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Preventing Harm in Perioperative Care: Epidemiological Surveillance, Patient Safety Culture, and Healthcare Quality Improvement

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ABSTRACT

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Perioperative patient safety remains a major challenge for healthcare systems worldwide, as preventable adverse events continue to contribute to postoperative morbidity, avoidable mortality, prolonged hospitalization, and increased healthcare costs. This narrative review aimed to analyze the epidemiological burden, clinical determinants, and organizational factors associated with preventable perioperative adverse events, emphasizing the contribution of epidemiological surveillance, safety culture, and continuous process improvement. Twenty scientific publications were examined, integrating international evidence with investigations conducted in Latin America. A descriptive and comparative analytical approach was employed, using the Define, Measure, Analyze, Improve, and Control (DMAIC) framework to organize the evaluation of patient safety challenges and preventive strategies. The reviewed evidence identified surgical adverse events affecting approximately 14.4% of patients, with potentially preventable events affecting 5.2%. International studies demonstrated reductions in postoperative complications and in-hospital mortality following the implementation of standardized surgical safety checklists and comprehensive perioperative safety systems. Latin American investigations documented a substantial burden of healthcare-associated adverse events, with nearly 60% of identified events considered potentially preventable in the Iberoamerican Study of Adverse Events. Additionally, institutional quality improvement initiatives demonstrated marked increases in anesthesia-related incident reporting, highlighting the importance of distinguishing improved surveillance capacity from changes in actual patient harm. The findings indicate that sustainable perioperative safety depends on coordinated clinical protocols, reliable epidemiological monitoring, multidisciplinary communication, institutional leadership, and continuous organizational learning. Strengthening these interconnected components may contribute to reducing avoidable harm and improving surgical care quality, particularly in healthcare environments characterized by heterogeneous resources and institutional capacities.

KEYWORDS

perioperative patient safety, preventable adverse events, anesthesiology, epidemiological surveillance, surgical complications, safety culture, healthcare administration, quality improvement, incident reporting, Latin America

INTRODUCTION

Patient safety remains a fundamental challenge in contemporary surgical care, particularly during the perioperative period, when patients are exposed to complex interventions requiring precise clinical judgment, continuous physiological monitoring, and effective coordination among multidisciplinary teams. Despite substantial advances in anesthetic techniques, surgical technology, and standardized clinical protocols, preventable adverse events continue to contribute to postoperative morbidity, prolonged hospitalization, increased healthcare expenditures, and avoidable mortality. These events frequently arise from interactions between clinical vulnerabilities and systemic deficiencies, including communication failures, inadequate supervision, inconsistent adherence to safety protocols, and weaknesses in institutional risk management. Consequently, perioperative safety has progressively evolved from an individual professional responsibility into a central component of healthcare quality and organizational performance [3]–[5].

The epidemiological burden of surgical adverse events demonstrates the importance of developing preventive strategies that extend beyond technical competence. Anderson et al. [3], in a systematic review of surgical adverse events, identified substantial rates of healthcare-associated harm and highlighted the proportion of incidents considered potentially preventable. Their findings emphasized the contribution of failures occurring throughout the surgical care pathway, including preoperative preparation, intraoperative management, and postoperative surveillance. Similarly, international investigations have demonstrated that structured safety interventions can improve clinical outcomes when effectively incorporated into routine practice. Haynes et al. [1] reported reductions in major complications and mortality following the introduction of the World Health Organization Surgical Safety Checklist, while de Vries et al. [2] demonstrated favorable outcomes associated with a comprehensive surgical safety system covering multiple stages of perioperative care.

Within anesthesiology, preventing adverse events requires particular attention to medication safety, airway management, hemodynamic stability, physiological monitoring, and the early recognition of clinical deterioration.

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International standards developed by the World Health Organization and the World Federation of Societies of Anaesthesiologists emphasize the importance of trained personnel, appropriate monitoring equipment, standardized procedures, and reliable institutional support [4]. Nevertheless, the effectiveness of these recommendations depends on their implementation within healthcare systems characterized by different levels of infrastructure, staffing, financial resources, and administrative capacity. Warner et al. [5] further emphasized the necessity of strengthening global perioperative safety through coordinated professional, educational, and organizational initiatives, reinforcing the importance of evaluating patient safety as an integrated healthcare system function rather than an isolated clinical outcome.

Epidemiological surveillance constitutes an essential mechanism for identifying adverse event patterns, evaluating preventability, and recognizing institutional vulnerabilities. Systematic incident reporting, standardized classification systems, clinical audits, and continuous monitoring of perioperative outcomes can provide valuable information for targeted preventive interventions. The international validation of the ClassIntra classification system demonstrated the feasibility of standardizing the assessment of intraoperative adverse events, potentially improving comparisons between institutions and supporting quality improvement initiatives [6]. However, surveillance effectiveness may be compromised by inconsistent definitions, incomplete documentation, underreporting, and organizational environments in which healthcare professionals perceive incident disclosure as punitive. These limitations reinforce the need to integrate epidemiological monitoring with institutional policies that encourage transparent reporting and systematic learning [7], [11].

Safety culture represents another critical determinant of perioperative outcomes. Beyond the implementation of checklists and technical protocols, effective prevention requires shared organizational values supporting teamwork, open communication, professional accountability, and continuous improvement. Systematic reviews have identified relationships between structured interventions, improved operating room communication, and favorable changes in teamwork and safety-related behaviors [8], [9]. Nevertheless, the presence of written institutional policies does not necessarily guarantee their consistent application. Sustainable improvements require leadership involvement, adequate allocation of resources, multidisciplinary participation, and mechanisms for translating reported incidents into measurable changes in clinical practice [10], [20].

These challenges acquire particular relevance in Latin America, where healthcare systems frequently operate under heterogeneous conditions regarding infrastructure, workforce availability, institutional financing, and quality assurance mechanisms. The Iberoamerican Study of Adverse Events, conducted across hospitals in Argentina, Colombia, Costa Rica, Mexico, and Peru, documented the importance of healthcare-associated harm within the regional hospital environment [12]. Additional investigations examining patient safety culture in Latin American institutions have identified opportunities to strengthen organizational communication, incident reporting, and management commitment to safety [13]. Brazilian studies have also contributed evidence regarding preventable surgical adverse events, perioperative mortality, and operating room safety practices [14]–[18]. Together, these findings support the need for context-sensitive improvement strategies that recognize differences in healthcare resources while maintaining internationally accepted patient safety standards.

Despite advances in the identification and prevention of perioperative complications, important questions remain regarding how epidemiological surveillance, organizational safety culture, and process improvement strategies can be integrated to reduce avoidable harm. Accordingly, this narrative review aims to examine the principal determinants of preventable perioperative adverse events, evaluate the contribution of surveillance and incident reporting systems, and analyze organizational interventions designed to strengthen patient safety. By integrating international evidence with research conducted in Latin America, the review seeks to identify practical opportunities for improving perioperative care through multidisciplinary collaboration, standardized clinical processes, and continuous institutional evaluation.

DEVELOPMENT

Epidemiological Burden and Preventability of Perioperative Adverse Events

Perioperative adverse events constitute a significant public health concern because of their implications for patient outcomes, hospital efficiency, and healthcare expenditure. Their occurrence reflects the interaction between patient-

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related risk factors, procedural complexity, clinical decision-making, and organizational conditions. A systematic review by Anderson et al. [3], encompassing 16,424 surgical patients, reported adverse events in 14.4% of patients and potentially preventable events in 5.2%. These findings demonstrate that a substantial proportion of surgical harm may be associated with modifiable aspects of healthcare delivery rather than unavoidable procedural complications.

The identification of preventable events requires standardized definitions and reliable epidemiological indicators. Complications associated with medication administration, inadequate monitoring, failures in perioperative communication, and delayed recognition of physiological deterioration should be evaluated according to their clinical consequences and potential preventability. The ClassIntra classification system provides a standardized approach to grading intraoperative adverse events, facilitating institutional comparisons and supporting the identification of patterns that may otherwise remain undetected [6]. Nevertheless, variations in hospital resources, surgical complexity, and documentation practices must be considered when interpreting epidemiological findings.

Clinical Risk Factors and Prevention Strategies

The prevention of perioperative adverse events depends on early risk identification, appropriate clinical preparation, and the consistent application of evidence-based interventions. In anesthesiology, particular attention must be directed toward airway management, cardiovascular instability, medication-related incidents, inadequate ventilation, and postoperative complications. International standards emphasize continuous physiological monitoring, qualified personnel, availability of essential medications and equipment, and effective communication throughout the anesthetic process [4], [5].

Standardized surgical safety protocols represent an important strategy for reducing preventable harm. Haynes et al. [1] demonstrated that implementing a surgical safety checklist was associated with reductions in major postoperative complications from 11.0% to 7.0% and mortality from 1.5% to 0.8%. Similarly, de Vries et al. [2] documented improvements in patient outcomes following the introduction of a comprehensive surgical safety system. These findings suggest that preventive interventions are most effective when integrated throughout the perioperative pathway rather than restricted to isolated procedural checkpoints.

