prescriptions of intravenous hydration and of electrolyte concentrations. Most of these errors occurred in the afternoon; 39% of these errors were made by nurses, while 36% were committed by physicians. In one third of the cases, the families were not informed about the error, and 12% of the involved patients required additional medications and treatment. No death occurred during the study period.[19] The most frequent errors observed in this study were incorrect information about the child's weight, leading to miscalculations, missing information about drug allergies, in addition to errors caused by similar drug names and labels. In most of these cases, the errors were regarded as preventable.

The study conducted by Folli et al., during a six-month period, in two pediatric hospitals in California, has shown that the highest incidence of errors occurred among patients aged less than two years, who were being treated at nurseries and intensive care units. The error rate was 1.35 for every 100 patients/day, and 4.9 for 1,000 drug prescriptions. Among the observed errors, 80% were associated with incorrect dosage. The mainly incorrectly prescribed drugs were antimicrobial drugs, followed by theophylline, pain-killers, electrolytes, intravascular fluids, and parenteral nutrition.[20]

A recent study carried out by Kaushal et al. reviewed 10,778 medical histories and found an error rate of 5.7% involving prescriptions, dosage, and administration of drugs to pediatric patients. Approximately 19% of all errors could have been prevented. The rate of potential adverse events in newborns was much higher than in any other patients.[21]

Why does the error occur?

For the analysis of the origin of errors and the reasons why they occur, we can use a comparison between the production sector of an industry and the team of health professionals of a hospital.

The industrial production sectors work with the hypothesis that human error is possible. Based on this assumption, they design mechanisms that are able to prevent or detect these errors beforehand. These mechanisms are aimed at providing consumers with a flawless end product.

One of the explanations for the large number of errors observed in clinical practice is exactly the lack of mechanisms that could reduce their occurrence or that could detect the error before reaching the end consumer (the patient). In other words, there is a belief that health professionals do not make errors and, therefore, mechanisms for their prevention and correction are not deemed necessary.

The education of physicians and nurses in their schools and practical training underscore a constant effort and quest for error-free work. A great emphasis is placed on perfection, both when diagnosis and treatment are concerned. In the daily routine of hospital practice, the message is clear: errors are unacceptable. The expectation that health professionals work error-free creates a consensual infallibility necessity, and errors are consequently seen as the result of carelessness, lack of attention or misinformation.

This perfectionism in medical practice, demanded from peers and from the patients as well, does not allow for a constructive approach to error as any professional involved in such a situation is segregated and stigmatized[22] (Table 5).

The physiological, environmental and psychological factors also contribute to the existence of errors. In this context, stress has a pivotal role. When under stress and

Table 5 - Error approach: comparison between industry and hospitals

Industry	Hospitals
• Hypothesis: human error might happen	• The health professional does not make mistakes (or is not allowed to make mistakes)
• The professional is trained to deal with errors	• The professional training does not approach the error
• It creates mechanisms to prevent or detect the error in an early stage	• There are not mechanisms to prevent or detect the error
• Error approach: punishment, marginalization	• Constructive error approach

faced with a problem, an individual tends to use a model he/she is acquainted with (even if it is inappropriate) rather than to use recently acquired and more appropriate models.

Psychological extremes, such as panic and boredom, relevantly influence the incidence of error. On the other hand, a little bit anxiety caused by moderate stress can even improve performance, since it channels the attention to the problem.[23]

Accidents rarely occur because of a single error, but rather from a breach in the defense barrier against accidents. The factors that influence human errors, that is, environmental, psychological and physiological factors, break this barrier by directly misleading attention. As these factors affect all cognitive processes, they can cause a large number and a wide variety of errors, which result in unsafe actions (Figure 1).

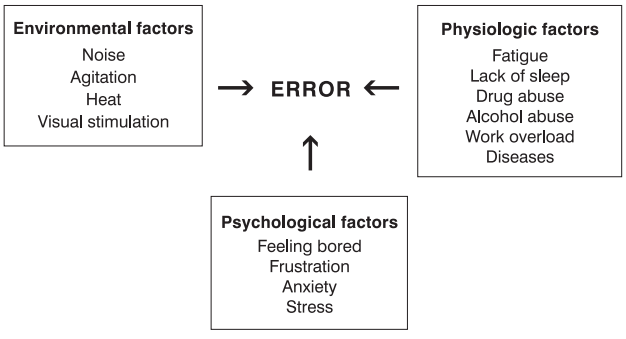

Figure 1 - Determinant factors for error occurence

How to deal with medical error?

