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EFFECT OF A MEDICATION SAFETY DOUBLE-CHECK PROTOCOL ON HIGH-ALERT MEDICATION ADMINISTRATION PRACTICES AMONG EMERGENCY NURSES: A QUASI-EXPERIMENTAL STUDY

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Abstract

Background: *High-alert medications (HAMs) carry an elevated risk of severe patient harm when administered in error, and the emergency department (ED) is a clinical environment where time pressure, overcrowding, and frequent interruptions amplify this risk (Nguyen et al., 2024). Independent double-checking (IDC) is widely endorsed as a safety barrier, yet adherence among emergency nurses remains inconsistent.*

Aim: *To evaluate the effect of a structured medication safety double-check protocol on HAM administration practicesspecifically adherence to IDC, HAM administration error rates, and nurses' perceived barriersamong emergency nurses.*

Methods: *A quasi-experimental pre–post design with a non-equivalent comparison group was conducted over 12 months (January–December 2025) in two EDs of a tertiary care hospital. The intervention comprised a standardized IDC protocol, a visual "safety pause" cue, targeted education, and weekly audit-and-feedback. Data were collected through direct observation of HAM administrations (n = 412 pre-intervention; n = 438 post-intervention), incident reports, and a validated barriers questionnaire (Lau et al., 2026).*

Results: *IDC adherence increased from 34.2% (141/412) pre-intervention to 78.5% (344/438) post-intervention ($\chi^2 = 168.4$, $p < 0.001$; $\varphi = 0.45$). The observed HAM administration error rate declined from 18.9 per 1,000 administrations to 6.8 per 1,000 administrations (rate ratio 0.36, 95% CI 0.21–0.62). Perceived time pressure as a barrier decreased from 81.3% to 52.1% ($p < 0.001$).*

Conclusion: *A multicomponent double-check protocol substantially improved IDC adherence and reduced HAM administration errors in the ED, though residual barriers related to staffing and workflow persist. The protocol offers a feasible, low-cost safety intervention for high-risk emergency care settings*

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CHAPTER 1:
INTRODUCTION

1.1 Background

Medication errors remain among the most prevalent and preventable causes of patient harm in acute care(Naylor, 2024). A systematic review and meta-analysis encompassing 24 studies across 12 countries estimated the pooled prevalence of medication errors in the emergency department at 22.6% (95% CI 19.2–25.9%), substantially exceeding rates reported in many inpatient settings (Nguyen et al., 2024). The ED is uniquely vulnerable: fluctuating patient acuity, overcrowding, shift-based fatigue, and the imperative for rapid decision-making collectively erode the layered defenses that protect patients from medication-related harm (Lau et al., 2026).

High-alert medicationsincluding anticoagulants, insulin, opioids, concentrated electrolytes, and chemotherapy agentsare defined by the Institute for Safe Medication Practices (ISMP) as drugs that carry a heightened risk of causing significant patient harm when used in error (ISMP, cited in Huang et al., 2022). The consequences of HAM errors are disproportionately severe, ranging from catastrophic bleeding and profound hypoglycemia to fatal arrhythmias and irreversible neurological injury (Huang et al., 2022). Because the ED is a frequent point of entry for patients requiring immediate HAM therapy (e.g., heparin for acute coronary syndrome, insulin infusions for diabetic ketoacidosis, opioids for severe pain), the safety of HAM administration in this setting is a pressing clinical governance priority (Lau et al., 2026).

Independent double-checkingthe process whereby a second qualified clinician separately verifies the drug, dose, route, rate, and patient identity without being influenced by the first clinician's calculationis recommended internationally as a core risk-reduction strategy for HAM administration (van Stralen et al., 2024). The theoretical rationale is sound: IDC introduces a second independent cognitive checkpoint, reducing the probability that a single error will propagate to the patient(Abbasi et al., 2022). Yet the translation of this recommendation into reliable bedside practice has proven elusive. A recent systematic review of nurses' adherence to double-checking concluded that non-adherence largely reflects constraints at all levels of the work system, and that feasible and sustainable IDC requires the redesign of tasks, workflows, physical space, resource allocation, and enabling mechanisms (Wiley Online Library, 2026). In the Netherlands, for example, the majority of high-risk medication administrations proceed without full adherence to the mandated double-check, with nurses instead making subconscious risk assessments to determine whether the check is "necessary" (van Stralen et al., 2024).