However, checklist effectiveness depends on meaningful multidisciplinary participation, adequate training, and institutional adherence. Completing a verification form without effective communication or confirmation of critical safety requirements may limit its preventive value. Therefore, healthcare institutions must evaluate not only protocol compliance but also the quality of implementation and its relationship with measurable clinical outcomes [8], [10].

Epidemiological Surveillance and Incident Reporting

Epidemiological surveillance provides the foundation for identifying recurring adverse events, evaluating institutional vulnerabilities, and establishing preventive priorities. Effective surveillance systems combine clinical record review, voluntary incident reporting, standardized adverse event classification, and longitudinal monitoring of perioperative outcomes. These mechanisms facilitate the distinction between isolated complications and recurrent process failures requiring organizational intervention [6], [7].

Nevertheless, underreporting remains an important limitation. Healthcare professionals may hesitate to disclose incidents because of fear of disciplinary consequences, uncertainty regarding reporting procedures, or insufficient institutional feedback. Lozito et al. [11] demonstrated that implementing an educational initiative supported by electronic reporting and structured feedback improved several dimensions of perioperative safety culture. These findings emphasize the importance of reporting systems that encourage participation and convert clinical incidents into opportunities for organizational learning.

From an administrative perspective, surveillance information should support indicators such as adverse event frequency, preventability, severity, perioperative mortality, protocol adherence, and incident reporting trends. Importantly, an increase in reported incidents does not necessarily indicate deteriorating clinical performance; it may instead reflect improvements in organizational transparency and reporting practices. Consequently, indicators should be interpreted collectively and adjusted, where appropriate, for differences in patient characteristics and procedural complexity [11], [20].

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Organizational Safety Culture and Healthcare Management

Safety culture encompasses the shared attitudes, professional behaviors, institutional values, and organizational practices that influence the prevention and management of healthcare-associated harm. In perioperative settings, effective safety culture requires interdisciplinary collaboration, open communication, leadership commitment, and clearly defined responsibilities across professional groups.

Evidence suggests that interventions designed to strengthen teamwork and communication can improve safety-related practices within the operating room. Russ et al. [8] highlighted the contribution of surgical checklists to communication and teamwork, while Sacks et al. [9] identified organizational interventions aimed at improving surgical safety culture. These findings demonstrate that technical protocols should be accompanied by strategies addressing interpersonal relationships, hierarchical barriers, and communication failures.

Healthcare administrators play a fundamental role by ensuring adequate staffing, maintaining essential equipment, promoting continuing education, and implementing mechanisms for evaluating clinical performance. A nonpunitive reporting environment should distinguish human error from reckless conduct while promoting professional accountability and institutional learning. Likewise, structured feedback and regular multidisciplinary evaluations can contribute to identifying system weaknesses before they result in severe patient harm [9], [11], [20].

Process Improvement and the Latin American Context

Continuous process improvement seeks to identify operational deficiencies, reduce unnecessary variability, and strengthen the reliability of perioperative care. Relevant interventions include standardized preoperative assessments, surgical safety checklists, structured handoff protocols, medication verification procedures, incident analysis, and periodic clinical audits. Their effectiveness depends on the capacity of healthcare institutions to evaluate implementation, identify barriers, and introduce corrective measures supported by objective indicators [2], [7], [10].

In Latin America, the implementation of these strategies must consider substantial differences in healthcare infrastructure, financial resources, workforce distribution, and institutional management. The Iberoamerican Study of Adverse Events (IBEAS), involving 11,379 hospitalized patients across five Latin American countries, reported an overall adverse event point prevalence of 10.5%, with almost 60% of events considered preventable [12]. Although these findings represent hospital-wide adverse events rather than exclusively perioperative incidents, they demonstrate the regional relevance of preventable healthcare-associated harm.

Additional investigations conducted in Brazil have identified opportunities to improve operating room safety culture, strengthen adherence to preventive practices, and reduce avoidable surgical complications [14]–[18]. Similarly, research involving Latin American healthcare institutions has emphasized persistent challenges associated with communication, institutional leadership, and adverse event reporting [13], [19]. These observations suggest that adapting international safety recommendations to regional circumstances requires not only technical interventions but also sustainable administrative and organizational strategies.

Overall, improving perioperative safety requires a coordinated approach integrating clinical prevention, epidemiological surveillance, organizational accountability, and continuous process evaluation. The available evidence indicates that preventing adverse events should not depend exclusively on individual professional performance but rather on the development of reliable healthcare systems capable of identifying risks, learning from incidents, and maintaining consistent standards of patient-centered care [5], [9], [20].

GENERAL OBJECTIVE AND SPECIFIC OBJECTIVES

General Objective

To critically analyze the epidemiological, clinical, and organizational determinants of preventable perioperative adverse events through an integrative examination of international and Latin American scientific evidence, emphasizing the role of epidemiological surveillance, institutional safety culture, and continuous process improvement in strengthening patient safety. This analysis seeks to identify evidence-based preventive strategies, establish practical

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recommendations for perioperative risk management, and promote multidisciplinary approaches that support safer, more efficient, and higher-quality surgical care [3]–[5], [12].

Specific Objectives

The specific objectives are organized according to the cognitive, psychomotor, and affective domains of learning, incorporating principles of Bloom's taxonomy to connect scientific knowledge with practical competencies and professional attitudes relevant to perioperative patient safety.

Cognitive Domain

- **Analyze** the principal epidemiological characteristics, clinical determinants, and organizational factors associated with preventable perioperative adverse events, distinguishing between unavoidable complications, preventable harm, and near-miss incidents [3], [6].
- **Evaluate** the effectiveness of epidemiological surveillance systems, surgical safety checklists, and institutional risk management strategies in identifying vulnerabilities and reducing adverse outcomes, considering evidence from international and Latin American healthcare settings [1], [2], [12].
- **Synthesize** scientific findings concerning communication failures, organizational safety culture, and healthcare administration to identify opportunities for strengthening multidisciplinary collaboration and institutional quality improvement [8], [9], [13].

Psychomotor Domain

- **Develop** a practical framework for the standardized identification, classification, and documentation of perioperative adverse events, incorporating internationally recognized clinical indicators and incident reporting principles [6], [7].
- **Design** structured approaches for implementing perioperative safety protocols, including verification procedures, standardized clinical handoffs, medication safety practices, and monitoring strategies adapted to different healthcare environments [4], [5].
- **Apply**, within proposed educational or quality improvement scenarios, systematic procedures for identifying process failures, organizing incident information, and developing corrective action plans based on measurable institutional indicators [11], [20].

Affective Domain

- **Promote** professional awareness of the ethical, clinical, and organizational importance of preventing avoidable perioperative harm, reinforcing patient-centered care and shared responsibility among healthcare professionals.
- **Value** transparent communication, interdisciplinary cooperation, and nonpunitive incident reporting as essential components of a sustainable institutional safety culture [9], [11].
- **Encourage** a proactive commitment to continuous learning, professional accountability, and evidence-based decision-making, recognizing the importance of institutional leadership and organizational participation in improving perioperative outcomes [5], [13], [20].

OBJECT OF STUDY

The object of study of this review is the occurrence, prevention, surveillance, and organizational management of adverse events associated with perioperative healthcare, emphasizing the relationship between clinical risk factors, institutional safety culture, and healthcare process reliability. The phenomenon under investigation encompasses preventable incidents arising during preoperative assessment, anesthetic management, surgical intervention, postoperative recovery, and transitions between different levels of care. Particular attention is directed toward adverse

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events associated with medication administration, inadequate physiological monitoring, communication failures, incomplete safety verification, and deficiencies in institutional risk management [3]–[5].

The population of interest comprises patients undergoing surgical procedures under different anesthetic modalities, including individuals exposed to elective and emergency interventions across healthcare institutions with varying levels of clinical complexity. The analysis also considers the participation of anesthesiologists, surgeons, nursing personnel, and healthcare administrators, whose coordinated actions influence the identification, prevention, and management of perioperative risks. Rather than directly examining individual patients, this review evaluates published scientific evidence concerning perioperative outcomes, professional safety practices, and institutional interventions implemented in diverse healthcare settings [6], [8], [9].

The institutional dimension of the object of study includes hospital surveillance systems, adverse event reporting mechanisms, standardized safety protocols, organizational communication practices, and continuous quality improvement strategies. These components are examined as interconnected elements of healthcare delivery, recognizing that preventable harm may emerge from failures involving multiple stages of the perioperative pathway. Relevant indicators include adverse event frequency, severity, estimated preventability, perioperative mortality, adherence to safety protocols, and incident reporting practices. Their interpretation requires consideration of differences in patient characteristics, procedural complexity, and institutional resources [2], [7], [11].

Geographically, the review adopts an international perspective while incorporating evidence from Latin American healthcare systems, where disparities in infrastructure, personnel availability, institutional financing, and surveillance capacity may influence patient safety outcomes. Investigations conducted across Argentina, Brazil, Colombia, Costa Rica, Mexico, and Peru provide relevant regional evidence for examining the applicability of international safety recommendations and identifying opportunities for context-specific process improvement [12]–[18].

