

Medication Errors in Intensive Care Units: A Narrative Review of Prevalence, Contributing Factors, and Consequences, with Evidence-Based Strategies for Safer Practice in India and Other Developing Healthcare Systems

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Abstract

Background: Medication errors (MEs) are among the most common preventable causes of patient harm in healthcare. Their frequency and severity are amplified in Intensive Care Units (ICUs) where patients are critically ill, receive complex and high-risk therapies, and are especially vulnerable to iatrogenic harm.

Objectives: This narrative review aims to synthesize the prevalence, unique contributing factors, and consequences of medication errors in ICU settings, with particular attention to India and other developing healthcare systems, and to outline evidence-based strategies for their prevention.

Methods: A narrative literature review was conducted using peer-reviewed articles, systematic reviews, and reports from recognized health authorities (including the World Health Organization) published mainly between 2008 and 2025. Sources addressing medication error prevalence, causes, and consequences in ICU and critical-care settings were prioritized, with supplementary sources on the broader Indian healthcare and economic context.

Results: Reported ICU medication error prevalence ranges widely, from approximately 1.32% to 31.7% of admissions in global reviews,¹ and from 8.1 to 2,344 per 1,000 patient-days,² reflecting differences in error definitions, detection methods, and reporting cultures across studies. Prescribing and transcription errors dominate in Indian ICUs,³ while administration errors involving intravenous and high-alert medications carry the greatest risk of harm. Errors arise from a complex interaction of workload and staffing pressures, incomplete standardization, communication breakdowns, technological limitations, knowledge gaps, and a persistent culture of blame that discourages reporting. Consequences extend beyond the patient to nurses' psychological well-being and to substantial healthcare-system costs, including prolonged ICU stay and increased treatment expenditure.

Conclusion: Medication errors remain a widespread, costly, and largely preventable threat to ICU patient safety, disproportionately underreported in India and other developing settings. A multi-pronged strategy combining standardized protocols, targeted technology, continuous education, non-punitive reporting systems, workforce well-being, and patient and family engagement is required to reduce this burden meaningfully.

Keywords: Medication Error, Intensive Care Units, Nursing Practice, Patient Safety, India, Error Prevention, Evidence-Based Practice

1. Background

1.1. Definition and Global Significance of Medication Errors

Medication errors (MEs) are among the most common preventable adverse events in healthcare, affecting patient outcomes and increasing healthcare costs worldwide. The US 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 under the control of a healthcare professional, patient, or consumer.⁴ MEs can occur at any stage of the medication-use process, from prescribing

through to administration and monitoring.

1.2. Economic and Public Health Burden: Global and Indian Context

The financial implications of MEs are substantial. Global costs are estimated at approximately US\$42 billion annually⁵, and in the United States alone, preventable medical errors are associated with over 200,000 deaths each year and healthcare costs of US\$20–45 billion, even when considering only hospital-acquired infections.⁶ In 2017, the World Health Organization (WHO) launched its Global Patient Safety Challenge, Medication Without Harm, formally recognizing MEs as a major public health

priority.⁵

India records up to 5.2 million medical errors annually, with medication-related harm contributing to roughly 10% of hospital admissions.⁷ Irrational medicine use compounds this burden: national estimates suggest that around 90% of medicines consumed in India are inessential or irrational, driving high out-of-pocket expenditure and household impoverishment.⁸ With over 50% of India's health expenditure financed out-of-pocket,⁹ medication errors add directly to this economic strain, compounding losses already projected from non-communicable diseases and mental disorders, and reflected in high compensation payouts for medical negligence, including a Supreme Court judgment awarding Rs. 11 crore (approximately US\$1.3 million) to a victim of medical negligence.¹⁰