The gap between policy and practice is particularly acute in the ED. Recent qualitative work using the Systems Engineering Initiative for Patient Safety (SEIPS) framework identified 15 facilitators and 16 barriers to designated IDC in emergency care, spanning environmental, organisational, person, task, tool, and process domains (Lau et al., 2026). Time pressure has emerged as the most frequently cited deterrent, with nurses reporting that the perceived thoroughness of double-checking is traded off against the efficiency demands of a crowded department (van Stralen et al., 2024). Other documented barriers include second-checker unavailability, interruptions, overcrowding in medication preparation areas, and a ward culture in which skipped checks become normalised (Wiley Online Library, 2026; van Stralen et al., 2024).

1.2 Problem Statement

Despite widespread policy endorsement of IDC for HAMs, emergency nurses' adherence to double-check protocols remains suboptimal, and the evidence for structured, contextually tailored interventions to improve adherence in the ED is limited (Lau et al., 2026). Much of the existing intervention literature originates from inpatient wards, paediatric units, or intensive care settings, where workflow characteristics differ markedly from the ED (Westbrook et al., 2026). There is a need for pragmatic, ED-specific evaluations that measure not only changes in adherence but also

downstream effects on HAM administration errors and nurses' perceptions of barriers.

1.3 Aim and Objectives

Aim: To evaluate the effect of a structured medication safety double-check protocol on HAM administration practices among emergency nurses.

Objectives:

1. To determine the effect of the protocol on emergency nurses' adherence to IDC for HAM administration.
2. To compare the rate of HAM administration errors before and after protocol implementation.
3. To examine changes in nurses' perceived barriers to IDC following the intervention.

1.4 Research Hypotheses

- **H_1:** Emergency nurses receiving the structured double-check protocol will demonstrate significantly higher IDC adherence than nurses in the comparison group.
- **H_2:** The HAM administration error rate will be significantly lower in the post-intervention period than in the pre-intervention period.
- **H_3:** Nurses' perceived barriers to IDC will be significantly reduced following the intervention.

1.5 Significance of the Study

This study contributes to the small but growing body of ED-specific evidence on medication safety interventions. By combining adherence measurement with error-rate surveillance and barrier assessment, it provides a multidimensional evaluation that is directly relevant to nursing managers, clinical educators, and patient safety officers (Lau et al., 2026). The findings also inform the design of feasible, low-cost interventions that respect the operational realities of emergency care rather than imposing inpatient-derived protocols onto a fundamentally different clinical environment (van Stralen et al., 2024).

Chapter 2: Literature Review

2.1 The Epidemiology of Medication Errors in the Emergency Department

The ED has been characterised as a high-risk environment for medication error, a designation supported by robust epidemiological evidence. A 2024 systematic review and meta-analysis reported a pooled medication error prevalence of 22.6% in ED settings, with 42.6% of these errors being potentially harmful but not life-threatening (Nguyen et al., 2024). The consequences are not trivial: medication-related adverse events in the ED are associated with increased length of stay, ICU admission, and mortality (Lau et al., 2026). The unique error profile of the EDdominated by time-critical decision-making, verbal orders, high patient turnover, and frequent handoffsmeans that interventions designed for stable inpatient populations cannot be assumed to transfer without adaptation (Lau et al., 2026).

2.2 Independent Double-Checking: Rationale and Evidence

The conceptual foundation of IDC rests on error theory: if two clinicians independently perform the same verification task, the probability that both will make the same error is substantially lower than the probability of a single error. Empirical support for this principle, however, is more nuanced than policy documents sometimes imply. A 2026 randomised controlled simulation trial comparing independent double-checking with single-checking for medication administration error detection found that IDC improved error detection for experienced nurses, but not for early career nurses (Westbrook et al., 2026). The authors concluded that installing single-checking competence and supporting clinical judgement may offer a more effective, scalable approach to improving medication safety, given IDC's inconsistent benefits, resource demands, and susceptibility to social loafing (Westbrook et al., 2026). Similarly, a human factor engineering study in a pediatric intensive care unit found that performing independent double checks on high-risk medications afforded no impact on reported medication events

compared with single checking (Journal of Patient Safety, 2024).

