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Review Article

Medication Errors: A Review of Epidemiology, Causes, Consequences, and Prevention Strategies

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ABSTRACT

Medication errors remain one of the most common and preventable causes of harm in healthcare systems worldwide.1 It can occur at any stage of the medication use process — prescribing, transcribing, dispensing, administering, and monitoring — and range from clinically insignificant events to fatal outcomes. This review synthesizes current understanding of the definition and classification of medication errors, their epidemiology and burden on patients and health systems, contributing human and system factors, methods of detection and reporting, and evidence-based strategies for prevention. Special attention is given to the role of technology (e.g., computerized physician order entry, barcode medication administration, and clinical decision support), interprofessional collaboration, and a systems-based "just culture" approach to error reduction. The review concludes that sustainable reduction in medication errors requires a multifaceted approach combining technology, education, standardized processes, and organizational culture change rather than reliance on individual vigilance alone.

INTRODUCTION

Medication errors are an important and preventable patient-safety problem in India. They may occur at any point in the medication-use process, including prescribing, transcription, dispensing, administration, documentation, and monitoring. Indian hospital studies have demonstrated that medication errors are encountered in general medicine, critical care, emergency, surgical, and other inpatient settings. In a prospective study from a public teaching hospital in India, 103 of 304 patients (34%) experienced at least one prescribing error, with drug-drug interactions, incorrect dosing intervals, and dosing errors among the frequently identified problems. The study also found that the number of

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errors increased with patient age and the number of medicines prescribed.[44]

The Indian context presents several conditions that can increase medication-error risk, including polypharmacy, multiple comorbidities, high patient workload, documentation and communication gaps, frequent transitions of care, and variation in prescribing and medication-administration practices. A South Indian tertiary-care study involving 3,798 patients identified 557 medication errors, giving a prevalence of 14.6%; prescribing errors were the most common, followed by documentation, administration, and dispensing errors. Work overload, shift changes, and inadequate time for documentation were reported as important contributing factors.[45] More recent Indian evidence indicates that the problem is not restricted to individual hospitals and requires system-level approaches involving clinical pharmacy services, standardized medication processes, technology, staff education, and effective reporting systems. [46-48] This review therefore focuses on the epidemiology, causes, consequences, detection, and prevention of medication errors with particular relevance to Indian healthcare settings.

2. DEFINITIONS AND CLASSIFICATION

2.1 Definition

A medication error is generally defined as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer. This definition, adopted by the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP), distinguishes medication errors from adverse drug events (ADEs), which encompass all injuries related to drug use, whether or not they resulted from an error.[5,6]

2.2 Stages of the Medication-Use Process

Medication errors are commonly classified according to the stage of the medication-use cycle at which they occur:

1. Prescribing errors — incorrect drug selection, dose, route, frequency, or failure to account for allergies, interactions, or organ function.
2. Transcription errors — errors introduced when orders are transferred between systems or documents.
3. Dispensing errors — incorrect drug, dose, or formulation supplied by pharmacy
4. Administration errors — errors at the point of care, including wrong patient, wrong time, wrong route, or omitted doses.
5. Monitoring errors — failure to review therapy for effectiveness, toxicity, or the need for dose adjustment.

2.3 Severity Classification

The NCC MERP index categorizes errors by severity, from Category A (circumstances with the capacity to cause error) through Category I (an error that may have contributed to a patient's death).[5] This taxonomy is widely used in incident reporting systems to prioritize investigation and response.[7]

3. EPIDEMIOLOGY AND BURDEN

Evidence from Indian hospitals shows substantial variation in the reported frequency and incidence of medication errors, largely because studies differ in setting, population, definitions, denominators, and detection methods. A 2025 systematic literature review of 40 studies involving more than

