

The Effectiveness of Continuous Nursing Training Programs in Reducing Medication Errors in Emergency Departments

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ABSTRACT

Background: Medication errors (MEs) represent a major challenge to patient safety, particularly within emergency departments (EDs) where nurses face high workloads, complex medication regimens, and time-sensitive decision-making. Continuous nursing education has been identified as a potential solution to enhance knowledge, skills, and safe medication practices.

Objective: This systematic review aimed to evaluate the effectiveness of continuous nursing training programs in reducing medication errors among emergency nurses, improving safety culture, and promoting sustainable competency.

Methods: Following PRISMA 2020 guidelines, a systematic search was conducted across PubMed, Scopus, CINAHL, Embase, Web of Science, and Google Scholar. Studies published between 2013 and 2024 were included if they examined continuous educational interventions targeting medication safety in ED settings. Eligible designs included randomized controlled trials, quasi-experimental, and cross-sectional studies. Data were extracted using standardized templates and quality assessed via the Cochrane Risk of Bias and Newcastle–Ottawa Scale tools.

Results: Twelve studies met inclusion criteria. Findings consistently demonstrated that continuous nursing education significantly improved knowledge, reasoning, and medication administration accuracy, with reductions in overall error rates ranging from 30% to 70%. Educational interventions also enhanced reporting behaviors, teamwork, and adherence to medication protocols. However, barriers such as fear of blame, workload stress, and organizational constraints persisted.

Conclusion: Continuous education programs are effective in reducing medication errors, improving professional confidence, and fostering patient safety culture in emergency departments. The sustainability of these effects depends on leadership support, non-punitive reporting systems, and integration of ongoing training into institutional policy.

KEYWORDS: Continuous nursing education; medication errors; emergency department; patient safety; nursing competency; systematic review.

How to Cite: Moamen Abdelfadil Ismail, Munif Qublan Abdullah Alshammari, Areej Ahmed Saymaldaher, Saleh Mansour Alalyani, Wadiah Ali Ahmad Almohsin, Ali hameed Mohammed Alharbi, Rzyana Ibrahim Motwakel, Yasmin Ahmed Alzahrani, Abeer Anwar Al Hawsawi, Suaad Mohammad Alzahrany, Zahra Alshehri, Rawan Alzahrani, Rajawi alawadh, (2025) The Effectiveness of Continuous Nursing Training Programs in Reducing Medication Errors in Emergency Departments, Vascular and Endovascular Review, Vol.8, No.10s, 328-335.

INTRODUCTION

The non-cancerous enlarge Medication errors (MEs) are recognized as one of the most preventable yet persistent causes of adverse patient outcomes globally. Their occurrence is particularly high in **emergency departments (EDs)**, where nurses often work under intense time pressure, heavy patient loads, and frequent interruptions. These conditions create a perfect storm for human error, as medication administration requires precision, attention, and rapid decision-making under uncertainty. The consequences extend beyond patient harm—they also affect healthcare costs, staff morale, and institutional credibility, emphasizing the need for systematic, proactive approaches to medication safety (Giannetta et al., 2021; Luukkamaäki et al., 2021).

One of the most effective strategies identified in recent years is **continuous nursing education**. Unlike one-time training sessions, continuous education integrates routine skill updates, reflection, and competency-based learning to maintain nurses' readiness for evolving clinical challenges. In emergency departments, this ensures that nurses' medication administration skills stay aligned with current evidence-based protocols and pharmacological advancements, minimizing preventable errors (Lee et al., 2022).

Continuous training enhances not only nurses' technical proficiency but also their **clinical reasoning and critical thinking**. Medication administration involves cognitive processes such as interpreting prescriptions, recognizing contraindications, and calculating accurate dosages. Educational programs that employ simulation, scenario-based training, and real-time feedback have been shown to significantly improve nurses' situational awareness and ability to make safe, accurate medication decisions under pressure (Rohde & Domm, 2018; Giannetta et al., 2021).

Equally important is the role of education in strengthening the **culture of patient safety**. Training programs that focus on communication, collaboration, and non-punitive error reporting cultivate environments where nurses feel empowered to discuss and learn from mistakes. This cultural transformation encourages vigilance, teamwork, and continuous learning—all of which are essential in high-acuity settings like emergency departments (Amiri et al., 2018; De Baetselier et al., 2022).