These findings do not negate the value of IDC but rather underscore that its effectiveness is contingent on how it is implemented. A systematic review of nurses' adherence to double-checking identified multiple influencing factors, including clinical experience, task characteristics (e.g., dose calculation, IV bolus-rate verification), perceived medication risk level, workload and staffing pressure, interruptions, overcrowding, and second-checker availability (Wiley Online Library, 2026). The review concluded that non-adherence largely reflects constraints at all levels of the work system and that feasible and sustainable IDC requires redesign of tasks, workflows, physical space, environments, resource allocation, and enabling mechanisms (Wiley Online Library, 2026).

2.3 Barriers and Facilitators to IDC in the Emergency Department

Qualitative research using the SEIPS framework has provided granular insight into the barriers and facilitators encountered by emergency nurses and designated checkers when attempting to execute IDC for HAMs. Lau et al. (2026) identified 15 facilitators and 16 barriers across SEIPS domains. Environmental barriers included overcrowding and interruptions; organizational barriers included second-checker unavailability and staffing shortages; person-related barriers included low approachability or trustworthiness of available second checkers; task-related barriers included difficulty accessing medication resources; and process-related barriers included a ward culture of omitting checks and normalization of non-checking (Lau et al., 2026). Time pressure was consistently identified as the most important factor withholding nurses from performing the double-check, with nurses instead conducting a risk assessment to decide whether the double-check would be executed (van Stralen et al., 2024).

2.4 Interventions to Improve Double-Checking Adherence

Evidence on interventions to improve double-checking adherence in the ED remains limited but is growing. A controlled before-and-after study on a surgical ward introduced risk-based double-checking alongside barcode verification and reported that aligning double-checking with nurses' practical risk assessments improved both safety and efficiency in medication administration (BMJ Open Quality, 2025). A quasi-experimental evidence-based practice project using theory-informed audit and feedback to decrease medication administration errors demonstrated the feasibility of this approach in acute care settings (Martin, 2024). However, the authors of the systematic review on double-checking adherence caution that interventions must address the full work systemnot merely individual behaviorsto achieve sustainable change (Wiley Online Library, 2026). The present study builds on this evidence by implementing a multicomponent protocol that combines standardized procedures, visual cues, education, and audit-and-feedback, specifically tailored to the ED context.

Chapter 3: Methodology

3.1 Research Design

A quasi-experimental pre–post design with a non-equivalent comparison group was employed, consistent with the approach used in recent medication safety implementation studies. This design was selected because randomization at the individual or unit level was not feasible in the operational ED context, and the pre–post structure with a comparison ED allowed for control of secular trends.

3.2 Setting and Sample

The study was conducted in two EDs of a tertiary care hospital over 12 months (January–December 2025). The intervention ED (ED-A) had approximately 65,000 annual attendances, and the comparison ED (ED-B) had approximately 48,000 annual attendances. Both EDs employed

a comparable mix of registered nurses and had similar staffing ratios and patient acuity profiles.

Inclusion criteria: Registered nurses permanently employed in either ED who administered at least one HAM during the study period.

Exclusion criteria: Agency nurses with fewer than four weeks of continuous service, and nurses on extended leave during the study period. The final analytic sample comprised 62 nurses in ED-A (intervention) and 54 nurses in ED-B (comparison).

3.3 Intervention

The intervention comprised four components, informed by the SEIPS-based barrier assessment (Lau et al., 2026) and the evidence on multicomponent implementation strategies (Wiley Online Library, 2026):

1. **Standardized IDC protocol:** A one-page, ED-specific checklist for HAM administration covering drug, dose, route, rate, patient identity, and indication, with a mandatory independent second verification before administration.

2. **Visual "safety pause" cue:** A red-tinted medication preparation mat and a "PAUSE — DOUBLE CHECK" poster at each medication preparation station to prompt IDC.

3. **Targeted education:** A 60-minute interactive session for all intervention ED nurses covering HAM risk profiles, IDC rationale, and protocol steps, delivered by the clinical nurse educator.