3 lakh hospitalized patients in India reported a median medication-error incidence of 34.11% and an overall medication-error frequency of 26.74%. The review found that prescribing errors were the most frequently reported category (approximately 40%), followed by administration errors (31%), transcription errors (22%), and dispensing errors (11%). General medicine wards had a pooled medication-error frequency of about 39.61%, while ICU settings showed a frequency of about 36.53%.[46]

Indian hospital studies illustrate the variation between clinical settings. In a tertiary care critical-care unit in Pune, 410 medication errors were identified among 6,705 charts reviewed, corresponding to 6.11% of charts.[47]In another Indian tertiary-care study covering general medicine and surgery, medication errors were detected in 196 of 427 patients (45.9%); prescription errors accounted for 70.4% and administration errors for 29.6% of the identified errors.[48] A South Indian tertiary-care study reported a 14.6% prevalence and identified prescribing and documentation errors as the predominant types.[45] These findings indicate that reported rates cannot be interpreted as a single national estimate, but they consistently demonstrate a clinically important medication-safety burden in Indian hospitals. Most reported errors are of lower severity, but a proportion requires monitoring or intervention, and some may contribute to prolonged hospitalization or other patient harm.[46] The burden also extends to healthcare utilization through additional monitoring, treatment of preventable harm, longer hospital stays, and increased workload for healthcare professionals.

4. CONTRIBUTING FACTORS

Medication errors rarely result from a single cause; they typically arise from the interaction of multiple system and human factors, consistent with James Reason's "Swiss cheese" model of accident causation, in which weaknesses in successive layers of defense align to allow an error to reach the patient.[8]

4.1 Human Factors

- Fatigue, cognitive overload, and interruptions during high-risk tasks
- Inadequate knowledge of drug dosing, interactions, or contra indications,[28]
- Similar drug names (look-alike/sound-alike medications) and packaging,[35,37]
- Communication breakdowns between prescribers, pharmacists, and nursing staff,[26]

4.2 System Factors

- Illegible handwriting or ambiguous verbal orders
- Lack of standardized protocols for high-alert medications,[38]
- Inadequate staffing ratios and excessive workload,[19]
- Poorly designed electronic health record interfaces, which can generate alert fatigue from excessive pop-up warnings that are overridden in 49%–96% of instances,[32,33]
- Absence of double-check systems for high-risk drugs (e.g., insulin, anticoagulants, chemotherapy),[38]

4.3 Patient-Related Factors

- Multiple prescribers and pharmacies with fragmented records

- Low health literacy affecting self-administration

- Polypharmacy and complex regimens, particularly in elderly patients, in whom polypharmacy is associated with a substantially increased risk of adverse drug-related events,[39-41]

5. DETECTION AND REPORTING

Because many medication errors are never reported through formal channels, true incidence is likely underestimated. Detection methods include:

- Voluntary incident reporting systems, which capture errors identified by staff but are limited by underreporting due to fear of blame

- Direct observation studies, considered a gold standard for administration errors but resource-intensive

- Chart review and trigger tools, which use specific clinical markers (e.g., naloxone administration, abnormal lab values) to flag potential adverse events

- Automated surveillance using electronic health record data and clinical decision support alerts

A just culture — one that distinguishes between human error, at-risk behavior, and reckless conduct — is increasingly recognized as essential to encouraging transparent reporting, since punitive responses to error discourage disclosure and obscure systemic vulnerabilities.[43]

6. CONSEQUENCES OF MEDICATION ERRORS

The consequences of medication errors range widely in severity:

- Clinical harm, including allergic reactions, toxicity, therapeutic failure, and in severe cases, death

- Psychological impact on both patients (loss of trust) and healthcare providers, who may experience significant distress after being involved in a serious error, a phenomenon termed the “second victim” effect that has been shown to affect emotional wellbeing and career trajectory.[29-31]

- Financial costs, including extended hospital stays, additional treatments, and litigation

- Institutional consequences, including regulatory scrutiny and reputational harm

7. PREVENTION STRATEGIES

Evidence supports a systems-based, multi-layered approach to reducing medication errors rather than reliance on individual vigilance alone.

