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Chapter 2

Defining Adverse Events and Determinants of Medical Errors in Healthcare

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Additional information is available at the end of the chapter

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Abstract

The concept of error typically regards an action, not its outcome, and its meaning becomes clear when separated into categories (medical error, nurse perceptions of (medication) error, diagnostic error). One wrong action may or may not lead to an adverse event either because the abovementioned action did not cause any serious damage to patients' health condition or because it was promptly detected and corrected. The concept of error, on the contrary, which is used alternatively in the study, refers to the adverse outcome of an action. The responsibility for the emergence of errors in healthcare systems is shared among the nature of the healthcare system that is governed by organizational and functional complexity, the multifaceted and uncertain nature of medical science, and the imperfections of human nature. Medical errors should be examined as errors of the healthcare system, in order to identify their root causes and develop preventive measures. The main aims of this chapter are the following: (1) to understand medical errors and adverse events and define the terms that describe them; and (2) the most excellent way to comprehend how medical errors and adverse events occur and how to prevent them. Moreover it makes clear their classification and their determinants.

Keywords: medical error, adverse event, mistake, patient safety, culture of safety, error of omission, negligence, harm, injury, definition, etymology, determinant(s), cause(s), risk factor(s)

1. Introduction

Early studies on patients' safety in the 1950s considered medical errors largely "inevitable diseases of medical progress" [1], and scientific literature often referred to them as "the price paid for modern diagnosis and treatment" [2]. Patients' insecurity regarding the quality of

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services provided grows constantly, as mortality and morbidity caused by medical errors demonstrate increasing trends throughout the ages, particularly in countries with deficient social and scientific maturity. In developed countries, one in 10 patients experiences adverse events during hospitalization, according to World Health Organization (WHO). These events could have been predicted and prevented. Moreover, the risk in developing countries is 20 times higher, compared to developed countries [3]. Two categories of errors, which are mentioned subsequently, are the most reported the latest years.

"Communication errors" between healthcare professionals could negatively have an effect on patient safety throughout routine care and even more so during emergency care and in code situations. Training and recent procedures have been established to decrease communication errors [4].

"Wrong-site procedures" are a high-impact, low-frequency "never event" that exists all through procedural specialties. Effects of "Wrong-site procedures" are significant, starting with the psychological and physical harm to the patient. Moreover, the affected patient's loved ones are likewise highly likely to suffer emotional effects of having been, not in a direct manner, unprotected to a wrong-site event [5].

2. Actions and omissions which are associated with errors in healthcare

In an attempt to create a glossary of terms regarding patient safety, the EU Patient Safety and Quality of Care Expert Group accepted Reason's definition of error, which identifies two types of errors (**Figure 1**) [6].

According to Reason [6], errors are separated into "active" and "latent" errors. In "latent errors," effects occur later, and they are attributed to poor planning, increased workload, poor organization, and inadequate training of the personnel; in "active errors," effects are direct and may be detected instantly upon occurrence [6]. The terms "active failures" and "latent conditions" or "latent failures," the definitions of which are presented subsequently, are also frequently used:

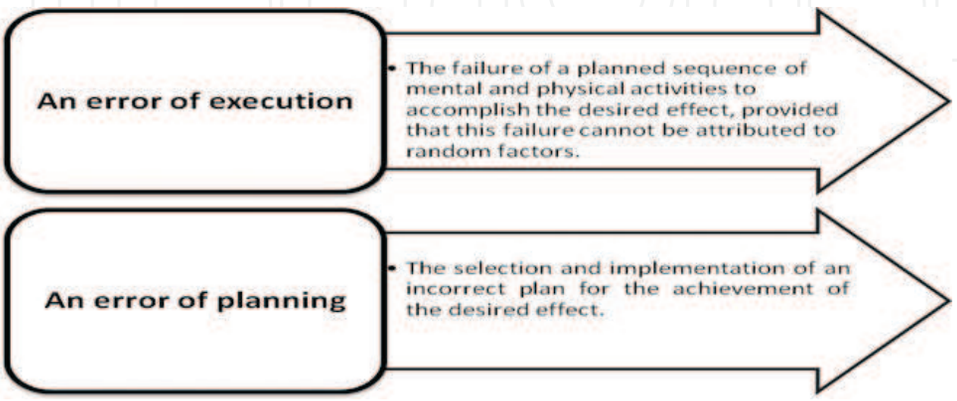

Figure 1. Types of errors by Reason. Source: Reason [6].