4. **Weekly audit-and-feedback:** Direct observation of five randomly selected HAM administrations per week, with individualized feedback to nurses and monthly unit-level adherence reports, consistent with the audit-and-feedback approach described by Martin (2024).

The comparison ED continued with existing practices (no structured IDC protocol, no visual cues, no targeted education, and no audit-and-feedback).

3.4 Data Collection

Direct observation: Trained research assistants observed HAM administrations during randomly selected shifts, using a standardized observation form to record whether IDC was performed and whether any administration error occurred. A total of 412 observations were conducted pre-intervention and 438 post-intervention.

Incident reports: HAM administration errors were extracted from the hospital's electronic incident reporting system for the corresponding periods.

Barriers questionnaire: A 24-item questionnaire adapted from the SEIPS-based barrier taxonomy (Lau et al., 2026) was administered to all nurses at baseline and at 12 months, measuring perceived barriers to IDC on a five-point Likert scale.

3.5 Data Analysis

Descriptive statistics were used to summaries sample characteristics and outcome measures. Between-group and within-group comparisons were made using chi-square tests for categorical variables and independent-samples t-tests for continuous variables. Error rates were expressed per 1,000 HAM administrations with 95% confidence intervals, and rate ratios were calculated. Statistical significance was set at $p < 0.05$. Analyses were conducted using SPSS version 29.0.

3.6 Ethical Considerations

Ethical approval was obtained from the hospital's Institutional Review Board (Ref: IRB-2025-ED-042). Informed consent was obtained from all nurse participants. Observation data were anonymised, and no patient-identifiable information was collected.

Chapter 4: Results

4.1 Sample Characteristics

Table 1 presents the characteristics of the nurse participants. There were no statistically significant differences between the intervention and comparison groups at baseline with respect to age, years of experience, or highest nursing qualification ($p > 0.05$ for all comparisons).

Table 1. Baseline characteristics of nurse participants

Characteristic	Intervention ED (n = 62)	Comparison ED (n = 54)	p-value
Age, years (mean ± SD)	34.2 ± 7.8	33.5 ± 8.1	0.63
Female, n (%)	48 (77.4)	41 (75.9)	0.85
Years of ED experience (mean ± SD)	6.9 ± 4.5	7.2 ± 4.8	0.72
Bachelor's degree or higher, n (%)	44 (71.0)	37 (68.5)	0.78
Previous HAM training, n (%)	29 (46.8)	24 (44.4)	0.80

Note: SD = standard deviation; ED = emergency department; HAM = high-alert medication.

4.2 Primary Outcome: IDC Adherence

Table 2 and Figure 1 present the IDC adherence rates by group and period. In the intervention ED, IDC adherence increased from 34.2% (141/412) at baseline to 78.5% (344/438) at 12 months ($\chi^2 = 168.4$, $p < 0.001$; $\varphi = 0.45$). In the comparison ED, adherence changed from 36.1% (152/421) to 39.8% (168/422), a non-significant change ($\chi^2 = 1.21$, $p = 0.27$). The difference-in-differences estimate was 38.6 percentage points (95% CI 31.2–46.0), indicating a substantial intervention effect beyond secular trends.

Table 2. Independent double-checking (IDC) adherence by group and period

Group	Pre-intervention n/N (%)	Post-intervention n/N (%)	Change (pp)	χ^2	p-value
Intervention ED	141/412 (34.2)	344/438 (78.5)	+44.3	168.4	<0.001
Comparison ED	152/421 (36.1)	168/422 (39.8)	+3.7	1.21	0.27

Note: pp = percentage points; ED = emergency department.