It is evident that medical errors have acquired an alarming status and become an important public health problem. Currently, there are no systematized measures or procedures that could show the best way to handle these situations.

The opinion of health professionals about these problems is still strongly associated with the idea of infallibility they were taught at school or at university. Errors are hardly admitted and this does not allow developing deeper awareness of the problem. Errors will always occur, but to mitigate them, it is necessary to admit they exist.

Almost every physician and professional directly involved in patient care has committed some error that resulted in injury or possible injury to the patient. The emotional impact is always strong, typically characterized by a mix of fear, guilt, anger, shame, and humiliation, and this experience is not usually shared with anyone. If there is some learning from the error, in this case, it will be kept to oneself, and the possibility of a broad assessment with the attempt to improve the practice as a whole will be missed.

The fear of being regarded as backsliding and incompetent, being censored or watched closely, encourages health professionals to cover up their errors and deny them.

The attempts to control and prevent medical errors have been death with inadequately by most institutions. Medical error is still regarded as an individual error; therefore, its control and prevention are based upon increased surveillance, censorship, and punishments. Usually, the adopted measures only try to repair the perceived errors that caused injury to the patient. They have therefore a localized dimension.

When one accepts that to err is human, a more systemic approach and a broader view of situations or of the group of failures that led to error would be the most efficient way to prevent it. Medical practice can be safer to patients and health professionals if appropriate technology and mechanisms that facilitate human work are used, and if mechanisms that can detect and repair failures are implemented and maintained.

When a medical error occurs, causing or not injuries to the patient, a problem arises: should the physician tell the patient about it or not? Greely has discussed what the reasons that lead physicians not to tell patients about their errors are. Among the reasons presented by health professionals, the major ones include: fear of increasing patient's anxiety, fear of losing patient's trust, and fear of being legally sued.[24] This author also affirms that even in cases in which the error requires additional medical treatment, monitoring, and future medical follow-up, and offers death risk, physicians do not reveal their errors.

Rosner, in 2000, published an article on the ethical and professional involvement of this matter and concluded that it is the duty of a physician who causes injury to a patient to be honest with him/her. This includes a formal request for

apology and, in some cases, material compensation. Honesty and apologies are mandatory. Admitting the error is not merely a matter of ethics, but also a practical prerequisite for the future prevention of errors.[25]

In 1998, Van Den Bent published a study that investigated the professionals who most frequently reported adverse drug events in hospitalized patients. The conclusion of this author was that physicians, despite all the social and cultural burden, were the ones who revealed their errors, when compared to nurses or to patients themselves.[26]

The attitude of patients towards the physicians who reported their errors was also investigated in an article published by Witman et al.[27] in 1996. Among 149 patients, 98% were interested in knowing about the medical errors that occurred during their treatment, 14% said they would change doctors after a slight error, and 65% said they would do so after a moderate error. All of the patients would take into consideration whether the error was revealed by the physician himself/herself or by others when making a decision on legally suing the physician in cases of moderate errors. Twelve percent of the patients would sue the physician even if he/she revealed the error, but this percentage would increase to 20% if other people told them about the error. The conclusion is that patients want to be informed about the errors that occurred during their treatment. This could even reduce the number of lawsuits and punitive actions, thus showing the importance of an honest and clear dialogue between physicians and patients.

Final considerations: suggestions and methods for the prevention of medical errors

It is quite clear that the way medical errors are looked at has to change. The current approach, which is focused on the individual, should be replaced with a more systemic method.[28] At present, medical errors are seen as a personal failure, lack of attention, and absent-mindedness, for which the health professional should be punished. In the systemic method, advocated by most authors, errors result from a myriad of factors, and mechanisms that can prevent them or mitigate their impact are therefore devised[29] (Figure 2).

The prevention of errors should rely on the search for the real causes, which usually include errors related to the system of organization and implementation of the service. Even a theoretically correct system does not totally eliminate the possibility of error, as the human component varies a lot in terms of abilities and working habits.[5]

Medical errors should be treated as part of the system, and comprehensive mechanisms should be devised in order to assess the actual scope of the problem and to find an efficient way to handle it. It is also important that universities change their approach to medical error so that it can be handled with maturity, thus allowing involved professionals to report their own errors.[30]

