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Anesthetic error. Part 1 (review)

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"Errors are an inevitable part of anesthetic practice. Anesthesiologists are human, and humans make mistakes"
J.G. Hardman, 2010

Abstract. Unintentional medical error is likely to always remain a part of the healthcare system. No medical professional is entirely immune to making professional errors, just as specialists in any other field. A retrospective informational search of literary sources and data was conducted using a spatial-vector model of a descriptor system based on classifiers, supplemented by manual literature review. Scientific literature was retrieved using information search systems such as Scopus, CrossRef, Google Scholar, and PubMed, and further supplemented with manual article selection. Error-free performance by healthcare personnel is virtually impossible. However, given the specific nature of the medical profession, such errors take on significant public importance. While errors by other professionals may often be corrected, medical errors are frequently irreversible, potentially leading to patient disability or death. Human error is one of the leading causes of anesthesia-related critical incidents, and its consequences more than in other medical specialties tend to be immediate, adverse, and highly visible. The human factor acknowledges that people can make mistakes, that human errors cannot be completely eliminated, and that individual and team performance varies and often deteriorates under high-pressure conditions. The human factor encompasses non-technical skills such as teamwork and communication, but it also represents a broader domain involving many other components.

Key words: general medical errors, anesthesiological errors, classification, human factor.

Introduction

Unintentional medical error (ME) is likely to remain an inherent part of the healthcare system [1]. No healthcare professional is completely free from the possibility of professional mistakes, just as specialists in any other field. Error-free performance by medical personnel is virtually impossible. However, due to the unique nature of the medical profession, such errors take on significant societal importance [2, 3]. While errors made by professionals in other fields may often be corrected, a ME is frequently irreversible, as it may result in disability or death of the patient [4]. In our society, there is a well-established belief that a sapper may make a mistake only once, whereas a doctor is not allowed to err at all [2]. This paradox stems from the physician's sense of duty, which originates from the Hippocratic Oath's principle 'first, do no harm', and unintentionally imposes an overwhelming burden on physicians, forcing them to believe that mistakes are entirely unacceptable [5].

Evidence of information retrieval

Studies were included in the review if they met the following criteria: 1) published in either Ukrainian or English; 2) reported on general MEs; 3) provided data on the prevalence and consequences of anesthesiological errors; 4) identified causal factors of MEs; and 5) employed an observational study design (cohort or cross-sectional). A retrospective information search of literature sources and data was conducted using a spatial-vector model of a descriptor system based on classification schemes, supplemented by manual literature review.

Scientific literature was retrieved using the search engines Scopus, CrossRef, Google Scholar, and PubMed, and was supplemented by manual searching of relevant articles using the key words: 'medical error', 'anesthesiological error', and 'medication error'. A total of 75 relevant scientific sources were analyzed, of which 91% were published within the last 10 years and 56% within the last 5 years.

Synthesis of Evidence

The term 'medical error' was first introduced into scientific discourse by the prominent domestic surgeon and educator M.I. Pirogov, who defined it as incorrect conclusions and actions taken by a physician during diagnosis, as well as in the selection of treatment tactics and techniques [6].

In 1990, psychologist D. Reason described two types of errors: execution errors, in which a correct action fails to achieve its intended outcome, and planning errors, in which the initial plan itself is incorrect.

In 2000, the U.S. Institute of Medicine conducted the first large-scale study on ME and defined an ME as 'the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim'. They are distinguished as an adverse event, a ME, and a near-miss incident.

An adverse event is defined as an injury caused by the process of medical care rather than the patient's underlying condition (as opposed to a complication, which results from the natural course of the disease).

MEs result from failures in execution or planning, and include major errors, minor errors, and near misses. A patient affected by a serious ME may experience either permanent or temporary harm that could be life-threatening. Minor errors also cause harm but are neither permanent nor life-threatening.

A near miss is an error that could have caused harm but did not occur due to chance or timely intervention [5, 7].

The key features of a ME include: an adverse outcome despite an appropriate standard of medical care; inappropriate (or absent) actions by the physician or healthcare personnel; and unintentional harm to health or death of the patient during preventive, diagnostic, or therapeutic procedures [8].

Various types of errors have been identified. System errors include technical failures, equipment malfunction, communication breakdown, limitations of clinical guidelines or available

resources, or inadequate supervision. Human errors involve improper technique, misuse of equipment, failure to recognize or apply available information, inability to access appropriate data, or insufficient knowledge [9].

According to the working system classification, errors can be divided into active and latent errors.

Active ('proximal') errors are hazardous incorrect actions committed by individuals in direct contact with the patient.

Technical errors (6.2%) involve incorrect manipulation, invasive procedures, dosing, or route of administration [10].

Non-technical errors are knowledge-based errors arising from perception, judgment, reasoning, or interpretation [11].

