ORIGINAL ARTICLE

# Adverse Events in Anesthesia: An Integrative Review

*Cassiane de Santana Lemos, MSc, Vanessa de Brito Poveda, PhD*

**Purpose:** *This study conducted an integrative review of the literature in a search for scientific evidence related to the occurrence of perioperative adverse events resulting from anesthesia.*
**Design:** *Integrative review.*
**Methods:** *The search was performed in the PubMed/MEDLINE, Virtual Health Library, Cumulative Index to Nursing and Allied Health, and Web of Science databases and portals, including studies published in Portuguese, English, or Spanish, from 1997 to 2017. The studies were supposed to assess adverse events associated exclusively with anesthesia care.*
**Findings:** *We selected 21 studies. The main adverse events in anesthesia were respiratory, drug error, cardiology, and neurology. Most of the events were related to human errors, slips, and lapses that resulted in damage to the patient, such as permanent injuries or death.*
**Conclusions:** *Care planning, efficient communication, and teamwork are critical to prevent adverse events in anesthesia.*

**Keywords:** *anesthesia, adverse effects, malpractice, medical errors.*
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**ANESTHESIA IS A COMPLEX** specialization that involves the application of technical skills and decision-making in critical situations. To control risks and prevent damage to the patient, planning of appropriate care by a multiprofessional team is paramount.[1] The anesthesia professional is expected to ensure proper functioning of the equipment, perform a preoperative assessment of each patient, properly calculate and administer medications, and respond precisely to care demands.[2]

*Cassiane de Santana Lemos, MSc, doctoral student at University of São Paulo, School of Nursing, São Paulo, SP, Brazil; and Vanessa de Brito Poveda, PhD, University of São Paulo, School of Nursing, São Paulo, SP, Brazil.*

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*Address correspondence to Cassiane de Santana Lemos, Dr Enéas de Carvalho Aguiar Avenue, 419, Cerqueira Cesar, São Paulo, SP, 05403000; e-mail address: cassilemos@usp.br.*

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An adverse event related to health care is characterized as any injury to the patient that could cause damage.[3] Adverse events in anesthesia may occur due to the pressure to perform activities, broader responsibility, stress, advanced technology equipment, and the high noise levels present in the operating room.[2] With the increased costs resulting from lawsuits filed against these professionals in the 1980s, and as the institutional leaders became aware that errors should be better studied to foster planned interventions, the field of anesthesiology has become a pioneer specialization in evaluating and developing actions to prevent adverse events and promote patient safety.[4]

In 2010, the European Board of Anesthesiology and the European Society of Anesthesiology produced the Helsinki Declaration on Patient Safety in Anesthesia. Among the several recommendations made to improve the quality of care, the document proposed the creation of systems for the reporting and control of adverse events in

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anesthesia.[5] Initiatives to improve the quality of anesthesia care led to a reduction in mortality over the years. However, morbidity rates associated with complications from anesthesia, understood as those that caused temporary or permanent damage to the patient, remained between 18% and 22%.[6,7]

Anesthesia morbidity is defined as a complication (excluding death) that occurs in the perioperative period and that may be classified as minor, intermediate, or major.[8] Minor morbidity may cause discomfort, such as nausea or vomiting, without prolongation of hospital stay or permanent sequelae. Intermediate morbidity is characterized as a serious distress, prolongation of hospital stay, or both, without permanent sequelae (eg, dental injury). Major morbidity generates permanent disability and sequelae (eg, spinal cord injury).

Failures in communication, nonadherence to care protocols, deficient teamwork, and human errors are factors that may contribute to the occurrence of adverse events in anesthesia.[9,10] Therefore, to increase safety in anesthesia, it is important to use modern technology combined with improvements in education, training, supervision, and guidelines for professionals to perform anesthesia.[11] Therefore, good professional performance is directly associated with knowledge, problem-solving skills, and rapid action when it comes to complications, vigilance, and teamwork.[12]

## Purpose

An analysis of incidents related to anesthesia care and an evaluation of the factors that contribute to the occurrence of adverse events are fundamental to highlight which aspects of daily practice can affect patient safety and which actions should be taken to prevent damage. PICO is an acronym for the elements of the clinical question: population (P), intervention or issue of interest (I), issue of interest and outcome (CO).[13] The acronym was used to define the research question, "What adverse anesthetic events occur in the perioperative period?"

In this context, the study aimed at conducting an integrative review of the literature in a search for scientific evidence related to the occurrence of perioperative adverse events resulting from anesthesia.

## Method

An integrative review is a research method used to review previous studies as well as to analyze and synthesize the literature to produce new knowledge and perspectives on a specific theme. The strategy includes identifying a problem; searching the literature; assessing the data, strengths, and limitations; and suggesting recommendations for future practices and developments.[14]

This study was an integrative review of the literature, in accordance with the principles set by the Center for Reviews and Dissemination guidelines for undertaking health care literature reviews.[15] The search carried out in this study covered the PubMed/MEDLINE, Virtual Health Library, Cumulative Index to Nursing and Allied Health, and the Web of Science databases and portals.

Studies that analyzed adverse events in the perioperative period of hospitalized patients exclusively associated with anesthesia care, published in Portuguese, English, or Spanish, from 1997 to 2017, were included. Articles involving experimental animal studies, which assessed adverse events for various causes, pediatric patient studies, case studies, experience reports, reviews, and editorials were excluded.

The search was performed using the controlled descriptors defined in the Descriptors in Health Sciences and Medical Subject Headings. Table 1 presents the search strategy used in the evaluated databases. The articles were selected by reading their titles and abstracts, followed by the thorough reading of the studies. Two independent reviewers selected the studies, and a third reviewer was consulted in the case of divergence.