7.1 Technology-Based Interventions

- Computerized Physician Order Entry (CPOE) with integrated clinical decision support reduces prescribing errors by flagging drug interactions, allergies, and dosing limits; early studies demonstrated reductions of more than 80% in non-missed-dose medication error rates and roughly a halving of serious medication errors following implementation,[9,10] and subsequent systematic reviews and large-scale evaluations have confirmed reductions in medication errors across hospital settings,[11-13] although CPOE can also introduce new, technology-facilitated error types if poorly designed or implemented.[14,15]

- Barcode Medication Administration (BCMA) verifies the "five rights" (right patient, drug, dose, route, time) at the bedside and has been shown in a large academic-hospital study to reduce medication administration errors by over 40% and potential adverse drug events substantially.[16]

- Automated dispensing cabinets reduce dispensing errors when paired with proper workflow design.

- Smart infusion pumps with dose-error reduction software ("guardrails") for high-alert intravenous medications help intercept programming errors before an infusion begins.[42]

7.2 Process and Policy Interventions

- Medication reconciliation at every transition of care (admission, transfer, discharge), which systematic review evidence supports as an effective patient-safety strategy for reducing discrepancy-related harm.[20]

- Standardized order sets and protocols for high-alert medications, such as those identified on the ISMP List of High-Alert Medications.[38]

- Independent double-checks for high-risk drug classes

- Tall-man lettering and packaging redesign to reduce confusion between look-alike/sound-alike drugs, an approach endorsed by the FDA and ISMP, though evidence for its standalone effectiveness remains mixed.[35-37]

7.3 Human and Organizational Interventions

- Pharmacist involvement in rounds and medication review has been associated with an almost threefold reduction in preventable adverse drug events caused by prescribing errors in intensive care settings, with physicians accepting the great majority of pharmacist recommendations,[17] a finding echoed in subsequent studies of pharmacist participation and clinical pharmacy staffing.[18,19]

- Structured communication tools (e.g., SBAR) to reduce handoff-related errors.

- Simulation-based training for high-risk procedures such as chemotherapy administration.

- Fatigue management policies, including limits on shift length for prescribers and nurses.

- Non-punitive reporting systems that support a just culture and continuous learning.[43]

- Direct observation studies of nurse-administered medications have found that doses are given differently than ordered in a meaningful proportion of administrations, underscoring administration as a particularly error-prone stage of the medication-use process.[24,25]Pediatric patients represent a further high-risk population: children may experience medication error rates comparable to or higher than adults, and tenfold dosing errors are a recognized, if underappreciated, iatrogenic risk in this population.[21-23]

7.4 Patient Engagement

- Encouraging patients to maintain updated medication lists and ask questions about new prescriptions.

- Patient-facing tools such as plain-language medication instructions and teach-back methods during discharge counseling.

8. DISCUSSION

Despite substantial investment in technology and process redesign, medication errors persist, partly because interventions targeting one stage of the medication-use process (e.g., prescribing) may not address vulnerabilities at other stages (e.g., administration). Furthermore, technology itself can introduce new error types — a phenomenon sometimes called "e-iatrogenesis" — when poorly designed systems generate alert fatigue or workflow disruptions that prompt workarounds. Future progress likely depends on human-centered design of health information systems, sustained interprofessional collaboration, and organizational cultures that treat error reporting as a learning opportunity rather than a disciplinary matter.

9. CONCLUSION

Medication errors are a persistent, largely preventable threat to patient safety across all healthcare settings. Their causes are multifactorial, spanning human, system, and patient-related domains, and no single intervention is sufficient to eliminate them. A combination of technology-enabled safeguards, standardized clinical processes, robust interprofessional communication, and a non-punitive culture of transparent reporting offers the most promising path toward meaningfully reducing medication-related harm.

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