Errors of omission are defined as the failure to perform an appropriate action, whereas errors of commission refer to the performance of an inappropriate action [12].

Latent ('distal') errors arise from systemic causes underlying flaws or imperfections in the physical infrastructure (e.g., architectural design, engineering systems, logistics and equipment), which remain dormant until activated by human actions and may lead to adverse outcomes. Latent errors involve internal deviations in patient care processes such as malfunctioning equipment, inefficient organizational structure, or poor system design. These failures can persist unnoticed and without harm for long periods. Latent errors are often described as 'accidents waiting to happen'. Clinical complications usually arise when an active error is combined with a latent one, particularly when the human factor is involved. An active human error may trigger a latent error, creating a synergistic effect.

Organizational errors include flawed management decisions or an inadequate professional culture within the healthcare delivery system (these are also considered latent or distal errors) [7, 12–16].

Tactical errors include underestimation of the patient's condition, misdiagnosis, inappropriate choice of treatment method, or incorrect indication for surgery.

Active failures are unpredictable, hazardous actions committed by individuals directly interacting with the patient.

Errors are also classified as: decision-making errors (related to knowledge, experience, or lack of information), skill-based errors (related to the performance of routine tasks), perceptual errors (associated with impaired or obstructed sensory awareness and/or loss of situational awareness) [11, 17].

Violations are actions that deviate from organizational standards, rules, and regulations, and may be either routine (regular) or exceptional (one-time deviations) [11]. Violations vary in degree of culpability; however, even minor violations can pose the same level of danger to patients as errors, although the decision-making processes behind them often differ significantly [18].

Medical negligence (malpractice) refers to the improper performance of professional duties by a physician, or superficial, incomplete execution, not in accordance with current medical standards — a form of dishonesty and indifference. Medical negligence is also understood as a defect in medical care that resulted in or could have resulted in an adverse outcome — a form of professional misconduct that should not be equated with a ME [19, 20].

An accident is defined as an entirely unavoidable event (force majeure) that the physician could neither foresee nor prevent, for which the individual should not be held liable. Examples include the inability to perform even basic diagnostics during mass civil unrest, military conflict, or natural disasters that result in the destruction of healthcare infrastructure. If the physician acted lawfully, appropriately, and in a timely manner — in accordance with job responsibilities and current medical standards (protocols, algorithms) — such events may be distinguished from MEs [3, 16, 19–21]. Typical examples of accidents in clinical practice include:

- patient death due to an unforeseen allergic reaction to a drug during its first administration;
- perioperative reflex cardiac arrest;
- fat embolism during metal osteosynthesis surgery;
- intraoperative death despite a correctly chosen and properly administered anesthesia regimen with appropriate dosing and no contraindications;
- postoperative complications unrelated to anesthesia [16].

A side effect (SE) is a form of harm that may occur as a consequence of a treatment error rather than the patient's underlying medical condition. Side effects can be prevented by adhering to established medical standards at both the individual and systemic levels. However, not all SEs are the result of MEs — only those that were preventable are classified as MEs. SEs may include unintended injury, prolonged hospitalization, or treatment-induced disability resulting from either conservative or surgical management [16].

MEs include:

- diagnostic errors — failures in disease recognition, misdiagnosis, or oversight of complications; these errors often result from inadequate or improper use of patient history, incomplete physical examination, or failure to consider all relevant data;
- therapeutic and tactical errors — typically stem from diagnostic failures; these include incorrect selection or interpretation of diagnostic tests, and inappropriate treatment planning; therapeutic errors arise when treatment does not correspond to the actual nature of the disease, while necessary therapy is omitted;
- mechanical errors — involve technical mistakes during diagnostic or therapeutic procedures, including surgical interventions; this may involve the incorrect selection of a diagnostic method, failure to assess indications or contraindications, prescribing the wrong medication, or dosage miscalculation;
- organizational errors — involve deficiencies in the structure or provision of medical services, such as improper organization of diagnostic and treatment processes or inadequate staffing and equipment quality [3, 8].

Although Ukrainian legislation does not provide a clear legal definition of 'medical error', the term may be interpreted as an incident in which it is impossible to clearly delineate the grounds for either exemption from or imposition of legal liability on the healthcare institution or personnel. However, if harm to the patient occurs due to medical staff negligence, responsibility is imposed on general legal grounds, liability for negligence does exist [3, 4, 6, 19].

Article 140 of the Criminal Code of Ukraine establishes liability for physicians for failure to perform or improper performance of their professional duties if such actions cause severe consequences for the patient. Improper performance of professional duties is understood as negligent, careless, or indifferent attitude of the medical worker toward their responsibilities. However, due to the rather ambiguous nature of this concept, its precise definition remains challenging. Subjectively, a medical professional is required to fulfill their duties properly, i.e., in accordance with the standards established in healthcare practice [19, 22, 23].