The strategy[16] used in the structuring and selection of the articles is presented in Figure 1. The database searches resulted in 770 articles. After reading the titles and abstracts of all those articles, 625 of them were excluded because they were published in other languages (French, German, and Japanese) or demonstrated a fragile

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**Table 1. Descriptors Used to Search the Literature According to the Investigated Database and Portal**

| Database and Portal | Search Strategy |
|---|---|
| PubMed/Medline | ("Anesthesia/adverse effects"[Mesh] OR "anesthesia incidents"[All Fields]) AND ("Medical Errors"[Mesh] OR "Malpractice"[Mesh]) AND ("humans"[MeSH Terms] AND ("aged, 80 and over"[MeSH Terms] OR "aged"[MeSH Terms] OR "middle aged"[MeSH Terms] OR ("middle aged"[MeSH Terms] OR "aged"[MeSH Terms]) OR "adult"[MeSH Terms:noexp] OR "young adult"[MeSH Terms] OR "adult"[MeSH Terms])) |
| VHL portal | tw:((anesthesia OR "anesthesia incidents") AND ("Medical Errors" OR malpractice)) AND (instance:"regional") AND (mh:("Anestesia/AE") AND limit:("humans" OR "adult" OR "middle aged" OR "aged") AND la:("en" OR "es" OR "pt")) |
| CINAHL | (anesthesia OR "anesthesia incidents") AND ("medical errors" OR malpractice) |
| Web of Science | (anesthesia OR "anesthesia incidents") AND ("Medical Errors" OR malpractice) |

VHL, Virtual Health Library; CINAHL, Cumulative Index to Nursing and Allied Health.

methodology (case studies, magazine editorials, letters to readers, and literature review).

After that, 71 articles remained apparently eligible for review and were then thoroughly read. Out of those, 50 articles were excluded because either they analyzed pediatric patients (35) or they evaluated adverse events that were not related to anesthesia or surgical patients (15). Data were extracted from the remaining 21 articles and studies included in the review after an analysis was made of the type of study, the investigated samples and study sites, as well as the objectives, main results, resulting complications, and causes of adverse events.

The concepts proposed by Melnyk and Fineout-Overholt involving the aspects of prognosis, prediction, or etiology[17] were used in the analysis of the level of evidence in the studies (Table 2). The analysis of the results was based on the evaluation of the causes of adverse events in anesthesia, according to factors such as human failure, clinical history of the patient, and equipment failure.

Human failures were defined as errors, lapse, slip, and violation. An error was classified as a failure in the planning of actions to reach the desired objective, whereas failures in the execution of a practical action were defined as a slip or lapse.[18] A slip occurs due to the lack of attention; a lapse is due to memory failure, such as events caused by inattention, worries, or changes in one's personal routine, without any intention to commit the fault.[18] On the other hand, a violation involves the disregard for procedures, standards, or rules as a consequence of motivational problems such as low morale, poor supervision of work, and poor commitment to rules.[18]

Failures may be active failures that result from the direct action of professionals, leading to an error or a violation and then causing an immediate adverse event, or latent failures related to administrative decisions, organizational processes, and the culture of institutions.[18] Inadequate organizational decisions reflected in planning, checking, communication, or regulation can influence several sectors and lead to severe workload, fatigue, teamwork deficiencies, and lack of materials and guidelines, all of which contribute to errors and consequent damage to the patient.[18,19]

The degree of severity of the injuries generated by adverse events was defined in the scale of the National Association of Insurance Commissioners, which ranges from 1 (emotional only) to 9 (death) (Table 3).[20]

## Results

Twenty-one articles published between 1997 and 2017 met the inclusion criteria. Most of the selected studies were published in the United States (10; 47.6%) and retrospectively evaluated the database regarding notifications of claims of

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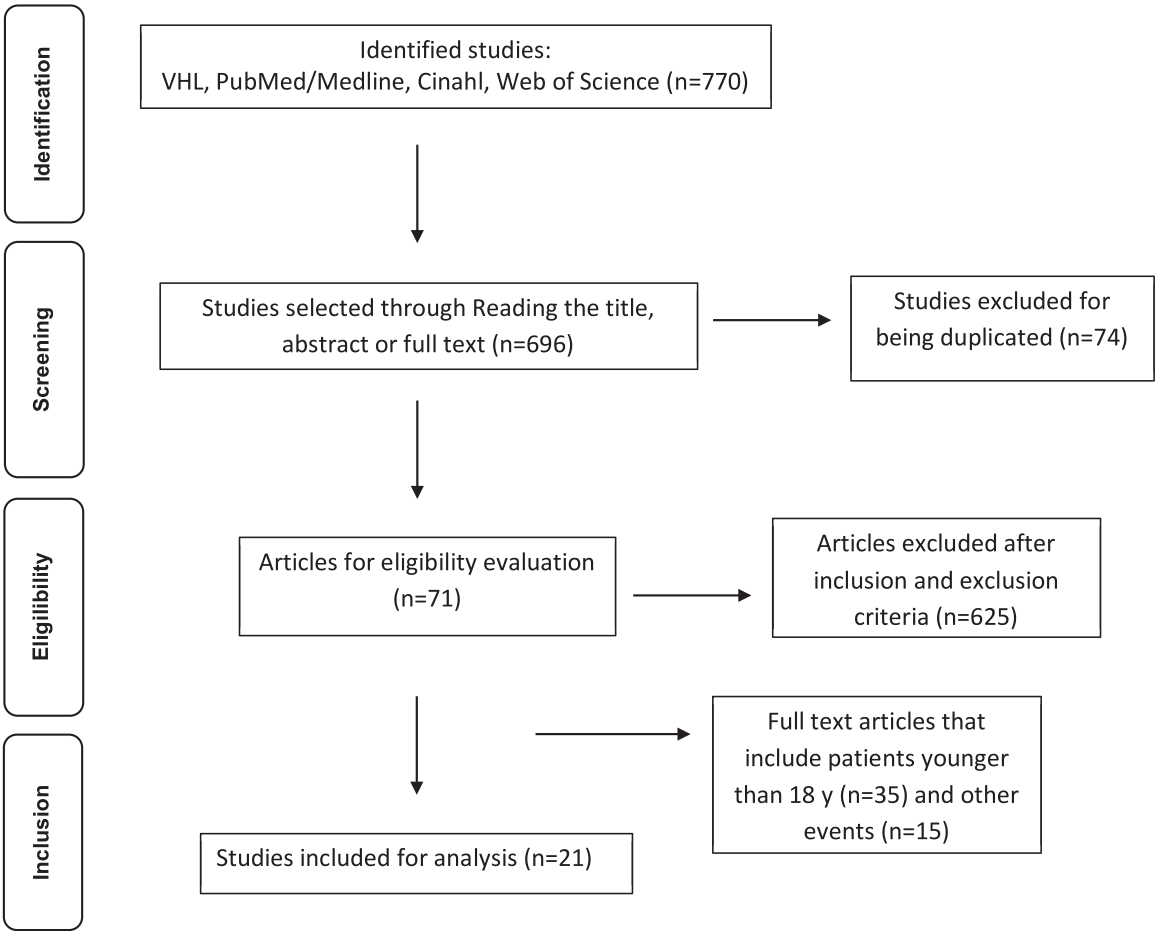