Accordingly, the central unit of analysis consists of published research examining the relationships among preventable perioperative harm, epidemiological surveillance, organizational safety culture, and healthcare management interventions. Through this approach, the review seeks to establish a conceptual and evidence-based foundation for understanding how coordinated clinical and administrative strategies may strengthen institutional reliability, support early risk identification, and contribute to the prevention of avoidable adverse outcomes in surgical care [5], [13], [20].

METHODOLOGY

Study Design and Methodological Approach

This study was designed as a structured narrative literature review with a descriptive, analytical, and comparative approach, aimed at examining the relationship between preventable perioperative adverse events, epidemiological surveillance, organizational safety culture, and healthcare process improvement. The methodological framework integrates scientific evidence from anesthesiology, epidemiology, and health services administration to identify clinical and organizational factors influencing surgical patient safety.

A process-based analytical methodology was selected, incorporating the **Define, Measure, Analyze, Improve, and Control (DMAIC)** model as a conceptual framework for examining preventable adverse events and evaluating potential institutional improvement strategies. Originally developed within quality management systems, DMAIC provides a structured approach to identifying operational problems, establishing performance indicators, investigating underlying causes, proposing corrective interventions, and assessing their sustainability. In this review, the framework is applied to the interpretation and organization of published evidence rather than to a prospective intervention involving patients or healthcare institutions [2], [9], [20].

Literature Search and Selection Criteria

The evidence base comprises 20 scientific publications issued between 2009 and 2024, including systematic reviews, observational investigations, multicenter studies, quality improvement research, and international recommendations concerning perioperative patient safety. The selected literature includes studies indexed in PubMed/MEDLINE and publications from recognized peer-reviewed medical journals.

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A reproducible search strategy for identifying and updating relevant publications is based on combinations of terms including *perioperative safety*, *preventable adverse events*, *anesthesia patient safety*, *surgical complications*, *epidemiological surveillance*, *incident reporting*, *safety culture*, *surgical safety checklist*, *quality improvement*, and *Latin America*. Boolean operators AND and OR allow the combination of clinical, epidemiological, and organizational concepts.

Eligible publications are those addressing perioperative adverse events, their preventability, safety surveillance mechanisms, institutional risk factors, or interventions designed to improve surgical care. Studies involving broader hospital patient safety indicators are considered when their findings provide relevant epidemiological or organizational context. Publications without sufficient relevance to these domains, as well as sources lacking identifiable scientific or institutional provenance, are excluded from the analytical framework.

Special consideration is given to Latin American investigations to explore regional differences in institutional resources, incident reporting practices, and safety culture. International standards and multicenter studies serve as comparative references for interpreting regional findings [4], [12]–[18].

Evidence Organization and Analytical Procedure

The selected publications are organized into five analytical categories: epidemiological burden and preventability of adverse events, perioperative clinical risk factors, surveillance and incident reporting, organizational safety culture, and healthcare process improvement.

For each source, the analytical framework considers the study design, population or institutional setting, principal safety indicators, reported findings, and relevance to the objectives of the review. Differences in definitions, surveillance methods, healthcare environments, and outcome measurements are considered to avoid inappropriate comparisons between heterogeneous investigations.

The evidence is synthesized qualitatively through the identification of recurring findings, complementary observations, and discrepancies among studies. Particular attention is given to distinguishing associations from demonstrated causal effects and to recognizing the limitations of transferring findings between healthcare systems with different organizational characteristics. No pooled statistical estimates or new patient-level outcomes are generated because the purpose is interpretative synthesis rather than quantitative meta-analysis [3], [6], [13].

Application of the DMAIC Framework

The DMAIC methodology provides the organizational structure for translating the reviewed scientific evidence into potential quality improvement strategies.

The **Define** component identifies preventable perioperative harm as the central problem and establishes the principal clinical and institutional processes involved. The **Measure** component examines indicators such as adverse event frequency, severity, preventability, reporting practices, and adherence to safety protocols. The **Analyze** component explores potential contributing factors, including communication deficiencies, failures in clinical verification, limitations in surveillance, and organizational weaknesses.

The **Improve** component evaluates evidence-based interventions, including standardized checklists, structured handoffs, incident reporting systems, multidisciplinary training, and institutional safety initiatives. Finally, the **Control** component considers mechanisms for maintaining improvements through continuous monitoring, clinical audits, performance indicators, and organizational feedback [1], [2], [8], [11], [20].

These components are used as an analytical framework; they do not imply that the proposed interventions were implemented or experimentally evaluated within this review.

Methodological Scope and Limitations

The narrative design allows integration of heterogeneous scientific evidence and facilitates examination of complex relationships between clinical practice, epidemiological surveillance, and institutional management. However, the

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restricted selection of 20 publications, differences in research designs, and variability in definitions of adverse events limit the generalizability of the findings.

The review does not involve direct patient recruitment, access to confidential clinical records, experimental interventions, or independent collection of patient-level data. Its conclusions are therefore derived exclusively from the interpretation of previously published scientific evidence.

The selected methodological approach provides a structured foundation for examining perioperative safety and formulating recommendations that may inform future institutional research, surveillance initiatives, and quality improvement programs.

PHASES OF DEVELOPMENT

The development of this review was organized according to the Define, Measure, Analyze, Improve, and Control (DMAIC) methodology, adapted to the examination of scientific evidence concerning perioperative patient safety. This framework provides a structured approach to understanding preventable adverse events, identifying clinical and organizational vulnerabilities, and evaluating strategies for improving healthcare processes. Each phase addresses a specific dimension of perioperative safety, integrating international research with evidence from Latin American healthcare institutions. Because this study is a narrative review, the phases represent analytical procedures and proposed applications rather than interventions performed in an actual hospital environment.

Define Phase: Identification and Delimitation of the Problem

The initial phase focuses on defining preventable perioperative adverse events as a multidimensional healthcare problem involving clinical practice, institutional organization, and patient safety management. The principal issue concerns the persistence of potentially avoidable harm despite advances in anesthesiology, surgical techniques, physiological monitoring, and standardized clinical protocols.

The problem is delimited to adverse events occurring throughout the perioperative pathway, including preoperative assessment, anesthetic induction, intraoperative management, postoperative recovery, and transitions between healthcare teams. Particular consideration is given to medication errors, failures in patient identification, inadequate communication, monitoring deficiencies, and incomplete implementation of safety procedures [3], [4], [7].

From an organizational perspective, the analysis recognizes that adverse events frequently emerge from interactions between human factors and institutional weaknesses. Consequently, the central question guiding this phase is how healthcare institutions can identify and address preventable perioperative risks through coordinated clinical, epidemiological, and administrative strategies.

The scope also incorporates regional considerations, recognizing that differences in resources, healthcare infrastructure, and institutional safety practices may influence the implementation of preventive interventions, particularly within Latin American healthcare systems [12], [13].

Measure Phase: Identification of Epidemiological and Safety Indicators

The second phase addresses the measurement of perioperative safety through epidemiological indicators and standardized assessment instruments. Accurate measurement is essential for distinguishing isolated clinical complications from recurrent patterns of preventable harm and determining the effectiveness of institutional safety strategies.

The analytical framework identifies several relevant indicators, including adverse event frequency, estimated preventability, event severity, perioperative mortality, incident reporting frequency, adherence to surgical safety protocols, and postoperative complications. These indicators provide complementary perspectives on clinical performance and organizational reliability.

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The ClassIntra classification system offers a standardized instrument for evaluating the severity of intraoperative adverse events, supporting comparisons across clinical environments and contributing to the systematic characterization of perioperative harm [6]. Likewise, investigations involving surgical checklists demonstrate the importance of monitoring clinical outcomes alongside protocol implementation [1], [2].

In the Latin American context, the Iberoamerican Study of Adverse Events provides relevant epidemiological evidence regarding healthcare-associated harm and preventability across several countries [12]. However, hospital-wide estimates should not be interpreted as direct measurements of perioperative risk.

For future institutional applications, meaningful comparisons would require standardized event definitions, clearly established observation periods, consistent denominators, and consideration of differences in patient complexity. Within the present review, measurement is limited to examining indicators reported in published investigations, without generating independent clinical datasets.

Analyze Phase: Evaluation of Contributing Factors and System Vulnerabilities

The third phase examines the clinical and organizational mechanisms associated with preventable perioperative adverse events. This analysis integrates evidence concerning human factors, communication barriers, medication safety, clinical monitoring, organizational leadership, and institutional reporting practices.

Communication failures represent an important area of concern, particularly during operating room preparation, transitions between professional teams, and postoperative handoffs. Inadequate transmission of clinical information may contribute to delays in treatment, omissions in preventive measures, and inappropriate management decisions. Research evaluating teamwork and safety culture has identified opportunities to improve multidisciplinary coordination through structured communication and organizational interventions [8], [9].

Institutional vulnerabilities may also include insufficient staffing, limited access to essential equipment, inconsistent application of safety protocols, inadequate professional training, and weaknesses in incident reporting systems. These conditions can influence the reliability of perioperative processes and the capacity of healthcare teams to anticipate clinical deterioration [4], [5].

From an epidemiological perspective, the analysis considers how incomplete reporting and differences in adverse event definitions may compromise institutional surveillance. Organizational environments characterized by punitive responses to human error can further discourage incident disclosure and reduce opportunities for identifying recurrent process failures [11], [20].