i. "Active failures": direct failures, unsafe acts carried out by people in direct contact with the patient or the system [7]. The effects become apparent almost instantly or at least within a few hours. These errors are often referred to as "errors on a knife-edge" [8]. It is true that people being on a "knife-edge" make errors, but this is only one part of the truth—and not even the most crucial.

ii. "Latent conditions or latent failures": latent conditions, inevitable inner pathogenic "micro-organisms" of the system that lead to errors. They arise from decisions taken at the strategic level and, thus, by the top management. Consequently, they are associated with the organization's structure, design, planning, training, forecasting, budget, resource allocation, etc. Latent conditions are manifested in two ways. The first way is by influencing working conditions so that the employees are prone to errors (e.g., time pressure, understaffing, lack/shortage of equipment, etc.) and the other way is by creating gaps in various organizational "defense levels" (e.g., unreliable alarm systems, design and construction defects, etc.). As the term suggests, latent conditions may remain ineffective inside the system for many years, and when combined with "direct failures," it may lead to the occurrence of several and different adverse events [6].

The difference between "direct" and "latent failures" lies, on the one hand, on timing, and, on the other hand, on the level of the system they will manifest. In "direct failures," people's actions have immediate effects, whereas in indirect failures, the effects may not be obvious or appear much later and only provided when they are combined with other direct failures. As a result, professionals being on a "knife-edge" are easier to blame. This may also be attributed to the fact that the detection of the root causes is rather hard and is often related to the organizational level. "Direct failures" usually occur to those who are directly related to the patient, whereas indirect failures are mostly associated with the organizational and administrative level. "Indirect failures" may be "transferred" along organizational and departmental pathways in the workplace (e.g., in an operation room (OR), etc.), locally generating the conditions that favor the occurrence of errors and misconducts.

Reason [7] compared the "individual's approach" to the effort made by an individual trying to kill a mosquito that bit them and the "system approach" to the effort to drain the swamp wherein mosquitoes procreate. "Individual approach" focuses on the errors of the employees, for example, by blaming them for carelessness. It is, however, a fact that errors are not realized only by incompetent but also by very competent healthcare professionals, and they are often the most competent professionals, who make the worst errors. "System approach" focuses on the conditions under which the employees perform their duties. This approach is mainly adopted by organizations that require highly reliable services (e.g., aviation), and it is considered the most appropriate by the scientists who have dealt in depth with errors in the healthcare sector [7, 9].

Based on previously mentioned definitions of errors, Reason [6, 7], focuses on the process design and implementation and not on the outcome and the consequences, thereof taking into consideration the fact that those psychological, physical, and technical failures abet to the conduction of an error. He, however, overlooks the errors caused by omissions (error of omission) [6, 7].

In contrast, Leape [10] refers to errors attributed to actions or omissions but overlooks the actions based on design errors, unless they lead to adverse effects. Reason's and Leape's definitions are subjected to several limitations. Although an action may be mistaken or the plan for the accomplishment of the desired effect may not be appropriate, errors or omissions must not be always blamed for adverse events in the healthcare sector, since there are other factors that contribute to them, such as an unexpected allergic response to a new medication treatment.

An equivalent definition of error, similar to the one provided by Reason [6], is the definition by the Institute of Medicine (IOM)[1] in the United States in 1999, in a published report, regarding errors in the healthcare sector. Therewith, a "medical error" is defined as the failure to complete a planned action or the use of ineffective planning for the accomplishment of an objective [11].

In a report published in 2000 regarding medical errors and patients' safety, Quality Interagency Coordination Task Force (QuIC) in USA attempts a conceptual clarification of error in the healthcare sector expanding the definition that was provided by the IOM the previous year. According to this definition, "error" is defined as the failure to complete a planned action as expected or as the use of incorrect/poor planning to achieve an objective. According to the same report, "medical errors" may also refer to processes, practices, and equipment [12].

In order to understand the concept of error in the healthcare sector more accurately this time, Reason [13] defined error as the variations in the provision of healthcare that may cause harm to the patient. Other definitions concerning medical errors, which were published recently, are presented in **Table 1**.