Figure 1. Inclusion and exclusion diagram of articles available in the investigated databases and portal. VHL, Virtual Health Library; CINAHL, Cumulative Index to Nursing and Allied Health.

adverse events in anesthesia (Table 4). According to the level of evidence proposed by Melnyk and Fineout-Overholt,[17] 15 (71.4%) studies were classified as level IV (descriptive studies) and six (28.5%) as level II (cohort studies) (Table 4).

**Table 2. Level of Evidence for Clinical Reasons of Prognosis, Prediction, or Etiology According to Melnyk and Fineout-Overholt[17]**

| Level | Strength of Evidence |
|---|---|
| I | Synthesis of cohort study or case-control studies |
| II | Single cohort study or case-control study |
| III | Meta-synthesis of qualitative studies or descriptive studies |
| IV | Only qualitative or descriptive study |
| V | Expert opinion |

The main categories of adverse events mentioned in the selected studies were related to respiratory events (57.1%), mostly involving aspiration (50%). The second main category involved medication errors (52.3%), with emphasis on incorrect medications (81.8%). Cardiologic events (52.3%) involved mostly hemorrhage (45.4%) and arrhythmias (45.4%), followed by neurological events (47.6%), with an emphasis on pain (60%) (Table 5).[21-41]

Table 6 indicates the degree of severity of the damage caused by adverse events in anesthesia, permanent injuries, and death involved in the highest rate of injuries to the patient. Among severe permanent damage, brain injury stood out and resulted from problems with the airway,[28,29,31,38,39] failure of the anesthesia equipment,[21] errors in the execution of

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**Table 3. Score, Category of Severity and Injury or Complication Generated by Adverse Events**

| Category | Score | Injury or Complication |
|---|---|---|
| Emotional only | 1 | Fright, no physical damage |
| Temporary | 2-Insignificant | Lacerations, contusions, minor scars, rash. No delay. |
| | 3-Minor | Infections, misset fracture, fall in hospital. Recovery delayed. |
| | 4-Major | Burns, surgical material left, drug side effect, brain damage. Recovery delayed. |
| Permanent | 5-Minor | Loss of fingers, loss or damage to organs. Includes nondisabling injuries |
| | 6-Significant | Deafness, loss of limb, loss of eye, loss one kidney or lung |
| | 7-Major | Paraplegia, blindness, loss of two limbs, brain damage |
| | 8-Grave | Quadriplegia, severe brain damage, lifelong care or fatal prognosis |
| Death | 9 | |

neuroaxial anesthesia,[26,31] medication errors,[30] poorly managed anesthesia, and poor communication among professionals.[29] Ten of the evaluated studies indicated that the damage caused by adverse events led to lawsuits that granted financial compensation to the patients.[21,22,24,26,29,30,32,34,36,39]

Human errors, slips, and lapses were identified as the contributing factors in most adverse events from anesthesia, followed by violation of care processes, as described in Table 7. When we analyzed the active failures that led to adverse events, we observed that failures in respiratory events occurred due to an incomplete or absent preoperative assessment,[24,38,41] inadequate planning of anesthesia and difficulties in the management of the airway,[24,29,31,41] inadequate ventilation and oxygenation due to multiple intubation attempts, and difficulty in intubation that resulted in permanent injury such as death[31,38] and brain injury.[28,31,38]

The adverse events related to medication presented a relationship with incorrect identification of medicine, a change of medication during the anesthetic induction, and latent failures (Table 7). The main cardiologic events were associated with a delay in the identification of hemodynamic alterations,[27,28,31,41] poor communication among professionals,[25,37] and inadequate preoperative assessment.[22,24,38,41] Such failures in the care of the patient led to brain injury and death.

Among the causes of adverse events of pain, the studies mentioned failures in the execution of regional anesthesia,[26,31-34] which caused the injury of nerves in most cases.[26,31,33,34] The causes for intraoperative awareness and awake paralysis during general anesthesia involved the failure of the vaporizers and an insufficient supply of inhalation agents,[21] the administration of a muscle relaxant in the incorrect sequence,[22,23,29,32] the use of a nitrous-narcotic-relaxant technique, hypotension, difficulty in intubation, inadequate doses of drugs,[22] medication error, and inadequate intraoperative monitoring.[32] These factors generated emotional alterations such as fear, panic, nightmares, and the need for psychological monitoring in the postoperative period.[22,23,32]

## Discussion

### *Adverse Event–Reporting Systems*

The reporting of near misses and adverse events related to healthcare is important because it allows for identification of potential risks in care, assessment of deficiencies in the structure and functioning of equipment,[11] and learning from the experience reports of professionals, all of which contribute to the training, education, and improvement of the safety standards of care.

The analysis may present limitations because the cause of the event may be multifactorial and not always identifiable in the report presented.[42] Thus, the results of this review demonstrated that most of the selected articles presented retrospective studies of adverse events in anesthesia as reported in the database. They reflected initiatives that have been used since the 1980s, such as those of the American Institute established in 1984 by the American Society of Anesthesiologists (ASA),

