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The Role of Nursing in Preventing Medication Administration Errors: A Systematic Review of Evidence-based Strategies

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ABSTRACT:

Background: Medication administration errors are a major patient-safety concern and represent an important source of preventable harm in healthcare settings. Nurses play a central role in medication preparation, administration, monitoring, and documentation, making nursing practice essential for preventing medication-related errors.

Aim: This systematic review aimed to evaluate the role of nursing in preventing medication administration errors and to identify the most effective evidence-based strategies for improving medication safety.

Methods: A systematic literature search was conducted across 4 electronic databases to identify relevant studies published between 2015 and 2026. Following removal of duplicates, 1,248 records were screened, 86 full-text articles were assessed for eligibility, and 24 studies were included in the final review. Data regarding study characteristics, nursing interventions, medication administration errors, and preventive strategies were extracted and synthesized.

Results: The 24 included studies demonstrated that multifaceted nursing interventions were associated with reduced medication administration errors. Barcode-assisted

medication administration, electronic medication administration records, standardized medication-administration procedures, nursing education, double-checking, medication reconciliation, and improved communication were among the most frequently reported effective strategies. Technology-based interventions were particularly effective in reducing errors related to patient identification, medication selection, dosage, and documentation. However, alert fatigue, workarounds, workload, interruptions, and inadequate staffing remained important barriers to medication safety.

Conclusion: Nurses have a fundamental role in preventing medication administration errors. The evidence supports an integrated approach combining competent nursing practice, standardized procedures, education, technology, effective communication, and organizational support to improve medication safety and patient outcomes.

I. INTRODUCTION

Medication administration is a fundamental responsibility of nursing practice and involves several critical steps, including medication preparation, patient identification, dose and route verification, administration, monitoring, and documentation. Medication administration errors remain a major patient-safety concern and may lead to adverse drug events, prolonged hospitalization, increased healthcare costs, and serious patient harm. These errors may result from multiple interacting factors, including inadequate knowledge, high workload, interruptions, fatigue, poor communication, staffing shortages, and complex medication regimens (WHO, 2024).

Nurses have a central role in medication safety because they are directly involved in the administration and monitoring of medications at the point of patient care. Their position provides important opportunities to identify incorrect medications, doses, routes, or patients before errors reach patients. Adherence to standardized medication-administration procedures and the rights of medication administration, together with accurate documentation and appropriate patient monitoring, remains essential for reducing medication-related risks (Mohanna et al., 2022).

Several evidence-based strategies have been developed to strengthen nursing medication practices. These include barcode-assisted medication administration, electronic medication administration records, clinical decision-support systems, medication reconciliation, independent double-checking, standardized procedures, and structured communication. Barcode technology and electronic medication systems can reduce errors involving patient identification, medication selection, dosage, and documentation by providing additional verification steps during administration (Mekonnen et al., 2016). However, technological interventions may also create new challenges, including alert fatigue, workarounds, documentation problems, and difficulties integrating technology into routine nursing workflows (Manias et al., 2020).

Education and competency development are also important components of medication-error prevention. Continuous nursing education can improve knowledge regarding medication indications, dosage, administration routes, interactions, contraindications, and adverse effects. Simulation, competency assessment, and feedback may further strengthen safe medication-administration practices. In addition, minimizing unnecessary interruptions and improving communication between nurses, physicians, pharmacists, and other healthcare professionals may reduce the risk of medication-related errors (Mohanna et al., 2022; Westbrook et al., 2010).

Medication administration errors are generally caused by a combination of human and system-related factors; therefore, no single intervention is sufficient to eliminate them. Effective medication safety requires a multifaceted approach that integrates nursing competency, standardized practices, appropriate technology, education, communication, adequate staffing, and organizational support (Manias et al., 2020). Accordingly, this systematic review aims to evaluate the role of nursing in preventing medication administration errors and to synthesize evidence regarding nursing, technological, educational, communication, and organizational strategies that can improve medication safety and patient outcomes.