Zhang et al. (2002) [14]	"Medical error" occurs when a healthcare provider chooses an inappropriate method to improve a patient's health status or fails to apply the appropriate method correctly in order to improve a patient's health status
National Patient Safety Foundation (NPSF) (2003) [15]	"Medical error" is the unintended outcome, caused by a certain defect in healthcare provision. Moreover, errors in the healthcare sector may be divided into "errors of practice" (wrong action), "errors of omission" (lack of the correct or appropriate action), and "errors of execution" (performance of the correct action executed wrongly)
Grober and Bohnen (2005) [16]	"Medical error" is an action or omission throughout the design and execution of a healthcare provision process that causes or is likely to cause adverse events
Kyritsi (2009) [17]	"Error" is any unintended event that poses a threat to patient's safety or any deviation from the rules and the established practices in the workplace
Raftopoulos (2009) [18]	"Error" is an action that fails to achieve the intended outcome, which may be analgesia, muscle relaxation, or any other recession of unpleasant symptoms
Kapaki (2015) [19]	"Medical error" refers to a healthcare professional's action or omission during the planning and implementation of healthcare provision, which contributes or could contribute to the further impairment of a patient's health status on the one hand and the healthcare provision system on the other

Table 1. Additional definitions of medical errors.

[1]Institute of Medicine (IOM) has been renamed to National Academy of Medicine (NAM).

3. Adverse events in healthcare

A previous literature review includes research on patient safety issues that mainly focus on adverse outcomes from the practice of medicine, adopting definitions of medical errors and related terms based on the adverse outcomes of medical practice [20–24]. This could be explained by the basic medical principle of Hippocrates, which is summarized in three words: "Primum non nocere" or "First, do no harm" [10, 25]. Moreover, the definition of patient safety dictates an outcome-based approach of medical error.

"Patients' safety" is defined as avoidance, prevention, and improvement of negative effects or injuries caused to patients during healthcare provision [26]. IOM defines "patient's safety" as freedom from random harm [11].

In his study "Hazards of Hospitalization," Schimmel [27] argued that the evaluation of undesirable effects resulting from healthcare provision, as well as the registration of their frequency, is necessary regardless of the severity of the effects. It is also paramount that an overall risk assessment is realized, regarding the patients' exposure to polypharmacy and complex procedures during healthcare provision. Within this context, he introduces the term "noxious episode" for the first time.

"Noxious episodes" are all the unpleasant events, the complications, and the misfortunes caused by acceptable diagnostic and therapeutic measures executed in the healthcare unit [27].

The term "potentially compensatable event" was introduced for the first time in 1977 in the study titled "The California Medical Insurance Feasibility Study," defining it as an event that occurs during healthcare provision and leads to disability or prolonged hospitalization [28].

Four major researches regarding errors in the healthcare sector were published in the 1990s, emphasizing the term "adverse event." According to "Harvard Medical Practice Study" [20, 21], "The Utah and Colorado Medical Practice Study" [22], "The Quality in Australian Health Study" [23, 24], and the study of IOM in US "To Err is Human: Building a Safer Health System" [11], an "adverse event" is defined as a localized damage or complication caused to patients by medical care that does not result from patient's impending disease and leads to patient's disability, prolonged hospitalization, or even death.

"An adverse or undesirable event" refers to an outcome of a process, whereas an error characterizes an action itself. This means that an error may cause an adverse event or not, either because this action caused no harmful effects and the patient did not experience any symptoms or because it was detected on time and was prevented. An error constitutes a necessary but not sufficient cause of an "adverse event." This is explained by the fact that "adverse events" do not always result from errors or omissions; they may also arise from appropriate actions with "adverse effects" (complications) that were either unknown at the time the action was taken or they were known and expected but could not be prevented (e.g., adverse drug events, etc.) [29].

Leape [10] classifies "adverse events" into three categories as shown in **Figure 2**.

