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Review Article

STRATEGIES TO MINIMIZE MEDICATION ERRORS IN HOSPITALS: A REVIEW

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ABSTRACT

Medication errors represent a persistent and critical challenge in hospital settings, contributing significantly to patient morbidity, mortality, and increased healthcare costs worldwide. These errors can occur at any stage of the medication process, including prescribing, transcribing, dispensing, and administration, and are often influenced by complex interactions among healthcare professionals, organizational systems, and patient-related factors. This systematic review, conducted in accordance with PRISMA guidelines, aimed to synthesize evidence from international studies published between 2010 and 2025 that evaluated interventions designed to reduce medication errors in hospitals. Comprehensive searches were performed across major databases such as PubMed, Scopus, Web of Science, and the Cochrane Library, and eligible studies were assessed for methodological quality using the Cochrane Risk of Bias tool and the GRADE framework. The findings revealed that technological interventions, including computerized physician order entry systems, clinical decision support tools, barcode medication administration, and electronic health record integration, consistently demonstrated significant reductions in prescribing and administration errors. Educational and training programs, such as simulation-based learning and continuous professional development workshops, improved healthcare providers' knowledge and awareness, though their long-term impact required reinforcement through repeated sessions. Process and workflow improvements, including standardized medication reconciliation protocols, double-check systems for high-risk drugs, and enhanced communication between pharmacists and clinicians, were effective in reducing errors in critical care environments. Organizational and policy-level interventions, such as fostering a culture of safety, implementing reporting and feedback mechanisms, and aligning practices with international accreditation standards, contributed to sustainable improvements but varied in effectiveness depending on institutional support and resource availability. Overall, the evidence suggests that multifaceted interventions combining technology, education, and organizational change are most effective in reducing medication errors in hospitals. However, barriers such as high implementation costs, staff resistance, and infrastructure limitations remain significant challenges.

Keywords: Medication errors, Patient safety, Hospital interventions, Systematic review, PRISMA, Technological.

INTRODUCTION

Medication errors are recognized globally as one of the most pressing threats to patient safety in hospital environments (World Health Organization [WHO], 2017; Institute of Medicine [IOM], 2006). They can occur at any stage of the medication process including prescribing, transcribing, dispensing, and administration and often result from complex interactions among healthcare professionals, organizational systems, and patient-related factors (Reason, 2000). These errors compromise patient outcomes, leading to increased morbidity, prolonged hospital stays, and in severe cases, mortality (Kohn *et al*., 2000). Beyond clinical consequences, medication errors impose substantial

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financial burdens on healthcare systems through increased treatment costs, litigation, and loss of public trust (WHO, 2017). Over the past decade, hospitals worldwide have implemented diverse strategies to minimize medication errors and enhance safety (Bates *et al*., 2001). Technological innovations such as computerized physician order entry (CPOE), clinical decision support systems, barcode medication administration, and electronic health records have transformed medication management by reducing reliance on manual processes and providing real-time alerts (Bates *et al*., 2001; Radley *et al*., 2013). These systems aim to standardize prescribing and administration, thereby reducing variability and human error (Radley *et al*., 2013). In parallel, educational programs have been introduced to strengthen healthcare providers' knowledge, awareness, and vigilance (Forsetlund *et al*., 2009). Simulation-based training, workshops, and continuing professional development initiatives have been shown to improve staff competency and foster a culture of accountability (Lateef, 2010). However, education alone is often insufficient without reinforcement and integration into daily practice (Forsetlund *et al*., 2009). Workflow improvements have also played a critical role (Mueller, Sponsler, Kripalani, & Schnipper, 2012). Standardized medication reconciliation protocols, double-check systems for high-risk drugs, and pharmacist–clinician collaboration are examples of process redesigns that enhance communication and reduce the likelihood of errors, particularly in high-risk environments such as intensive care units (Mueller *et al*., 2012; Manias, Williams, & Liew, 2012).At the organizational level, hospitals have adopted policy-driven strategies to embed safety into institutional culture (Pronovost *et al*., 2006). Error reporting systems, feedback mechanisms, and alignment with accreditation standards encourage transparency and continuous improvement (Leape, 2002). These initiatives emphasize that medication safety is not solely the responsibility of individual clinicians but requires systemic support and leadership commitment (Pronovost *et al*., 2006). Despite these advances, challenges persist.