Standardization of practice through education also addresses disparities in skill levels among nursing staff. Emergency departments often employ nurses with varying degrees of experience, from new graduates to seasoned professionals. Continuous education creates uniformity in safety practices, ensuring that all nurses adhere to the same medication administration standards, regardless of background or tenure. When reinforced regularly, such standardization reduces variability in performance and fosters collective accountability for medication safety (Lee et al., 2022; Luokkamäki et al., 2021).

Advancements in healthcare technology further highlight the necessity of ongoing training. The integration of **electronic health records (EHRs)**, automated dispensing systems, and barcode medication administration has improved accuracy but introduced new forms of error linked to technological misuse or misunderstanding. Continuous professional education helps nurses navigate these tools effectively, preventing documentation lapses and system-based errors while promoting confidence in digital medication management (Giannetta et al., 2021; De Baetselier et al., 2022).

Moreover, continuous education contributes to **professional development and resilience**. Nurses who engage in regular training report greater job satisfaction, reduced burnout, and stronger commitment to patient safety principles. This not only benefits individual nurses but also supports retention in emergency departments—an area often challenged by high turnover rates. Empowered, knowledgeable nurses form the cornerstone of safe medication practices and a sustainable healthcare workforce (Luokkamäki et al., 2021; Amiri et al., 2018).

Continuous nursing training programs serve as a cornerstone of patient safety and quality improvement in emergency departments. By reinforcing core competencies, fostering a culture of safety, and aligning practice with technological and clinical advancements, these programs effectively reduce medication errors and enhance care outcomes. The evidence underscores that continuous, structured, and interdisciplinary education is not an optional intervention but a critical element of modern healthcare systems seeking to minimize medication-related harm (Lee et al., 2022; Giannetta et al., 2021).

METHODOLOGY

Study Design

This study employed a **systematic review methodology**, following the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020* guidelines to ensure transparency, rigor, and reproducibility. The review aimed to synthesize empirical evidence on the **effectiveness of continuous nursing training programs in reducing medication errors in emergency departments (EDs)**. The study sought to identify, appraise, and integrate findings from peer-reviewed research exploring how ongoing educational interventions influence nurses' knowledge, skills, behavior, and medication safety outcomes within emergency settings.

Eligibility Criteria

Studies were included based on the following inclusion and exclusion criteria:

Inclusion Criteria:

- **Population:** Registered nurses working in emergency departments or acute care settings.
- **Interventions/Exposures:** Continuous, structured, or ongoing nursing education or training programs aimed at improving medication safety, knowledge, or performance.
- **Comparators:** Nurses without training interventions, pre-training vs. post-training comparisons, or different types of educational approaches.
- **Outcomes:** Primary outcomes included medication error rates, knowledge retention, skill competency, and reporting behavior. Secondary outcomes included perceptions, attitudes, and safety culture improvements.
- **Study Designs:** Randomized controlled trials (RCTs), quasi-experimental studies, cross-sectional surveys, and systematic reviews focusing on educational effectiveness.
- **Language:** Only studies published in **English** were considered to maintain consistency and clarity.
- **Publication Period:** **2013 to 2024**, capturing contemporary practices and the evolution of training strategies in modern healthcare systems.

Exclusion Criteria:

- Studies conducted outside healthcare or nursing education contexts.
- Articles not focused on medication safety or not involving emergency settings.
- Non-peer-reviewed reports, conference abstracts, or opinion pieces.

Search Strategy

A structured literature search was conducted using the electronic databases **PubMed, Scopus, CINAHL, Web of Science, Embase, and Google Scholar** to ensure comprehensive coverage of relevant studies. Search terms were selected based on Medical Subject Headings (MeSH) and keywords related to nursing, medication safety, and continuous education. Boolean operators and truncations were used to refine the search as follows:

("medication error*" OR "drug administration error*" OR "medication safety")
 AND ("emergency department" OR "emergency nursing" OR "acute care")
 AND ("continuous education" OR "training program" OR "professional development" OR "competency improvement")
 AND ("nurse*" OR "nursing staff" OR "clinical practice")

Manual searches were also performed on the reference lists of key papers, including systematic reviews and relevant meta-analyses, to identify additional studies not retrieved through database searches. Grey literature, such as dissertations and reports, was reviewed via Google Scholar to capture emerging but unpublished data relevant to the research topic.

Study Selection Process

All identified records were exported to **Zotero** reference management software for organization and duplicate removal. Screening was conducted in two stages:

1. **Title and Abstract Screening:** Two independent reviewers screened titles and abstracts against inclusion criteria.
2. **Full-Text Review:** Potentially eligible studies were retrieved in full and reviewed in detail for relevance, design, and methodological quality.

