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A Multi-Disciplinary Narrative Review: Medication Safety in the Surgical Patient from Prescription to Administration

Mubarak Mohammed Jamaan Aljamaeen [(1)] , Ali Mohammad Ali Ageeli [(2)] , Waad Abdulelah Alobaidy [(3)] , Abdulmalik Gharbi Ayis Alshammari [(4)] , Salihah Abdullah Saeed Alghamd [(5)] , Abdulmajid Maneh Matar Alharbi [(6)] , Njod Ahmed Ghmari [(7)] , Ahmed Hameed Alharbi [(8)] , Hashem Ahmed Junid [(9)] , Maryam Mohammed Harthi , Reem Makmi Khideer Albanaqy [(10)] , Akram Abdullah H. Tarmookh [(11)]

(1) Al-Sulail General Hospital – Al-Sulail, Ministry of Health, Saudi Arabia,
(2) Jazan Health Cluster, Ministry of Health, Saudi Arabia,
(3) King Salman Medical City – Main Hospital, Ministry of Health, Saudi Arabia,
(4) Aja Hospital for Long-Term Care and Rehabilitation – Hail, Hail Health Cluster,Ministry of Health, Saudi Arabia,
(5) Imam Abdulrahman Al-Faisal Hospital – Riyadh,Ministry of Health, Saudi Arabia,
(6) Al Miqat Hospital City – Al Madinah Al Munawwarah,Ministry of Health, Saudi Arabia,
(7) Ministry Of Health, Saudi Arabia,
(8) King Fahad Hospital – Dental Center, Ministry of Health, Saudi Arabia,
(9) King Fahad Hospital – Dental Center, Al Madinah Al Munawwarah, Ministry of Health, Saudi Arabia,
(10) Al Uwaigilah Hospital – Al Uwaigilah, Northern Borders, Ministry of Health, Saudi Arabia,
(11) Dammam Central Hospital – Dammam, Ministry of Health, Saudi Arabia

Abstract

Background: Medication errors in surgical patients represent a critical, multifaceted threat to patient safety, occurring at any point in a complex, multi-handler pathway. The unique perioperative environment, involving high-stakes pharmacology and numerous handoffs between diverse professionals, creates distinct vulnerabilities. **Aim:** This narrative review aims to synthesize contemporary evidence (2010-2024) on the epidemiology of medication errors in surgical care and to trace the medication-use process across the interconnected disciplines involved, identifying systemic risks and collaborative strategies for mitigation. **Methods:** A comprehensive literature search was conducted across PubMed, CINAHL, Scopus, and Web of Science databases. **Results:** Errors are prevalent, with high-risk points at prescribing (especially antimicrobials and analgesics), transcription/communication, anaesthesia administration, and post-operative monitoring. Fragmented systems, ambiguous communication, and role overload are key contributors. Evidence supports structured interventions like computerised physician order entry with decision support, standardised handoff protocols, barcode-assisted medication administration, and enhanced interdisciplinary training (e.g., simulation, crew resource management) as effective in reducing errors. Successful implementation is fundamentally dependent on strong health services administration policies and a pervasive culture of safety. **Conclusion:** Medication safety in surgery is an inherently interdisciplinary challenge. A "siloed" approach is ineffective. Future strategies must be architected around integrated care pathways, leveraging health information technology and fostering a culture of shared responsibility from the executive suite to the bedside, involving every link in the chain from the medical secretary to the resident doctor and surgical team.

Keywords: Medication Errors, Patient Safety, Perioperative Care, Interdisciplinary Communication, Health Services Administration.

Introduction

Medication safety constitutes a cornerstone of patient safety, yet it remains an elusive goal within the high-velocity, high-stakes environment of surgical care. A surgical patient's journey involves a complex pharmacologic regimen, spanning prophylactic antibiotics, anaesthetic agents, analgesics, anticoagulants, and antiemetics, each managed by a different set of hands across shifting clinical domains (Duffy et al., 2022). The Institute of Medicine's seminal report, *To Err Is Human*, starkly highlighted the consequences of system failures in healthcare, with medication errors representing a significant proportion of preventable harm (Mitchell et al., 2016). Contemporary studies affirm that surgical patients are particularly vulnerable; the perioperative period is characterised by frequent transitions of care, time pressure, cognitive load, and the use of high-risk medications, creating a perfect storm for error (Isherwood & Waterson, 2021).