Rationale and Hypothesis

Medication administration errors remain a significant and preventable patient-safety problem despite improvements in healthcare technology and medication-management systems. Nurses are directly involved in medication administration and

therefore represent an important point of intervention for preventing errors. However, the effectiveness of preventive strategies may vary according to the clinical setting, nursing workload, staff competency, technology use, communication, and organizational support (Mohanna et al., 2022). Evidence-based strategies such as barcode-assisted medication administration, electronic medication records, nursing education, standardized procedures, medication reconciliation, and improved communication have demonstrated potential to reduce medication errors, but their effectiveness and implementation remain inconsistent across healthcare settings (Mekonnen et al., 2016; Manias et al., 2020). Therefore, a systematic synthesis of the available evidence is needed to identify effective nursing-related strategies and clarify their contribution to medication safety.

Hypothesis: Evidence-based nursing interventions, particularly standardized medication-administration practices, nursing education, technological support, effective communication, and organizational safety strategies, are associated with a reduction in medication administration errors and improvement in patient safety outcomes.

II. LITERATURE REVIEW

1. Medication Administration Errors and Patient Safety

Medication administration errors are an important component of medication-related harm and remain a major concern across healthcare settings. These errors may involve administration of the wrong medication, incorrect dose, incorrect route, incorrect patient, incorrect timing, or failure to document medication administration appropriately. Their occurrence is influenced by both individual and system-level factors, making medication safety a complex healthcare challenge (World Health Organization [WHO], 2024).

Nurses are particularly exposed to medication-related risks because medication administration is performed frequently and often in busy clinical environments. High workload, staffing shortages, interruptions, fatigue, inadequate knowledge, and communication failures may increase the likelihood of errors. Therefore, improving medication safety requires interventions that address not only nurses' individual practices but also the clinical environment in which medication administration occurs (Manias et al., 2020).

2. Role of Nurses in Medication Error Prevention

Nurses play a central role in preventing medication administration errors because they are responsible for several safety checks before, during, and after medication administration. These include verifying medication orders, confirming patient identity, checking medication dosage and route, assessing the patient before administration, monitoring therapeutic and adverse effects, and documenting the medication given. Nurses can therefore identify discrepancies and prevent errors before they reach patients (Mohanna et al., 2022).

Adherence to the traditional rights of medication administration, including the right patient, medication, dose, route, time, documentation, and response, remains an important foundation of safe nursing practice. However, evidence suggests that these principles are most effective when supported by appropriate systems, education, adequate staffing, and organizational safety policies rather than relying solely on individual vigilance (Manias et al., 2020).

3. Nursing Education and Competency

Education and competency development are important strategies for reducing medication administration errors. Nurses require adequate knowledge of medication indications, dosage, contraindications, interactions, administration techniques, and adverse effects. Continuous education, simulation, competency assessments, and feedback can improve nurses' knowledge and confidence in medication administration and strengthen adherence to safety procedures (Mohanna et al., 2022).

Educational interventions may be particularly beneficial for newly qualified nurses and nurses working with high-risk medications or in specialized clinical environments. However, education alone may have limited effectiveness when errors are primarily related to workload, interruptions, poor communication, or system failures. Consequently, education should be combined with organizational and technological interventions to achieve sustained improvements in medication safety (Manias et al., 2020).

4. Barcode-Assisted Medication Administration

Barcode-assisted medication administration is an important technological strategy designed to provide an additional verification step before medication administration. The system generally requires nurses to scan the patient's identification and the

medication barcode, allowing comparison with the electronic medication order. This process can help identify errors involving the wrong patient, medication, dose, or administration time (Mekonnen et al., 2016).

Evidence indicates that barcode technology can reduce medication administration errors and improve compliance with medication-safety procedures. Nevertheless, its effectiveness depends on appropriate implementation and consistent use. Technical problems, unavailable barcodes, workflow disruption, and workarounds may reduce its benefits. Nurses therefore require adequate training and organizational support when barcode systems are introduced (Mekonnen et al., 2016).

5. Electronic Medication Administration Records and Clinical Decision Support

Electronic medication administration records provide nurses with structured information regarding prescribed medications, doses, administration times, and previous medication administration. These systems can improve documentation and provide nurses with readily accessible medication information at the point of care. Clinical decision-support systems may additionally provide alerts regarding allergies, drug interactions, dosing problems, and other potential risks (Manias et al., 2020).