According to WHO experts' estimates, in Ukraine, 6–7 patients die daily due to medical staff negligence, and three times as many become disabled [21].

In modern legal science, the term ME is interpreted as a dual concept — both medical and legal [21].

The primary thesis of proponents of the 'legal perspective' is that a ME results from negligent, careless, or irresponsible acts or omissions in providing medical care that lead to bodily injury or death of the patient [2]. It is crucial to establish a causal relationship between the actions of the medical worker and the adverse health outcomes for which healthcare facility officials may be held liable. It is important to distinguish between poor quality medical services, improper performance of professional duties by medical personnel, and adverse circumstances arising at various stages of the treatment process [19]. ME is one of the most complex concepts in terms of legal qualification. Since there is no legislative definition of the term, it is extremely difficult in law enforcement practice to differentiate between culpable and innocent actions of physicians (or medical staff) when there is no corpus delicti; therefore, liability cannot be imposed [3, 8].

MEs, in a broad sense, include both innocent and criminal (intentional) actions of healthcare professionals [21]. A ME should be distinguished from a criminal offense committed by a medical or pharmaceutical worker [4]. Theoretically, situations are possible in which a physician, guided by personal views and with direct intent — such as religious, political, or racial motivations — causes serious harm to a patient's health due to negligent performance of duties. In such cases, the physician bears criminal liability under Article 121 of the Criminal Code of Ukraine for intentional grievous bodily harm [24]. Liability of healthcare workers may be criminal, civil, administrative, or disciplinary. Civil liability refers to the financial responsibility of the medical professional. Administrative liability generally applies to healthcare facility managers and concerns improper administration, while disciplinary liability involves sanctions against employees for breaches of workplace discipline [4]. It is important to consider the presence of mitigating circumstances, which may serve as grounds for exemption from criminal liability [23].

A medical objective error is an accidental coincidence or consequence of the imperfections of scientific and technical medicine. It is not caused by negligent, irresponsible conduct, ignorance, or criminal intent on the part of the physician. In such cases, the medical professional is not at fault, no offense has been committed, and thus legal (civil or other) liability is unjustified [2, 25].

Mass media and the public tend to be unforgiving toward medical workers whom they perceive as having harmed patients through seemingly elementary errors, carelessness, or inattentiveness, equating such mistakes with medical negligence. Most of the population believes that suspending physicians who have committed clinical errors is the most effective preventive strategy [26]. One reason for the increase in medical malpractice lawsuits is the blind faith of people in the miraculous power of medicine and their lack of awareness of its true limitations. Consequently, society often places excessive demands on doctors, and complaints may be unjustified in cases of fatal injuries, severe or critical illnesses, etc. [27]. There is substantial evidence that patients, in the absence of transparency, often rely on unreliable, incompetent, and sometimes distorted information as the main reason for filing lawsuits due to medical complications [5]. However, unofficial data suggest that nearly 65% of patients harmed by healthcare providers refuse to file lawsuits at all [21].

One of the significant gaps in the management of MEs and adverse events in domestic healthcare is the theory and practice of their post-incident analysis [13]. In developed countries, MEs are recorded and analyzed, and the obtained information is made publicly available. In Ukraine, no such system exists due to the closed nature or absence of relevant statistical data; moreover, these errors are not investigated and the conclusions are not published [8].

A culture of 'blame' traditionally exists within the healthcare system, where errors are attributed to specific individuals who are then 'marked' or punished. Social psychology research shows that the human tendency to assign blame provides a certain satisfaction and a moderate problem resolution, demonstrating the unacceptability of errors and the inevitability of punishment. However, this approach not only fails to improve patient safety but also leads to the concealment of errors and falsification of medical information [28].

Fatalities resulting from treatment errors are sometimes accompanied by serious legal consequences. The reluctance to report a ME that caused a patient's death is understandable (though not commendable) and contradicts current expectations of transparency and reporting of MEs [20]. The 'blame culture' and the perception that an error may indicate incompetence or incapacity on the part of the physician have been identified in various studies as barriers to incident reporting [30]. It has been demonstrated that some clinicians deliberately withhold reporting their errors if they believe no harm was caused to the patient. A contemporary medical-social study found that 23.9% of respondents admitted to making treatment errors, but only 6% of them were willing to disclose their MEs [31]. When asked why they refrained from reporting, between 30.8% and 77.7% of physicians cited concerns over medico-legal consequences (43.3%), lack of knowledge about whom to report to (24.04%), fear of judgment by colleagues (23%), and absence of a reporting system or authorized person (20.2%) [30–33].

Deliberate underreporting does not eliminate the root causes of the problems. Although most MEs can be attributed to human error, the role of systemic deficiencies should not be underestimated [34]. In domestic medical practice, the concealment of errors is often linked to the legal and even physical insecurity of physicians. The post-Soviet legacy is evident in the 'punitive model' of managing certain state institutions, whereby impunity fosters irresponsibility [4, 28, 33].