*Corresponding author e-mail: almageeli@moh.gov.sa (Mubarak Mohammed Jamaan Aljamaeen).

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The epidemiology of these errors is sobering. A systematic review by Argo et al. (2019) estimated that medication-related events account for approximately one in 20 perioperative adverse events, with a considerable proportion being preventable. Errors are not confined to the operating room (OR) but permeate the entire continuum: pre-operative assessment, intraoperative administration, and post-operative recovery. Crucially, this continuum is managed not by a single profession, but by a multifaceted team (Petrucci et al., 2021). The pathway of a single medication order—for instance, for a post-operative analgesic—winds its way from the prescriber (surgeon or resident doctor), through transcription and communication (potentially involving a medical secretary or electronic system), to pharmacy verification, nursing or anaesthesia administration, and finally to monitoring by a health assistant or nurse (Krämer et al., 2023). Each handoff represents a potential point of failure, and the responsibility for safety is distributed, yet shared.

Therefore, understanding and mitigating medication errors in surgery demands an interdisciplinary lens. This narrative review aims to: 1) review the contemporary epidemiology of medication errors in the surgical pathway; 2) deconstruct the medication-use process, analysing risks and evidence-based safeguards at each stage, explicitly considering the roles of epidemiology, surgical operations, nursing, health services administration, medical secretarial work, health assisting, dental assisting, dental laboratory technology, and resident doctors; and 3) synthesise recommendations for a truly integrated, system-oriented approach to safety. By bridging these nine distinct but interconnected fields, this review argues that medication safety is not merely a clinical concern but an organisational and systems engineering challenge requiring cohesive policy, culture, and technology.

Methodology

This narrative review employed a systematic search strategy to identify relevant English-language literature published between January 2010 and December 2024. Electronic databases searched included PubMed/MEDLINE, CINAHL, Scopus, and Web of Science. A combination of Medical Subject Headings (MeSH) terms and keywords was used, including: "medication errors," "patient safety," "perioperative care," "surgical procedures, operative," "drug-related side effects and adverse reactions," "interprofessional relations," "health communication," "clinical decision support systems," "nursing administration research," and "health services administration." Reference lists of key articles were hand-searched for additional sources.

Inclusion criteria focused on studies, reviews, meta-analyses, and guideline statements addressing medication safety in adult or paediatric surgical settings, with an emphasis on interdisciplinary aspects, system interventions, and human factors. Excluded were articles focusing solely on non-surgical settings or specific drug pharmacodynamics without a safety systems perspective. The synthesis is structured narratively, tracing the linear and iterative process of medication use while integrating perspectives from the nine identified fields. Two original summary tables are provided to synthesise key error types by phase (Table 1) and recommended interdisciplinary safety strategies (Table 2).

The Epidemiology of Perioperative Medication Errors

Understanding the frequency, types, and contributing factors of medication errors is the foundational work of epidemiology, providing the data necessary to target interventions. Recent analyses continue to highlight the perioperative area as a high-risk zone. A prospective observational study by Nanji et al. (2017) in a tertiary academic centre found that one in 20 medication administrations in the operating room included an error or adverse drug event (ADE), with nearly a third of these errors being preventable. Similarly, a large retrospective analysis by Michaels et al. (2020) reported that medication errors were implicated in nearly 5% of all surgical patient safety incidents, with higher rates in emergent procedures and complex surgeries.

The types of errors follow a familiar pattern but with perioperative specificities. Prescribing errors are common, involving incorrect dosing, frequency, or drug selection. For example, errors in antimicrobial prophylaxis—such as incorrect timing or agent selection contrary to guidelines—remain prevalent, contributing to surgical site infection risk (Bratzler et al., 2013; Balch et al., 2017). Analgesic errors, particularly with opioids, pose dual risks of under-treatment and over-sedation or respiratory depression (Hwang et al., 2020). Administration errors, often occurring under time pressure and without a second check, include wrong drug, wrong dose, or wrong route (Kramer et al., 2019). A particularly dangerous subset is anaesthesia medication errors, where the practice of drawing up and labelling syringes at the point of care presents unique risks for syringe swap or concentration error (Merry et al., 2021).