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**Table 4. Characterization of the Studies According to the Sample, Objective, Conclusion, and Level of Evidence**

| Article | Study Design | Study Location | Sample | Objective | Conclusion | Level of Evidence |
|---|---|---|---|---|---|---|
| Caplan, 1997[21] | Retrospective, descriptive | The United States | 3,791 claims of adverse events related to anesthesia, occurring in the period of 1961 to 1994 | To identify the causes and prevention strategies related to adverse events in equipment for ventilatory support, as notified in the American Society of Anesthesiology Closed Claims Project | Adverse events due to ventilatory support equipment generate high lesion severity and costs and indicate the inappropriate use of equipment. The anesthesia equipment circuit presented the largest number of events due to failures and disconnection. | IV |
| Domino, 1999[22] | Retrospective, descriptive | The United States | 4,183 claims of adverse events in anesthesia evaluated in the period of 1961 to 1995 | To identify patients and anesthetic factors associated with intraoperative awareness, as described by 35 insurance companies in the American Society of Anesthesiology Closed Claims Project | Errors in medication identification and syringe exchange generated paralysis in the conscious patient. Intraoperative awareness events were more frequent in the female gender and use of the nitrous oxide, hypnotic, and muscle relaxant technique. | IV |
| Fasting, 2000[23] | Prospective, pretest and post-test | Norway | 8,300 events related to anesthetic care in procedures of 1996 to 1999 | To describe the frequency of adverse events in anesthesia related to medication errors before and after changing the color of labels to identify syringes | Low incidence of medication errors was recorded. Muscle relaxants presented the highest category of errors, and a color change of the syringe identification labels did not eliminate the frequency of errors by syringe exchange. | IV |
| Moody, 2001[24] | | The United States | | | | IV |

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|---|---|---|---|---|---|---|
| | Retrospective, descriptive | | 223 claims of adverse events in anesthesia notified in the period of 1989 to 1994 | To review and analyze claims notified by the American Association of Nurse Anesthetists regarding inadequate preanesthetic care | Inadequate preanesthetic evaluation may contribute to adverse events in anesthesia. Errors can be reduced by studying the origin of events and education and by applying standards and care protocols. | |
| El Dawlatly, 2004[25] | Retrospective cohort | Saudi Arabia | 71 events related to anesthetic care in the period of 1998 to 2002 | To evaluate the events related to anesthesia reported to an anesthesia department of two university hospitals | Emergency surgery and ASA III-IV classification were predictors for anesthesia events. An analysis of the events can contribute to improving preventive strategies. | II |
| Lee, 2004[26] | Retrospective, descriptive | The United States | 1,005 claims related to adverse events in regional anesthesia in the period of 1980 to 1999 | To analyze the factors contributing to the high severity of lesions associated to regional anesthesia, comparing obstetric and nonobstetric patients, as reported to the American Association of Nurse Anesthetists Foundation Closed Claims Project | Claims in regional anesthesia were related to blockades, generating temporary or low-severity injuries in obstetric patients. Complications such as cardiac arrest and neuroaxial hematomas associated with coagulopathy resulted in significant morbidity and mortality and delayed diagnosis contributed to neurological complications. | IV |
| Ruibal, 2006[27] | Retrospective cohort | Spain | | | | II |

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**Table 4. Continued**

| Article | Study Design | Study Location | Sample | Objective | Conclusion | Level of Evidence |
|---|---|---|---|---|---|---|
| | | | 547 incident records in anesthesia evaluated in a public hospital from 1999 to 2004, among 68,627 surgical procedures | To identify changes related to morbidity and mortality in anesthesia after the implementation of an anesthesia incident–reporting system and to evaluate the effects of the implemented measures | The analysis and communication of critical incidents in anesthesia services can contribute to improvement in health care. | |
| Cheney, 2006[28] | Retrospective cohort | The United States | 6,750 events related to anesthetic care occurring in the period of 1975 to 2000 | To investigate factors associated with a decreased number of events in anesthesia related to death and brain injury, as reported in the American Society of Anesthesiology Closed Claims Project | There was a reduction in the number of death claims and permanent brain injury from 1975 to 2000. The use of monitors such as an oximeter and capnograph was associated with a reduction in the number of respiratory events. | II |
| Cook, 2009[29] | Retrospective, descriptive | The United Kingdom | 841 claims of adverse events in anesthesia evaluated between 1995 to 2007 | To identify the financial impact of adverse events in anesthesia for the English health service, as reported to the National Health Service Litigation Authority (NHSLA) | An adverse event–reporting system can clinically and financially benefit patients, anesthesiologists, and the health care system. | IV |
| Cranshaw, 2009[30] | Retrospective cohort | The United Kingdom | 1,067 claims of adverse events related to anesthesia, evaluated in the period of 1995 to 2007 | To identify adverse events in anesthesia related to medication administration and allergic reactions reported to the | Avoidable reactions and severe allergic reactions are the main factors for patient claims. The most important adverse | II |

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|---|---|---|---|---|---|---|
| | | | | National Health Service Litigation Authority (NHSLA) and to evaluate avoidable errors | events were awake paralysis and respiratory depression by opioids, with neurological sequelae. The results may contribute to cost-benefit evaluations for implementing strategies to reduce errors, such as double-checking medications. | |
| Davies, 2009[31] | Retrospective cohort | The United States | 7,328 claims in the period of 1990 to 2003 | To compare adverse event claims in obstetric anesthesia before and after 1990 and maternal and newborn death and brain injury in the American Society of Anesthesiology Closed Claims Project | Newborn death and brain injury have declined over the years but still generate claims for negligence. Maternal nerve injury and newborn death were the most common complications after 1990 and were associated with delayed anesthesia, ineffective communication, difficulty in intubation, and hypotension. Maternal death was associated with delayed diagnosis and cardiac arrest for high neuroaxial blockade. | II |
| Mihai, 2009[32] | Retrospective, descriptive | The United Kingdom | 161 claims of adverse events related to improper anesthesia, evaluated from 1995 to 2007 | To identify the financial impact of adverse events in anesthesia for the English health service, as reported to | Intraoperative awareness during general anesthesia, awake paralysis, and inadequate regional | IV |

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**Table 4. Continued**

| Article | Study Design | Study Location | Sample | Objective | Conclusion | Level of Evidence |
|---|---|---|---|---|---|---|
| | | | | the National Health Service Litigation Authority (NHSLA), and to assess changes in practice that reduce the impact of events | anesthesia were causes of lawsuits. Most of the events are preventable through communication about preoperative risk, patient risk stratification, validation of methods for correct choice of anesthesia, and reduced medication errors. | |
| Orebaugh, 2009[33] | Retrospective, descriptive | The United States | 5,436 regional blockades carried out in the period from 2006 to 2008 | To evaluate the frequency of events related to regional blockades, with and without the use of ultrasound and nerve stimulator, as reported in a university hospital quality system | Retrospective analysis of adverse events suggests that the use of ultrasound for regional blockades is associated with a reduction in central nervous system toxicity by a local anesthetic. | IV |
| Szypula, 2010[34] | Retrospective, descriptive | The United Kingdom | 841 claims of adverse events related to anesthesia, notified in the period of 1995 to 2007 | To analyze the factors contributing to lawsuits and financial impact, comparing regional anesthesia in obstetric and nonobstetric patients | Claims in nonobstetric patients indicated greater severity and cost, including events due to nerve damage, epidural and inadequate anesthesia, and ophthalmic blockades. A national reporting system could benefit patients, anesthetists, and the health system. | IV |