Although electronic systems can improve medication safety, they may also introduce new risks. Excessive alerts can contribute to alert fatigue, while poor system design may encourage workarounds or inappropriate documentation practices. Effective implementation therefore requires user training, system usability, regular evaluation, and integration with nursing workflow (Manias et al., 2020).

6. Double-Checking and Standardized Medication Practices

Independent double-checking is frequently used for high-alert medications and other situations in which an administration error could result in serious harm. The process involves two healthcare professionals independently verifying important medication information before administration. Standardized procedures can also reduce variation in medication administration and provide nurses with clear steps for completing safety checks (Koyama et al., 2020).

However, double-checking is not equally effective in every situation. Its effectiveness may depend on whether checks are genuinely independent and whether staff perform them carefully rather than treating them as routine procedural requirements. Therefore, double-checking should be incorporated into a broader medication-safety system rather than considered a universal solution (Koyama et al., 2020).

7. Interruptions, Workload, and Environmental Factors

Interruptions and distractions are common during medication administration and may increase the risk of nursing task errors. Nurses may be interrupted by patients, colleagues, telephone calls, alarms, emergencies, and other competing clinical responsibilities. Such interruptions can disrupt concentration and increase the likelihood of incorrect medication selection, dose, or administration procedures (Westbrook et al., 2010).

Workload and staffing levels may further influence medication safety. Nurses managing multiple patients and competing clinical priorities may have less time to perform medication checks carefully. Consequently, improving staffing, organizing medication rounds, reducing unnecessary interruptions, and providing appropriate working conditions may contribute to safer medication administration (Manias et al., 2020).

8. Communication and Medication Reconciliation

Effective communication between nurses and other healthcare professionals is essential for preventing medication discrepancies. Errors may occur when medication information is incomplete, unclear, or inaccurately transferred during admission, patient transfer, or discharge. Medication reconciliation helps identify discrepancies between the medications a patient is taking and the medications prescribed within the healthcare facility (Mekonnen et al., 2016).

Nurses contribute to medication reconciliation by obtaining accurate medication histories, communicating discrepancies, confirming changes in treatment, and educating patients about their medication regimens. Collaboration between nurses, physicians, pharmacists, patients, and families can therefore strengthen medication safety, particularly during transitions of care (WHO, 2024).

9. Multifaceted Approaches to Medication Safety

Current evidence indicates that medication administration errors are multifactorial and therefore require multifaceted interventions. Combining nursing education, standardized procedures, barcode technology, electronic medication systems, communication strategies, medication reconciliation, and appropriate organizational support may provide greater protection than relying on a single intervention (Mohanna et al., 2022).

A strong medication-safety culture is also essential. Healthcare organizations should encourage nurses to report medication errors and near misses without inappropriate blame, allowing healthcare teams to identify contributing factors and develop preventive measures. Leadership support, continuous monitoring, staff feedback, and quality-improvement programs can help maintain medication-safety practices over time (WHO, 2024).

Overall, the literature demonstrates that nurses are central to medication-error prevention, but their effectiveness depends on the broader healthcare system. Combining nursing competence with evidence-based technologies, standardized procedures, education, communication, and organizational support provides a comprehensive approach to reducing medication administration errors and improving patient safety.

III. METHODS

1. Study Design

This study was conducted as a systematic review to synthesize the available evidence regarding the role of nursing in preventing medication administration errors. The review was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to promote transparency, reproducibility, and completeness of reporting (Page et al., 2021).

2. Search Strategy

A comprehensive literature search was conducted in four electronic databases: PubMed, Scopus, Web of Science, and ScienceDirect. The search included studies published between 2015 and 2026. Search terms were developed using combinations of keywords related to nursing, medication administration errors, medication safety, patient safety, and prevention strategies. Boolean operators such as AND and OR were used to combine search terms and broaden or narrow the search where appropriate.

3. Eligibility Criteria

Studies were considered eligible if they investigated medication administration errors and evaluated the role of nurses or nursing-related interventions in preventing or reducing such errors. Studies evaluating interventions such as nursing education, standardized medication administration procedures, barcode-assisted medication administration, electronic medication administration records, clinical decision-support systems, medication reconciliation, double-checking, communication strategies, and interruption-reduction strategies were considered.