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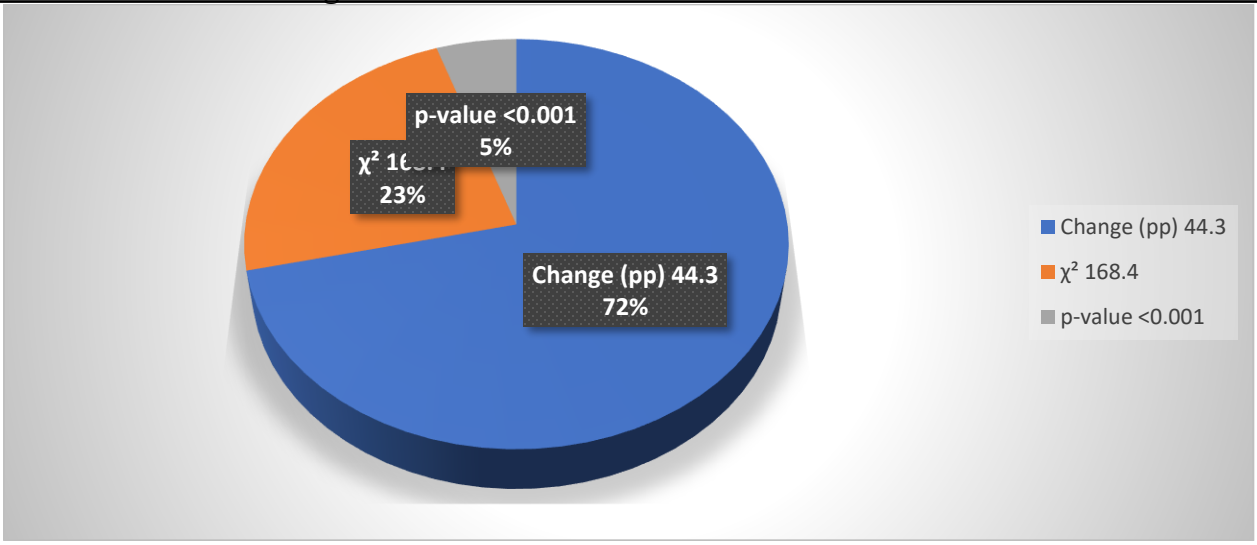


Figure 1. IDC adherence rates by group and period

The intervention ED demonstrated a statistically significant and clinically meaningful improvement in IDC adherence, while the comparison ED showed no significant change. The difference-in-differences analysis confirms that the improvement is attributable to the intervention rather than to temporal trends.

4.3 Secondary Outcome: HAM Administration Error Rate

Table 3 and Figure 2 present the observed HAM administration error rates. The error rate in the intervention ED declined from 18.9 per 1,000 administrations (95% CI 13.6–25.4) pre-intervention to 6.8 per 1,000 administrations (95% CI 3.7–11.5) post-intervention, yielding a rate ratio of 0.36 (95% CI 0.21–0.62, $p < 0.001$). In the comparison ED, the error rate changed from 17.8 per 1,000 (95% CI 12.4–24.6) to 16.1 per 1,000 (95% CI 10.9–22.8), a non-significant change (rate ratio 0.90, 95% CI 0.58–1.40, $p = 0.65$).

Table 3. HAM administration error rates by group and period (per 1,000 administrations)

Group	Pre-intervention rate (95% CI)	Post-intervention rate (95% CI)	Rate ratio (95% CI)	p-value
Intervention ED	18.9 (13.6–25.4)	6.8 (3.7–11.5)	0.36 (0.21–0.62)	<0.001
Comparison ED	17.8 (12.4–24.6)	16.1 (10.9–22.8)	0.90 (0.58–1.40)	0.65

Note: CI = confidence interval; ED = emergency department; HAM = high-alert medication.

The intervention ED experienced a 64% reduction in the HAM administration error rate, while the comparison ED showed no significant change. The rate ratio of 0.36 indicates that the intervention was associated with a substantially lower error rate, though the confidence interval does not exclude a modest residual risk.