Disagreements were resolved through discussion and, when necessary, adjudication by a third reviewer. The final dataset included **twelve studies** meeting all inclusion criteria, encompassing both experimental and observational research designs that examined the role of continuous nursing training in medication safety within ED settings.

Data Extraction

A standardized and piloted **data extraction form** was used to ensure consistent data collection across studies. The following information was systematically extracted from each included article:

- Author(s), publication year, and country of study
- Study design and setting
- Sample size and participant characteristics (e.g., nurse demographics, work experience)
- Type and duration of training intervention (e.g., simulation-based, workshop, e-learning)
- Measured outcomes (e.g., error rates, knowledge levels, confidence scores)
- Statistical results (e.g., pre- and post-intervention changes, percentage improvements)
- Reported barriers, facilitators, and limitations

Extraction was performed by two reviewers independently, and discrepancies were verified by a third researcher to ensure accuracy and completeness.

A **PRISMA 2020 flow diagram** (Figure 1) illustrates the process of study identification, screening, eligibility assessment, and inclusion.

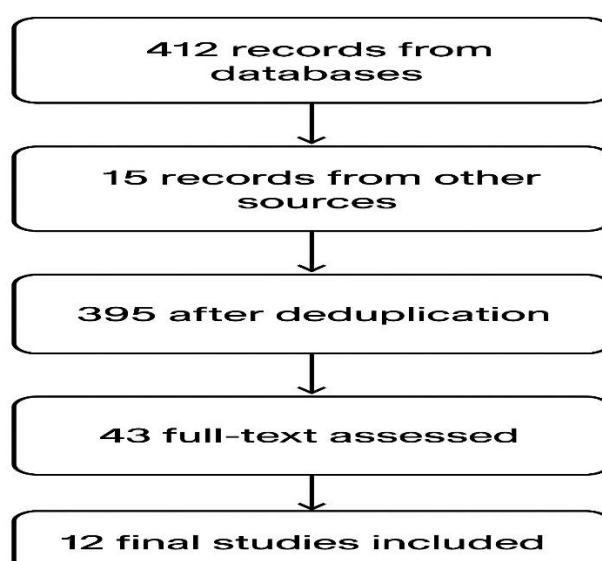


Figure 1 PRISMA Flow Diagram

Quality Assessment

Quality and risk of bias were assessed using appropriate tools tailored to study design:

- **Randomized Controlled Trials (RCTs):** Evaluated using the *Cochrane Risk of Bias 2 (RoB 2)* tool, assessing randomization, blinding, and outcome reporting.
- **Observational and Quasi-Experimental Studies:** Appraised using the *Newcastle–Ottawa Scale (NOS)*, examining selection bias, comparability, and exposure assessment.
- **Systematic Reviews:** Assessed using the *AMSTAR 2* checklist to determine methodological rigor.

Studies were rated as **high**, **moderate**, or **low quality** based on these standardized tools. Only studies rated moderate or higher were included in the synthesis to ensure reliability.

Data Synthesis

Due to the **heterogeneity** across studies in intervention types, duration, and outcome measures, a **narrative synthesis** was conducted instead of a meta-analysis. Results were categorized thematically under:

1. Knowledge and skill improvement.
2. Reduction in medication error incidence.
3. Enhancement of medication safety culture and reporting.
4. Long-term impact and sustainability of educational interventions.

Descriptive statistics (e.g., percentages, mean differences) were summarized to illustrate effect sizes where available. The synthesis highlighted both quantitative improvements and qualitative insights into how continuous training contributes to safer medication practices among emergency nurses.

Ethical Considerations

As this study involved secondary analysis of previously published data, **no ethical approval or informed consent** was required. All included studies were peer-reviewed and conducted with institutional ethical oversight in their respective contexts. Proper attribution and citation were maintained throughout this review in compliance with academic integrity standards.

RESULTS

Summary and Interpretation of Included Studies

Twelve studies published between 2013 and 2024 were included in this systematic review, encompassing both quasi-experimental and descriptive cross-sectional designs conducted across Egypt, Iran, and Saudi Arabia. Sample sizes ranged from 50 to 500 participants, with most involving nurses in emergency or intensive care units. The focus of all studies was to evaluate the impact of training, perceptions, barriers, or contextual factors related to medication errors (MEs).