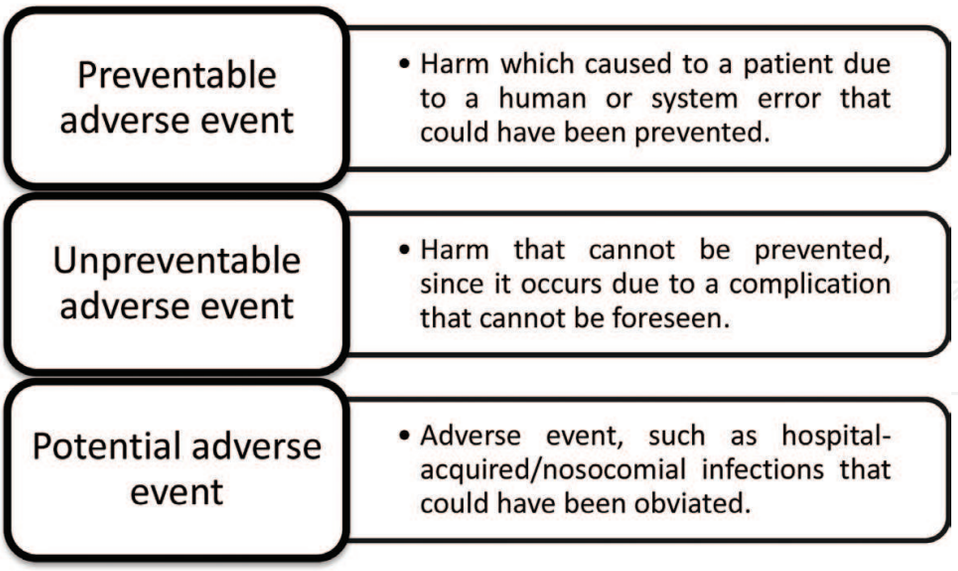

Figure 2. Adverse events classification by Leape. Source: Leape [10].

Literature also makes frequent reference to "adverse events," the severity, and criticality of which could have been significantly limited, provided that different actions had been followed (ameliorable adverse event) [30].

In addition to the conceptual clarification of the term "adverse event," studies, such as the Harvard Medical Practice Study [20, 21] and the Utah and Colorado Medical Practice Study [22], introduced the term "negligent adverse event" for the first time as a subcategory of the "preventable adverse events," which, however, meet the legal criteria defining negligence.

Other than words such as "mistake," "error," and "adverse or undesirable event," literature regarding patient safety issues also makes frequent use of several relevant terms without any clear and distinct conceptual differentiation. According to Cook et al. [31], it is a fact that the approach of patient safety issues is not the same among all healthcare professionals.

4. Other terms used in literature

Another term similar to "adverse event" that ranks second in terms of incidence is the term "sentinel event." The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) (2003) defined it as an unexpected event that involves death, serious physical or psychological damage, or risk of those. Serious physical or psychological damage refers to the loss of a body part or a function, whereas the risk of such damages refers to any variation of the procedure, the revision of which would entail the risk of serious medical error occurrence or would pose a threat of an adverse event. The term "sentinel," is interpreted as a guard or a watchman and is used for events that require immediate investigation and handling [32]. Such events are as follows:

i. any event that led to amputation of a human body part or loss of function, not related to the underlying disease; and

ii. events such as suicide, rape, delivery of a newborn to the wrong family, violent abduction of a patient, surgery on the wrong body part of a patient, etc.

The terms "close call" or "near miss" are almost identical and refer to certain actions or situations, which could have caused an "adverse event" but were timely detected and prevented or randomly prevented [33].

A term that is often used when referring to "adverse drug events" is that of "side effects," which regard the known effects of a drug and are different than those for which the drugs were originally designed [34].

"Iatrogenic injury" or "illness" is another term, which refers to undesirable effects that result, partly or entirely, from the medical process or medication treatment and do not constitute a direct or an indirect complication of the patient's initial state or the disease. This term is similar (or identical) to the side effects. The difference between "iatrogenic injuries" and "side effects" is that the first are not known and therefore they are totally unexpected. Furthermore, they are not caused due to technical failures, and therefore they do not constitute a criminal offense. This term is not also different from an "adverse event" [35].

The term "incident" occurs frequently in cases relating to patient safety, and it is used as a general term until the moment the event has been classified [36]. It characterizes an event that has already led or could lead to an artless injury and patient complain, and loss or damage [37]. The National Research Council (NRC) defined "incident" as an event that could be considered an accident, if it had taken place under slightly different circumstances. A critical event regards an event that leads to serious damage or even death [38].

The concept of "error" is often confused with the concept of "injury". WHO defines "injury" as tissue damage caused due to a factor or under certain circumstances? "Errors" become noticeable when they cause a certain "adverse event" or "injury" to the patient and influence health outcomes in a negative way [34]. Leape [10] argues that most "errors" do not lead to "injury".

The term "harm," which is typical of the body's structural or functional impairment and the resulting negative effects, is also frequently used in the study [34].

The term "hazard" has the meaning of risk factor and refers to anything that causes damage. A "hazard" is also defined as a factor, a situation, or an action, which may lead to or increase risk. In his article titled "The hazards of hospitalization" published in 1964, Schimmel refers to the terms "hazard," "adverse reaction," "adverse episodes," "incidence," and "risk" and categorizes reactions into those caused by diagnostic or therapeutic interventions that occurred in the hospital and those resulting from physicians' or nurses' errors of negligence [27].