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|---|---|---|---|---|---|---|
| Clarke, 2011[35] | Prospective, descriptive | Australia | 6,101 regional ophthalmic blockades evaluated in the period from 2001 to 2008 | To evaluate the adverse events related to ophthalmic, peribulbar, and subtenonian blockades | The study had a low incidence of adverse events in the peribulbar and subtenonian blockades. However, it indicates the importance of demarcation and confirming the eye to be operated on. | IV |
| Rathmell, 2011[36] | Retrospective, descriptive | The United States | 1,627 claims of adverse events in anesthesia evaluated in the period from 2005 to 2008 | To identify adverse events in anesthesia related to interventions in chronic cervical pain, as reported in the American Society of Anesthesiology Closed Claims Project | The lesions generated in interventions in treating chronic cervical pain were severe and associated with trauma to the spinal cord by needle. The events mainly occurred in general anesthesia and sedation. | IV |
| Hudson, 2015[37] | Retrospective cohort | Canada | 14,421 patients submitted to cardiac procedures from April to October 1999 | To evaluate the mortality and morbidity of patients with and without care transfer (handoff) by the anesthesiologist | Transfer of anesthesia care during intraoperative cardiac surgery was associated with a 43% risk of mortality and a 27% higher risk of morbidity. | II |
| Roh, 2015[38] | Retrospective, descriptive | South Korea | 105 adverse events related to anesthetic care reported from 2009 to 2014 | To identify adverse events related to anesthesia, as reported to the Korean Society of Anesthesiologists | Failure to follow airway guidelines led to secondary hypoxia, airway obstruction, and respiratory depression in procedures with sedation, indicating a lack of vigilance in less | IV |

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**Table 4. Continued**

| Article | Study Design | Study Location | Sample | Objective | Conclusion | Level of Evidence |
|---|---|---|---|---|---|---|
| | | | | | invasive procedures and a high proportion of perioperative mortality due to acute myocardial infarction. Most cases were classified as preventable if standard care had been followed. | |
| Lee, 2015[39] | Retrospective, descriptive | The United States | 9,799 claims of adverse events in anesthesia evaluated from 1990 to 2009 | To identify adverse events in anesthesia related to respiratory depression by administration of opioids, as reported to the American Society of Anesthesiology Closed Claims Project | The data demonstrated that most of the events related to respiratory depression are preventable, mainly occurring in the first 24 hours after surgery, preceded by a period of drowsiness before critical events that result in death or severe brain injury. | IV |
| Erdmann, 2016[40] | Prospective, descriptive, exploratory | Brazil | 376 associated anesthesiologists of the Anesthesiology Society of Santa Catarina | To verify the prevalence of medication administration errors during anesthesia among anesthesiologists, as well as the circumstances in which they occurred and to verify possible associated factors | Most of the anesthesiologists interviewed committed more than one medication error in anesthesia, associated to distraction or fatigue. | IV |

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|---|---|---|---|---|---|---|
| Schulz, 2017[41] | Retrospective, descriptive | The United States | 266 claims of anesthesia associated with anesthesiologists, evaluated between 2002 and 2013 | To evaluate the frequency and type of situational awareness that caused death or brain injury among claims associated with anesthesia, as reported to the American Society of Anesthesiology Closed Claims Project | The absence of situational awareness to identify alterations in the anesthetic procedure may have contributed to negligence. Definitions for situational awareness errors were developed and applied for analyzing cases of severe injury. | IV |

ASA, American Society of Anesthesiologists.

which created the Closed Claims Project (ASA-CCP).[43,44]

The ASA-CCP was created with the objective of producing a database in which claims for inadequate care against anesthetist professionals reported by insurance companies in lawsuits could be analyzed to develop strategies to prevent and reduce damage to the patient.[43,44] The ASA-CCP database indicated that among the notifications, 17% were related to the respiratory system, 10% to cardiovascular events, 10% to device failures, 8% to drug reactions, and 7% to regional blockades. The main injuries caused by the identified adverse events in 26% of cases were death, followed by temporary or permanent nerve injury (22%), permanent brain injury (9%), and other injuries (pneumothorax, airway lesion, ocular, headache, and emotional stress).[44]

In 1987, the Australian Patient Safety Foundation was created to coordinate the Australian Incident Monitoring Study and investigate critical events in anesthesia. This allowed for an analysis of factors that contributed to failures and human errors as well as strategies to minimize adverse events and institute corrective measures. The data indicated that the injuries were mainly caused by system failure, human error, and difficulties in the management of crisis situations.[45]

In 1999, the Swiss Society of Anesthesiology and Reanimation created the Swiss Anesthesiology Closed Claims Analysis Project to monitor adverse events in anesthesia. Among the events, 40% were related to nerve injuries, 15% to respiratory events, 10% to lesions related to surgical positioning, 7% to events with central catheters causing cardiac tamponade and subclavian artery puncture, 5% to cardiovascular events, and 2% to the incorrect administration of medications.[46] The adverse events described by the Swiss project led to permanent lesions such as ocular, brain, and nerve injury; paraplegia; or tetraplegia.[46]

### *Categories of Adverse Events*

Adverse events involving the respiratory system, medication, and cardiologic and neurological problems presented the highest number of reports in the studies selected in this review. Therefore,