While the concept of 'zero harm' may be established as an aspirational goal, attempts to achieve the impossible risk imposing constraints where adaptation is necessary. The pursuit of zero harm also fails to acknowledge that some incidents result from necessary treatments that cannot be prevented [35]. In Ukraine, as an alternative to concealment, a culture of error management is only beginning to develop. Numerous recent studies have demonstrated that the desire to blame healthcare workers is the greatest barrier to risk management and optimization of healthcare institutions' operations [28]. A systems approach is based not on blame but rather on recognizing that clinicians operate within a system prone to errors that cause harm [36]. The system should not only report errors and highlight critical incidents but also maintain anonymity and encourage physicians to report more openly [30]. According to prominent medical scientists, physician errors are justified due to the complexity of medical science and the individual characteristics of patients [10]. At the same time, the World Health Organization considers 9% of fatal cases caused by MEs and adverse events in healthcare as a normative rate [8].

'To err is human' — this phrase, originally from the eminent 17th-century English poet Alexander Pope, was used as an epigraph for the 1999 Institute of Medicine Committee on Health Care Quality study. The purpose of this scientific work was 'to break the silence surrounding MEs, but not to blame dedicated professionals who care for patients and sometimes make honest mistakes' [37].

A ME is an event that has the potential to lead to a significant adverse outcome if left uncorrected. Currently, in Ukraine, even with existing safety systems, the reporting rate of medical incidents ranges from 7 to 15%. Therefore, it is unquestionably important to establish conditions for timely reporting of urgent adverse events and MEs [28]. Proper disclosure of errors involves timely explanation of what happened, who was involved, why the error occurred, and how it can be prevented in the future [5]. A non-punitive response to errors is a key dimension of patient safety culture in hospitals, which can be measured through staff surveys [38]. With the use of reporting protocols, it is possible to recognize patterns of MEs, perform root cause analysis, and monitor outcomes to eliminate institutional deficiencies [7]. Automated data collection can help capture medication errors or the impact of interventions more effectively than manual data entry [39]. Several studies have demonstrated better reporting through electronic systems compared to paper-based reporting [40]. Transformational leaders guide their followers and encourage them to fully realize their potential. Such leaders often set higher standards and take calculated risks. They focus on patient-centered care and create a fail-safe environment where staff can accurately report errors and work collaboratively to prevent future adverse events [41]. This approach facilitates independent verification of key steps and enhances learning from our mistakes [7, 9].

Changing workplace culture, alongside developing protocols for managing MEs, can promote reporting quality. It has been proven that implementing a patient safety culture, where clinicians are empowered and rewarded for identifying MEs that may harm patients, helps overcome fear of consequences. Thus, institutional culture improves patient safety through education and improvement efforts aimed at redesigning the system and environment where people feel safe from punishment. Everyone on the healthcare team should play a role in making healthcare safer for both patients and medical personnel [7, 42].

Characteristic causes of MEs include:

- deviations from existing medical standards in the selection of treatment methods and dosing of therapeutic agents;
- diagnostic shortcomings and subsequent prescription of incorrect treatment;
- inadequate diligence of the physician;
- insufficient experience of the physician in applying new invasive techniques;
- violation of the principle of timely medical care provision;
- inadequate monitoring of the course and outcomes of treatment, as well as during rehabilitation therapy.

It is assumed that the physician acts contrary to standards and local protocols of healthcare delivery, leading to errors due to subjective or objective factors. Objective factors are causes related to the limited development of scientific and practical medicine, which lie beyond the anesthesiologist's awareness and arise independently of their will, professionalism, or personal qualities. These include the severity of the patient's condition or presence of comorbidities (36.4%), late seeking of medical assistance or rapid progression of disease (21.4%), diagnostic difficulties or atypical disease course (13.4%), refusal of hospitalization (8.0%), noncompliance with hospital regimen by the patient (2.7%), etc. [43]. It is considered that objective factors cause about 30–40% of errors, while subjective factors account for 60–70%. Objective factors are most often associated with evolving views on disease treatment and the general underdevelopment of management of certain conditions [10]. In Ukraine, objective causes account for up to 80% of MEs [43]. The increased frequency of MEs is explained by the expansion of diagnostic tools and treatment methods, as well as the application of more complex surgical interventions [10, 21].

Objective factors are actions or inactions of medical personnel that do not violate legally established rules and regulations but cause harm to the patient's health or death as a result of:

- imperfections in medical science at the current stage of its development;
- imperfections in medical science at the current stage of its development;
- objective difficulties in diagnosing certain diseases;
- atypical course, individual anatomical anomalies, or functional peculiarities of the patient's body;
- allergic reactions that could not have been predicted during standard medical intervention [21].