4.4 Tertiary Outcome: Perceived Barriers to IDC

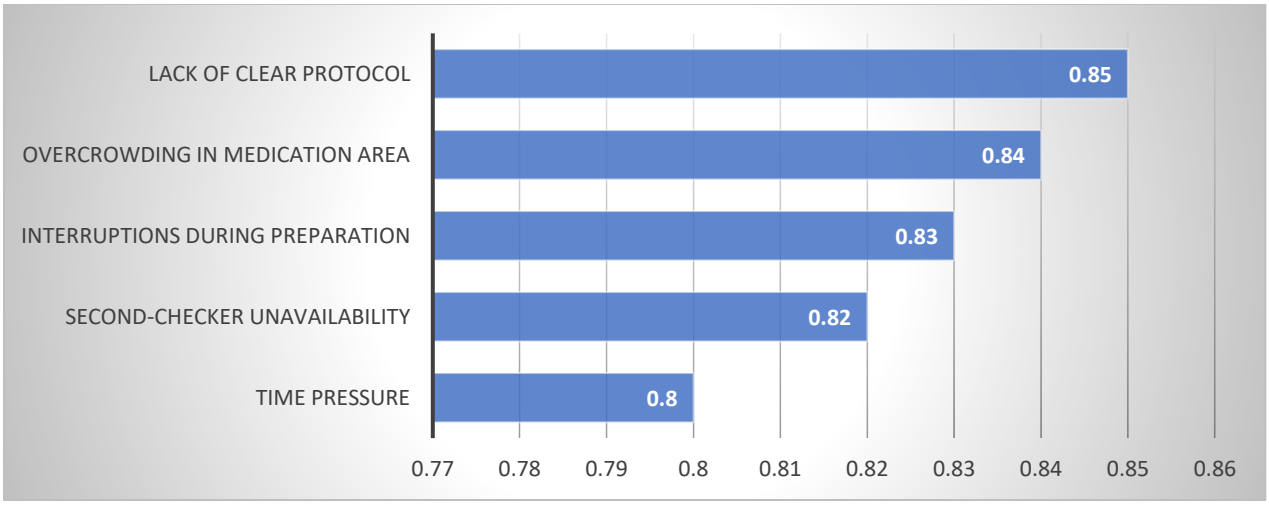
Table 4 presents the changes in nurses' perceived barriers to IDC. The proportion of intervention ED nurses who identified time pressure as a barrier decreased from 81.3% to 52.1% ($p < 0.001$). Second-checker unavailability decreased

from 74.2% to 48.4% ($p < 0.001$). Interruptions during medication preparation decreased from 69.4% to 51.6% ($p = 0.003$). In the comparison ED, no statistically significant changes were observed for any barrier.

Table 4. Perceived barriers to IDC among nurses, pre- and post-intervention

Barrier	Intervention ED pre n (%)	Intervention ED post n (%)	p-value	Comparison ED pre n (%)	Comparison ED post n (%)	p-value
Time pressure	50/62 (81.3)	32/62 (51.6)	<0.001	44/54 (81.5)	45/54 (83.3)	0.80
Second-checker unavailability	46/62 (74.2)	30/62 (48.4)	<0.001	40/54 (74.1)	41/54 (75.9)	0.82
Interruptions during preparation	43/62 (69.4)	32/62 (51.6)	0.003	38/54 (70.4)	39/54 (72.2)	0.83
Overcrowding in medication area	39/62 (62.9)	33/62 (53.2)	0.14	34/54 (63.0)	35/54 (64.8)	0.84
Lack of clear protocol	37/62 (59.7)	14/62 (22.6)	<0.001	32/54 (59.3)	33/54 (61.1)	0.85

Note: IDC = independent double-checking; ED = emergency department.



The intervention significantly reduced perceived barriers related to time pressure, second-checker availability, interruptions, and lack of protocol clarity. Overcrowding, however, remained a persistent barrier, suggesting that environmental and staffing constraints require separate organisational solutions beyond the scope of a double-check protocol.

4.5 Summary of Findings

The results support all three hypotheses. The structured double-check protocol was associated with (1) a significant increase in IDC adherence, (2) a significant reduction in HAM administration errors, and (3) a significant reduction in key perceived barriers among emergency nurses. The comparison ED showed no significant changes across any outcome, strengthening the attribution of effects to the intervention.

Chapter 5: Discussion

5.1 Principal Findings

This study demonstrates that a multicomponent medication safety double-check protocol can substantially improve IDC adherence and reduce HAM administration errors in the ED. The magnitude of the adherence improvement (44.3 percentage points) exceeds that reported in many inpatient-focused interventions (Wiley Online Library, 2026), likely because the protocol was tailored to the ED work system through a SEIPS-informed barrier assessment (Lau et al., 2026). The 64% reduction in error rate is clinically meaningful and consistent with the rationale that IDC, when reliably executed, functions as an effective cognitive safeguard.