5. Determinants of medical errors

The first study regarding "errors" in the healthcare sector was conducted in 1960 at a New York City hospital and indicated that 60% of the "errors" are caused by healthcare professionals' negligence [39].

This study was followed by Vincent's research effort in 1989, which regarded the underlying causes of "errors" in the healthcare sector and classified them into the following categories [40]:

i. individual characteristics of health professionals that commit the errors,

ii. temporary situations such as the consumption of pharmaceutical preparations and alcohol by health professionals,

iii. organizational factors, and

iv. patients' characteristics.

In his development of organizational accident causation model (Swiss cheese model applied to clinical events), Reason [6] suggests that a factor may cause more than one "error" and one "error" may be attributed to more than one factor. In the event, however, that no efforts are made in order to improve the overall factors causing the errors and address errors on an individual basis, no progress will be made and new errors will continue to arise. Reason grouped the factors that influence clinical practice negatively into five levels [6, 40].

In 1995, Leape et al. published one of the largest studies regarding "errors," which constituted a key presumption for the need to study organizational factors that contribute to the occurrence of "errors" [9]. The study examined the weaknesses of the system that led to the emergence of 334 errors. The authors attempted to answer three major questions: (1) why did the error occur, (2) which was the basic cause of the error, and (3) what were the system's weaknesses. According to the findings of the study, the weaknesses of the system may be categorized as listed in **Table 2**.

A similar classification of "error determinants" was also attempted by Helmreich in the "The university of Texas Threat and error management model" in 2000. Helmreich distinguished between the organizational factors, the individual factors, and factors regarding teamwork and the patient [41].

Carver and Hipskind [43] confirm that a medical error is an "avoidable adverse effect" of medical care, whether or not it is substance to the patient. Among the difficulties that usually happen throughout providing healthcare are adverse drug events and irregular transfusions, incorrect identification of an illness, under- and overtreatment, surgical injuries and wrong-site surgery, suicides, restraint-related injuries or death, falls, burns, pressure ulcers, and incorrect patient identities. High error rates with important effects are most probable to happen in intensive care units (ICUs) [42], operating room (OR), and emergency departments (EDs). Furthermore, "medical errors" are connected with unused procedures, immediate necessity, and the seriousness of the medical condition being treated [43].

The responsibility for the emergence of errors is apportioned among the nature of the healthcare system that is characterized by organizational and functional complexity, the multifaceted and uncertain nature of medical science, and the imperfections of human nature [44, 45].

5.1. Factors related to the nature of the healthcare system

According to the theory of physical accidents, which was formulated for the first time in 1984 by the sociologist Charles Perrow, accidents are inevitable; therefore, they occur naturally,

Weaknesses of the system	Clarification
Dissemination of pharmaceutical knowledge	A set of interpersonal interactions and relationships is established between theoretical researchers, pharmaceutical industry, journalists, practicing medical professionals, and prospective patients such that researchers' involvement with the development of new drugs is inevitably a procedure in which a number of "goods" become fungible
Control of medicine dosage and patient's identity authentication	A considerable number of nursing tasks entail an extent of risk, and medication administration possibly carries the most extensive risk. Nursing stuff has followed, in the customary way, the five rights of medication administration (patient, drug, route, time, and dose) to help prevent errors
Availability of information regarding the patient	Instructions of language usage in medical settings could be efficacious in classifying and giving attention to language barriers and would enhance knowledge of health inequalities
Copy of the instructions	A medication order is written instructions provided by a prescribing practitioner for a particular medication to be administered to an individual. The prescribing practitioner may also give a medication order orally to a licensed person such as a pharmacist or a nurse
Allergic reactions	As a whole, medications have the possibility to provoke side effects, but only about 5–10% of adverse reactions to drugs are allergic. Allergy indicators are the outcome of a chain reaction that begins from the immune system. Your immune system controls how your body protects itself
Medication order tracking	Hospital sector has long faced challenges connected with getting, written by hand, medication orders from the prescriber to the pharmacist
Intra-hospital communication	There is notable dialog of, and investment in, information technologies, communication systems receive much less attention and the clinical adoption of even simpler services like voice mail or electronic mail is still not ordinary in a considerable number of healthcare services
Use of devices	Adverse Device Effect (ADE): adverse event connected with the use of an investigational medical device
Dosage standardization and administration frequency	One more plan to decrease "medication error" is drug dosage standardization. Standard doses minimize the interpatient variation of drug dosages
Standardization of medical products distribution process within the department	Standardization is a significant term in the healthcare industry. With hospital budgets getting tighter, standardization is perfect for operating under cost constraints. But the negativity connected with the term makes it not easy for providers and hospital management to encourage standardization to clinical end users
Process standardization	
Patient transport process	Patient transportation is a considerable action in healthcare with important resource consequences for healthcare systems. Much attention has concentrated on the emergency transport of acute- and critical-care patients
Conflict resolution	There are four widespread sources for interpersonal conflict: personal differences, informational deficiency, role incompatibility, and environmental stress. There are five frequent responses used in dealing with conflict: forcing, accommodating, avoiding, compromising, and collaborating. Managers on healthcare sector should become comfortable with using all of these approximations
Preparation of intravenous solutions by nurses	
Staffing and work allocation	Allocation of nursing time to patients at an educated guess influences quality and carefulness of nursing acts and evaluations. Also, there may be skill-mix issues
Feedback following the emergence of unintended events	The healthcare sector has an obligation to guarantee that their staff is skilled enough and confident in dealing with all particular kinds of feedback in a way that is individually centered