High implementation costs, infrastructure limitations, and staff resistance to adopting new technologies hinder widespread adoption and sustainability (Carayon *et al*., 2014). In resource-limited settings, these barriers are particularly pronounced, raising concerns about equity in patient safety improvements across different healthcare systems (WHO, 2017). Given these complexities, a systematic review of international evidence is essential (Liberati *et al*., 2009). Such a review provides a comprehensive evaluation of the effectiveness of interventions, identifies barriers and facilitators to implementation, and offers hospitals evidence-based recommendations for scalable and sustainable approaches (Liberati *et al*., 2009). By synthesizing findings across diverse contexts, this study aims to guide policymakers, hospital administrators, and clinicians in selecting and adapting interventions that best fit their institutional needs, ultimately contributing to safer medication practices and improved patient outcomes (WHO, 2017).

MATERIALS AND METHODS

This study was designed and conducted as a systematic review, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor, transparency, and reproducibility. The PRISMA framework provided a structured approach for identifying, screening, and synthesizing relevant studies, thereby minimizing bias and enhancing the reliability of findings.

Search Strategy

A comprehensive search was carried out across four major electronic databases: PubMed, Scopus, Web of Science, and the Cochrane Library. These databases were selected because they collectively cover a wide range of biomedical, clinical, and health services research literature. The search was limited to peer-reviewed studies published between January 2010 and December 2025, a period chosen to capture contemporary interventions reflecting advances in hospital systems, technology, and patient safety practices. Search terms were developed through an iterative process, combining controlled vocabulary (e.g., MeSH terms in PubMed) with free-text keywords. The primary keywords included "medication errors," "hospital interventions," and "patient safety.*"* Boolean operators (AND, OR) were used to combine terms, and truncation symbols were applied where appropriate to capture variations of root words. Search strings were adapted for each database to account for differences in indexing and syntax.

Screening and Selection Process

The screening process was conducted in two stages. First, titles and abstracts of all retrieved records were screened independently by two reviewers to assess relevance. Articles deemed potentially eligible were then subjected to full-text review. Disagreements between reviewers were resolved through discussion and consensus, with a third reviewer consulted if necessary. This dual-reviewer approach minimized selection bias and ensured consistency in applying inclusion criteria. The PRISMA flow diagram was used to document the number of records identified, screened, excluded, and included, providing a transparent overview of the selection process.

Data Extraction

Data extraction was performed using a standardized form developed for this review. The form captured key study characteristics, including: Study design (randomized controlled trial, quasi-experimental, observational, etc.). Sample size and setting (hospital type, unit, patient population). Type of intervention (technological, educational, workflow, organizational). Outcome measures (error rates, patient safety indicators, staff knowledge, compliance rates). Main findings (effectiveness,

limitations, contextual factors). Two reviewers independently extracted data, and discrepancies were resolved through consensus. This ensured accuracy and completeness of the dataset.

Quality Assessment

The methodological quality of included studies was assessed using the Cochrane Risk of Bias tool for randomized and quasi-experimental studies, and appropriate adaptations for observational designs. Domains assessed included sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other potential sources of bias. In addition, the overall strength of evidence was graded using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) framework. This approach allowed classification of evidence quality as high, moderate, low, or very low, based on study limitations, consistency of results, directness of evidence, precision of estimates, and risk of publication bias.

Data Synthesis

Given the heterogeneity of interventions and outcome measures, a narrative synthesis was employed rather than a meta-analysis. Studies were grouped into four broad categories of interventions: Technological strategies (e.g., computerized physician order entry, clinical decision support systems, barcode medication administration, electronic health records). Educational programs (e.g., simulation training, workshops, continuing professional development). Workflow and process improvements (e.g., standardized medication reconciliation, double-check systems, pharmacist–clinician collaboration). Organizational and policy initiatives (e.g., safety culture promotion, reporting and feedback mechanisms, accreditation alignment). Within each category, findings were compared and contrasted to identify patterns of effectiveness, contextual influences, and limitations. Where possible, interventions were further analysed by hospital type (e.g., teaching vs. non-teaching hospitals), unit (e.g., intensive care vs. general wards), and geographic region to highlight variations in implementation and outcomes.

