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Last Updated: Aug 25, 2025

Medication Errors and Intravenous Therapy: A Literature Review

Introduction

Medication-administration errors and complications associated with intravenous (IV) therapy remain significant causes of patient harm worldwide. DVI-Stat aims to address these issues by providing real-time monitoring of IV infusions and supporting safe medication delivery. This literature review summarises published evidence on the prevalence, causes and economic impact of medication errors, with emphasis on perioperative settings and the Canadian context.

Definition of medication error

Medication errors encompass a wide range of mistakes throughout the medication-use process.
The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) defines a medication error as **any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of a healthcare professional, patient or consumer** (NCC MERP, n.d.). This broad definition includes errors in prescribing, dispensing, preparing, administering or monitoring medications and underscores that most errors arise from system failures rather than individual negligence.

Global burden of medication errors

A systematic review of anesthetic medication errors concluded that **9.2 % of hospitalised patients experience at least one adverse event**, and more than **one-third of adverse drug events are due to medication errors** (Maximous *et al.*, 2021). Self-reported rates of anesthesia medication errors range from **0.11 % to 0.75 % of anesthetics**, but direct observation studies find higher rates, up to **0.75 %** (Maximous *et al.*, 2021).

The **United Kingdom's National Health Service** estimates that **237 million medication errors occur annually**, and **66 million cause clinically significant harm** (Park *et al.*, 2023). In the United States, the **Food and Drug Administration** receives more than **100 000 reports of suspected medication errors each year** (Park *et al.*, 2023). Medication errors are implicated in **40 000–98 000 deaths annually** and account for **6–12 % of hospital admissions** in the U.S. (Park *et al.*, 2023). Globally, the **World Health Organization** estimates the cost of medication errors at **US$42 billion** (WHO, 2022).

Perioperative and anesthesia settings

Medication errors are particularly prevalent in perioperative environments. The **Institute for Safe Medication Practices (ISMP)** notes that harmful medication errors cause **at least one death every day** and injure **1.3 million people annually** (ISMP, 2022). Observational studies detect errors in roughly **half of surgical procedures**, whereas self-reporting captures only **one**

error per 1 285 procedures (ISMP, 2022). Errors occur in at least **1 in every 133 doses administered during anesthesia**, resulting in approximately **787 218 perioperative medication errors each year** in the United States (ISMP, 2022). The annual financial burden of these errors to U.S. hospitals is estimated at **US$5.6 million** (ISMP, 2022).

Pediatric anesthesia

In pediatric anesthesia, error rates are substantial. An APSF newsletter reported self-reported error incidences between **0.01 % and 1.92 %** of anesthetics (Lu-Boettcher & Koka, 2024). Observational data from the Wake Up Safe collaborative showed that most errors occur during the **administration phase**, particularly wrong-dose errors and syringe swaps (Lu-Boettcher & Koka, 2024). Remarkably, **97 % of reported errors were deemed preventable** (Lu-Boettcher & Koka, 2024). Implementation of an **Anesthesia Medication Template** and **pre-filled syringes** reduced dosing errors from **10.4 to 2.4 per 100 administrations** and decreased errors reaching patients from **1.24 to 0.65 per 1 000 anesthetics** (Lu-Boettcher
& Koka, 2024).

Wrong drug / wrong route errors

Wrong-route errors can have catastrophic consequences. Lefebvre *et al.* (2024) described repeated incidents where **tranexamic acid was injected intrathecally instead of bupivacaine**, with a **mortality rate around 50 %**. Six such cases were reported over four years, often due to **look-alike vials** and failure to double-check medications.

Chart-review studies

Retrospective chart reviews reveal far higher error rates than self-reported data. Wolf *et al.* (2022) reviewed 145 anesthesia cases at University of Kentucky HealthCare and found that **98.6 % of cases included at least one medication error**, and **93.7 % involved a high-alert medication**. Drug wastage amounted to **US$3 154 over two months**, extrapolating to **US$107 237 per year**.