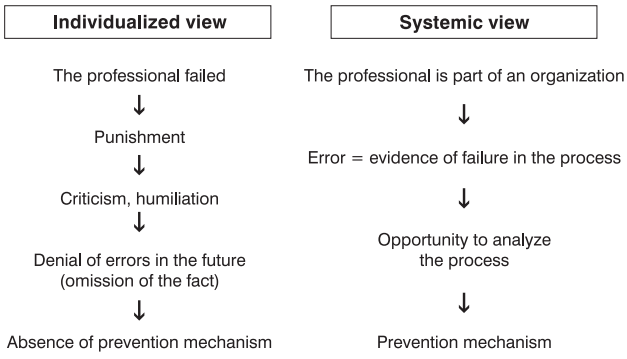

Figure 2 - Comparison between the individualized and the systemic views regarding the medical error

The entire health professional team has to be aware of the need for the implementation of such changes. The old approach to errors, with increased surveillance and identification of individuals off-track should be rejected and seen as counterproductive.[31] In addition to introducing new errors due to stress in the workplace, this approach encourages technical and intellectual dishonesty, allowing health professionals to shift the responsibility onto others or allowing them to hide the errors, even if this could cause extensive damage.[32]

Another way to reduce the frequency of errors related to medical techniques and procedures consists of the implementation of procedure standards and routines. In some sectors, such as intensive care units, in which several procedures are repeated, the implementation of procedure routines can and should be encouraged so that actions can be easily predicted and errors can be better monitored.

Bates has stated that medicine is like a small industry, with few standardized routines and with relatively less safety than other industrial areas.[33] In fact, most systems currently used in medicine were never formally planned and previously tested and are therefore little efficient. For instance, medication errors that cause allergic reactions in patients whose information had been included in the medical history but was not available to the health professional at the moment of prescription. This situation could have been easily dealt with if an electronic prescription had been used, that is, all the information fed into the patient's medical history would be available for cross-reference, and the prescription of such drug would immediately indicated, thus saving the physician time and avoiding unnecessary worry.

Errors related to medical techniques and procedures can be prevented through the implementation of continued training, application of performance tests and continued education, focused on the specific needs of each sector and

on the implementation of procedure routines. Encouraging technical update among employees improves work efficiency, reduces the frequency of technical errors and increases self-esteem, thus creating a strong link with work requirements.

Technology cannot replace the professional involved in patient care, but it can organize and make data available, detecting the existence of links between them, in addition to performing repetitive and tiring tasks, such as checking for potential problems and failures. This allows professionals to do the tasks that are executed by persons, such as making complex decisions and communicating.

Electronic prescriptions reduce errors and adverse drug events by up to 80%.[33] These prescriptions allow easily readable information to be presented in a structured fashion (dose, route of administration, interval) to any health professional. The information can be checked for possible drug interactions, incorrectly prescribed dose, side effects and presence of allergies.[34]

The use of a bar code on drugs has proved efficient in reducing medication errors. The regulation of this measure is dependent on the agreement between drug manufacturers and will probably be put in effect in the USA soon. The use of bar codes on medications is important because it allows for an automated control over the distribution of drugs to patients, ensuring that the drugs dispensed to the patient match the prescription, in addition to showing who dispensed them and who received them, as well as the administration intervals. Other innovations, such as an electronic system for checking prescriptions, the automated distribution of drugs and automatic detection of adverse effects, are under way, and will surely make the medication system safer for patients.[35]

In the future, physicians will prescribe medications on-line and will have an immediate feedback on problems such as allergies and drug interactions, helping to choose the best treatment. The prescriptions will be electronically sent to the drugstore or pharmacy, where an automated system will be in charge of basic tasks, and pharmacists will handle complex decisions. In this case, pharmacists will be better informed about patients' clinical problems. The distribution of drugs will also be automated, controlled by nurses by means of bar codes; this way, it will be possible to know when, by whom, to whom, and at what dose the drug was administered.[1]

Evidently, this potentially safe system of drug administration would be coordinated by health professionals. Therefore, these professionals would have fewer mind-boggling tasks and more pleasant and rewarding ones. Physicians could better discuss their treatment options with patients and technical assistants. Pharmacists would handle complex prescriptions and advise physicians on drug selection. Nurses would have more time to talk, get acquainted with their patients, and monitor them better.

The implementation of all these changes is expected to be slow and gradual, but it will never happen if the process is not started. Making physicians and nurses aware that errors are inevitable companion of human condition, even of informed and highly qualified professionals, is perhaps the first and foremost step to make the necessary changes. Errors should be accepted as evidence of system failure and seen as an opportunity to review the process and improve patient care.

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