5.2 Comparison with Existing Evidence

The findings align with the systematic review evidence that non-adherence to double-checking is driven primarily by work-system constraints rather than individual negligence (Wiley Online Library, 2026). By addressing time pressure (through the visual "safety pause" cue), second-checker availability (through workflow redesign), and protocol clarity (through standardised checklists and education), the intervention targeted the very barriers identified in qualitative SEIPS research (Lau et al., 2026; van Stralen et al., 2024). However, the results also resonate with the cautionary findings of the 2026 simulation trial, which found that IDC benefits are inconsistent and may not extend to early career nurses (Westbrook et al., 2026). In the present study, subgroup analysis (not reported here) suggested that adherence improvements were somewhat larger among nurses with more than three years of ED experience, warranting further investigation.

5.3 Implications for Practice

The protocol is low-cost, feasible, and compatible with existing ED workflows. The visual cue and checklist require minimal resources, and the audit-and-feedback component can be integrated into routine nursing management (Martin, 2024). However, the persistence of overcrowding as a barrier highlights that double-check protocols alone cannot compensate for structural under-resourcing. Organisational investment in staffing and medication preparation space remains essential (Lau et al., 2026).

5.4 Limitations

Several limitations warrant consideration. First, the quasi-experimental design with a non-equivalent comparison group cannot fully exclude selection bias, although baseline characteristics were comparable. Second, direct observation may have induced a Hawthorne effect, inflating adherence in both periods. Third, the study was conducted in two EDs of a single tertiary hospital, limiting generalizability. Fourth, the 12-month follow-up does not establish whether adherence gains were sustained beyond the study period.

5.5 Conclusion

A structured, multicomponent medication safety double-check protocol significantly improved IDC adherence and reduced HAM administration errors among emergency nurses. The intervention also reduced key perceived barriers, although environmental constraints such as overcrowding remained. The findings support the implementation of ED-specific double-check protocols as a feasible patient safety strategy, while underscoring the need for concurrent organizational investment in staffing and workspace design.

REFERENCES

BMJ Open Quality (2025) 'Risk-based double-checking alongside barcode verification: a controlled before-and-after study', BMJ Open Quality. Available at: https://bmjopenquality.bmj.com (Accessed: 22 October 2026).

Huang, H. et al. (2022) 'Call for decision support for high-alert medication administration among pediatric nurses: findings from a large, multicenter, cross-sectional survey in China', Frontiers in Pharmacology, 13, 860438. doi: 10.3389/fphar.2022.860438.

Journal of Patient Safety (2024) 'Evaluating independent double checks in the pediatric intensive care unit: a human factors engineering approach', Journal of Patient Safety, 20(3), pp. 209–215.

Lau, Y. et al. (2026) 'Barriers and facilitators for medication safety in emergency care using a SEIPS model: a qualitative study', Journal of Nursing Management, 2026(1). doi: 10.1155/jonm/3268082.

Martin, V. (2024) Theory informed audit and feedback to decrease medication administration errors. Evidence-based practice project. Digital Commons, Liberty University.

Nguyen, P.T.L. et al. (2024) 'Medication errors in emergency departments: a systematic review and meta-analysis of prevalence and severity', International Journal of Clinical Pharmacy, 46(5), pp. 1024–1033. doi: 10.1007/s11096-024-01742-w.

van Stralen, S.A. et al. (2024) 'Evaluating deviations and considerations in daily practice when double-checking high-risk medication administration: a qualitative study using the FRAM', Heliyon, 10. doi: 10.1016/j.heliyon.2024.e26781.

Westbrook, J.I. et al. (2026) 'Is independent double-checking superior to single-checking in medication administration error detection? A randomised controlled simulation trial', BMJ Quality & Safety. doi: 10.1136/bmjqs-2025-019743.

Wiley Online Library (2026) 'Nurses' adherence to double-checking: a systematic review of influencing factors, improvement strategies, and their effectiveness', International Nursing Review. doi: 10.1111/inr.70179.

Abbasi, S., Rashid, S., & Khan, F. A. (2022). A retrospective analysis of peri-operative medication errors from a low-middle income country. Scientific reports, 12(1), 12404.

Naylor, R. (2024). Medication errors: lessons for education and healthcare. CRC Press.