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**Table 5. Type of Adverse Events According to Occurrence Category (N = 21)**

| Category (N; %) | Type of Adverse Events | n | % | Article |
|---|---|---|---|---|
| Respiratory (12; 57.1) | Aspiration | 6 | 50 | Moody[24]; Cheney[28]; Cook[29]; Davies[31]; Roh[38]; Schulz[41]. |
| | Inadequate ventilation | 4 | 33.3 | Moody[24]; Cheney[28]; Cook[29]; Schulz[41]. |
| | Difficult intubation | 4 | 33.3 | Cheney[28]; Davies[31]; Roh[38]; Schulz[41]. |
| | Hypoxia | 3 | 25 | Fasting[23]; Ruibal[27]; Cook[29]. |
| | Respiratory depression | 3 | 25 | Cranshaw[30]; Roh[38]; Lee[39]. |
| | Premature extubation | 3 | 25 | Cheney[28]; Cook[29]; Roh[38]. |
| | Obstruction | 3 | 25 | Cheney[28]; Davies[31]; Roh[38]. |
| | Pneumothorax | 3 | 25 | Cook[29]; Rathmell[36]; Roh[38]. |
| | Bronchospasm | 2 | 16.6 | Roh[38]; Schulz[41]. |
| | Esophageal intubation | 2 | 16.6 | Cheney[28]; Cook[29]. |
| | Airway trauma | 1 | 8.3 | Cook[29]. |
| Drug error (11; 52.3) | Wrong drug | 9 | 81.8 | Fasting[23]; El Dawlatly[25]; Ruibal[27]; Cheney[28]; Cook[29]; Cranshaw[30]; Mihai[32]; Szypula[34]; Erdmann[40]. |
| | Wrong dose | 7 | 63.6 | Domino[22]; Fasting[23]; Cheney[28]; Cook[29]; Cranshaw[30]; Lee[39]; Erdmann[40]. |
| | Syringe swap | 4 | 36.3 | Domino[22]; Fasting[23]; Cook[29]; Mihai[32]. |
| | Ampoule swap | 2 | 18.1 | Domino[22]; Fasting[23]. |
| | Allergic or adverse drug reaction | 2 | 18.1 | Cheney[28]; Cook[29]. |
| Cardiology (11; 52.3) | Hemorrhage | 5 | 45.4 | Cheney[28]; Davies[31]; Hudson[37]; Roh[38]; Schulz[41]. |
| | Arrhythmias | 5 | 45.4 | Domino[22]; Moody[24]; El Dawlatly[25]; Ruibal[27]; Roh[38]. |
| | Hemodynamic instability | 4 | 36.3 | Domino[22]; El Dawlatly[25]; Davies[31]; Szypula[34]. |
| | Stroke | 3 | 27.2 | Cheney[28]; Rathmell[36]; Hudson[37]. |
| | Pulmonary embolism | 2 | 18.2 | Cheney[28]; Roh[38]. |
| | Myocardial infarction | 2 | 18.2 | Cheney[28]; Roh[38]. |
| Neurology (10; 47.6) | Pain | 6 | 60 | Lee[26]; Cook[29]; Davies[31]; Mihai[32]; Orebaugh[33]; Szypula[34]. |
| | Intraoperative awareness | 5 | 50 | Caplan[21]; Domino[22]; Fasting[23]; Cook[29]; Mihai[32]. |
| | Awake paralysis | 5 | 50 | Domino[22]; Fasting[23]; Cook[29]; Cranshaw[30]; Mihai[32]. |
| | Headache | 2 | 20 | Lee[26]; Davies[31]. |
| | Convulsion | 1 | 10 | Orebaugh[33]. |
| | Meningitis | 1 | 10 | Szypula[34]. |
| Ophthalmic (2; 9.5) | Globe perforation | 2 | 100 | Szypula[34]; Clarke[35]. |
| | Hemorrhage | 1 | 50 | Clarke[35]. |

planning of the care before the anesthetic induction is paramount to prevent these adverse events.

The care plan defined by anesthesia professionals should include preanesthetic assessment, identification of the patient's health conditions, and evaluation of the resources required for intraoperative monitoring. The use of a checklist containing information on the patients and all equipment as a care plan before the performance of any anesthetic induction would contribute to ensuring that any and all materials and equipment the anesthetic procedure requires are available and fully operational, and would serve to alert the team about potential difficulties related to anesthesia.[47,48]

The preanesthetic assessment should include an effective airway assessment to verify the clinical conditions of the patient (obesity, history of snoring) as well as anatomical aspects (mouth opening, thyrotonian distance, head and neck movement, teeth protrusion).[49] It is also important to identify

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**Table 6. Category of Severity and Injury or Complication Generated by Adverse Events*(N = 21)**

| Category | Score | Injury or Complication | N | % | Article |
|---|---|---|---|---|---|
| Emotional only | 1 | Emotional/psychological distress | 4 | 19.4 | Domino[22]; Fasting[23]; Lee[26]; Mihai[32]. |
| Temporary | 3-Minor | Infections | 3 | 14.2 | Szypula[34]; Rathmell[36]; Roh[38]. |
| | 4-Major | Prolonged stay | 3 | 14.2 | Caplan[21]; El Dawlatly[25]; Ruibal[27]. |
| Permanent | 5-Minor | Nerve injury | 6 | 28.5 | Lee[26]; Cook[29]; Davies[31]; Orebaugh[33]; Szypula[34]; Roh[38]. |
| | | Cardiac arrest without brain injury | 2 | 9.5 | El Dawlatly[25]; Cheney[28]. |
| | | Dental injury | 1 | 4.7 | Cook[29]. |
| | 7-Major | Paraplegia | 2 | 9.5 | Rathmell[36]; Roh[38]. |
| | | Blindness | 2 | 9.5 | Lee[39], Clarke[35]. |
| | 8-Grave | Brain injury | 9 | 42.8 | Caplan[21]; Lee[26]; Cheney[28]; Cook[29]; Cranshaw[30]; Davies[31]; Roh[38]; Lee[39]; Schulz[41]. |
| | | Cardiac arrest with brain injury | 5 | 23.8 | Lee[26]; Cook[29]; Cranshaw[30]; Davies[31]; Roh[38]. |
| | | Quadriplegia | 2 | 9.5 | Rathmell[36]; Roh[38]. |
| Death | 9 | Death | 11 | 52.3 | Caplan[21]; Lee[26]; Cheney[28]; Ruibal[27]; Cook[29]; Cranshaw[30]; Davies[31]; Roh[38]; Lee[39]; Hudson[37]; Schulz[41]. |

* Table constructed on the basis of the criteria defined by the National Association of Insurance Commissioners scale.

risk factors that make it difficult to ventilate a patient, as well as the availability of the necessary equipment and preparation for the possibility of an intervention in the case of difficult airways,[50] such as the use of a face mask, the insertion of supraglottic devices, and a tracheal intubation or access to the neck.