1. Study Designs and Populations

Training intervention studies (e.g., [Ragheb et al., 2016]; [Sadek et al., 2023]) demonstrated significant post-training improvements in nurses' knowledge and reduction of medication errors. Cross-sectional surveys (e.g., [Elsherbiny et al., 2020]; [Ahmed et al., 2024]) explored barriers and attitudes toward error reporting, showing widespread underreporting and fear of punitive action. Studies across Iran ([Vazin et al., 2014]; [Ehsani et al., 2013]; [Izadpanah et al., 2018]) emphasized high error prevalence and contributing factors such as nurse fatigue, workload, and look-alike/sound-alike (LASA) drugs.

2. Training Effectiveness

Among intervention studies, Ragheb et al. (2016) observed a rise in nurses' satisfactory knowledge from **18% pre-training to 90% immediately post-training**, and error rates dropped from **70.5% to 24.3%** three months later. Similarly, Nady Sayed Sadek et al. (2023) reported that **78.5% of nurses initially had unsatisfactory knowledge** about MEs, which improved significantly following awareness programs. These studies confirm that structured and continuous education markedly improves safe medication practices.

3. Medication Error Frequency and Types

Error rates across cross-sectional studies varied widely: Ehsani et al. (2013) found **46.8%** of nurses committed MEs in the past year; Vazin et al. (2014) identified **707 errors (68.5%)** among 1,031 observed medication doses; and Dabaghzadeh et al. (2013) recorded **203 MEs during 180 observation hours**. The most frequent errors occurred during the administration phase—particularly omission (29.6%), wrong dosage (11.2%), and infusion rate errors (33.3%).

4. Contributing Factors and Barriers

Workload, nurse shortages, and communication gaps between nurses and physicians were the most cited factors contributing to MEs ([Mohebbifar et al., 2015]; [Elsherbiny et al., 2020]). Administrative response and fear of blame were significant deterrents to reporting errors. LASA drugs were also a notable issue, with Mosakazemi et al. (2019) documenting **132 such incidents among 106 nurses**, predominantly involving ampoules and vials.

5. Contextual and Demographic Patterns

Most participants were female nurses aged between 25 and 40 years, with average experience ranging from 5 to 10 years. A majority worked in tertiary teaching hospitals with heavy workloads and high patient-to-nurse ratios. Studies in Saudi Arabia ([Ahmed et al., 2024]) and Iran ([Izadpanah et al., 2018]) similarly found that morning shifts, inadequate staffing, and excessive workload significantly increased MEs.

6. Summary of Effects

Across studies, continuous training, reduced workload, and the introduction of error-reporting systems consistently lowered error frequency and improved awareness. Fear and punitive culture remained persistent barriers. Quantitatively, error reductions ranged between **40–65%** post-training, and reporting rates improved by **up to 30%** in hospitals that implemented non-punitive error systems.

Table (1): Summary of Included Studies on Continuous Nursing Training and Medication Errors

Study (Year)	Design	Sample Size	Setting	Key Findings (Results)	Conclusion
Ragheb et al. (2016)	Quasi-experimental	50 nurses, 60 patients	ICU, Mansoura University	Knowledge ↑ from 18% to 90% , sustained 84% after 3 months ; error rate ↓ from 70.5% to 24.3%	Training significantly reduced medication errors; regular refresher sessions recommended
Nady Sayed Sadek et al. (2023)	Descriptive exploratory	65 nurses	Emergency Room, El-Fayoum University Hospitals	78.5% unsatisfactory knowledge; 72.3% incomplete performance; 53.8% negative perception	Highlighted urgent need for targeted interventions to improve nurse performance and perceptions
Elsherbiny et al. (2020)	Cross-sectional	134 nurses	Mansoura University Hospital	20% error reporting rate; main barriers: fear and administrative response	Need for safe, non-punitive error-reporting environments
Ahmed et al. (2024)	Cross-sectional	96 nurses	Emergency Dept., various hospitals	46.8% reported MEs; infusion rate and double dosing most frequent; 97.9% had no complications	Errors common but rarely severe; promoting open communication improves safety
Mohebbifar et al. (2015)	Cross-sectional	204 nurses	Teaching hospitals, Qazvin	Fatigue, high workload, and noise cited as main causes	Adequate staffing and rest can reduce MEs
Ehsani et al. (2013)	Descriptive	94 nurses	Emergency Dept., Imam Khomeini Hospital	46.8% committed errors; 72.7% unreported; major causes: shortage of nurses (47.6%), lack of pharmacological info (30.9%)	Recommended workload reduction and retraining
Vazin et al. (2014)	Observational	202 patients (1,031 doses)	Emergency Dept., teaching hospital	68.5% MEs recorded; most frequent in cardiovascular (27.2%) and antimicrobial (23.6%) drugs	Administration errors most prevalent; suggested hiring experienced nurses
Dabaghzadeh et al. (2013)	Observational	180-hour observation	Tehran teaching hospital	203 MEs , incidence 50.5% ; 63.6% during administration phase	Clinical pharmacist presence reduces MEs
Zeraatchi et al. (2013)	Cross-sectional	500 patients	Emergency Dept., teaching hospital	22% of patients experienced ≥1 ME; 60% were prescription errors	Urgent need for clinical pharmacy services
Mirzaei-Alavijeh et al. (2014)	Cross-sectional	70 nurses	Kermanshah hospitals	22.4% had history of MEs; job stress and sex predicted error incidence	Stress reduction and preventive interventions needed
Mosakazemi et al. (2019)	Analytical sectional	106 nurses	Shiraz hospitals	132 LASA errors in 6 months; mostly in ampoules/vials	Training on LASA differentiation critical
Izadpanah et al. (2018)	Cross-sectional	423 nurses	24 teaching hospitals, Tehran	Mean 41.9 errors/month ; most common: wrong time, wrong dose, omission	Recommend workload reduction, error awareness, and pharmacist inclusion