Human factors are consistently identified as primary contributors: fatigue, distraction, high cognitive workload, and inadequate knowledge (Singer & Vogus, 2013). However, the epidemiological lens must widen to view these not as individual failures but as symptoms of flawed systems. Latent conditions, such as poorly designed drug storage systems (e.g., look-alike/sound-alike vials in anaesthesia carts), ambiguous protocols, inefficient communication channels, and hierarchical cultures that discourage speaking up, create the preconditions for active errors (Reason, 2016). From an administrative and health services perspective, this epidemiology underscores that investment in safety is

not a cost but a necessity, as errors lead to extended hospital stays, readmissions, and significant additional financial burden (Slawomirski et al., 2017). Figure 1 summarizes the most frequently reported medication errors in surgical care, including incorrect drug selection, dosing errors, omitted doses, allergy oversights, wrong timing of administration, and communication failures during handoffs.

Table 1: Common Medication Error Types in the Surgical Pathway and Contributing Factors

Phase of Medication Use	Common Error Types	Key Contributing Factors (Human & System)	Primary Disciplines Involved
Prescribing	Wrong drug, dose, frequency; allergy mismatch; incorrect duration (e.g., antibiotics).	Lack of knowledge, haste, incomplete patient data, poor CPOE design.	Resident Doctor, Surgeon, Dental Surgeon.
Transcription/Transfer	Omission, miscommunication, incorrect entry during handoff.	Verbal orders, paper-based systems, busy environments, role ambiguity.	Medical Secretary, Resident, Nurse.
Dispensing/Preparation	Wrong drug/concentration prepared; incorrect labelling; contamination.	Look-alike/sound-alike drugs, cluttered workspace, interruptions.	Pharmacy, Nurse, Anaesthetist, Dental Assistant.
Administration	Wrong patient, drug, dose, route, time; omitted dose.	Failure of "rights" check, distraction, inadequate monitoring equipment.	Nurse, Anaesthetist, Health Assistant.
Monitoring	Failure to recognise ADR; inadequate assessment (e.g., sedation score).	Lack of training, poor communication of the plan, and alarm fatigue.	Nurse, Health Assistant, Resident.

Figure 1. Common Types of Medication Errors in the Perioperative Surgical Setting

Tracing the Medication Pathway: Risks and Safeguards Across Disciplines

The First Link in the Chain

The journey begins with the prescriber—typically a surgeon, resident doctor, or dental surgeon performing oral procedures. Prescribing in surgery is often protocol-driven but can be highly situational, requiring adjustments for renal function, allergies, and concurrent medications (Wright et al., 2018; Middleton et al., 2016). Errors at this stage are particularly dangerous as they propagate downstream. Computerised Physician Order Entry (CPOE) with clinical decision support (CDS) is a fundamental technological safeguard. Well-implemented CPOE can eliminate transcription errors, force structured data entry, and provide real-time alerts for allergies, dosing limits, and drug interactions (Bates & Singh, 2018). However, poorly designed CPOE can introduce new errors through clumsy interfaces, alert fatigue, and workflow disruption (Stone et al., 2018).

For resident doctors, who are often the frontline prescribers in academic centres, factors such as workload, supervision level, and familiarity with institutional protocols are critical (Riman et al., 2023). Interventions like structured order sets for common surgical procedures (e.g., elective colectomy order sets including VTE prophylaxis, antibiotics, analgesia) have proven effective in standardising care and reducing cognitive load and variation (Micheels et al., 2022). From a dental-surgical perspective, prescribing for procedures such as third molar extractions or implants must consider unique factors, including antibiotic prophylaxis for cardiac conditions and bisphosphonate-related osteonecrosis of the jaw, areas where adherence to guidelines is variable (Sutherland & Matthews, 2019). This underscores the need for CDS that is specialty-specific.