In this sense, the study observed an increase in the number of events that resulted from a difficulty of intubation and aspiration. This emphasized the importance of previously identifying a difficult airway, to limit the intubation attempts to three before the use of other techniques, and the need to develop strategies to manage difficult airways during extubation.[44]

Over the years, advancements in technologies related to anesthesia monitoring, such as capnography and pulse oximetry, have contributed to a reduction in respiratory events, but these still stand out as the cause of a significant portion of the reports associated with anesthesia care.[46] Studies have shown that the main adverse events related to medication were the result of errors in the use or dosage of the drug involved, but also to distraction, pressure to perform activities, and incorrect identification of ampoules.[51,52] To prevent damage and ensure safety in the administration of medication, professionals must follow recommendations such as correct identification of drugs and maintaining full attention during preparations. Syringes must be identified immediately after the aspiration of a medication, and professionals must avoid any distraction during the preparation of the medication and perform a double-check with another professional during the administration.[53]

Adverse cardiac events, such as intraoperative hemorrhage, were associated with a failure to identify alterations immediately, delay in the definition of an intervention and treatment, and ineffective communication among professionals in an emergency.[54] Intraoperative arrhythmias are caused by the clinical conditions of the patient, the type of surgery, and anesthesia.[55]

Intraoperative awareness is an experience of memories of sensory perceptions during the surgery. Such occurrence leads to post-traumatic stress in most patients who have experienced

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**Table 7. Failures and Causes of Adverse Events in Anesthesia of the Selected Studies (N = 21)**

| Active Failure | Cause | N | % | Article |
|---|---|---|---|---|
| Error | Delay recognizing hemodynamic alterations/anesthetic complications | 7 | 33.3 | Moody[24]; Ruibal[27]; Cheney[28]; Davies[31]; Lee[39]; Roh[38]; Schulz[41]. |
| | Administration/maintenance inadequate of regional anesthesia | 1 | 4.7 | Cook[29]. |
| | Malpractice in cardiac arrest care | 1 | 4.7 | Davies[31]. |
| | Incorrect identification of medications | 1 | 4.7 | Domino[22]. |
| Slip/Lapse | Incorrect execution of regional/ophthalmic blockades | 8 | 38 | Lee[26]; Davies[31]; Cook[29]; Mihai[32]; Orebaugh[33]; Szypula[34]; Clarke[35]; Rathmell[36]. |
| | Medication changes during anesthetic induction | 6 | 28.5 | Domino[22]; Fasting[23]; Cook[29]; Mihai[32]; Cranshaw[30]; Erdmann[40]. |
| | Difficulty in the control/management of the airway | 4 | 19 | Moody[24]; Cook[29]; Davies[31]; Schulz[41]. |
| | Professional misuse of equipment | 2 | 9.5 | Caplan[21]; Domino[22]. |
| | Incorrect puncture of central venous cannulation | 1 | 4.7 | Cook[29]. |
| Violation | Absence of an oximeter/capnograph | 5 | 23.8 | Lee[26]; Mihai[32]; Roh[38]; Lee[39]; Schulz[41]. |
| | Inadequate preoperative assessment | 4 | 19 | Domino[22]; Moody[24]; Roh[38]; Schulz[41]. |
| | Failure to check equipment | 3 | 14.2 | Caplan[21]; El Dawlatly[25]; Ruibal[27]. |
| Latent failure | Communication failures | 7 | 33.3 | El Dawlatly[25]; Ruibal[27]; Davies[31]; Mihai[32]; Cook[29]; Hudson[37]; Erdmann[40]. |
| | Fatigue | 2 | 9.5 | Hudson[37]; Erdmann[40]. |
| | Pressure to perform | 1 | 4.7 | Erdmann[40]. |
| Other conditions | Patient clinical problems | 5 | 23.8 | Moody[24]; El Dawlatly[25]; Lee[26]; Davies[31]; Hudson[37]. |
| | Equipment failures | 3 | 14.2 | Caplan[21]; Ruibal[27]; Cheney[28]. |

the situation. Several aspects may contribute to intraoperative awareness, including inadequate concentration of intravenous and inhalational anesthetic agents after anesthetic induction; the interruption of drug infusion due to disconnection or obstruction[11]; and additional risk factors associated with the patient, such as obesity, female gender, cardiac and abdominal surgeries, emergency cesarean section, difficulty of intubation, and patients with a previous history of intraoperative awareness.[56]

Monitoring the depth of anesthesia or the minimal alveolar concentration of inhalational agents would allow for interventions that could contribute to reducing cases of intraoperative awareness, as well as the administration of adequate anesthetic drugs, thereby preventing damage to the patient.[57,58] Adverse events included pain during regional anesthesia in obstetric patients,[26] dorsal pain, pain during surgery,[31] and inadequate regional anesthesia,[26,31-34] all of which contributed to nerve damage.

Over the years, general anesthesia has been replaced by regional anesthesia in obstetric procedures, reducing the number of maternal deaths but increasing the number of claims due to pain and nerve injuries.[59] Studies have indicated that the lithotomy position and the duration of surgery are risk factors for pain after regional anesthesia.[60] Among obstetric patients, emphasis was found in cases of obesity, spinal anatomy alterations, and the use of the subarachnoid technique after failure of an epidural puncture.[61]

Pain and possible neurological lesions after regional anesthesia may be associated with a traumatic injury during the insertion of the puncture needle, the spinal puncture level, and the clinical

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history of the patient (progressive neurological diseases, anatomical variations, previous history of pain).[62]

### *Failures and Causes of Adverse Events*

The studies included in this review indicated that adverse events in anesthesia and patient injuries were related to failures in the actions of professionals, involving both active failures in the planning or execution and latent failures that included organizational structure. The literature has shown that failures in anesthesia are due to the lack of attention, inadequate care planning, limitations of the work environment, incorrect clinical judgment, delayed identification of changes, and decision-making. Physical and emotional factors, such as fatigue and stress, can also contribute to failures.[2]