Latin American evidence is incorporated to examine how structural inequalities and institutional characteristics may influence safety practices. Regional studies highlight the importance of strengthening organizational communication, reporting mechanisms, and preventive strategies while recognizing substantial differences among healthcare systems [13]–[19].

Improve Phase: Development of Evidence-Based Preventive Strategies

The fourth phase focuses on identifying interventions capable of reducing preventable perioperative harm and improving institutional performance. Preventive strategies are examined according to their clinical relevance, feasibility, organizational requirements, and potential contribution to patient safety.

One of the principal interventions involves the consistent implementation of standardized surgical safety checklists. International research has demonstrated favorable associations between comprehensive safety interventions and reductions in postoperative complications and mortality [1], [2]. Nevertheless, effective implementation requires meaningful participation by the surgical team, appropriate training, and verification of critical clinical information.

Additional improvement strategies include structured perioperative handoffs, standardized medication verification, systematic assessment of anesthetic risk, continuous physiological monitoring, and multidisciplinary simulation-based education. Institutional initiatives should also encourage transparent incident reporting and provide mechanisms for communicating the findings of safety evaluations to healthcare professionals [4], [8], [11].

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From an administrative perspective, improvement strategies should prioritize interventions according to the severity and frequency of identified risks, available resources, and institutional implementation capacity. The participation of clinical leadership, quality improvement committees, and healthcare administrators is essential for translating recommendations into sustainable operational practices [9], [20].

For resource-constrained institutions, particularly in heterogeneous Latin American healthcare environments, adaptable and context-sensitive interventions may offer a practical foundation for strengthening safety without assuming that all hospitals possess equivalent technological or financial capabilities [5], [13].

Control Phase: Continuous Monitoring and Sustainability of Safety Improvements

The final phase addresses the mechanisms required to maintain institutional safety improvements and prevent the recurrence of previously identified process failures. Sustainable patient safety depends on continuous monitoring, periodic evaluation, organizational feedback, and the integration of preventive measures into routine healthcare practice.

The proposed control framework includes regular clinical audits, evaluation of checklist adherence, review of reported incidents, monitoring of perioperative complications, and assessment of corrective actions. These activities should be supported by clearly defined institutional responsibilities and standardized indicators that allow meaningful comparisons over time.

An essential component involves establishing feedback mechanisms through which surveillance findings inform professional training, protocol revision, and administrative decisions. Evidence concerning perioperative safety culture supports the importance of institutional learning and structured reporting initiatives in strengthening the identification and management of clinical risks [11], [20].

Sustainability also requires evaluating whether preventive interventions remain effective under changing organizational conditions, including workforce turnover, increasing surgical demand, and variations in patient complexity. Accordingly, the control phase should emphasize continuous adaptation rather than assuming that the initial implementation of a safety protocol guarantees permanent improvement.

Integration of the Development Phases

The five DMAIC phases provide a complementary framework for examining perioperative safety through clinical, epidemiological, and organizational perspectives. Defining the problem establishes the scope of preventable harm; measuring relevant indicators supports systematic evaluation; analyzing contributing factors identifies potential institutional vulnerabilities; improving processes provides a foundation for targeted preventive strategies; and controlling performance emphasizes the importance of maintaining organizational improvements.

Their integration highlights the need to move beyond isolated preventive measures toward coordinated systems of risk identification, multidisciplinary collaboration, and continuous quality improvement. Although the present review does not experimentally evaluate DMAIC implementation, the framework offers a structured basis for developing future institutional interventions and research initiatives aimed at reducing preventable perioperative adverse events [2], [5], [9], [20].

RESULTS AND DISCUSSION

Figure 1.
Frequency and Preventability of Surgical Adverse Events

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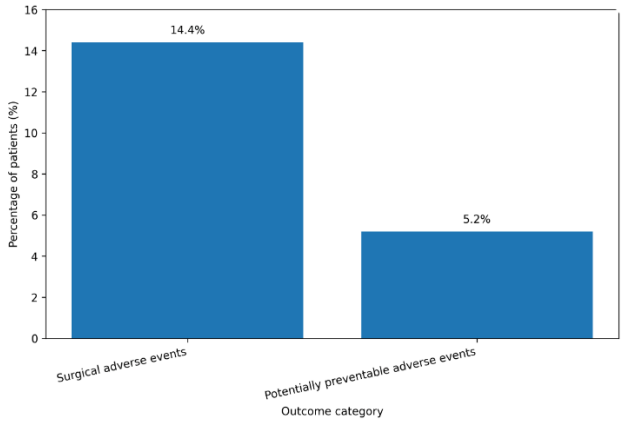

Figure 1 shows that surgical adverse events affected **14.4%** of patients, whereas **5.2%** of patients experienced events classified as potentially preventable [3]. This distribution indicates that adverse events in surgical care represent a clinically relevant burden and that a meaningful proportion of this burden may be attributable to modifiable failures in healthcare delivery rather than to unavoidable complications alone.

The difference between the two bars is important because it demonstrates that not all adverse events are considered preventable, but a substantial fraction may still be reduced through better perioperative management, improved communication, more reliable surveillance systems, and stronger adherence to safety protocols [3]. From a descriptive perspective, the figure highlights that potentially preventable events account for more than one-third of the total adverse event frequency reported in the review, emphasizing the operational significance of targeted prevention strategies.

These data also support the view that perioperative harm should not be interpreted exclusively as a consequence of surgical complexity or patient-related risk. Instead, the reported frequencies suggest that part of the observed harm may be linked to process failures occurring across the surgical pathway, including preoperative preparation, intraoperative decision-making, postoperative monitoring, and institutional organization of care [3]. Accordingly, the figure visually reinforces the relevance of epidemiological surveillance and structured patient safety interventions in identifying and reducing avoidable harm.

In addition, Figure 1 provides a useful quantitative baseline for the rest of the results section, since it illustrates the general magnitude of the problem before examining more specific interventions such as surgical safety checklists, comprehensive safety systems, and incident reporting initiatives [1]–[3]. For this reason, the figure functions as an epidemiological point of departure, summarizing both the overall burden of adverse events and the subset of events that may be amenable to prevention through clinical and organizational improvement [3].

Figure 2.
Changes in Surgical Complications and Mortality Following Checklist Implementation

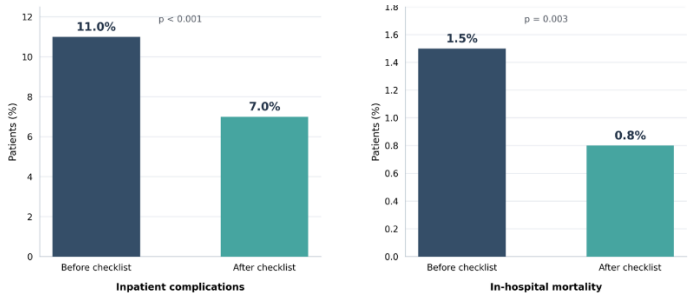

Figure 2 illustrates the changes in postoperative complication rates and in-hospital mortality following the implementation of the World Health Organization Surgical Safety Checklist, as documented by Haynes et al. [1]. The multicenter investigation included 7,688 patients undergoing noncardiac surgical procedures across eight hospitals representing different geographic regions and healthcare environments. Of these, 3,733 patients were evaluated before checklist implementation, while 3,955 patients were assessed during the subsequent intervention period. The graphical representation distinguishes postoperative complications from mortality, allowing both outcomes to be examined independently according to their respective frequencies and statistical significance.

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The first panel demonstrates a reduction in the proportion of patients experiencing major inpatient complications, from 11.0% before checklist implementation to 7.0% afterward. This corresponds to an absolute reduction of 4.0 percentage points and an approximate relative reduction of 36.4% compared with baseline measurements. The difference was statistically significant ($p < 0.001$), demonstrating a measurable change in postoperative morbidity between the two observation periods. These findings are consistent with previous investigations emphasizing the importance of standardized perioperative verification procedures and coordinated clinical practices in surgical patient safety [1], [2].

The second panel presents the corresponding changes in in-hospital mortality. Before implementation, mortality was recorded in 1.5% of patients, compared with 0.8% following the introduction of the checklist. This represents an absolute reduction of 0.7 percentage points and an approximate relative reduction of 46.7%. The reported difference was statistically significant ($p = 0.003$), indicating that the observed decline in mortality was unlikely to be explained by random sampling variability alone under the statistical assumptions of the original investigation. Although the absolute reduction was smaller than that observed for postoperative complications, the relative change was substantial because of the lower baseline mortality frequency [1].

The graphical distribution demonstrates a consistent downward pattern across both evaluated outcomes. However, the differences in baseline frequency require consideration when interpreting the magnitude of these changes. Postoperative complications occurred considerably more frequently than deaths, resulting in a larger absolute reduction, whereas mortality exhibited a greater proportional decrease. Presenting these indicators in separate panels allows their respective changes to be visualized without obscuring differences in measurement scales.

An important characteristic of the investigation was its inclusion of hospitals from diverse healthcare environments, encompassing institutions with different levels of resources and organizational structures. This multicenter composition provided an opportunity to examine the implementation of standardized safety procedures across heterogeneous surgical settings. Nevertheless, the reported values represent aggregated findings and should not be interpreted as identical improvements in every participating institution. Differences in patient characteristics, surgical complexity, institutional resources, and implementation practices may have influenced the observed outcomes [1], [4].