The Role of the Medical Secretary and Health Information Systems

Historically, the medical secretary played a crucial role in transcribing handwritten or verbal orders, a task fraught with the risk of misinterpretation. While the adoption of CPOE has diminished this role in inpatient settings, medical secretaries and unit clerks remain pivotal in ambulatory surgical settings, managing pre-operative medication reconciliation forms and communicating between clinic, pharmacy, and patient. Errors here can lead to patients arriving for surgery on incorrect medications (e.g., not holding anticoagulants as instructed). Clear protocols, standardized forms, and

closed-loop communication (read-back of verbal orders) are essential (Dejos, 2021).

In the digital age, "transcription" has evolved into data transfer across health information systems. Interoperability failures—where the electronic health record (EHR) in the pre-op clinic does not communicate seamlessly with the OR or post-anaesthesia care unit (PACU) system—can lead to information gaps. Health services administration is directly responsible for investing in and managing integrated IT systems that support a seamless flow of accurate medication information (Wu et al., 2022). Figure 2 illustrates the complete medication-use pathway for surgical patients, highlighting the sequential stages of prescribing, transcription and verification, pharmacy dispensing, administration, patient monitoring, and post-operative evaluation.

Figure 2. Stages of Medication Safety in the Surgical Patient: From Prescription to Post-Operative Care

Dispensing and Preparation

Once an order is verified by the pharmacy (a critical checkpoint), the medication enters the preparation phase. In the OR, this is often done by the anaesthetist or anaesthesia assistant, drawing drugs from ampoules into unlabelled syringes—a known high-risk practice. The implementation of standardised drug trays, prefilled syringes, and bar-code-assisted syringe labelling systems has shown promise in reducing errors (Merry et al., 2021). In dental surgery, the dental assistant may be responsible for preparing local anaesthetics or antibiotics, requiring strict adherence to sterile technique and correct labelling (Urman et al., 2021).

For forward-based medications, nurses perform the final check before administration. Technologies like automated dispensing cabinets (ADCs) and, more powerfully, barcode medication administration (BCMA) are key (Villemure et al., 2019). BCMA requires nurses to scan the patient's wristband and the medication barcode before administration, electronically verifying the "five rights." While highly effective, its success depends on integration into workflow, hardware reliability, and a supportive culture that addresses workarounds (e.g., scanning barcodes on paper charts instead of the patient) (Holden et al., 2020).

Administration and Monitoring

Administration is the point of no return. In the OR, anaesthetists administer potent, fast-acting drugs with narrow therapeutic indices. Safety relies on vigilance, standardised protocols (like the WHO Surgical Safety Checklist's sign-in and sign-out), and a culture where all team members—including nurses and scrub technicians—feel empowered to question a potential error (World Health Organization, 2021). The concept of the "sterile cockpit"—minimising non-essential conversation during critical phases—is borrowed from aviation to reduce distraction (Hellingel et al., 2019).

Post-operatively, administration and monitoring fall heavily on nursing and health assistants. The opioid epidemic has cast a sharp light on this phase. Monitoring for respiratory depression using validated tools like the Pasero Opioid-Induced Sedation Scale (POSS) and continuous pulse oximetry is now the standard of care for patients on patient-controlled analgesia (PCA) (Jungquist et al., 2020). Health assistants, often tasked with routine vital sign monitoring, must be trained to recognise and escalate signs of opioid-induced oversedation. Similarly, monitoring for bleeding in patients on therapeutic anticoagulation requires clear parameters and communication channels.

The Central Role of Health Services Administration and Safety Culture

Clinical interventions cannot succeed without the foundational support of strong health services administration (Sculli et al., 2022). Leadership must create the framework for safety through policy, resource allocation, and culture shaping. Key administrative actions include: mandating the use of evidence-based safety technologies (CPOE, BCMA), funding interdisciplinary simulation training, establishing a non-punitive error reporting system, and analysing reported events through a robust root cause analysis (RCA) process (Tawfik et al., 2023).

Culture is the mediator between policy and practice (Harolds, 2022; Foslien-Nash & Reed, 2020). A culture of safety is characterised by psychological safety, where any team member can speak up about concerns without fear of reprisal; a just culture, which fairly distinguishes between human error, at-risk behavior, and reckless conduct; and a learning culture, where errors are investigated systemically rather than individually (Singer & Vogus, 2013). For the medical secretary who spots an ambiguous order, the dental assistant who questions a drug label, or the health assistant who is worried about a patient's respirations, psychological safety is the enabling condition for intercepting errors (Mrusek et al., 2020).