Table 2. The weaknesses of the system.

since they constitute inherent features of complex systems. The more complex a system is and the stronger the bonds between the individual elements of the system are, the more complicated and unpredictable are the consequences from a possible error. Perrow uses the term "accident" in order to describe a fact that entails damage to a given system that disorganizes the consecutive or future outcome of the system [46]. Perrow's theory is also supported by Reason in 1990, who argues that complex systems entail unfavorable developments. This is the reason why complex systems provide multiple methods for error detection and recording [6].

Another key factor that determines errors in the healthcare sector is technology. Problems often arise from human interaction with technology, or insufficiency, or poor maintenance of the technological equipment. This fact is proven in a study by Taxis and Barber [47], in relation to intravenous (IV) medication errors, where 79% of errors are associated with the lack of knowledge regarding the drug preparation and administration and machinery operation (e.g., pumps). According to the results of a current study, the unforeseen potentially fatal events within 24 h of admission from the ED could be a helpful trigger tool to recognize "preventable adverse events" with grave harms to body in ED [48].

5.2. Factors associated with the healthcare professionals' human nature

"Medical and nursing errors" are human errors committed by persons acting in a certain capacity (physicians, nurses), in a certain environment, and under special conditions. Human intelligence is not infallible; therefore, the resulting action cannot be infallible. Causes associated with the human factor contributing to the emergence of errors in the healthcare sector are the following.

5.2.1. Professional burnout

The term "professional burnout" was used in literature for the first time in 1974 by Freundenburger. In one of his articles, he described the psychosomatic symptoms that appeared in healthcare professionals occupied with mental illnesses [49]. In 1982, Christina Maslach described this phenomenon as "a syndrome of mental and physical exhaustion, where an employee loses interest for the patients, ceases to be satisfied from his/her work and performance, and forms a negative opinion about his/her self" [50]. According to Maslach and Jackson [51], the three most important components of burnout are the emotional burnout, depersonalization or cynicism, and the sense of ineffectiveness (lack of personal achievements).

According to international studies, the factors relating to "professional burnout" are categorized into factors relevant to the working environment, individual factors, and personality factors. Workload [52–55], high stress levels [56–59], conflicts with colleagues superiors or relatives [59, 60], social support from colleagues and superiors [52, 55], job satisfaction [59, 61, 62], balance among work family and personal development [53, 55], sense of control [53], organizational support [55, 63], autonomy [52, 53], inadequate time to study [52, 62], sufficient staffing [63–65], training in communicational skills [58], and salaries [52, 53] are among the factors relating to the working environment, which are systematically highlighted as closely linked to a professional burnout caused at physicians and nurses.

With regard to individual factors, demographic parameters reveal that age appears to be systematically associated with "professional burnout," with the younger employees exhibiting it to a larger degree [52–54, 58]. In relation to gender, the findings are contradictory [54, 66–69] although studies reveal that higher levels of professional stress for women are systematically encountered [66, 67]. Marriage appears to have a protective effect on the occurrence of "professional burnout" in women. Support provided by husbands or wives as well as work life balance are also among the factors that systematically demonstrate negative correlation with "professional burnout" [54].

Among the personality traits systematically associated with "professional burnout" are empowerment [70], empathy [70], tolerance to stress [71, 72], sense of effectiveness [54], and mental well-being [73].