In the wider Asian context, a multicenter study in Malaysian neonatal ICUs estimated the potential economic impact of medication administration errors at approximately US\$27,452 in aggregate, with moderately severe errors costing an average of US\$14.04 each.¹¹ Standardized national data on the direct economic cost of medication errors in India and other Asian countries remain limited by underreporting and inconsistent methodology, but the available evidence indicates that the financial burden is substantial and contributes meaningfully to healthcare costs, patient impoverishment, and broader economic loss.¹²

1.3. Why Intensive Care Units Are Especially Vulnerable

ICUs are particularly vulnerable to medication errors due to the complexity of patient conditions, the frequency of treatment modifications, and the sheer volume of medications administered.^{13,14} Critically ill patients often undergo polypharmacy and necessitate parenteral administration, requiring precise dosage calculation and continuous monitoring.¹⁵ Nurses, as frontline caregivers, play a central role in medication safety since drug administration is one of their most frequent clinical interventions; errors at this stage can prolong hospitalization, increase treatment costs, and lead to severe complications.¹⁶

2. Objectives

This narrative review aims to (i) describe the prevalence and types of medication errors reported in ICU settings globally, with particular attention to India and other developing healthcare systems; (ii) examine the human, systemic, and technological factors that contribute to these errors; (iii) characterize their consequences for patients, nursing staff, and healthcare systems; and (iv) synthesize evidence-based strategies to prevent and mitigate medication errors in critical care, to inform nursing practice and policy in resource-constrained ICU settings.

3. Methods

This is a narrative review rather than a systematic review or meta-analysis. Relevant peer-reviewed literature, systematic reviews, and institutional reports (including WHO publications) were identified through targeted searches of PubMed, Scopus, and Google Scholar, using combinations of the terms "medication error," "intensive care unit," "critical care," "nursing," "India," and "patient safety," supplemented by manual screening of reference lists of key articles. Sources published mainly between 2008 and 2025 were included; older or foundational sources were retained where they remained the most relevant available evidence. Given the narrative design, no formal risk-of-bias assessment or quantitative pooling of results was performed; findings are synthesized thematically.

4. Results

4.1. Prevalence and Types of Medication Errors in ICUs

Medication errors account for a disproportionate share of medical errors in ICUs relative to general wards- as high as 78% of medical errors compared with 28% on general wards in one Indian analysis.¹⁷ Reported prevalence and incidence vary considerably across studies owing to heterogeneous definitions and methodologies, but they consistently point to a high burden: rates range from 1.32% to 31.7% of ICU admissions globally,¹ with some studies reporting rates as high as 8.1 to 2,344 errors per 1,000 patient-days.² In India, a prospective observational study in a tertiary-care critical care unit found an incidence of 6.11% (410 errors among 6,705 charts reviewed) over six months,¹⁷ while pediatric and neonatal ICUs in India have reported markedly higher error frequencies of 41.7% and 76.6%, respectively.

Errors can occur at any stage of the medication-use process-prescribing, transcribing, dispensing, preparation, administration, and monitoring. Prescribing errors are the most frequently identified type in ICUs, reported at 129.1 per 1,000 patient-observation-days and accounting for 40% of all identified errors in one Indian critical-care study,¹⁷ commonly arising from incorrect drug selection, dosage, or frequency, as well as incomplete prescriptions (58.5%), or illegible handwriting (18.3%).³

Transcription errors are particularly prevalent in Indian ICU settings. In some units, the single most frequent error type, accounting for 44.1% of total errors, most often due to incomplete prescriptions (60.7%), highlights a critical vulnerability in the transfer of information from physician orders to patient charts.³

Administration errors - incorrect dosing, wrong timing, wrong route, omitted doses, or administration of an unordered drug - constituted 14% of all errors in an Indian critical-care study, primarily driven by wrong-dose administration (62%) and omission errors (22.4%).³ Intravenous medications carry the highest observed error

rate of any route, owing to their rapid onset of action and direct systemic delivery.¹⁷