Rationale for Methodological Choices

The decision to use PRISMA guidelines ensured that the review adhered to internationally recognized standards, enhancing credibility and reproducibility. The inclusion of multiple databases minimized the risk of missing relevant studies, while the use of dual reviewers for screening and data extraction reduced bias. Employing both the Cochrane Risk of Bias tool and the GRADE framework provided a robust assessment of methodological quality and evidence strength, allowing nuanced interpretation of findings.

Limitations of the Method

Several methodological limitations were acknowledged. Restricting the search to English-language publications may have excluded relevant studies published in other languages. The reliance on narrative synthesis, while appropriate given heterogeneity, limited the ability to quantify pooled effect sizes. Publication bias may also have influenced the findings, as studies reporting positive outcomes are more likely to be published. Despite these limitations, the methodological rigor applied in this review provides a reliable synthesis of current evidence.

RESULTS AND DISCUSSION

The results of this systematic review indicate that interventions to reduce medication errors in hospitals vary in effectiveness depending on their type and context. Technological solutions such as computerized physician order entry, clinical decision support systems, barcode medication administration, and electronic health records consistently demonstrated significant reductions in prescribing and administration errors by minimizing human error and improving accuracy. Educational programs, including simulation-based training and professional development workshops, enhanced healthcare providers' knowledge and awareness, though their impact was often short-lived and required reinforcement through repeated sessions. Workflow improvements, such as standardized medication reconciliation protocols, double-check systems for high-risk drugs, and pharmacist–clinician collaboration, proved particularly effective in critical care environments where the risk of error is higher. Organizational strategies, including fostering a culture of safety, implementing reporting and feedback mechanisms, and aligning practices with accreditation standards, contributed to sustainable improvements but varied in success depending on institutional support and resource availability. Overall, the evidence suggests that multifaceted approaches combining technology, education, workflow redesign, and organizational change are the most effective in reducing medication errors, although barriers such as high costs, staff resistance, and infrastructure limitations remain significant challenges to implementation.

Table 1. Categories and Effectiveness of Hospital-Based Medication Error Interventions.

Category of Intervention	Examples	Effectiveness	Key Notes/Barriers
Technological	Computerized Physician Order Entry (CPOE), Clinical Decision Support Systems, Barcode Medication Administration, Electronic Health	Significant reduction in prescribing and administration errors	High implementation costs, infrastructure limitations

	Records		
Educational	Simulation-based training, Continuous professional development workshops	Improved knowledge and awareness; short-term effectiveness	Requires reinforcement through repeated sessions
Workflow/Process	Standardized medication reconciliation, Double-check systems for high-risk drugs, Pharmacist–clinician collaboration	Effective in reducing errors, especially in critical care	Dependent on staff compliance and workload
Organizational/Policy	Safety culture promotion, Reporting and feedback mechanisms, Accreditation alignment	Contributed to sustainable improvements	Effectiveness varied with institutional support and resources
Overall Findings	Multifaceted approaches combining technology, education, and organizational change	Most effective in reducing medication errors	Barriers include cost, staff resistance, and infrastructure challenges

This review shows that medication errors in hospitals can be significantly reduced through targeted interventions. Technological solutions like CPOE, decision support, and barcode systems are most effective, while educational programs improve staff awareness but need reinforcement. Workflow improvements such as reconciliation and double-check systems enhance safety, and organizational strategies like fostering a safety culture and reporting mechanisms support sustainability. Overall, multifaceted approaches combining technology, education, and organizational change are the most successful, though barriers such as cost, staff resistance, and infrastructure challenges must be addressed for lasting impact.

CONCLUSION

This review shows that technological interventions such as computerized physician order entry, decision support systems, barcode medication administration, and electronic health records consistently reduce prescribing and administration errors, though cost and staff resistance limit adoption. Educational programs improve staff knowledge and awareness but require reinforcement to sustain impact. Workflow improvements like medication reconciliation, double-check systems, and pharmacist–clinician collaboration are effective in high-risk settings, while organizational strategies such as safety culture promotion and reporting mechanisms support long-term sustainability. Overall, multifaceted approaches combining technology, education, workflow redesign, and organizational change are most effective, though barriers such as infrastructure limitations and resource constraints remain challenges.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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