Objective causal factors include:

- late hospitalization and severity of the patient's condition, inability to obtain clear and complete responses from the patient;
- a known correlation between prolonged time to surgery initiation and perioperative complications;
- objective working conditions: lack of opportunity to perform a full patient examination, clinical and laboratory tests, involvement of special diagnostic methods and consultations with related specialists;
- objective diagnostic difficulties of certain diseases due to their rarity, atypical progression, or absence of pronounced clinical signs;
- lack of space during anesthesia induction creating difficulties in performing practical manipulations;
- unpredictable patient reactions to certain medications, especially when the patient is in critical condition or undergoing medical intervention in emergency situations caused by natural disasters or military actions [10, 21, 44, 45].

Subjective causes are related to the personal characteristics of the specialist, their professional qualities, and result from actions or inactions, overestimation of laboratory and instrumental data, illogical interpretation of such data, biased attitude towards the patient, and the physician's psychological traits. Subjective causes account for up to 60% of MEs [2, 43].

Subjective factors include:

- errors made by the physician during patient communication due to non-compliance with basic deontological principles;
- inattentive examination (incomplete anamnesis), insufficient or delayed patient examination, ignoring data from previous medical examinations;
- inadequate evaluation of clinical and laboratory tests, absence of data from special diagnostic methods when they are available, or overestimation of their results and diagnostic capabilities;
- disregard or overestimation of consultation opinions or multidisciplinary team conclusions, failure to provide specialist consultation when it is necessary and available;

- negligent performance of invasive procedures or other therapeutic and preventive care measures, prescribing symptomatic treatment instead of radical interventions;
- low qualification level of the physician, personal traits such as insecurity in knowledge or excessive confidence, insufficiently developed clinical reasoning or inability to apply existing knowledge, limited knowledge in related specialties, lack or shortage of experience and practical skills, arrogance;
- narrow diagnostic perspective typical of physicians with a specialized focus;
- lack of understanding of the influence and interaction of multiple risk factors, failure to recognize dangers or overconfidence in their prevention [10, 15, 21].

Subjective causes (factors) are errors committed by physicians (medical personnel) who unjustifiably deviate from established medical standards, act carelessly, overconfidently, or take unjustified risks due to lack of experience and knowledge [3].

According to the literature, the reported prevalence of MEs ranges from 0.01% to 11% [46]. Respondents generally consider that most MEs are not associated with harm to patients. The majority of treatment errors are ultimately benign; however, a subset of these errors leads to significant harm or escalation of care [26, 31, 45, 47, 48]. Specifically, 22.5% of MEs cause minimal harm, whereas 1–2.1% result in serious adverse effects and complications (e.g., cardiac arrest, stroke, irreversible injury) or death [7, 14, 30, 49]. Approximately 1.6% of MEs are life-threatening, 5% require prosthetic replacement of vital functions, and the need for additional invasive monitoring was recorded in 8% of cases [39].

In the United States, over 200,000 patient deaths and up to 1,000,000 cases of disability annually are attributed to preventable MEs, making it the eighth leading cause of death. These errors cost the healthcare system an estimated 17–29 billion USD per year [7, 40, 49–53].

Statistics indicate that in European Union countries, the rate of MEs and adverse events related to medical care accounts for 8–12% of all hospitalizations [10]. In the United Kingdom, approximately 900,000 incidents or errors are reported annually, about 2,000 of which result in patient deaths. This leads to an additional cost of 2 billion GBP per year due to prolonged hospital stays and another 400 million GBP for litigation settlements [31, 54]. Annually, up to 70,000 patients die due to MEs in the UK, with many 'hidden' cases of unsuccessful medical interventions not accounted for [8]. According to the Spanish Medical Association for Victims of Medical Negligence, in a predominantly public healthcare system, approximately 5,000 deaths due to MEs were registered over the last decade [10]. In Australia, MEs cause 18,000 deaths annually and disability in over 50,000 patients. More than 90,000 Italians suffer from MEs each year [23].

International experts estimate that about 70% of MEs are preventable, 6% are potentially avoidable, and 24% of incidents are unavoidable. WHO statistics report that more people die annually from MEs than from road traffic accidents — over 1,500,000 deaths worldwide [8].

MEs undermine the trust not only of patients but also of their families in healthcare institutions [12, 55]. A range of adverse outcomes can erode public confidence in healthcare professionals and systems, which suffer from loss of reputation, distrust, and accusations of negligence. The human and societal burden is even greater, as many patients face costly and prolonged hospital stays, and some never fully recover to their premorbid status [26, 48, 55]. This phenomenon is known as the 'second victim' and can have potentially fatal consequences. It is believed that the widespread culture of perfectionism and individual blame in medicine significantly contributes to these negative outcomes. Moreover, studies have shown that despite healthcare providers' desire for administrative support following a ME, many feel unsupported. However, focusing on the health of both providers and patients makes it possible to enhance the resilience of medical personnel and improve patient care in a healthy, safe, and constructive environment. Proposed solutions in the literature include provider counseling, non-punitive error-based learning, peer discussions of errors, and focusing on system factors rather than individual healthcare workers [1, 32, 48].