The effects of "professional burnout" on physicians and nurses are manifested not only on the individual level but also on the organizational, thus affecting the quality of the healthcare provision at the organization in which they are occupied. "Professional burnout" may also cause physiological symptoms to employees either in the form of plain discomfort or more serious health problems, emotional problems such as the feeling of discouragement, low self-esteem and self-confidence, behavioral symptoms such as coldness, indifference, lack of care interest and respect for the patients, and psychiatric disorders such as stress and depression. There is also evidence that "professional burnout" may influence individuals' satisfaction regarding life in general, their social and personal life and may also be contagious to other health professionals (colleagues or trainees) [74].

The effects of professional burnout expand, as previously mentioned, to the healthcare provision organization, increasingly slowing the implementation of the employees' project, leading to absences and reduced performance. It has also been associated with an increased intention of the personnel to leave employment/retire [53, 64, 75]. "Early" retirement of physicians and nurses intensifies the already existing problem of staff shortage contributing to the lower quality of offered services, since insufficient staffing is associated with patient mortality, adverse events, and the quality of services provided, as substantiated by the existent literature [64]. The retirement of the aforementioned health professionals also has a financial impact to the organization, as the latter bears a large cost for their replacement [11].

Shanafelt et al. [62] examined the relationship between burnout in medical residents and their opinion regarding their practices regarding healthcare provision to patients. On the one hand, according to the findings, 76% of the physicians who participated in the study suffered from professional burnout. On the other hand, "burnout physicians" were more likely to report "inappropriate patient healthcare practices," such as inappropriate behavior toward patients, omissions in diagnostic treatment, and medication errors at least on a weekly or a monthly basis, in comparison to those that did not suffer from a professional burnout [62].

5.2.2. Workload

Workload has been directly associated with the emergence of errors during clinical practice and is mainly attributed to the lack of personnel [47, 64, 76, 77]. Understaffed healthcare units

in combination with workload are likely to endanger patient's safety [76]. A study conducted in 1998 in Australia by Beckmann et al. has shown that lack of personnel is associated with increased medication errors, inadequate patient supervision, equipment preparation, and omissions in documentation of medical and nursing care [78]. Similar were the findings of a study by Giraud et al., in 1993, which identified heavy workload as the main cause for an increasing rate of errors [79]. In a study realized by Blendon et al. [80], the physicians participating in the research argued that the main cause of errors in clinical practice is the lack of nursing personnel.

In their research published in 1995, Roseman and Booker demonstrated the correlation between workload and the errors in healthcare, quantifying workload with the use of nine indexes. It was found that three out of nine workload indexes that were examined (number of patient days per month, number of emergency shift staff, and overtime of permanent nursing staff) could significantly predict the risk of medication error. More specifically, the number of errors increased as the number of patient days and the number of emergency staff's shifts increased, whereas it decreased as the number of overtime of the permanent nursing staff increased. The latter is reasonable, since permanent nursing staff is better trained and oriented in a specific department compared to emergency staff [81]. According to the findings of Mayo and Duncan's study [82], the interruption of nurses by a relative or another healthcare professional during the preparation of medication is ranked second among the factors that cause the emergence of errors. However, a study by Osborne et al. [83] ranks the same factor as fourth.

5.2.3. Lack of knowledge and experience

According to a study realized by Arndt [84], regarding the effects of errors on nurses' psychology, the respondents reported that errors were caused by lack of knowledge regarding medicine administration. In a study by Taxis and Barber [47], regarding intravenous medication errors, 79% of errors were related to lack of knowledge regarding medicine preparation, administration, and machine operation (pumps), and 15% were related to heavy workload and often interruptions. Blais and Bath [85] identified three categories of errors relevant to the calculation of drug dosage: mathematical, conceptual, and measurement errors. In Osborne's study [83], 5.3% of errors are caused by wrong calculations. The experience of healthcare professionals constitutes another factor regarding errors. In his study, Walters [86] mentions that there is a statistically important relation between the number of errors made by nurses with a greater working experience (less errors) and the errors made by professionals with less working experience (more errors). Due to the lack of experience, newly recruited healthcare professionals are the first to blame when an error occurs. In several occasions, however, newly recruited in the unit are hesitant and lack initiatives out of fear of making an error that may have adverse effects on patients' health status. On the other hand and according to the study, the most experienced professionals are those that indeed make fewer errors compared to beginners [87]; however, they may commit errors with very serious consequences for patients' health status [7].