Documentation errors are also common, often linked to insufficient time for accurate record-keeping in the fast-paced ICU environment.¹⁸ Dispensing errors are comparatively less frequent but still occur, particularly with high-alert medications (HAMs) such as sedatives, anticoagulants, vasopressors, potassium chloride, tramadol, aspirin, insulin, and metoprolol, which carry a narrow therapeutic index and a high potential for severe harm.¹⁹ Antibiotics are the drug class most frequently implicated in errors in Indian ICUs (19.75%), with underdosing of broad-spectrum agents a particular concern given its contribution to antimicrobial resistance; antihypertensive agents (11.21%) and analgesics (9.75%) are also commonly implicated.¹ Pediatric and neonatal ICU patients are especially susceptible because of weight-based dosing complexity and physiological immaturity.²⁰

4.2. Explaining the Wide Variation in Reported Prevalence (1.32%–31.7%)

The tenfold-to-thirtyfold spread in reported ICU medication error rates does not necessarily reflect real differences in underlying safety and largely reflects methodological heterogeneity across studies. Four factors principally drive this variation. First, the denominator and unit of measurement differ: some studies express prevalence as a percentage of medication orders or charts

reviewed, others as errors per 1,000 patient-days, and others as the proportion of patients affected, making rates numerically incomparable.² Second, the detection method differs: direct observation of drug preparation and administration consistently identifies far more errors than voluntary self-report or retrospective chart review because most errors are never spontaneously reported.¹⁷ Third, the definition of what counts as an error varies: some studies include only errors reaching the patient, while others also capture near misses and errors intercepted before administration - in one Indian study, 87.1% of identified errors were intercepted before reaching the patient.²¹ Fourth, case-mix and setting differ: neonatal and pediatric ICUs, which require weight-based dosing, report substantially higher rates than general adult ICUs, and units with more complex, high-acuity patients and higher medication volumes generate proportionately more opportunities for error.²⁰ Underreporting driven by a prevailing culture of blame further widens the gap between true and documented error rates in many developing-country settings, including India.²²

4.3. Summary of Key Studies

Table 1 summarizes key studies referenced in this review that report the prevalence, design, and predominant error type for medication errors in ICU and critical-care settings, illustrating the range of methodologies underlying the prevalence estimates discussed above.

Table 1. Prevalence, Design, and Predominant Error Type in Key ICU Medication Error Studies

Author (Year)	Country	Study Design	ICU Type	Prevalence / Incidence of MEs	Most Common Error Type
Mohan et al. (2019)	India	Prospective observational	Adult tertiary-care ICU	6.11% (410/6,705 charts)	Prescribing (40%)
Seta et al. (2020)	India	Prospective observational	Adult critical care unit	Transcription errors 44.1% of total errors	Transcription (incomplete prescriptions)
Juneja & Mishra (2022)	India	Prospective observational	Adult ICU	87.1% intercepted before reaching the patient	Prescription errors
Aradhya et al. (2023)	India	Prospective, pharmacist-led	Adult ICU	High-alert medication incidents (proportion not pooled)	High-alert medication errors
Kwiecień-Jaguś et al. (2025)	Global (systematic review)	Systematic review	Adult ICU / operating room	1.32%–31.7% of admissions	Varies by stage; antibiotics most implicated drug class
Wilmer et al. (2010)	Global (systematic review)	Systematic review	Adult ICU	8.1–2,344 per 1,000 patient-days	Administration errors
Alshammari et al. (2021)	Saudi Arabia	Multiregional survey	Mixed hospital / critical care	Self-reported concept and reporting variation	Administration & reporting-practice gaps
Henry Basil et al. (2024)	Malaysia	Multicenter direct observation	Neonatal ICU	Economic impact ~US\$27,452 (aggregate); ~US\$14.04/error (moderate severity)	Administration errors

4.4. Causes of Medication Errors in Intensive Care Units

Medication errors in ICUs stem from a complex interplay of human, systemic, and technological factors, often exacerbated by the high-pressure critical-care environment.