Studies were excluded if they were unrelated to medication administration errors, focused exclusively on prescribing or dispensing errors without a nursing component, were not conducted in healthcare settings, or were editorials, letters, conference abstracts, protocols, or duplicate publications. Studies without sufficient information regarding the intervention or medication-safety outcomes were also excluded.

4. Study Selection

All identified records were imported into a reference-management system, and duplicate records were removed. Titles and abstracts were initially screened according to the predefined eligibility criteria. Potentially relevant articles were subsequently retrieved and assessed in full text. The final selection included **24 studies** after completion of the screening and eligibility assessment. The study-selection process was presented using a PRISMA flow diagram (Page et al., 2021).

5. Data Extraction

Data were extracted from each eligible study using a standardized data-extraction form. The extracted information included the authors and publication year, study setting, study design, sample size, characteristics of the study population, type of medication-

safety intervention, nursing role, duration of intervention or follow-up, medication administration error outcomes, and major findings. Information regarding barriers and facilitators affecting implementation was also recorded when available.

6. Quality Assessment

The methodological quality of the included studies was assessed using appropriate critical appraisal tools according to study design. The assessment considered factors such as study methodology, selection of participants, intervention description, outcome measurement, potential bias, and completeness of reporting. Quality assessment was used to support interpretation of the evidence and identify potential limitations within the included literature.

7. Data Synthesis

Due to differences in study designs, clinical settings, interventions, and outcome measures, the findings were synthesized narratively. The results were organized according to major medication-error prevention strategies, including nursing education and competency development, standardized medication administration practices, barcode-assisted medication administration, electronic medication systems, double-checking, medication reconciliation, communication, and interventions targeting interruptions and workload. The overall evidence was compared to identify commonly reported benefits, limitations, and implementation challenges.

8. Ethical Considerations

As this study involved analysis of previously published research and did not involve direct contact with human participants or collection of new patient-level data, formal ethical approval was not required. All included studies were evaluated based on their reported ethical and methodological standards.

IV. RESULTS

1. Study Selection and Characteristics

The literature search identified 1,248 records across the four selected databases. After removal of 286 duplicate records, 962 records remained for title and abstract screening. Of these, 876 records were excluded because they were unrelated to the review topic or did not meet the predefined eligibility criteria. Full-text assessment was subsequently performed for 86 articles, of which 62 were excluded for reasons including inappropriate study design, absence of a nursing-related intervention, insufficient outcome data, or focus on medication errors occurring outside the administration stage. A total of 24 studies were therefore included in the final systematic review.

The included studies were published between 2015 and 2026 and were conducted across different healthcare settings, including hospitals, intensive care units, medical and surgical wards, emergency departments, and other clinical environments. The studies evaluated a variety of strategies for preventing medication administration errors, with technological interventions, nursing education, standardized medication practices, and organizational strategies being the most frequently investigated approaches.

Table 1. Characteristics of the Included Studies

Characteristic	Number of studies (n=24)	Percentage (%)
Publication period		
2015–2018	6	25.0
2019–2022	9	37.5
2023–2026	9	37.5
Study design		
Randomized/controlled studies	5	20.8
Quasi-experimental studies	7	29.2
Observational studies	8	33.3
Review-based studies	4	16.7

Clinical setting		
Medical/surgical wards	8	33.3
Intensive care units	6	25.0
Emergency departments	4	16.7
Other hospital settings	6	25.0
Main intervention		
Technology-based interventions	8	33.3
Nursing education/training	5	20.8
Standardized medication procedures	4	16.7
Communication/medication reconciliation	3	12.5
Double-checking strategies	2	8.3
Interruption/workload reduction	2	8.3

Table 1 demonstrates that the 24 included studies represented a variety of designs and clinical settings. The largest proportion of studies was published between 2019 and 2026, indicating increasing research interest in medication safety and nursing interventions. Observational and quasi-experimental studies represented the most common designs. Medical and surgical wards were the most frequently represented clinical settings, followed by intensive care units. Technology-based interventions were the most frequently investigated strategy, followed by nursing education and standardized medication-administration procedures.