5.2.4. Communication difficulties among healthcare professionals

Communication among healthcare professionals constitutes an important factor not only for preventing but also for making errors [76]. In a study by Taxis and Barber [47], regarding

IV medication errors, 16% of the errors are associated with poor communication among healthcare professionals, whereas in a study by Blendon et al. [80], physicians argue that poor communication among professionals causes errors at a level of 39%. In the same study, the citizens, who were also included in the study responded that poor communication among healthcare professionals promotes errors at a level of 67%. Mayo and Duncan [82] also believe that conversations between nurses and supervisors regarding errors that are considered a "taboo" are necessary. Interprofessional cooperation between physicians and nurses is also of significant importance. The fact that is of particular importance in Arndt's [84] study is that some physicians had a good communication and cooperation with the nurses, and often after evaluating the error and provided no serious damage was caused to the patient, they covered up for the errors realized by the nurses. According to Helmreich [41], the risk of errors in surgeries increases when there are problems in communication, information transmission, leadership, interpersonal relationships, and conflicts. Van Cott [88] generally indicates that a high rate of errors results from communication problems, oral or written, which can be prevented provided appropriate training is present. Cooke and Salas [89] highlighted that in a stressful environment, people tend to fail to express orally what they mean. Even if they do manage to express it orally, it is not certain that the intended recipients will hear it. Even if they hear it, it is not certain that they will understand it. Finally, even if they do understand it, it is not certain that they will act accordingly. It is for this reason that confirmation should be required, in order to prevent a gap between the abovementioned steps [89].

5.2.5. Environmental conditions

Roseman and Booker [81] examined the association between "medication errors" and daytime, the latter being an environmental specificity regarding a particular geographical area. The study was conducted in Anchorage in Alaska, where daytime is gradually changing from 5.5 h in December to 19.5 h in June. This change in daytime throughout the year leads to mood disorders called "Seasonal Affective Disorder (SAD)," which is characterized by a recurring depression in the fall or in the winter that normally resolves in the spring. More than half of the errors occurred in the first quarter of the year, and, more specifically, 22% of the errors occurred in February and 29% in March. This finding is considered significant; however, further research is required [81].

5.3. Factors associated with the nature of medical science

Other than the error factors that are associated with the healthcare system per se and the factors related to the human nature, there are also factors related with the uncertain and multifaceted nature of medical science. Every medical action initially affects the bodily integrity and secondarily the patient's personality and privacy. Every medical and nursing intervention poses threats, which according to the law of probability will eventually be realized. Medicine and Nursing are empirical sciences, and the uncertainty factor lurks in every stage of healthcare provision (prevention, diagnosis, treatment, research). Patients and their relatives are not trained to identify the finite limits of the medical science in the case of aggressive diseases and death [90, 91].

6. Clinical vignette

Eighty-year-old Denisa Conolly used to wake up during the night with symptoms of dyspnea and wheezing. Her physician diagnosed her with asthma and prescribed albuterol, an asthma bronchodilator. Two days later, Mrs. Conolly was admitted to the hospital at the Coronary Care Unit (CCU) suffering from a heart attack. In his letter to the Head of Medical Services, the cardiologist reported that a diagnostic error had been realized by Mrs. Conolly's physician regarding the abnormal congestive heart failure and had administered treatment for asthma. The cardiologist reported that treatment might have accelerated the heart attack.

7. Conclusion

There is an urgent need to develop a commonly accepted definition of the "medical error" among the scientific community, which will contribute to further research regarding "error phenomena" in healthcare, facilitating data collection, synthesis, and analysis, avoiding the usage of terms with a similar meaning. Furthermore, it will contribute to a better quality control of the offered healthcare services and will also serve legal and insurance purposes. As every "human error," "medical errors" do not constitute unpredictable situations but the outcome of aggregated risk factors. The analysis of errors allows early identification and change of the conditions that favor such errors. The causes of errors in healthcare are not unambiguous or independent from each other.

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Competing interests

The authors affirm that they have no competing interests.

Abbreviations

CCU	Coronary Care Unit
ED	Emergency Department
EU	European Union
ICU	intensive care unit
IOM	Institute of Medicine

IV	intravenous
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
NPSF	National Patient Safety Foundation
NRC	National Research Council
OR	operation room
QuIC	Quality Interagency Coordination Task Force
SAD	Seasonal Affective Disorder
WHO	World Health Organization

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