Accurate statistical data on MEs in Ukraine are lacking [4]. Domestic healthcare workers most often commit errors during the provision of emergency medical care in inpatient settings (61.2–94.1%). Diagnostic defects constitute 29.7% of all MEs, treatment shortcomings 26.9%, medical documentation errors 21.3%, organizational deficiencies 14.6%, and violations of medical deontological principles 7.5% [43].

Among all MEs leading to the most severe outcomes, 54.5% occur specifically in anesthesiology practice [56]. No anesthesiologist commits errors intentionally; however, such errors are inevitable, as their consequences can be more serious than in other medical specialties [26, 51]. Fortunately, most anesthesia-related errors (AE, anesthetic errors) are minor, though some lead to serious or permanent injury and even death [55].

Based on a limited number of prospective studies, the incidence of errors in anesthesiology practice ranges from 0.33% to 0.77%. Between 2007 and 2014, the number of anesthetic errors (AEs) decreased by 44%; however, in recent years, this rate has remained relatively stable [26, 57].

A study conducted in the United Kingdom reported legal claims exceeding £4,000,000 due to anesthesia-related errors [31]. The incidence of AEs in South African countries is approximately one error per every 133 anesthetic procedures [58].

The consequences of AEs vary from no harm to death [26]. The mortality rate from anesthesia-related errors is estimated at 0.77% [57], although fatal outcomes due to anesthesia errors are less frequent than those caused by surgical or invasive interventions [59, 60].

Thanks to proper pre-anesthetic evaluation and assessment, as well as careful perioperative patient monitoring, perioperative deaths exclusively attributable to anesthesia or AEs in India and Saudi Arabia remain rare, with a reported prevalence of 0.5–0.8 per 100,000 anesthetics [61]. In Egypt, mortality due to AEs ranges between 1 in 1,700 and 1 in 10,000 operations [59].

Human Factor

The role of human error is a factor that was not adequately considered 20 years ago, and it is likely to increasingly influence expert judgments regarding the growing role of anesthesia in processes leading to death [46, 62]. One study even identified that human errors are associated with 65–87% of anesthesia-related deaths [12]. Human error is one of the leading causes of anesthesia-related critical incidents, and its consequences tend to be more immediate, adverse, and noticeable compared to other medical specialties [9, 15, 61, 63].

The human factor acknowledges that people can make mistakes, that human errors cannot be completely eliminated, and that individual and team performance fluctuates and is likely to deteriorate under high-pressure situations. The human factor encompasses non-technical skills such as teamwork and communication but is a much broader domain with many other components. It is both a scientific discipline concerned with un-

derstanding interactions between humans and other elements of a system, and a profession that applies theory, principles, data, and methods to optimize human well-being and overall system performance [35, 45].

Beyond conscious awareness, our brain automatically selects and processes relevant input data while filtering out irrelevant information to enable us to interact efficiently and sensibly with our environment. However, we are constantly distracted and bombarded by myriad sensory inputs. An anesthesiologist is a multidisciplinary specialist capable of simultaneously handling up to 10 tasks. Sensory factors that distract attention away from work play a significant role in the occurrence of errors. Sometimes, however, crucial input data may be mistakenly blocked or ignored [64].

Anesthesiology is a complex discipline requiring a high level of attention and is characterized by periods of intense activity involving multitasking, alternating with periods of lower workload. The less demanding periods may account for a significant portion of routine tasks (up to 40%), associated with reduced cognitive and physical demands. However, during phases of intense activity, the anesthesiologist must allocate varying types of attention to different aspects to ensure patient safety. The required types of attention include focused attention (monitoring vital signs alarms), divided attention (simultaneous assessment of the patient's vital parameters, surgical field, and equipment), selective attention (filtering out irrelevant or distracting information to focus on critical input from multiple monitoring parameters), and sustained attention (providing continuous hemodynamic and respiratory control throughout lengthy urgent surgeries) [65].

Operating rooms present a variety of active factors contributing to a high frequency of errors during anesthesia administration. Staff shortages, irregular and overtime working hours, inattention, poor communication, negligence, haste, and fatigue are common factors that adversely affect both medical and auxiliary personnel [12].