The intervention incorporated structured verification procedures addressing essential aspects of perioperative care, including patient identification, anticipated clinical risks, communication among surgical team members, and confirmation of critical safety requirements. These components correspond to broader recommendations emphasizing the importance of multidisciplinary coordination, standardized clinical processes, and effective communication in preventing avoidable surgical harm [4], [8], [9].

The findings also provide a quantitative reference for comparison with investigations examining more comprehensive perioperative safety interventions. De Vries et al. [2] subsequently documented reductions in complications and mortality following the implementation of the Surgical Patient Safety System, which incorporated verification procedures across multiple stages of surgical care. Although the studies differed in design, institutional characteristics, and intervention scope, both reported favorable changes in clinical outcomes following the introduction of structured safety systems [1], [2].

However, the before-and-after design employed by Haynes et al. [1] does not independently establish that every observed improvement resulted exclusively from checklist implementation. Changes in institutional practices, professional awareness, patient characteristics, or other concurrent factors may have contributed to the differences between observation periods. Accordingly, the results demonstrate a statistically significant association between checklist implementation and improved clinical outcomes rather than definitive proof of an isolated causal effect.

Figure 3.
Clinical Outcomes Before and After Comprehensive Surgical Safety Interventions

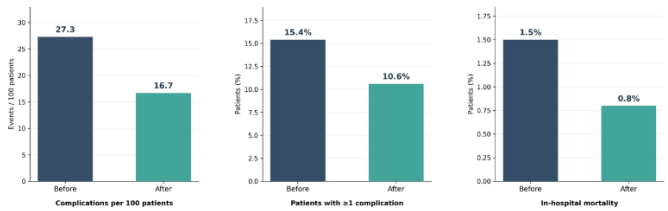

Figure 3 presents the changes in postoperative complications and in-hospital mortality associated with the implementation of the Surgical Patient Safety System (SURPASS), as reported by de Vries et al. [2]. The investigation evaluated 7,580 surgical patients across six intervention hospitals, including 3,760 patients during the baseline period and 3,820 patients following the introduction of the comprehensive surgical safety system. The graphical representation compares three clinical indicators: the number of complications per 100 patients, the percentage of

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patients experiencing at least one complication, and the in-hospital mortality rate. These measurements provide complementary perspectives on the frequency, distribution, and severity of adverse clinical outcomes.

The first indicator demonstrates a reduction in the overall frequency of postoperative complications, from 27.3 to 16.7 complications per 100 patients following SURPASS implementation. This represents an absolute decrease of 10.6 complications per 100 patients and an approximate relative reduction of 38.8%. The distinction between complications per 100 patients and the percentage of affected patients is particularly important because individual patients may experience multiple postoperative complications during the same hospitalization. Consequently, this indicator reflects the total burden of recorded complications rather than exclusively the proportion of patients affected [2], [3].

The second indicator illustrates a reduction in the percentage of patients experiencing at least one postoperative complication, from 15.4% before implementation to 10.6% afterward. This corresponds to an absolute decrease of 4.8 percentage points and an approximate relative reduction of 31.2%. Unlike the previous indicator, this measurement focuses on the proportion of patients affected by complications, independently of whether an individual experienced one or several events. The simultaneous reduction in both indicators demonstrates that the observed improvement involved fewer recorded complications overall and a smaller proportion of patients experiencing postoperative morbidity [2].

The third indicator presents changes in in-hospital mortality, which decreased from 1.5% during the baseline period to 0.8% following the implementation of SURPASS. This represents an absolute reduction of 0.7 percentage points and an approximate relative reduction of 46.7%. Although mortality occurred less frequently than postoperative complications, the proportional reduction was substantial. The decrease in mortality accompanied the reductions observed in the other clinical indicators, establishing a consistent pattern of improved postoperative outcomes within the intervention hospitals [2].

A distinguishing characteristic of the SURPASS intervention was its comprehensive approach to surgical safety. Unlike protocols concentrated exclusively on activities performed inside the operating room, SURPASS incorporated structured verification procedures across the surgical care pathway, including preoperative assessment, preparation for surgery, intraoperative management, postoperative recovery, and discharge-related processes. This broader structure allowed the investigation to evaluate a safety system addressing multiple opportunities for communication failures, incomplete clinical information, and discontinuities in patient care [2], [4].

The observed findings are consistent with those reported by Haynes et al. [1], who documented reductions in postoperative complications and mortality following implementation of the World Health Organization Surgical Safety Checklist. Both investigations identified favorable changes in clinical outcomes after introducing standardized safety procedures. However, the interventions differed in their scope, implementation strategies, and institutional contexts. Therefore, the magnitude of their reported reductions should not be interpreted as evidence of the comparative superiority of one intervention without accounting for these methodological differences [1], [2].

An additional component of the SURPASS investigation was the inclusion of five control hospitals, where complication rates remained relatively stable, changing from 30.4 to 31.2 complications per 100 patients. This finding provides an important comparative reference because the reduction observed in intervention hospitals was not reproduced in the control institutions during the corresponding observation periods. Nevertheless, differences between hospitals and potential temporal confounding must still be considered when interpreting the association between implementation and clinical outcomes [2].

The results also illustrate the relevance of distinguishing between the frequency of adverse outcomes and their potential preventability. Although reductions in postoperative complications were observed following SURPASS implementation, the graphical indicators do not establish that every avoided complication was necessarily preventable through the intervention. Surgical outcomes are influenced by patient characteristics, procedural complexity, underlying diseases, and institutional factors. Accordingly, changes in complication rates should be interpreted alongside the characteristics of the evaluated populations and the clinical circumstances surrounding surgical care [2], [3], [6].

From an epidemiological perspective, the three indicators provide different but complementary measurements of postoperative outcomes. Complications per 100 patients quantify the total frequency of recorded complications relative to the surgical population, while the proportion of patients experiencing complications estimates the frequency of affected individuals. Mortality represents a separate outcome reflecting the most severe clinical endpoint included in the comparison. Evaluating these indicators together provides a more complete description of the observed changes than relying on any single measurement [2], [6].

The graphical findings further demonstrate the importance of standardized clinical documentation and consistent outcome definitions. Accurate comparisons between observation periods require reliable identification of complications, appropriate classification of clinical events, and comparable surveillance procedures. The development

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and validation of structured intraoperative adverse event classification systems, including ClassIntra, reflect broader efforts to improve the consistency and interpretability of perioperative safety measurements [6].

The multicenter characteristics of the investigation strengthen the relevance of the findings by demonstrating changes across several participating hospitals rather than within a single institution. However, the aggregated results should not be interpreted as identical effects across every surgical specialty, patient subgroup, or healthcare setting. Institutional differences in staffing, organizational practices, surgical volume, and baseline safety performance may influence the magnitude of observed changes. These considerations are particularly relevant when comparing international evidence with investigations conducted in Latin American healthcare institutions, where resource availability and organizational conditions may differ substantially [12]–[16].

Figure 4.

Prevalence and Preventability of Healthcare-Associated Adverse Events in Latin America

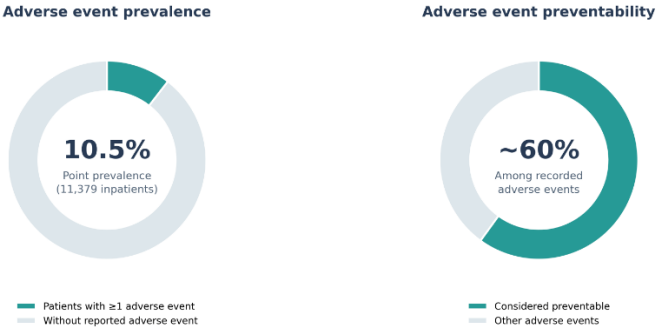

Figure 4 illustrates the prevalence and estimated preventability of healthcare-associated adverse events in Latin America, based on findings from the Iberoamerican Study of Adverse Events (IBEAS), reported by Aranaz-Andrés et al. [12]. The investigation examined 11,379 hospitalized patients across 58 hospitals located in Argentina, Colombia, Costa Rica, Mexico, and Peru. The graphical representation highlights two epidemiological indicators: the point prevalence of healthcare-associated adverse events, estimated at 10.5%, and the proportion of identified adverse events considered potentially preventable, approximately 60%. These measurements provide complementary information regarding the magnitude of patient harm and the potential opportunities for prevention within the participating healthcare institutions.

The first indicator demonstrates that approximately 10.5% of hospitalized patients experienced at least one healthcare-associated adverse event at the time of evaluation. Expressed in epidemiological terms, this corresponds to approximately 105 affected patients per 1,000 hospitalized individuals. The finding indicates that adverse events represented a substantial burden within the evaluated hospital populations. However, the estimate reflects a point-prevalence measurement rather than the cumulative incidence of adverse events throughout hospitalization. Consequently, it should not be interpreted as the probability that every admitted patient will experience an adverse event during the entire hospital stay [12].