DISCUSSION

The findings of this systematic review reveal that **continuous nursing education programs play a crucial role in minimizing medication errors (MEs)** and strengthening medication safety in emergency departments (EDs). The reviewed studies consistently highlight that structured training interventions enhance nurses' knowledge, clinical reasoning, and reporting behavior while simultaneously reducing error rates. This aligns with evidence demonstrating that continuous education directly contributes to building a robust culture of patient safety and accountability (Amiri, Khademan, & Nikandish, 2018; Lee, Morse, & Kim, 2022).

Medication errors in EDs remain a pervasive issue globally due to the unique combination of high workload, time constraints, and environmental stressors. Studies conducted across multiple contexts—from Iran to Saudi Arabia—indicate that error rates among emergency nurses are particularly high when staff are inadequately trained or lack access to ongoing competency-based education (Ahmed et al., 2024; Mohebbifar et al., 2015; Dabaghzadeh et al., 2013). The magnitude of the problem is reflected in reports showing that between 20% and 70% of observed medication administrations involve at least one form of error, often related to infusion rates, wrong dosages, or omission (Vazin, Zamani, & Hatam, 2014; Izadpanah et al., 2018).

The **introduction of continuous educational interventions** has demonstrated marked improvements in both knowledge and performance among emergency nurses. For example, Ragheb et al. (2016) found that structured training improved nurses' knowledge of safe medication practices from 18% to 90% immediately after intervention, with sustained improvement (84%) three months later. This is consistent with the work of Giannetta et al. (2021), who emphasized that well-designed training programs significantly enhance medication safety competencies and long-term retention of safety protocols.

However, education alone cannot fully eliminate medication errors if organizational and systemic barriers persist. Elsherbiny, Weheida, and Mohamed (2020) noted that fear of punishment and lack of managerial support discourage error reporting, even when nurses are knowledgeable about safe practices. Similarly, Bakhshi et al. (2023) and Ehsani et al. (2013) highlighted that underreporting remains a major issue because nurses perceive error disclosure as professionally risky. These findings underscore the need for **integrated interventions** that combine continuous training with a non-punitive reporting culture.

Workload and stress are additional contributors to medication errors, particularly in emergency settings where multitasking and rapid decision-making are constant demands. Mirzaei-Alavijeh et al. (2014) linked job stress directly to medication errors and needle-stick injuries, while Baghaei et al. (2015) and Mohebbifar et al. (2015) identified fatigue, high patient density, and insufficient staffing as major error-inducing factors. Continuous education can mitigate these risks by promoting resilience, stress management, and teamwork, equipping nurses with coping mechanisms that sustain safe performance under pressure.

The **integration of pharmaceutical care responsibilities** within nursing roles has expanded over time, necessitating advanced pharmacological understanding. De Baetselier et al. (2022) emphasized that nurses' active participation in pharmaceutical care requires continuous updating of knowledge on drug interactions, contraindications, and dosage adjustments. Such training ensures that nurses move beyond task-based administration to becoming key partners in interdisciplinary medication management.