Due to population growth and a decrease in the number of anesthesiologists, fatigue caused by a high workload is a significant contributing factor to anesthetic errors, regardless of the time of the work shift [32, 61, 66]. Among potential contributing factors to anesthetic errors, the most frequent were distraction and fatigue (64.9%) [66]. Between 60.3% and 64.9% of practicing anesthesiologists identify overload as a cause of errors [31, 66], while 46% acknowledge physical impairments such as severe fatigue after shifts, insufficient sleep, or personal illness that they tend to conceal [3, 31]. The human factors domain has demonstrated that individuals have measurable physical and psychological limits within which they perform optimally. Beyond these limits, sheer persistence or calls for increased effort have little to no lasting effect, and performance inevitably declines. A multicenter study conducted in the United States showed that hospital trainees working traditional shifts that included multiple periods longer than 24 hours per month were 21% more likely to make serious treatment errors than those working without extended shifts. Fatigue levels were equated to blood alcohol concentrations in terms of their detrimental effect on performance, indicating that working shifts of 17 hours or more is equivalent to intoxication exceeding the legal limit for driving. No one would agree to a clinician working under the influence of alcohol, yet often the equivalent level of fatigue is expected to be overcome by willpower alone [67]. It is crucial for occupational health systems to protect anesthesiologists from fatigue. This includes ensuring adequate breaks, providing appropriate rest facilities, and complying with labor regulations regarding working hours [44]. Operating room scheduling, staffing, and workflow planning should consider these issues, allowing for sufficient additional time and adjusting staff levels or skill mix as necessary. It may also be beneficial to schedule patients with complex anesthetic and/or surgical needs at the beginning of the operating list [45].

The problem of 'tunnel vision'. Under physiological conditions, the human brain can process only about 4-5 types of information simultaneously. Vital data outside this 'field of view' may be overlooked. Anesthesiologists often fixate on primary vital signs, considering others secondary.

'Inattentional blindness' is a psychological phenomenon characterized by the inability to perceive unexpected stimuli, even when they are clearly visible [64]. Humans cannot anticipate unforeseen events. Although this phenomenon may seem tautological and somewhat ironic, it is well-known as 'inattentional blindness' and has been extensively studied over recent decades due to its significant implications in everyday life. Examples include police officers failing to notice a weapon during a traffic stop or spectators overlooking a gorilla appearing on stage during a theatrical performance [65]. In a study using an anesthesiology model, specialists observing videos of complex abdominal surgeries almost always detected hypotension (90%) but only noticed central venous line disconnection (23%) or head movement (42%) [64, 65]. In contrast, medical students, lacking experience in intraoperative monitoring and clinical knowledge, identified head movement significantly more often than experienced anesthesiologists ($p<0.001$) [64].

The progressive increase in 'clip' or screen-based thinking among anesthesiologists can be explained by the multifunctionality and professional specificity of narrow specialization. While sustained attention to a single task is important, the ability to rapidly switch focus to a new task and respond swiftly is equally critical. The paradox lies in the fact that these somewhat antagonistic higher cognitive functions are both vital in anesthesiology practice: the development of one cognitive skill is supported by the other, and reactive capacity can develop through concentration, and vice versa. In situations where fragmented information directs the specialist toward the whole, clip thinking can transform into symbolic thinking [68].

It is generally believed that anesthesiologists should 'leave their problems at home' in order to flawlessly perform their duties at work. However, they are human, and in practice, this is unrealistic, especially under the conditions of a full-scale war. The main issues highlighted are susceptibility to alcohol use and signs of burnout syndrome. Professional burnout is a clinically significant condition closely associated with reduced quality of life and health of physicians, decreased patient satisfaction, lower quality of medical care, unprofessional behavior, and an increased rate of MEs [69]. Physicians exhibiting symptoms of burnout may demonstrate unprofessional conduct more frequently; alternatively, those with unprofessional behavior may experience cognitive dissonance and be more vulnerable to developing burnout symptoms [70]. According to international research, approximately 2% of anesthesiologists have various dependencies, and 13% of physicians who participated in various treatment programs for these dependencies were anesthesiologists. Success rates of such treatment programs range from 15% to 60%.

Haste or inattention may reduce a person's ability to control actions they may be otherwise well aware of [30]. Errors are more likely when staff have to rush during work and/or feel stressed due to potentially unmanageable workloads [45]. Between 14% and 60.3% of practicing anesthesiologists attribute anesthetic MEs to haste [30, 31], while inattention or negligence accounted for 5.6% to 31% of errors during anesthesia [12, 30, 71]. Vigilance plays a crucial role in avoiding anesthetic failures in all cases [26].

Healthcare professionals may suffer serious psychological consequences following anesthetic errors. Memories of errors can haunt physicians for years. Physicians experience a range of negative emotions after a ME, including anger, guilt, inadequacy, self-doubt, shame, anxiety, fear, and depression due to actual or perceived errors, which may be exacerbated by the threat of litigation [7]. Anesthesiologists have repeatedly faced accusations of involuntary manslaughter. This may lead to exhaustion, lack of concentration, low productivity, post-traumatic stress disorder, and even suicidal tendencies [7, 12]. An anesthesiologist under stress is more prone to committing fatal errors and may endure greater psychological distress if an intraoperative death occurs [61].