The second indicator demonstrates that approximately 60% of the identified adverse events were considered potentially preventable. This proportion suggests that a substantial share of documented healthcare-associated harm was associated with circumstances that might have been modified through appropriate preventive practices, organizational improvements, or safer clinical processes. Nevertheless, preventability represents an assessment based on clinical judgment and established methodological criteria rather than definitive proof that every classified event could have been avoided under all circumstances. Differences in documentation quality, institutional characteristics, and clinical complexity may influence these classifications [12], [18].

An important methodological distinction concerns the denominators used to calculate the two indicators. The 10.5% prevalence estimate refers to the proportion of hospitalized patients affected by healthcare-associated adverse events, whereas the approximately 60% preventability estimate refers to the proportion of identified adverse events classified as potentially preventable. These percentages therefore represent different epidemiological measurements and should not be interpreted as directly comparable components of the same population distribution. Their graphical presentation serves to describe two complementary dimensions of patient safety rather than two mutually exclusive categories [12].

The multicountry composition of the IBEAS investigation constitutes a relevant characteristic of the evidence. By including hospitals from Argentina, Colombia, Costa Rica, Mexico, and Peru, the study provided information from healthcare institutions operating within different national health systems and organizational environments. This geographical distribution allowed the investigation to examine patient safety across a broader regional context than

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would have been possible through a single-country assessment. Nevertheless, the aggregated estimates do not establish that adverse event prevalence or preventability was identical across all participating countries or hospitals [12].

The observed prevalence is consistent with the broader recognition of healthcare-associated adverse events as an important challenge for patient safety. Investigations conducted in Brazil have similarly examined preventable adverse events in hospital environments, identifying the relevance of clinical documentation, care processes, and institutional practices in the characterization of avoidable harm [16], [18]. Although these investigations differ in design, populations, and outcome definitions, they contribute complementary evidence regarding the persistence of patient safety challenges within Latin American healthcare institutions.

A fundamental consideration when interpreting Figure 4 is that IBEAS evaluated healthcare-associated adverse events across hospitalized populations rather than exclusively among patients undergoing surgical procedures. Consequently, the reported 10.5% prevalence and approximately 60% preventability should not be presented as specific estimates of perioperative adverse events. The study provides regional epidemiological context for understanding preventable patient harm, but direct numerical comparisons with exclusively surgical investigations require caution because the evaluated populations and event definitions differ [3], [12].

This distinction is particularly relevant when comparing the IBEAS findings with the systematic review conducted by Anderson et al. [3], which reported adverse events affecting 14.4% of surgical patients and potentially preventable events affecting 5.2%. Although both investigations examined adverse events and preventability, their respective methodologies, clinical populations, and epidemiological measurements were not equivalent. Therefore, differences between the reported percentages cannot independently establish that surgical care presents a greater or lower risk than general hospital care within the evaluated settings [3], [12].

The regional findings can also be considered alongside investigations examining patient safety culture in Latin American hospitals. Camacho-Rodríguez et al. [13] reviewed evidence concerning institutional safety culture, while Oliveira et al. [14] examined healthcare professionals' perspectives on operating room safety. These investigations address organizational dimensions that are not directly quantified by the IBEAS prevalence indicators but are relevant to understanding the environments in which healthcare-associated adverse events are identified and documented. Their inclusion provides additional context regarding communication, professional participation, and institutional safety practices [13], [14].

Similarly, research conducted by Gutierres et al. [15] identified recommendations for strengthening patient safety practices in operating rooms, emphasizing the relevance of standardized procedures and coordinated professional activities. Evidence concerning medication errors in surgical and postanesthetic care settings in Colombia further demonstrates that patient safety challenges may involve specific clinical processes requiring systematic monitoring and prevention strategies [19]. These investigations complement the regional epidemiological findings by examining particular aspects of healthcare delivery that may contribute to the occurrence or prevention of adverse events.

From an epidemiological standpoint, the IBEAS findings illustrate the importance of distinguishing the occurrence of adverse events from assessments of their preventability. Prevalence measurements describe the proportion of affected patients within a defined population and observation period, whereas preventability assessments seek to characterize the extent to which identified harm may have been avoided. Both measurements contribute to the description of patient safety, but they require different methodological procedures and should be interpreted according to their respective definitions [12], [18].

The findings also highlight the relevance of standardized surveillance methods for generating comparable regional evidence. Differences in clinical documentation, adverse event identification, and institutional reporting practices may influence the frequency of events detected. Therefore, variations between hospitals or countries should not automatically be attributed to differences in healthcare quality without considering surveillance sensitivity and methodological consistency. The development of standardized adverse event classification systems represents an important contribution to improving the reliability of patient safety measurements across heterogeneous healthcare environments [6], [12].

Although the IBEAS investigation provides valuable multicountry evidence, its findings must be interpreted within the limitations of the study design. Point-prevalence assessments capture adverse events identified within a defined observation period and may not fully represent complications developing after discharge or events that are insufficiently documented. Furthermore, the participating hospitals may not represent every healthcare institution within the five countries examined. Accordingly, the reported estimates should be understood as findings from the evaluated hospital population rather than universal prevalence measurements applicable to all Latin American healthcare systems [12].

Overall, Figure 4 demonstrates that healthcare-associated adverse events represented a substantial burden among hospitalized patients in the participating Latin American institutions, with a reported point prevalence of 10.5% and approximately 60% of identified events considered potentially preventable. The findings provide an important regional

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epidemiological reference for the broader analysis of perioperative patient safety, while emphasizing the need to distinguish hospital-wide adverse event measurements from surgical-specific outcomes. Their principal contribution lies in documenting the frequency and potential preventability of healthcare-associated harm within a multicountry Latin American population, complementing the international evidence on surgical complications, institutional surveillance, and standardized patient safety practices [3], [12]–[16], [18].

Figure 5.
Changes in Anesthesia-Related Safety Incident Reporting Following Targeted Quality Improvement Interventions

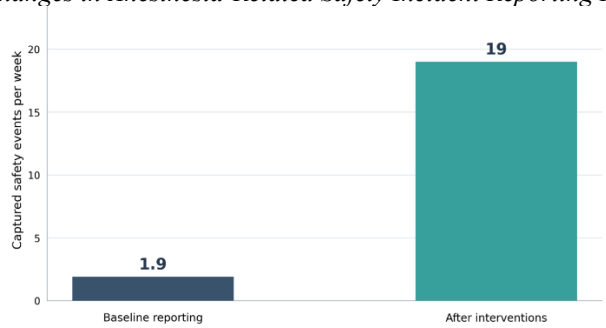

Figure 5 illustrates changes in the frequency of reported anesthesia-related safety incidents following the implementation of targeted quality improvement interventions, based on the investigation conducted by McSoley et al. [20]. The study examined incident reporting practices within a pediatric anesthesia service, focusing on the identification and documentation of intraoperative safety events. The graphical representation compares the average number of incidents captured per week before and after the interventions, demonstrating an increase from 1.9 to 19 reported incidents. This difference represents a tenfold increase in the frequency of documented safety events and provides a quantitative measure of the changes observed in institutional reporting activity.

The baseline reporting frequency of 1.9 incidents per week indicates that relatively few anesthesia-related safety events were being captured through the existing reporting mechanisms during the initial observation period. Following the introduction of targeted interventions, the average increased to approximately 19 incidents per week, corresponding to an absolute difference of 17.1 additional reports per week. Expressed as a relative change, the increase represents approximately 900% above the baseline reporting frequency. These calculations describe the magnitude of the observed change in incident documentation rather than a corresponding increase in the underlying occurrence of patient harm [20].

An essential consideration when interpreting this figure is the distinction between the frequency of reported incidents and the actual incidence of anesthesia-related adverse events. Reporting systems depend on the ability and willingness of healthcare professionals to recognize, document, and communicate safety concerns. Consequently, the number of captured events may change substantially even when the underlying clinical risk remains relatively stable. The increase demonstrated in Figure 5 should therefore be interpreted primarily as evidence of improved incident detection and reporting activity rather than as proof of deterioration in perioperative patient safety [11], [20].

The clinical environment evaluated in the investigation involved approximately 1,000 general anesthetics per week, providing important context for the reported incident counts. When considered against this approximate procedural volume, the baseline average of 1.9 reports corresponds to approximately 1.9 documented incidents per 1,000 anesthetics, whereas the postintervention average of 19 reports corresponds to approximately 19 documented incidents per 1,000 anesthetics. These derived values provide an illustrative normalization of reporting frequency based on the approximate weekly procedural volume. However, they should not be interpreted as validated incidence rates of patient harm because reported events may differ in severity, clinical consequences, and classification, and the procedural denominator was presented as an approximate service volume [20].

The magnitude of the observed increase demonstrates the sensitivity of incident reporting indicators to changes in institutional surveillance practices. Unlike postoperative complication rates or mortality measurements, reporting frequency reflects both the occurrence of recognizable safety events and the performance of the mechanisms used to capture them. Accordingly, improvements in accessibility, professional engagement, and institutional reporting procedures may increase the number of documented events without producing a proportional change in clinical outcomes. This distinction is particularly relevant when comparing reporting-based quality improvement studies with investigations evaluating postoperative morbidity and mortality [1], [2], [20].