4.4.1. Workload and Staffing Issues

Intense workload, persistent time pressure, and high nurse-to-patient ratios are major contributors to errors. Managing multiple devices and responding to frequent

alarms can overwhelm staff, increasing cognitive overload,^{23,24} and fast-paced emergency care can lead to missed safety steps such as dose verification or patient-identity confirmation.²³ Understaffing compounds this, diminishing capacity for meticulous medication checks;²⁵ in one recent survey, 58% of nurses reported feeling pressured to compromise patient safety for the sake of efficiency, and 35% cited inadequate staffing.²³ The persistent global nursing shortage directly affects care quality by increasing workforce stress and fatigue.

4.4.2. Lack of Standardized Protocols

Despite the critical nature of ICU care, some units lack standardized protocols and resources for patient safety, or staff bypass existing checklists under high workloads, increasing variability and error risk.²⁵ Adherence to guidelines from bodies such as the American Nurses Association is important for embedding consistent medication safety practices.²⁶

4.4.3. Communication Barriers

The involvement of multiple specialists - physicians, nurses, and allied health professionals - in ICU care creates scope for communication lapses that threaten coordinated care.²⁷ Miscommunication is especially common during handovers or shift changes; incomplete updates on medication or patient status can cause delays or errors, with a substantial proportion of nurses citing poor doctor-nurse communication as a key contributor to medication errors.

4.4.4. Technological Limitations

Technologies such as computerized physician order entry (CPOE) and barcode medication administration (BCMA) reduce errors but are not foolproof in ICUs. Poor integration into clinical workflows can prompt workarounds under time pressure, and excessive alerts can cause "alert fatigue," leading clinicians to disregard critical warnings;²⁸ inadequate technical infrastructure can further limit their effectiveness.²⁹

4.4.5. Knowledge Gaps

Insufficient knowledge of medication error prevention and of pharmacology specific to critically ill patients contribute to errors; ongoing education and simulation-based training are needed to reinforce safe practice. In one Indian study of nursing students, 64.5% demonstrated an inadequate knowledge of medication error prevention, highlighting a critical gap in foundational education.³⁰ Less-experienced nurses may have lower awareness of medication safety, repeat errors more often, and make less effort to reduce them.^{31,32}

4.4.6. Organizational Culture

A significant challenge in India is the pervasive

underreporting of medication errors, largely driven by fear of blame or reprimand. This "culture of blame," rather than a learning culture, obscures the true scope of the problem and hinders systematic learning from errors; nurses often perceive a medication error report as tantamount to a "letter of apology" or even a "criminal offence," which discourages voluntary reporting.²²

4.5. Impact of Medication Errors in Intensive Care Units

The consequences of medication errors in ICUs are particularly severe, given the fragility of patients and the complexity of their care.

4.5.1. Impact on Patients

Medication errors in ICUs can cause severe complications, including increased morbidity, prolonged hospital stay, and higher mortality, and are a leading cause of patient injury and death in hospital settings. A large meta-analysis of 81 studies found that approximately 1 in 30 patients is exposed to preventable medication harm, with more than a quarter of this harm classified as severe or life-threatening, and ICUs among the settings with the highest rates of preventable harm.

In an Indian critical-care study, while a high proportion of errors (87.1%) were intercepted before reaching the patient, 12.4% reached the patient but caused no immediate observable harm,²¹ suggesting a substantial rate of near-misses, while the potential for severe adverse events among the remainder stays high. Medication errors generally contribute to increased morbidity, mortality, and healthcare costs.

4.5.2. Impact on Nurses

Nurses in ICUs are significantly affected by MEs, often experiencing shame, embarrassment, and fear of appearing incompetent or being blamed.³³ This fear acts as a strong barrier to reporting, perpetuating a cycle of underreporting, and the associated emotional toll can compound existing stress and workload, contributing to burnout.³⁴ Nurses often perceive that administrative systems focus on individual culpability rather than systemic causes, further discouraging reporting.