Table 2: Interdisciplinary Strategies for Enhancing Medication Safety in Surgical Care

Strategy	Description	Key Disciplines Engaged	Supporting Evidence
Enhanced CPOE with Specialty-Specific CDS	Implementing order entry systems with built-in checks, guidelines, and procedure-specific order sets.	Admin, Surgeons, Residents, Pharmacy	Bates & Singh, 2018; Micheels et al., 2022
Standardised Handoff Protocols (e.g., SBAR)	Using structured communication tools (Situation-Background-Assessment-Recommendation) during care transitions.	Nursing, Residents, Surgeons, Assistants	Dejos, 2021; Müller et al., 2018
Bar-Code Medication Administration (BCMA)	Scanning patient and drug barcodes at bedside to verify the "five rights" before administration.	Admin, Nursing, IT	Holden et al., 2020
Anaesthesia Medication Safety Standards	Use of prefilled syringes, standardised labelling, and checklists for high-alert medications.	Admin, Anaesthetists, Surgeons, Nurses	Merry et al., 2021
Interdisciplinary Simulation Training	Team-based simulations of error scenarios (e.g., anaphylaxis, wrong drug) to practice communication and response.	All Disciplines (Nursing, Medicine, Assistants)	Gjeraa et al., 2016
Robust Medication Reconciliation	A formal process of verifying the patient's complete medication list at every transition point.	Pharmacy, Nursing, Residents, Medical Secretaries	Barnsteiner, 2008
Cultivation of a Just Culture	Organizational policy and leadership modeling that encourages reporting and focuses on system learning.	Admin, All Clinical Staff	Sculli et al., 2022; Singer & Vogus, 2013

Synthesis and Future Directions

This review elucidates that medication safety in the surgical pathway is not a series of independent actions but a tightly coupled system. An error is rarely the fault of a single individual; it is typically the result of a chain of latent conditions and active failures that traverses multiple professional domains (Ferreira & Souza, 2021). The evidence is clear: technological solutions like CPOE and BCMA are powerful but insufficient on their own. They must be embedded within a holistic framework that includes standardised processes (checklists, order sets), interdisciplinary education (simulation, CRM training), and a supportive culture and administration (Borycki et al., 2016).

Future directions must focus on deeper integration. First, the evolution of the EHR towards a truly intelligent, interoperable platform that provides a unified medication view across all settings—from the dental office to the OR to the surgical ward—is paramount (Harrison et al., 2007; Coiera et al., 2016). Second, the role of human factors engineering must be expanded, involving front-line staff (including medical secretaries and assistants) in the co-design of workflows and technologies to reduce cognitive burden and fit clinical reality (Russ et al., 2020). Third, research should continue to explore the specific vulnerabilities and safety models within dental-surgical practices and other outpatient procedural areas, which have historically received less attention than hospital-based surgery (Cresswell et al., 2021).

Ultimately, achieving safer medication use for surgical patients requires a paradigm shift from a focus on individual vigilance to a commitment to system resilience (Wildenbos et al., 2016). Every discipline reviewed—from the epidemiologist tracking error rates to the administrator funding new technology, to the resident writing the order, to the secretary transmitting it, to the nurse and assistant administering and monitoring—holds a piece of the safety puzzle. Only through deliberate, collaborative effort to connect these pieces can a truly robust defence against medication errors be constructed.

Conclusion

Medication safety in the surgical patient is a quintessential interdisciplinary challenge. This review has traced the perilous journey of a medication order, highlighting how risks manifest and can be mitigated at each stage through the concerted action of a diverse team. The convergence of fields such as nursing, surgery, health administration, and the various assisting professions is not incidental but essential. Sustainable improvement will come not from targeting any single link in the chain, but from strengthening the entire system—its technology, its processes, its people, and, most importantly, the culture that binds them together in a shared mission of safety. As healthcare grows more complex, this integrated, system-wide perspective is the only path forward to reliably protect patients from harm.

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