The findings are consistent with broader evidence emphasizing the importance of organizational safety culture in perioperative environments. Lozito et al. [11] examined the contribution of structured safety reporting initiatives to

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institutional learning, while Sacks et al. [9] reviewed interventions intended to strengthen teamwork, communication, and safety culture in surgical settings. These investigations provide complementary perspectives on the relationship between professional participation and the identification of patient safety vulnerabilities. Although the studies employed different approaches and outcome measures, they collectively demonstrate the relevance of organizational conditions in shaping the effectiveness of safety reporting systems [9], [11], [20].

The investigation also highlights the methodological challenges associated with interpreting changes in institutional incident reporting. A higher number of reports may reflect improved surveillance sensitivity, greater professional participation, changes in event definitions, or modifications in reporting accessibility. Conversely, a lower reporting frequency does not necessarily indicate safer clinical care, particularly when institutional barriers discourage the documentation of incidents. Therefore, reporting indicators should be interpreted alongside information concerning surveillance procedures, organizational practices, and clinical outcomes [6], [11], [20].

The distinction between adverse events and near-miss incidents is especially relevant within anesthesia services. Some reported incidents may involve actual patient harm, whereas others may represent circumstances in which a potential hazard was identified before producing an adverse clinical outcome. These categories differ in their clinical consequences and epidemiological significance. Their inclusion within reporting systems can broaden institutional awareness of safety vulnerabilities, but meaningful analysis requires consistent definitions and appropriate classification. Standardized approaches to intraoperative adverse event classification, such as ClassIntra, provide a methodological reference for improving the consistency of perioperative safety measurements [6].

The pediatric anesthesia setting represents another important characteristic of the investigation. Pediatric patients differ from adult surgical populations in physiological characteristics, anesthetic requirements, procedural complexity, and the clinical consequences of specific adverse events. Furthermore, the organizational structure and reporting practices of a specialized anesthesia service may differ from those of general hospitals or institutions operating with fewer resources. Consequently, the magnitude of the increase observed in Figure 5 should not be assumed to occur identically in adult anesthesia services or other healthcare environments [4], [5], [20].

From an epidemiological perspective, Figure 5 provides an example of how the measured frequency of safety events may be influenced by the surveillance system itself. An increase in captured incidents can occur because previously unreported events become visible through more effective documentation mechanisms. This phenomenon is particularly important when evaluating temporal changes in institutional safety indicators. Without considering changes in reporting sensitivity, an apparent increase in adverse event frequency could be incorrectly interpreted as worsening clinical performance. Conversely, improved reporting should not automatically be equated with improved patient outcomes unless supported by independent clinical indicators [6], [20].

The findings can also be contrasted with the reductions in postoperative complications and mortality reported by Haynes et al. [1] and de Vries et al. [2]. Those investigations primarily evaluated clinical outcomes following the implementation of structured surgical safety interventions, whereas McSoley et al. [20] examined the capture of anesthesia-related safety events. Although all three studies address perioperative patient safety, their principal outcome measures differ substantially. The reductions observed in Figures 2 and 3 describe changes in postoperative morbidity and mortality, while the increase presented in Figure 5 describes changes in institutional reporting activity. These findings should therefore be considered complementary rather than contradictory [1], [2], [20].

The graphical comparison further demonstrates the importance of maintaining consistent measurement units when evaluating quality improvement initiatives. The values of 1.9 and 19 represent average weekly counts of reported incidents, not percentages of affected patients or complication rates. Their interpretation must remain linked to the reporting interval and institutional context. Although normalization by procedural volume may facilitate comparisons, reliable epidemiological rates require clearly defined denominators, consistent event classifications, and standardized observation periods [6], [20].

An additional methodological consideration concerns the attribution of observed changes to the implemented interventions. The investigation documented a substantial increase in captured events following targeted quality improvement activities, but before-and-after comparisons may be influenced by concurrent organizational changes, variations in professional participation, and modifications in clinical workload. Therefore, the findings support an association between the interventions and increased reporting activity without independently establishing the contribution of each individual intervention component [20].

DISCUSSION

The findings of this review demonstrate that preventable perioperative adverse events remain a significant challenge for healthcare systems, despite advances in anesthetic techniques, surgical technology, physiological monitoring, and standardized clinical protocols. The evidence suggests that perioperative safety is determined not only by technical competence but also by the interaction of clinical practices, epidemiological surveillance, organizational culture, and

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healthcare management. Across the reviewed investigations, interventions addressing several components of the surgical care pathway were associated with improvements in clinical outcomes, while initiatives focused on incident reporting strengthened the identification of potential patient safety vulnerabilities [1]–[5].

The epidemiological findings reported by Anderson et al. [3] establish an important foundation for understanding the magnitude of surgical harm. The identification of adverse events in 14.4% of surgical patients, including potentially preventable events affecting 5.2%, indicates that a considerable proportion of postoperative morbidity may be associated with modifiable healthcare processes. However, these estimates require cautious interpretation because preventability classifications depend on retrospective clinical assessments, documentation quality, and the criteria employed to distinguish unavoidable complications from healthcare-associated harm. Differences in surgical populations, institutional resources, and surveillance methods may also contribute to variations in reported frequencies. Consequently, adverse event rates should not be interpreted as isolated measures of professional performance but rather as indicators requiring contextual evaluation.

The reductions in postoperative complications and mortality documented by Haynes et al. [1] and de Vries et al. [2] provide complementary evidence regarding the effectiveness of structured surgical safety interventions. In the former investigation, implementation of the World Health Organization Surgical Safety Checklist was associated with reductions in major complications from 11.0% to 7.0% and mortality from 1.5% to 0.8%. Similarly, the SURPASS study demonstrated a reduction in complications from 27.3 to 16.7 per 100 patients, accompanied by decreases in the proportion of patients experiencing complications and in-hospital mortality. Although the interventions differed in their scope, both investigations documented favorable clinical changes following the introduction of standardized safety procedures. These findings support the incorporation of systematic verification processes into perioperative care, while the observational characteristics of the studies require caution when attributing all observed improvements exclusively to checklist implementation.

An important distinction between these investigations concerns the comprehensiveness of the interventions. The World Health Organization checklist primarily emphasizes critical safety verification during specific moments surrounding surgical intervention, whereas SURPASS incorporates checkpoints distributed throughout the surgical care pathway. This difference reflects the possibility that adverse events may originate outside the operating room, including during preoperative assessment, transfer between clinical services, postoperative monitoring, and discharge planning. The findings of de Vries et al. [2] are therefore consistent with a broader organizational approach in which patient safety depends on the continuity and reliability of multiple interconnected processes. Nevertheless, current evidence does not establish that one checklist model is universally superior across all healthcare environments.

The effectiveness of standardized safety protocols is also influenced by the quality of their implementation. Russ et al. [8] identified improvements in teamwork and communication associated with surgical checklist use, while Sacks et al. [9] described the contribution of organizational interventions to surgical safety culture. These findings indicate that procedural standardization and professional collaboration are closely related components of perioperative safety. A checklist may reinforce communication, but its presence alone cannot ensure that relevant clinical information is accurately exchanged or that identified risks are effectively addressed. Institutional adherence should therefore be evaluated through the quality of safety practices rather than exclusively through documentation completion rates.

Within anesthesiology, this issue acquires particular importance because clinical deterioration may develop rapidly and require immediate coordinated responses. Airway complications, hemodynamic instability, medication-related incidents, and inadequate monitoring frequently involve processes in which communication, equipment availability, and professional preparedness are essential. The international standards proposed by Gelb et al. [4] emphasize the need for qualified anesthesia personnel, appropriate physiological monitoring, reliable equipment, and standardized practices. Warner et al. [5] further highlighted the importance of advancing perioperative safety through coordinated international efforts and strengthening institutional support for anesthesia services. Together, these recommendations demonstrate that technical expertise must be supported by organizational conditions that allow professionals to deliver consistently safe care.

Epidemiological surveillance emerged as another fundamental dimension of the reviewed evidence. The standardized classification of intraoperative adverse events through systems such as ClassIntra provides opportunities to improve

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the consistency of safety measurements and facilitate comparisons between healthcare institutions [6]. However, differences in reporting definitions and surveillance practices remain substantial challenges. Clinical complications, preventable adverse events, and near-miss incidents represent distinct categories that should not be combined indiscriminately. Without standardized definitions, institutions may generate misleading indicators, making it difficult to distinguish actual changes in patient outcomes from modifications in documentation practices.

The investigation by McSoley et al. [20] illustrates this distinction. Following targeted quality improvement interventions, anesthesia-related safety event reporting increased from an average of 1.9 to 19 incidents per week. Although this represented a tenfold increase in captured events, it should not be interpreted as evidence that the underlying frequency of patient harm increased proportionally. Instead, the observed change primarily reflected improvements in reporting processes and institutional detection capacity. This finding highlights an important limitation of surveillance indicators: reporting frequency is influenced by organizational culture, accessibility of reporting mechanisms, and professional willingness to disclose incidents. Consequently, higher reporting rates may coexist with improvements in institutional safety practices.