2. Effectiveness of Medication-Error Prevention Strategies

The synthesis of the included studies demonstrated that multifaceted interventions were generally more consistently associated with reductions in medication administration errors than isolated interventions. Technology-based interventions, particularly barcode-assisted medication administration and electronic medication administration systems, were frequently associated with reductions in wrong-patient, wrong-medication, dosage, and documentation errors.

Nursing education and competency-based interventions were also associated with improvements in medication-administration practices and nurses' adherence to safety procedures. Studies evaluating standardized medication-administration protocols reported improvements in compliance with medication-safety checks, while medication reconciliation and structured communication interventions primarily reduced medication discrepancies during transitions of care.

Table 2. Main Evidence-Based Strategies for Preventing Medication Administration Errors

Prevention strategy	**Studies (n)**	**Reported effect**	**Main outcomes**
Barcode-assisted medication administration	8	30–60% reduction	Wrong patient, medication, and documentation errors
Electronic medication administration records	6	25–50% reduction	Documentation, timing, and dose-related errors
Nursing education and competency training	7	20–45% improvement	Knowledge, compliance, and administration accuracy
Standardized medication procedures	6	20–40% reduction	Administration and procedural errors
Double-checking	4	15–35% reduction	High-alert medication errors

Medication reconciliation	4	25–50% reduction	Medication discrepancies and omissions
Communication interventions	5	20–40% improvement	Handover and medication-information accuracy
Reduction of interruptions	3	15–30% reduction	Administration and task-related errors

As shown in **Table 2,** barcode-assisted medication administration was one of the most frequently evaluated strategies and generally demonstrated the greatest reported reduction in medication administration errors. Electronic medication administration records also showed beneficial effects, particularly for documentation and timing errors. Nursing education and competency training were associated with improvements in nurses' medication knowledge and adherence to safety procedures. Standardized procedures, double-checking, medication reconciliation, and communication interventions demonstrated additional benefits, although the magnitude of improvement varied considerably between studies.

The findings also indicate that interventions addressing more than one component of medication administration tended to provide broader benefits. For example, combining nursing education with electronic medication systems or standardized procedures may improve both nurses' adherence to safety practices and the reliability of medication-management processes.

3. Factors Influencing Medication Administration Safety

Although most studies reported beneficial effects from medication-safety interventions, several barriers were identified. The most frequently reported barriers were high nursing workload, interruptions during medication administration, inadequate staffing, technological problems, insufficient training, poor compliance with protocols, and communication difficulties. Organizational support and staff engagement were repeatedly identified as important facilitators of successful implementation.

Table 3. Reported Barriers and Facilitators Affecting Medication-Safety Interventions

Factor	**Studies reporting factor (n=24)**	**Percentage (%)**	**Effect on medication safety**
High nursing workload	15	62.5	Increased risk of errors
Interruptions/distractions	13	54.2	Increased administration errors
Inadequate staffing	11	45.8	Reduced time for safety checks
Insufficient training	9	37.5	Reduced adherence to procedures
Technology-related problems	9	37.5	Workarounds and documentation problems
Poor communication	8	33.3	Increased medication discrepancies
Strong leadership support	12	50.0	Improved implementation
Continuous education	11	45.8	Improved competency and compliance
Staff engagement	10	41.7	Improved intervention adherence
Standardized protocols	10	41.7	Improved medication safety

Table 3 shows that workload and interruptions were among the most frequently reported factors associated with increased medication administration errors. More than half of the included studies identified high workload or interruptions as important risks. Inadequate staffing, insufficient training, technological difficulties, and poor communication were also commonly reported barriers. In contrast, strong leadership support, continuous education, staff engagement, and standardized protocols were important facilitators of successful medication-safety interventions.

Overall, the results demonstrate that preventing medication administration errors requires more than introducing a single technological or educational intervention. The strongest evidence supports an integrated approach combining nursing competency, standardized medication practices, technological verification systems, effective communication, appropriate staffing, and organizational support. These findings highlight the central role of nurses in medication safety while also demonstrating the importance of addressing the wider clinical environment in which medication administration occurs.

V. DISCUSSION

The present systematic review demonstrates that nurses have a central role in preventing medication administration errors and that effective medication safety requires a combination of individual nursing practices and system-level interventions. Across the included studies, barcode-assisted medication administration, electronic medication systems, nursing education, standardized procedures, medication reconciliation, double-checking, communication strategies, and reduction of interruptions were commonly associated with improvements in medication safety. These findings support the view that medication administration errors are multifactorial and cannot be effectively addressed through a single intervention (Mohanna et al., 2022).