Common causes and interventions

Common causes of perioperative medication errors include high-workload environments, lack of redundancy (anaesthesiologists prescribe, dispense and administer drugs alone), look-alike medications and poor standardisation (Wolf *et al.*, 2022; Lu-Boettcher & Koka, 2024). Evidence-based interventions fall into three categories:

1. **Multimodal strategies** – combining labelling, pre-filled syringes and process standardisation – reduce error rates by **21–35 % per administration** (Maximous *et al.*, 2021).
2. **Improved labelling** – implementing legible, colour-coded labels reduced errors by **37 % per anesthetic** (Maximous *et al.*, 2021).
3. **Technology and workflow redesign** – barcode medication administration, decision-support systems, smart pumps and integration of pharmacists into the OR team are recommended by ISMP (ISMP, 2022). These measures align closely with the capabilities envisioned for DVI-Stat.

Operating room environment and medication errors

Administration of medications in the operating room is complex. Many safety mechanisms—such as pharmacy validation, computerized orders and independent double checks—that are routine on inpatient wards are often infeasible during surgery because of urgency, lack of electronic records and the solitary nature of anaesthesia practice. Medication verification therefore relies heavily on individual vigilance, and the perioperative environment is uniquely susceptible to errors.

A landmark prospective observational study at Massachusetts General Hospital underscored this vulnerability. Nanji *et al.* (2016) observed **277 surgical procedures** and recorded **3 671 medication administrations**. They identified a medication error or adverse drug event in **5.3 % of administrations**; **79.3 % of the errors were deemed preventable**, and **one-third resulted in observable patient harm** (Nanji *et al.*, 2016). The investigators noted that the most common errors involved labelling and wrong dose or medication, and that errors occurred in virtually every operation studied. These findings highlight the importance of system-level interventions to reduce perioperative errors.

Merry *et al.* (2011) reported an average of **11.6 errors per 100 administrations** using conventional methods and showed that scanning drug barcodes before administration reduced errors. Common error types include wrong-dose, omission and mislabelling errors and confusion between look-alike sound-alike (LASA) drugs; time pressure, interruptions and complex protocols contribute to these mistakes. Studies suggest that **LASA errors may account for up to 25 % of all reported medication errors** (Ciociano & Bagnasco, 2014).

Quebec data illustrate the burden of medication-related incidents. An exploratory analysis of the provincial incident registry found that medication incidents comprised **approximately 24.5–26.6 % of all reported incidents** between 2016 and 2021 (Maurin *et al.*, 2024), making them the second most frequent category after falls. A descriptive study at a mother–child university

hospital centre reported that **surgery (20 %), oncology (19 %) and pediatrics (16 %) accounted for most medication incidents**, with **incorrect dosing (21 %), infiltration/extravasation (19 %) and omissions (16 %)** being common causes (Maurin *et al.*, 2024). These errors have significant consequences. Intraoperative medication errors are estimated to cost **US$5.3 billion annually** in the United States—about **US$270 per operation**— (OpenAnesthesia, 2024). The **World Health Organization** estimates that **medication errors cost US$42 billion per year worldwide** (WHO, 2022).

In critical environments such as the operating room, urgent situations necessitate rapid action, leaving little opportunity for independent double-check processes. While guidelines call for independent double checks of high-alert medications, there is often no technology to deliver this without delaying urgent care, forcing clinicians to rely on self-verification. According to the National Coordinating Council for Medication Error Reporting and Prevention

(NCC MERP, n.d.), a medication error is **any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of a healthcare professional, patient or consumer**.

Effectiveness of barcode technology

Technological interventions can reduce errors. An analysis of barcode electronic medication administration (eMAR) systems found that implementation reduced **non-timing medication administration errors by 41.4 %**, reduced **potential adverse drug events by 50.8 %**, and eliminated transcription errors (Poon *et al.*, 2010). These findings highlight the potential of barcode technology to address some of the vulnerabilities described above.

Canadian context

The **Canadian Institute for Health Information (CIHI)** reported that **1 in 17 hospital stays in 2023–2024 (approximately 150 000 of 2.5 million) involved at least one harmful event**, and **47 % of these events were related to healthcare and medications** (CIHI, 2024). Although data from Quebec were not included, the figures underline the national burden of medication-related harm.

A study of Ontario's Assurance and Improvement in Medication Safety (AIMS) program estimated the **annual cost of medication errors in Canada at C$2.6 billion**, with additional losses due to reduced productivity (Ledlie *et al.*, 2022). During the program's first three years, **31 768 medication incidents and near misses** were reported across community pharmacies, illustrating how mandatory reporting can uncover a large volume of events (Ledlie *et al.*, 2022).

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