Adverse events in anesthesia such as cardiac arrest were attributed to human failures as a result of errors in equipment checks, lack of vigilance, and negligence. Inadequate supervision of the anesthesia procedure, drug overdose, medication errors, airway obstruction, aspiration of gastric contents, insufficient monitoring, and lack of postoperative care have all contributed to cases of death associated with anesthesia.[11]

A study[63] carried out with anesthesia professionals indicated that human failures occurred in 82% of preventable adverse events due to professional inexperience, lack of familiarity with the equipment or material, ineffective communication with the team, urgency in the execution of tasks, lack of attention, and fatigue. The failures involved the disconnection of the anesthesia circuit or a failure of the oxygen/nitrous oxide supply as a result of the lack of attention of the anesthetic professional, medication error due to a needle exchange, ineffective airway control due to an early extubation, and hypovolemia due to a delayed identification of hemodynamic changes.[63]

An analysis of the human factors contributing to respiratory adverse events highlighted the failure to anticipate risks; incorrect decision-making in emergency situations; work environment factors, such as the shortage of professionals and pressure to perform activities; and personal factors that included fatigue and stress.[64]

Another study indicated failure in communication and the judgment of complex situations and insufficient training as causes of adverse events. Thus, to prevent events and complications, proper planning and good judgment in decision-making are important, as well as effective communication and good teamwork, appropriate knowledge of the application techniques and the use of devices, and the paramount capacity to interrupt ineffective techniques.[65] Moreover, professionals do not report adverse events that occur during procedures because they fear the legal and professional implications of such events. In addition, they do not have easy access to reporting systems due to the absence of anonymous reporting channels, the lack of feedback, and scarce follow-up on reported events.[66,67]

Therefore, the application of care guidelines and care protocols could minimize human failures and reduce deviation from recommended care standards.[8] However, this would require the engagement of professionals concerned with the care process to develop actions compatible with daily practice, appropriate information about the execution of the recommended activities, and continuous evaluation of the intercurrences to enforce any improvements.[68]

Absence of a professional follow-up, resistance to the application of guidelines and care protocols, failures in professional communication to exchange information about the patient, poor supervision of the provided care, and lack of teamwork at critical moments are all factors that contribute to the occurrence of adverse events and mortality.[8] Thus, it is essential for communication and teamwork among the different professionals in the surgical environment, including nurses, surgeons, and anesthesia professionals, to reduce any damage to the patient.[10]

The use of a checklist before any anesthetic induction could effectively improve the communication between the practitioners of nursing and anesthesia, providing them with better chances to predict critical moments and effectively work as an integrated team.[47,48] Accordingly, skills related to communication, teamwork, and action in times of crisis should be stimulated through proper education and training of professionals.[1]

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Organizational factors such as the pressure to perform activities and achieve higher productivity, as well as long or intense workloads can all contribute to the development of fatigue and stress among anesthesia professionals. One study indicated that 28.2% of professionals committed errors in anesthesia due to fatigue, with predictors being the time they had to rest between shifts, longer hours worked per shift, physical symptoms (headache, fatigue, irritability, sleep deprivation), and psychological symptoms (pressure to perform tasks, severity of the patients), all of which influenced the performance of those professionals, leading to a decrease in the quality of care.[69]

A study among residents of anesthesia indicated that 79% of the professionals felt that work pressure influenced their health and that such stress contributed to lower productivity.[70] Resident anesthesiologists subjected to a higher risk of burnout and depression have reported medication errors and less attention to patient care planning (monitoring and checking of anesthesia equipment, preoperative assessment, double-checking of medications) more often than others. This association was also observed between the higher risk of burnout and the greater number of hours worked and shifts per week.[71]

Proper communication and participation in processes of decision-making and management, support from the organizational leadership aiming at the development of work, interpersonal relationships among coworkers, interpersonal trust and group cohesion, and professional recognition are all critical dimensions of the organizational climate that can affect the mental health of these professionals.[72]

### *Study Limitation*

Most of the selected articles presented retrospective studies of adverse events in anesthesia reported in the database, which may limit the association of factors related to the injuries generated by the events. In addition, the studies did not analyze the total number of patients submitted to anesthetic interventions, a fact that restricts the estimate of damage and risks associated with the adverse event.

### *Implications for Clinical Practice and Research*

A reduction in active failures and latent failures could be accomplished through the engagement of professional societies in the development of guidelines and care protocols to guide and assist the process of decision-making of professionals in their daily practice, thereby fostering organizational initiatives to implement a safety culture and improve institutional processes. Transparency, communication, teamwork, professional development, patient engagement, and an organizational safety culture are key factors for patients' safety.[73]

Institutional leaders should promote an organizational culture in which mistakes can be identified and reduced before they cause damage to the patient, but also one that promotes the practice of learning from previous mistakes and modifies care processes to avoid any recurrence, thereby eliminating the culture of individual punishment. In addition, information-sharing initiatives among health institutions, professional societies, and safety organizations could foster a centralized and coordinated supervision of patient safety.[73]

Health professionals, including nurses, physicians, and assistants, need support from their work places to perform their duties better. Such support includes training and better work conditions.[73] Training sessions must provide these professionals with tools to improve the quality and safety of their actions and contribute to their professional satisfaction and engagement.[73] Work conditions could be improved by establishing respectful environments in their organizations, including the creation of fatigue management systems and better communication programs.[73]

## Conclusion

This integrative review of the literature showed that the main adverse events occurring during the perioperative period were respiratory events and medication errors associated with human errors, most of which generated permanent injuries such as brain injury and death.

Care planning developed by the professionals involved is critical to prevent and reduce risks to

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the patient. Such planning involves following guidelines and care protocols to orient and direct actions, enhanced teamwork for better communication, and support of the performance of tasks, along with institutional support to assist professionals in the proper development of their activities and achieve better performance in their daily practice.

In addition, professional societies and government health systems need to develop and expand their health-related adverse event–reporting systems further to integrate as many health institutions as possible. It is important to strengthen the health safety culture and encourage professionals to report events. In this way, national and international panoramas on the injuries caused by flaws in care assistance could be obtained and interventions could then be applied to the real need for improvements.

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