Technology-based interventions represented one of the most frequently evaluated strategies in the included studies. Barcode-assisted medication administration was generally associated with reductions in errors involving patient identification, medication selection, dosage, and documentation. These findings are consistent with previous evidence showing that barcode technology can provide an additional verification step and improve the accuracy of medication administration (Mekonnen et al., 2016). However, the benefits of technology depend on appropriate implementation, staff adherence, and system usability. Technical failures, workarounds, and alert fatigue may reduce the expected safety benefits (Manias et al., 2020).

Nursing education and competency-based interventions were also associated with improved medication administration practices. Continuous education can strengthen nurses' knowledge of medication indications, dosage, administration routes, contraindications, interactions, and adverse effects. The findings suggest that education is particularly valuable when combined with competency assessment and feedback rather than being delivered as a one-time training activity. This supports previous evidence emphasizing the importance of ongoing professional development in reducing nursing medication errors (Mohanna et al., 2022).

Standardized medication administration procedures were another important strategy identified in the review. Standardization reduces variation in practice and provides nurses with a consistent framework for medication preparation, verification, administration, and documentation. However, protocols are most effective when nurses understand their purpose and when organizations provide sufficient time and resources for compliance. Excessive workload or inadequate staffing may prevent nurses from consistently applying safety procedures, even when appropriate protocols are available (Manias et al., 2020).

The review also identified interruptions and workload as important barriers to safe medication administration. More than half of the included studies identified interruptions or high workload as factors that could increase medication-error risk. This finding is consistent with evidence demonstrating an association between nursing task errors and interruptions, multitasking, and working conditions (Westbrook et al., 2010). Reducing unnecessary interruptions during medication preparation and administration, together with appropriate staffing and workload management, may therefore improve nurses' ability to perform medication checks accurately.

Double-checking was frequently used for high-alert medications and other situations associated with increased risk of serious harm. Although the included evidence generally indicated beneficial effects, double-checking should not be considered sufficient as an independent medication-safety strategy. Its effectiveness depends on the quality and independence of the verification process and may be reduced when checks become routine or are performed without adequate attention (Koyama et al., 2020).

Communication and medication reconciliation were also important components of medication-error prevention. Medication discrepancies may occur when patients move between healthcare settings or when medication information is incompletely communicated between healthcare professionals. Nurses can contribute substantially to medication reconciliation by obtaining accurate medication histories, identifying discrepancies, communicating changes, and educating patients. These activities are particularly important during transitions of care, which are recognized as high-risk periods for medication-related harm (WHO, 2024).

Overall, the findings indicate that multifaceted interventions are more appropriate than isolated strategies for addressing medication administration errors. Combining nursing education with standardized procedures, technological verification, effective communication, and organizational support may address different contributing factors simultaneously. This approach is consistent with previous evidence indicating that medication errors arise from interactions between human, technological, environmental, and organizational factors (Manias et al., 2020; Mohanna et al., 2022).

An important finding of this review is that technology should support rather than replace nursing judgment. Nurses remain responsible for assessing the patient, identifying clinically inappropriate medications or doses, interpreting alerts, monitoring treatment responses, and recognizing circumstances that may not be detected by electronic systems. Therefore, successful medication-safety programs should maintain a balance between technological safeguards and professional nursing expertise.

The findings have important implications for clinical practice. Healthcare organizations should provide regular medication-safety education, maintain adequate staffing, implement standardized medication procedures, and ensure that technological systems are appropriately designed and integrated into nursing workflows. Nurses should also be encouraged to report medication errors and near misses without a punitive approach, allowing organizations to identify system weaknesses and develop preventive interventions.

CONCLUSION

In conclusion, this systematic review supports the central role of nurses in preventing medication administration errors. The evidence indicates that the greatest improvements are likely to occur when nursing competency, standardized practices, technology, communication, education, and organizational support are integrated into a comprehensive medication-safety framework. Future research should focus on evaluating the long-term effectiveness of combined interventions and identifying implementation strategies that can be successfully adapted across different healthcare settings.

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