4.5.3. Impact on the Healthcare System: ICU-Specific Consequences

Beyond the global US\$42 billion annual cost noted above (Section 1.2), the consequences for ICUs specifically are best understood through their effect on length of stay, morbidity, and resource use rather than through the aggregate global figure alone. ICU-acquired medication errors are associated with prolonged ICU and hospital stay, additional diagnostic and therapeutic interventions to manage resulting complications, and increased consumption of already scarce critical-care beds and staff

time.¹² Adverse drug events arising from ICU medication errors have been linked to greater use of blood products, additional laboratory monitoring, and, in severe cases, escalation of organ support — each adding materially to the cost of an ICU admission beyond routine care.¹⁵ Beyond direct treatment costs, MEs generate legal liabilities and diminish satisfaction among patients, families, and staff, contributing to a broader loss of trust in the healthcare delivery system.¹² The prevailing blame-oriented culture in many ICUs, particularly in India, further impedes systematic efforts to uncover and learn from errors, hindering quality improvement at the unit and institutional level.³⁵

5. Discussion

Taken together, the evidence indicates that medication errors in ICUs are common, multifactorial, and disproportionately costly given the acuity of the patients affected. The true burden—particularly in India and other developing healthcare systems—is likely understated because of inconsistent definitions and a persistent culture of blame that suppresses reporting. Addressing this burden requires a coordinated, multipronged approach spanning organizational protocols, technology, education, communication, culture, workforce well-being, and patient engagement.

5.1. Evidence-Based Strategies for Prevention

5.1.1. Standardized Protocols

Implementing uniform guidelines for prescribing, dispensing, and administering medications is essential in ICUs, including strict adherence to the "five rights" of medication administration (right patient, drug, dose, route, time) and clear protocols for patient identification. Standardized treatment guidelines, such as those advocated by the Indian Public Health Standards (IPHS), are pivotal for consistent medication-safety practice across diverse healthcare settings, particularly where complex critical-care protocols are common.

5.1.2. Technology Integration

Electronic health records (EHRs), barcode scanning, and automated dispensing systems can meaningfully reduce ICU medication errors. Computerized provider order entry (CPOE) standardizes orders, reduces handwriting errors, and provides decision support, and is highly effective for reducing error rates when combined with clinical decision support systems, especially in developing-country settings.³⁶ Barcode medication administration (BCMA) verifies the "five rights" through scanning, reducing administration errors and improving nursing satisfaction.²⁸ Smart infusion pumps mitigate risk associated with intravenous medications by preventing incorrect rates or dosages.³⁷ EHRs enable real-time access to patient information, reduce errors, and

streamline documentation and team communication.³⁸ Artificial intelligence and predictive analytics are increasingly used to support diagnostics, process clinical data, and flag patients at risk, potentially enabling faster identification of unsafe prescribing patterns.³⁹ Clinical mobility tools - handheld computers, tablets, and smartphones - support real-time data sharing and more efficient workflows in dynamic ICU environments.³⁸

5.1.3. Continuous Education and Training

Regular workshops and simulation-based training for ICU nurses are vital to build competency and close knowledge gaps. Simulation with lifelike mannequins and attention to human factors meaningfully reduces medication error risk among prescribers, nurses, and pharmacy staff by providing a safe environment to rehearse high-stakes scenarios.⁴⁰ Nurses should also be proficient in medication history-taking and reconciliation at transitions of care, to identify allergies, adverse reactions, and drug interactions, with education aligned to clinical career stage.⁴¹

5.1.4. Improved Communication and Interdisciplinary Collaboration

Structured handover processes and interdisciplinary collaboration are essential to prevent misunderstandings and clarify roles in the complex ICU environment.⁴² Open dialogue among nurses, physicians, pharmacists, and support staff is paramount, particularly during shift changes, to ensure continuity of care.⁴³ Involving clinical pharmacists in ICU rounds is particularly effective in preventing adverse drug events and provides a crucial checkpoint at each stage of the medication process.⁴⁴

5.1.5. Error Reporting Systems and Culture of Safety

Establishing non-punitive reporting mechanisms is critical to proactively identify and address ICU errors.⁴⁵ Reporting systems should be user-friendly, accessible, and protect anonymity, and feedback on the results of error analysis should be routinely provided to those who report.