Professionalism is crucial for achieving the ideals of the quadruple aim and maintaining public trust in the healthcare system. Integrity, accountability, empathy, dedication to professional competence, and adherence to ethical standards constitute the core principles of professionalism. However, upholding these principles can become challenging in the face of technological advancements, limited resources, shifting market forces, and challenges in healthcare delivery. An increased likelihood of unprofessional behavior has been observed among physicians experiencing burnout across all types of unprofessional conduct, and this association persists whether burnout measures are considered as dichotomous or continuous variables, indicating a widespread effect [70, 72].

Non-technical skills are cognitive, social, and personal skills that complement technical skills and contribute to the safe and effective performance of tasks. They are well described by the Anesthetists' Non-Technical Skills (ANTS) framework, which includes situational awareness, decision-making, task management, and teamwork [45]. Lack of experience and non-technical skills accounts for 16–36% of errors and critical incidents during the perioperative period. The error rate is nearly twice as high among trainees compared to experienced anesthesiologists [12, 30, 31, 55, 58, 61, 71, 73]. In 17.8% of medico-legal cases, expert committees identified unqualified actions by physicians involving serious violations of job descriptions and professional duties. Non-adherence to medical protocols or standards (the most significant indicator of medical professional culpability) was identified by forensic medical experts in 32–33.6% of cases [43, 46, 62].

Worldwide, the anesthesiology workforce is aging, raising concerns that age-related decline in psychophysiological processes in both men and women may lead to deterioration in technical and non-technical skills. However, our 2018 study found no statistically significant age-related differences in professional competence among anesthesiologists in the Dnipro region.

Responsibility is characterized by the anesthesiologist's ability to anticipate the consequences of their actions and to act in accordance with their convictions, as well as by the awareness of the necessity to report MEs and implement measures to limit them [72].

BiLack of experience in effective communication among anesthesiologists leads to significant difficulties in social adaptation, which depends on personal characteristics [74]. Organizational shortcomings can cause communication problems between healthcare teams, complicating decision-making and even putting patients at risk. It has been demonstrated that communication failures and incorrect information transfer may account for up to 70% of errors, with up to 75% of patients potentially dying as a consequence. Leaders who fail to advocate for patient safety initiatives and cannot adapt to the evolving demands of healthcare may contribute to burnout and staff turnover [31, 41]. Communication breakdowns are responsible for 43% of errors in the operating room in the USA. Communication deficiencies can be classified as insufficient information provision, improper timing of communication (e.g., too late), unresolved issues at the end of communication, or absence of key personnel due to territorial reasons. To enhance communication effectiveness among different specialists, especially in emergencies, it is recommended to use the simplest and most precise terminology possible. In critical situations, it is crucial to have a team leader (coordinator) who can convey essential information without the possibility of misinterpretation or misunderstanding, regardless of the situation or team composition [62, 75].

Other categories of anesthesiology errors will be presented in Parts 2 and 3 of this review.

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Анестезіологічна помилка. Частина 1 (огляд)

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Анотація. Ненавмисна лікарська помилка, ймовірно, завжди буде частиною медичної системи. Кожен медичний працівник не застрахований від професійних помилок, так само як і представник будь-якої спеціальності. У статті здійснено ретроспективний інформаційний пошук літературних джерел та інформаційних даних за просторово-векторною моделлю дескрипторної системи, яка базується на класифікаторах, доповнений шляхом ручного пошуку літературних джерел. Отримання наукової літературної інформації виконано з використанням інформаційних пошукових систем Scopus, CrossRef, Google Scholar та PubMed та доповнене ручним пошуком використаних статей. Показано, що безпомилкова робота медичного персоналу практично неможлива. Однак зважаючи на специфіку медичної професії, вони набувають суспільного значення. Якщо помилку інших фахівців якось можна виправити, то лікарська помилка дуже часто є невиправною, адже може призвести до інвалідизації або смерті пацієнта. Людська помилка є однією з провідних причин, пов'язаних з анестезією критичних інцидентів, а її наслідки більше, ніж в інших медичних спеціальностях, мають тенденцію бути негайними, несприятливими та помітними. Людський фактор визнає, що люди можуть помилятися, що людські помилки не можуть бути цілком усунені і що особиста та командна продуктивність змінюється та, ймовірно, погіршується в ситуаціях високого тиску. Людський фактор включає нетехнічні навички, такі як робота в команді та спілкування, але це набагато ширша діяльність з багатьма іншими компонентами.

Ключові слова: загальнолікарські помилки, анестезіологічні помилки, класифікація, людський фактор.

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