The relationship between incident reporting and safety culture is particularly relevant for healthcare administration. Lozito et al. [11] described the contribution of structured reporting initiatives to improving perioperative safety culture, while Sacks et al. [9] emphasized the importance of organizational interventions in strengthening communication and teamwork. These findings suggest that effective surveillance requires more than technological infrastructure. Healthcare professionals must perceive reporting systems as accessible, clinically relevant, and oriented toward organizational learning. At the same time, institutional leadership must distinguish unintentional human error from negligent or reckless behavior, maintaining accountability without creating environments in which professionals avoid reporting incidents because of disproportionate punitive consequences.

The Latin American evidence included in this review introduces additional considerations regarding the transferability of international safety recommendations. The Iberoamerican Study of Adverse Events documented a point prevalence of approximately 10.5% among hospitalized patients in five Latin American countries, with nearly 60% of identified events considered potentially preventable [12]. These findings reveal a substantial burden of healthcare-associated harm within the participating institutions. Nevertheless, because IBEAS evaluated hospital-wide adverse events rather than exclusively surgical complications, direct numerical comparisons with perioperative studies must be avoided. Differences in study design, patient populations, and event definitions limit the extent to which these estimates can be considered equivalent.

Research examining patient safety culture in Latin American hospitals has identified opportunities for strengthening organizational communication, institutional leadership, and incident reporting practices [13]. Additional investigations conducted in Brazil have addressed operating room safety culture, preventable surgical adverse events, anesthesia-related mortality, and the implementation of preventive practices [14]–[18]. Evidence from Colombia has also documented medication-related errors in surgical and postanesthetic care environments [19]. Collectively, these studies demonstrate the relevance of examining patient safety within the specific organizational circumstances of Latin American healthcare systems.

However, Latin America should not be interpreted as a homogeneous healthcare environment. Differences in hospital financing, workforce distribution, technological resources, professional training, and regulatory structures may influence institutional safety performance. Consequently, interventions developed in highly resourced healthcare systems may require adaptation before implementation in institutions with different operational capabilities. The fundamental objectives of perioperative safety remain consistent across settings, but the mechanisms used to achieve them may vary according to local resources, surgical complexity, and administrative capacity [5], [12]–[18].

From a healthcare management perspective, the results support the relevance of integrating patient safety indicators into institutional quality improvement processes. The DMAIC framework provides a structured approach for organizing this integration by defining preventable harm, measuring relevant outcomes, analyzing contributing factors, identifying potential improvements, and establishing mechanisms for continuous monitoring. In this review, DMAIC served as a conceptual analytical framework rather than an experimentally evaluated intervention. Therefore, its practical effectiveness in reducing perioperative adverse events cannot be established from the present analysis alone.

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Nevertheless, the framework is compatible with the principal findings of the reviewed literature. Standardized outcome measurement addresses the epidemiological challenges identified by Anderson et al. [3] and Dell-Kuster et al. [6], while interventions involving checklists and multidisciplinary communication correspond to the improvement strategies evaluated by Haynes et al. [1], de Vries et al. [2], and Russ et al. [8]. Similarly, incident reporting initiatives described by Lozito et al. [11] and McSoley et al. [20] illustrate how continuous monitoring and organizational feedback can contribute to the identification of process vulnerabilities.

An additional consideration involves the distinction between process indicators and clinical outcome indicators. Checklist completion, reporting frequency, and participation in safety training provide information about institutional activity, but they do not independently demonstrate reductions in morbidity or mortality. Conversely, complication rates and mortality indicators are influenced by patient characteristics, procedural risk, and clinical complexity. A comprehensive institutional evaluation should therefore consider both categories of measurement, avoiding conclusions based on a single indicator. This distinction is particularly important when assessing improvement strategies in hospitals with differing patient populations and healthcare resources.

Several limitations should be acknowledged when interpreting the findings of this review. First, the narrative design and focused selection of 20 publications do not provide the exhaustive coverage expected from a systematic review. Second, the included investigations vary considerably in methodological design, study populations, definitions of adverse events, observation periods, and institutional characteristics. Third, some influential studies employed before-and-after designs, which are vulnerable to temporal confounding and changes unrelated to the intervention. Fourth, the inclusion of broader hospital patient safety investigations alongside exclusively perioperative studies introduces heterogeneity that limits direct comparisons between reported indicators. Finally, the review did not conduct a quantitative meta-analysis or independently assess the effectiveness of proposed institutional interventions.

Despite these limitations, the convergence of evidence across different research designs supports a consistent understanding of perioperative safety as an organizational and clinical priority. Studies examining surgical outcomes, professional communication, institutional safety culture, and incident reporting describe complementary components of healthcare quality rather than isolated phenomena. The evidence indicates that improving safety requires reliable clinical processes, meaningful multidisciplinary participation, standardized epidemiological monitoring, and sustained institutional commitment [1], [2], [8], [9], [20].

Future research should prioritize prospective multicenter investigations using standardized definitions of perioperative adverse events and clearly established measures of preventability. Particular attention should be directed toward the evaluation of intervention effectiveness across healthcare institutions with different resource levels, including hospitals in Latin America. Research examining the relationship between reporting culture, clinical outcomes, and organizational performance would also contribute to distinguishing improvements in incident detection from actual reductions in avoidable harm. Furthermore, longitudinal evaluations of process improvement frameworks could clarify their contribution to the sustainability of perioperative safety initiatives.

Taken together, the reviewed findings indicate that the prevention of perioperative adverse events cannot be achieved through isolated technical measures or administrative policies alone. The integration of evidence-based clinical protocols, epidemiological surveillance, multidisciplinary communication, and organizational quality improvement represents a coherent approach to addressing the complexity of surgical patient safety. The central challenge for healthcare institutions is not simply to establish preventive standards, but to ensure that these standards are consistently implemented, evaluated, and adapted to the clinical and organizational conditions in which perioperative care is delivered.

CONCLUSION

Preventable perioperative adverse events remain a major challenge for healthcare quality, reflecting the complex interaction of clinical risks, human factors, organizational vulnerabilities, and limitations in institutional surveillance. The evidence reviewed demonstrates that perioperative safety extends beyond individual technical competence and requires coordinated strategies integrating anesthesiology, surgical practice, epidemiology, and healthcare administration. Although complications cannot be entirely eliminated, a substantial proportion of healthcare-associated

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harm may be reduced through standardized preventive measures, effective communication, and systematic evaluation of clinical processes [3]–[5].

The findings indicate that structured surgical safety interventions are associated with measurable improvements in patient outcomes. International investigations demonstrated reductions in postoperative complications and in-hospital mortality following the implementation of standardized checklists and comprehensive perioperative safety systems [1], [2]. However, the effectiveness of these strategies depends on consistent implementation, multidisciplinary participation, and institutional capacity to maintain adherence over time. The evidence therefore supports approaching surgical safety as a continuous process encompassing preoperative preparation, intraoperative management, postoperative recovery, and transitions between healthcare teams.

Epidemiological surveillance and incident reporting represent essential components of this process. Standardized adverse event classification, reliable documentation, and periodic evaluation of clinical indicators facilitate the identification of recurrent vulnerabilities and opportunities for prevention. Nevertheless, reporting frequency must be distinguished from the actual incidence of patient harm, since improvements in institutional transparency may increase the number of documented incidents without indicating deterioration in clinical outcomes [6], [11], [20]. Consequently, comprehensive safety assessments should integrate surveillance indicators with measures of morbidity, mortality, preventability, and protocol adherence.

Organizational safety culture also emerged as a fundamental determinant of sustainable improvement. Effective communication, interdisciplinary collaboration, professional accountability, and supportive institutional leadership contribute to environments in which adverse events can be identified and addressed systematically. Healthcare administrators therefore have a central responsibility in ensuring adequate resources, facilitating professional development, strengthening reporting mechanisms, and promoting continuous evaluation of patient safety practices [8], [9], [13].

Evidence from Latin America reinforces the relevance of preventable healthcare-associated harm while highlighting the importance of adapting international recommendations to heterogeneous institutional circumstances. Regional investigations demonstrate persistent opportunities to strengthen surveillance, communication, and safety management within hospitals operating under different resource conditions [12]–[19]. Accordingly, the development of effective preventive strategies should consider local infrastructure, workforce capacity, clinical complexity, and institutional priorities without compromising fundamental patient safety standards.

The application of the DMAIC framework as an analytical model provides a structured approach for connecting epidemiological findings with potential institutional improvement strategies. Defining safety problems, measuring relevant indicators, analyzing contributing factors, identifying preventive interventions, and establishing continuous monitoring mechanisms offer a coherent basis for future quality improvement initiatives. Nevertheless, the present narrative review does not establish the clinical effectiveness of DMAIC implementation, which requires prospective evaluation under real healthcare conditions.

Ultimately, strengthening perioperative safety requires moving from isolated preventive actions toward integrated systems characterized by reliable clinical practices, transparent surveillance, multidisciplinary collaboration, and sustained organizational learning. Future research should prioritize standardized epidemiological measurements and multicenter evaluations, particularly in Latin American healthcare settings, to determine which interventions achieve meaningful and sustainable reductions in avoidable harm. The available evidence supports the conclusion that **perioperative patient safety is not merely a procedural requirement but a fundamental indicator of healthcare system quality, institutional responsibility, and the capacity to deliver consistent, patient-centered surgical care.**

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