5.1.6. Workforce Development and Wellbeing

Addressing chronic understaffing, excessive workload, and burnout among nurses is critical for medication safety in ICUs.⁴⁶ This requires greater investment in nursing education and training, competitive compensation, improved staff-to-patient ratios, and mental health support to build a resilient critical-care workforce.⁴⁷ Limiting mandatory overtime and offering wellness programs and peer-support groups can further reduce burnout risk.⁴⁸

5.1.7. Patient and Family Engagement

Engaging patients and families as active partners in

medication management is a valuable, often underused, safety strategy, even where ICU patient communication is limited.⁴⁹ Ensuring families understand medications, side effects, and adherence requirements is important, with nurses acting as educators and families empowered to ask questions, voice concerns, and take part in collaborative treatment planning.⁵⁰ Accessible channels for patients and families to report concerns provide an additional layer of defence and valuable feedback for system improvement.⁵¹

Research Highlights

What Is Already Known?

- Medication errors are a leading cause of preventable patient harm, with a global economic burden of approximately US\$42 billion annually.
- ICUs report a disproportionately high share of medication errors compared with general wards, driven by patient complexity, polypharmacy, and high medication volumes.
- Underreporting, driven by a culture of blame, is a recognized barrier to understanding the true scale of medication errors in India and other developing healthcare systems.

What Does This Study Add?

- Medication errors are a leading cause of preventable patient harm, with a global economic burden of approximately US\$42 billion annually.
- This review consolidates and explains the wide (1.32% – 31.7%) variation in reported ICU medication error prevalence, attributing it to differences in denominators, detection methods, error definitions, and case-mix, rather than treating it as an unexplained inconsistency.
- It separates the global economic burden of medication errors from ICU-specific consequences (prolonged stay, escalated organ support, additional monitoring), which are often conflated in prior narrative reviews.
- It provides a structured summary table of key prevalence studies across India, Southeast Asia, the Middle East, and global systematic reviews, offering a single reference point for comparing study design and reported error rates.
- It identifies specific evidence-based, resource-sensitive strategies (protocol standardization, targeted technology, non-punitive reporting, workforce well-being, and family engagement) that are particularly relevant to India and other developing ICU settings.

5.2. Strengths and Limitations of This Review

This review draws on a broad base of ICU-specific and India-focused literature and explicitly addresses why reported prevalence estimates vary so widely, a source of confusion in much of the existing literature. As a narrative rather than systematic review, however, it did not apply formal inclusion/exclusion criteria, a standardized search protocol, or a quality-appraisal tool. The included studies are heterogeneous in design, setting, and outcome definition; the summary table (Table 1) should therefore be read as illustrative of the range of methodologies and rates reported, not as a pooled or directly comparable estimate. Comprehensive, standardized economic data specific to Indian ICUs remain scarce, and several

sources cited in earlier drafts of this manuscript could not be fully verified against primary bibliographic databases; these have been flagged for the authors to confirm before final publication.

6. Conclusion

Medication errors are a widespread and costly problem in global healthcare, and this burden is magnified in ICUs, where patient acuity and treatment complexity heighten risk. Despite broad recognition of the problem, its true extent is often underreported - particularly in India and other developing healthcare systems - because of inconsistent definitions and a prevailing culture of blame. Errors commonly arise at high-risk transitions of care and stem from a mix of systemic failings, human limitations, and barriers to effective technology use. A coordinated strategy combining standardized protocols, appropriately implemented technology, continuous education, open communication, non-punitive reporting, workforce well-being, and patient and family engagement offers the most realistic path to safer ICU medication practice.

Conflict of Interest Disclosures

The author declares no conflict of interest.

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