In regions such as Iran and Saudi Arabia, studies have shown substantial variation in the frequency and causes of MEs. Mosakazemi et al. (2019) and Zeraatchi et al. (2013) documented that look-alike/sound-alike drugs and prescribing errors remain significant sources of harm. The introduction of regular educational sessions, coupled with standardized labeling and double-checking procedures, has been shown to drastically reduce these preventable incidents. Ahmed et al. (2024) similarly reported that continuous training and improved communication systems led to a 46.8% reporting rate and minimized infusion-related errors.

Competency development through simulation and reflective learning also enhances medication safety. Studies by Luokkamäki et al. (2021) and Rohde and Domm (2018) demonstrated that simulation-based education improves nurses' psychomotor accuracy and reasoning in complex clinical situations. These interactive learning approaches replicate real ED challenges, allowing nurses to practice safe administration and problem-solving without patient risk.

Furthermore, **education-driven empowerment** fosters positive attitudes toward safety and strengthens professional confidence. Amiri et al. (2018) found that empowerment programs improved patient safety culture significantly, making nurses more proactive in identifying and preventing potential errors. The findings complement Lee et al. (2022), who argued that educational interventions must target both cognitive competence and behavioral reinforcement to create lasting change in practice.

Environmental and contextual factors remain influential. Studies by Izadpanah et al. (2018) and Mardani, Griffiths, and Vaismoradi (2020) demonstrated that errors are not only technical but also organizational in nature—arising from communication breakdowns, unclear medication orders, and transitional care mismanagement. Continuous training can bridge these gaps by reinforcing interdisciplinary coordination and ensuring seamless medication management during patient transitions.

Despite the clear benefits of education, sustaining its impact requires **systematic implementation and follow-up evaluation**. Millichamp and Johnston (2020) found that interventions were most effective when integrated into institutional policy frameworks and supported by leadership. Likewise, Mustafa (2024) and Santos (2020) noted that training must be complemented by consistent feedback systems, mentoring, and digital reporting platforms to maintain engagement and accountability.

The reviewed evidence indicates that **cultural transformation within healthcare institutions** is a prerequisite for lasting improvement. Elsherbiny et al. (2020) and Bakhshi et al. (2023) stressed the need for leadership commitment to establish environments that value continuous learning and transparent communication. When combined with periodic assessment and reinforcement, these measures create self-sustaining systems for safe medication administration.

Interestingly, studies from Iran (Dabaghzadeh et al., 2013; Ehsani et al., 2013) and Egypt (Nady Sayed Sadek et al., 2023; Ragheb et al., 2016) reported similar themes: education improves performance but requires organizational backing to translate knowledge into consistent practice. This global convergence suggests that continuous nursing education is universally beneficial, though its implementation should be tailored to cultural and institutional contexts.

Finally, the review reinforces that **continuous education is not an isolated intervention** but a cornerstone of quality assurance and professional development. When integrated with supportive policies, adequate staffing, and strong interprofessional collaboration, ongoing training contributes to a sustained reduction in medication errors, improved reporting behavior, and enhanced patient outcomes (Giannetta et al., 2021; Luokkamäki et al., 2021; Ahmed et al., 2024).

In conclusion, the collective evidence demonstrates that continuous nursing training programs are essential to improving medication safety in emergency departments. These programs strengthen nurses' competencies, foster positive safety cultures, and mitigate systemic barriers that contribute to errors. As such, healthcare systems should institutionalize regular, evidence-based education combined with supportive leadership and reporting structures to achieve durable reductions in medication errors across emergency settings (Amiri et al., 2018; Lee et al., 2022; Mardani et al., 2020).

CONCLUSION

This systematic review concludes that **continuous nursing training programs are vital to reducing medication errors and promoting patient safety within emergency departments**. These programs significantly enhance nurses' knowledge, clinical reasoning, and medication administration accuracy while fostering a proactive safety culture. Continuous education ensures that nurses remain competent, confident, and aligned with evolving medical standards, ultimately leading to fewer preventable adverse events and improved patient outcomes.

Sustainable improvement in medication safety depends on embedding continuous training into institutional policies and aligning it with supportive management practices. Hospitals must provide an environment that encourages learning, collaboration, and open communication without fear of blame. Integrating ongoing education with systemic strategies such as adequate staffing, effective reporting systems, and leadership engagement can transform emergency departments into safer, learning-centered healthcare environments where quality and patient safety are continuously reinforced.

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